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Using Transdisciplinary Approach in Biology Instruction

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ABSTRACT

This study aimed to determine the effectiveness of integrating Transdisciplinary Approach in Biology instruction. The study was conducted in a public high school in Carmen, Cebu and employed a quasi-experimental method, particularly the pretest-posttest design. Respondents were grouped into control and experimental group. Both groups were given a pretest and posttest. The experimental group was exposed to the integration of Transdisciplinary Approach, while the control group underwent the conventional way of teaching. The experimental group completed an attitude survey to assess their attitude toward the intervention. Both the experimental group and control group performed Below Average on the pretest. In the posttest, the performance of the control group was still Below Average. However, the experimental group showed an Average performance in their posttest. The control group showed no significant improvement while the experimental group showed significant improvement in Biology from pretest to posttest. The experimental group manifested Positive attitude towards the use of transdisciplinary approach in their biology class. Based on the findings of this study, the integration of Transdisciplinary Approach was proven to be more effective than the traditional teaching approach in enhancing and improving the biology performance of the students. The researcher recommends that: curriculum experts promote and support the integration of transdisciplinary approach in every subject area; educational institutions provide trainings on its implementation and develop manuals to properly orient the teachers; teachers focus more on pragmatic teaching rather than conventional classes and future researchers carry out similar studies with a broader scope.

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1. INTRODUCTION

THE PROBLEM AND ITS SCOPE

Rationale

The Department of Education is committed to holistically equip learners with 4th industrial revolution skills through an integrative education system that is responsive to the needs of individuals and society (Baska & Little, 2017). Republic Act No. 10533, one of the DepEd's major reforms, emphasizes students' participation in a dynamic social process that adapts to and reflects changing social and cultural paradigms (Official Gazette, 2014). This means that students must be able to make connections between ideas and experiences in order to apply knowledge and abilities to complex problems. With this, teachers must be creative and innovative educators whose main goal is to improve students' achievement by figuring out how to give them a holistic view of reality.

Among the other disciplines, Biology is the branch of knowledge that most likely pervades every facet of our daily living (Braund & Reiss, 2015). However, Biology is considered a difficult subject by most students because of the concepts that are too abstract and the nature of Biology that forces them to memorize biological facts to learn them (Tekkaya et al., 2018). Human Organ Systems are some of the Biology topics that students perceived as difficult to understand because they find the human body processes too complicated to understand and can only be learned through memorization (Tekkaya et al.,

2018). As a public-school teacher, the researcher has also experienced first-hand that some students consider Biology as a subject matter that only requires memorization skills and that terms are too foreign for them to understand.

According to Cimer (2016), one possible reason why Biology is difficult for most students is the way Biology is taught. Students may regard Biology as a science that only needs the memory of factual knowledge if teachers are excessively knowledge-based and if learning is only limited within the four corners of the classroom. As a result, students lose interest in Biology and develop negative views towards the subject. For this reason, the researcher opted to think of a teaching approach that may be suited for Biology instruction that may help students apply what they had learned in class to their daily lives and may guide the teachers on how to break the barrier between classroom setting and real-life situations.

UNESCO (2018) proposed integrating transdisciplinarity as one of the key methods for finding solutions to 21st-century challenges. The transdisciplinary approach focuses on project-based programs where students go above and beyond the bare minimum to answer open-ended questions, have lower absenteeism, retain what they have learned, apply learning to real-life problems, and have fewer discipline problems (Geres-Smith, 2020). According to Ghasr (2020), this method focuses on interactions among, across, and beyond disciplines with the purpose of better comprehending the contemporary environment and addressing complex societal issues.

With this concern, the researcher believes that transdisciplinary approach should be employed as an intervention to help learners develop specific learning capacities while simultaneously learning in a real-world situation. The literatures also show that there are few educational studies on the integration of transdisciplinary approach in the field of Biology, which prompted the researcher to conduct this research. With this presumption, the researcher intends to evaluate the effectiveness of integrating the transdisciplinary approach into Biology instruction.

The Problem

Statement of the Problem

This study aimed to determine the effectiveness of integrating Transdisciplinary Approach in Biology instruction among Grade 11-Humanities and Social Sciences students.

Specifically, this study sought to answer the following questions:

1. What is the pretest and posttest performance of the Grade 11 students in the:
1.1. control group (exposed to conventional teaching approach) and;
1.2. experimental group (exposed to the integration of transdisciplinary approach)?
2. Is there a significant mean improvement in the academic performance from the pretest to posttest of the Grade 11 students in the:
2.1. control group, and;
2.2. experimental group?
3. Is there a significant difference in the mean improvement in the academic performance between the control group and the experimental group?
4. What is the level of attitude of the experimental group toward the integration of transdisciplinary approach in teaching Biology?
5. What intervention may be proposed to enhance the performance of the students in Biology?

Statement of the Hypotheses

These were the null hypotheses that were used to answer the problems of the study:

Ho1: There is no significant difference between the hypothetical mean and actual mean of the pre-test and posttest performance of the Grade 11 students in the:
1.1. control group, and;
1.2. experimental group.

Ho2: There is no significant mean improvement in the academic performance from the pre-test to the post-test of the students in the:
2.1. control group, and;
2.2. experimental group.

Ho3: There is no significant difference in the mean improvement in the academic performance between the control group and the experimental group.

Theoretical Background

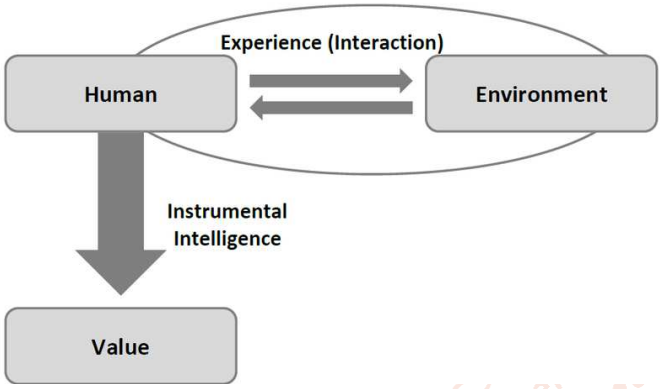
Related Theories

The theories that anchored the integration of Transdisciplinary Approach were the Progressive Education Philosophy by John Dewey and Susan Drake's Hierarchy of Curriculum Integration. On the other hand, the theories and philosophies that anchored the Conventional Teaching Approach were Essentialism Philosophy by William Bagley, Direct Instruction Theory by Siegfried Engelmann and Doug Carnine and Cognitive Psychology by Ulric Neisser.

Progressive Education Philosophy. A change in perspective about the nature of the kid, classroom processes, and the school's aims had increasingly dominated educational discourse by the turn of the

century. A term informally referred to as "Progressive Education," described to have more child-centered components, became part of a more significant dramatic rebellion opposing school formality and a challenge to tradition (Reese, 2017). Though progressive education is generally a new concept, it actually has a long history. John Dewey was an American philosopher, pragmatist, and educator whose critical writings helped launch the progressive education movement.

Figure 1 The Framework of John Dewey's Progressive Education Philosophy (Dewey, 1956)



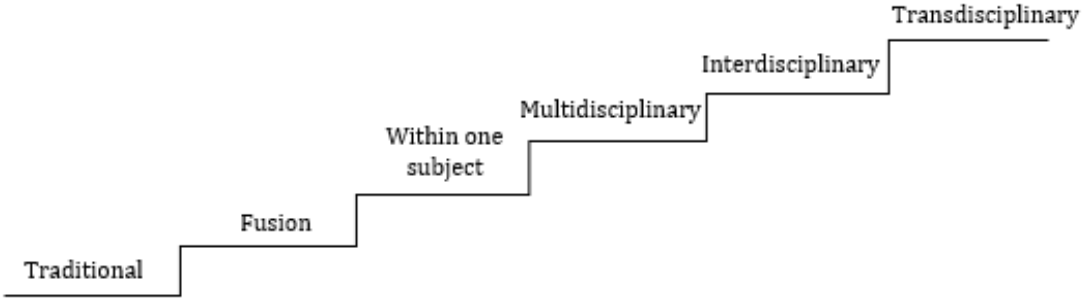
According to Dewey's Philosophy of Progressive Education, pedagogical approaches used by schools cannot be abstracted or separated from life. Instead, the school serves as a community that prepares students for a bigger society. Dewey views art in the context of cultural development to be an aesthetic experience, suggesting that by elevating our quality of life, this experience might help us achieve significance and self-realization (Dewey, 1956). As shown in **Figure 1**, Dewey (1956) believes that the individual's interactions with their environment determine the values that underpin such interactions and develop their pragmatic intelligence. As a result, education is created through actual experiences.

According to Lee & Oh (2019), the concept of pragmatism is a significant component of this philosophy. Dewey contends that education must be democratic and pragmatic. He considers that all participants are equivalent and share the goal of instilling social consciousness in students (Dewey, 1956). Dewey's curriculum comprised of three elements in the past: intellect, knowledge, and recreation (Dewey, 1956). Combining these three characteristics, in theory, permits education to advance and transcend formal means, understanding that education tries to influence life, social improvement, and personal growth.

There is a need for current traditional education structures to be reconstructed employing aspects from Dewey's study when we contextualize Dewey's pedagogical philosophy to modern education. The most crucial aspect is removing the assumption that the educational experience is limited to the classroom setting and recognizing the need to integrate education into daily life. Students would be able to regularly let their experiences shape their education and social consciousness because of this. Dewey's Philosophy of Progressive Education is related to the integration of transdisciplinary approach since the goal of this approach is to connect learnings to the students' individual real-life experiences and make these experiences as the foundation for academic improvement and self-development.

Hierarchy of Curriculum Integration. The second theory that anchored the integration of Transdisciplinary Approach is the Hierarchy of Curriculum Integration by Susan Drake. Curriculum integration is defined by Drake (2007) as establishing connections between real-life situations and academic content areas. It is a creative method of teaching children to comprehend ideas and concepts that are related to various learning areas. Through the discussion and selection of themes, queries, and areas of interest, child-centered integration encourages students to engage in decision-making (Drake and Burns (2004). Drake and Reid (2018) stated that students can no longer merely memorize a series of facts just to pass an exam. They must be lifelong learners capable of managing and interpreting large amounts of data as well as problem-solving complex issues of the day. Students need the ability to navigate life in an ever-changing and increasingly complex environment.

Figure 2 A representation of Hierarchy of Curriculum Integration (Drake, 2007. p.27)



According to Drake (2007), curriculum intelligence makes education relevant to learn. As represented in **Figure 2**, the hierarchy of curriculum integration begins with traditional and progresses to

transdisciplinary. According to Drake (2007), students are better prepared to be lifelong learners and global citizens through an integrated curriculum.

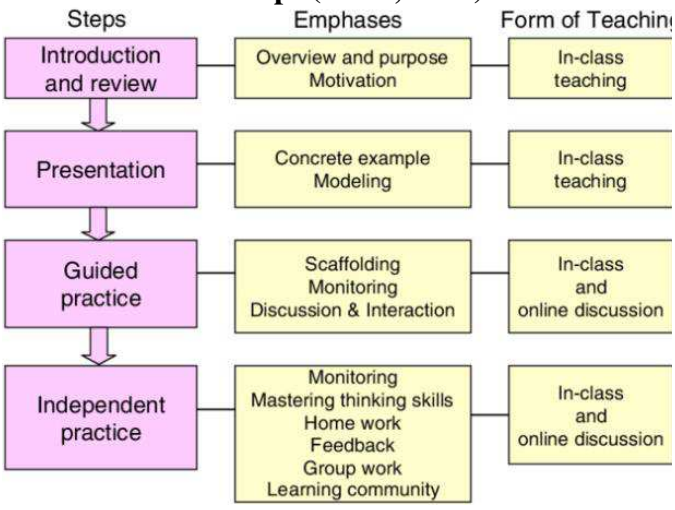
In his paper, Drake (2007) distinguished each step. Students are taught in each discipline separately at the traditional level. The Fusion level uses a topic to connect numerous fields. For example, social responsibility, environmental issues, and social action, for example, are all incorporated into the subject of Science (Drake, 2007). The third level is where sub-disciplines are combined into a single subject area. After the third level comes the three (3) curriculum integration approaches. Multidisciplinary is the approach where disciplines are linked by a common theme, which is studied in multiple classrooms simultaneously. Next to multidisciplinary is interdisciplinary. Drake (2007) explained that in the 5th level, subject areas are linked by overarching questions, cross-disciplinary standards, or a shared conceptual focus. The last level represents transdisciplinary integration. This approach varies from others in sense that it begins with the real-world setting rather than the disciplines. The disciplines are woven throughout the learning and teaching process, but they are not the center of attention (Ozer, 2010). Drake's Hierarchy of Curriculum Integration (2007) anchored the integration of transdisciplinary approach since this approach believes that learning cannot be genuinely authentic unless it is based on experiences outside the classroom.

The two theories served as the foundations in the integration of transdisciplinary approach. The Philosophy of Progressive Education supports the integration of transdisciplinary approach since during the implementation of the intervention, there are activities in which the students were given the chance to interact with their environment. Field trips, experiments, and explorations are just a few of the activities that are designed to help students build their character while also developing their pragmatic intelligence (Drake & Burns, 2004). Meanwhile, the Hierarchy of Curriculum Integration also scaffolds the integration of the transdisciplinary approach because it involves activities like discussing societal issues, reading news and histories. With these activities, students are establishing connections between real-life situations and academic contents. Transdisciplinary approach is focused on student-centered activities in which they are also engaged in dealing with their own experiences. These are the same ideas that the two theories wanted to emphasize.

Essentialism. The first theory that anchored the Conventional Teaching Approach is the philosophy of Essentialism. This philosophy stresses the development of core skills (Lynch, 2016). According to this theory, the mind should be trained. Essentialist educators place a premium on transmitting a series of increasingly tricky concepts and learner advancement to the next grade or level (Edupedia, 2018). Subjects are grouped chronologically to provide a full grasp of today's reality, focusing on the material world's and culture's historical context (Lynch, 2016). William C. Bagley was one of the proponents of essentialism. Bagley believed that education should be used to protect society rather than transform it (Lynch, 2016). Bagley recommended schools and educators develop what is now known as the core curriculum and stick to it. This theory reinforces the conventional teaching approach since both emphasize teacher authority and places a greater attention on rigid discussion.

Direct Instruction Model. The next teaching method that supported the Conventional Teaching Approach is the Direct Instruction by Engelmann and Carnine (1982). The use of concise, explicit teaching strategies, typically to teach a particular skill, is known as direct instruction. It's a teacher-directed approach, which means the teacher needs to stand in front of the class and to present the material (Howard, 2021). This teaching method states that the most effective way of teaching is through clear, specific, guided instructions (Engelmann and Carnine, 1982). This method of instruction stands in contrast to other teaching methods, which could be more passive. It's a popular teaching method that relies on rigid lesson plans and lectures with no room for variation (Teachnology, Inc, n.d.). Recitation, workshops, seminars, case studies, and internships are not emphasized in the Direct Instruction (Engelmann and Carnine, 1982). Direct instruction supports the notion of conventional way of teaching since both highlight passive discussion and even the conduct of activities were advised to be minimized.

Figure 3 Diagram of the Direct Instruction Concept (Main, 2019)



Main (2019) introduced the four main features of the direct instruction concept (see Figure 3), which ensure that students learn better and quicker than any other teaching method available. The first feature is that students are assessed at the beginning of each program to see which topics in education they have mastered and which areas they need to improve on. Then, students with common learning stages are clustered together rather than those in the same grade level. The second feature is that the programs are designed to ensure that students master the content. They are organized in such a way that the skills are introduced gradually (Main 2019). This signifies the increase of the likelihood of student achievement, as the children learn and apply the skills before moving on to the next set. The next and the third feature is that teaching is adapted to each student's learning pace. A unique feature of DI is that students are taught at their own pace. The last feature according to Main (2019) is that prior to publication, programs are re-evaluated and revised. This implies that the program being offered to students has already been proven to be effective.

Cognitive Psychology. The last theory that anchored the Conventional Teaching Approach is Cognitive Psychology by Ulric Neisser. In the year 1967, cognitive psychology was born, and it played a role in the shift away from behaviorism. According to UNESCO-IBE (1995), individuals are no longer seen as collections of responses to external stimulations, as behaviorists understand them, but rather as information processors. Learning is defined as the acquisition of knowledge in cognitive psychology (Neisser 1967). The learner is an information processor who absorbs data, performs cognitive operations on it, and stores it in memory. As a result, lecturing and reading textbooks are its preferred methods of instruction and the learner is just a passive receiver of knowledge.

For a long time, the educational system has employed the traditional teaching approach. The use of conventional approach as a teaching method is scaffolded by the following theories and philosophies: Essentialism, Direct Instruction, and Cognitive Psychology. The three teaching methods emphasized teacher's authority inside the classroom and mastery of the content. Essentialism places greater attention on the mastery of essential ideas and skills. In order to do this using the conventional teaching approach, the teacher is the source of knowledge and subject matter is the center of the curriculum. Direct Instruction is crucial to the traditional teaching approach, which aims to guarantee that learners have mastered the content. To make this happen, the teacher adapts the independent practice method, in which each student works at their own pace throughout the discussion. Lastly, the Cognitive Psychology acknowledges the student's capability of absorbing information given by the teacher during the lecture discussion. It anchored the use of conventional teaching approach since this approach recommends the use of lecture and textbooks for the learning process. Although there are numerous creative approaches to facilitate class discussion, the traditional teaching approach will always be employed in classrooms and can be fully utilized by the teacher when necessary.

Related Literature

K-12 Curriculum Integration. With the full implementation of R.A 10533, which is also known as "Enhanced Basic Education Act of 2013", the Philippine education system is envisioned and expected to develop responsible and productive individuals equipped with essential skills, competencies, and values for both life-long learning (Official Gazette, 2014). The main goal of identifying and amending laws governing the country's education sector is to make the Philippines more globally competitive and equip the learners to survive in a fast-tracking social world (Tobias et al., 2018). Its goal is to allow students to expand their current knowledge while expressing themselves through their abilities, interests, learning styles, and potential. It emphasizes students' participation in a dynamic social process that adapts to and reflects changing social and cultural paradigms.

Since the Kto12 curriculum was born, the Department of Education has been conducting a series of capability-building activities intended to assist teachers in addressing and improving issues related to the K–12 curriculum framework, competencies, teaching plans, and assessment, thus helping them in realizing the importance of understanding the nature of 21st-century learners to respond appropriately to their different needs (Altun, 2014). According to the Division of Cebu Province website (n.d) (http://www.cebuprovince.deped.gov.ph/), the trained K–12 teachers are supposed to be creative, imaginative educators whose primary aim is to improve students' achievement. This is why DepEd is looking for ways to construct a rigorous, relevant, and engaging curriculum that adheres to the Gender and Development (GAD) Principles. Although efforts have been made to improve student achievement, the difficulty of delivering quality education to learners in the country remains (Pressreader, 2016).

Academic Performance of K-12 Students. Philippine politicians looking into the implementation of the K–12 curriculum has recommended that the primary education system be improved, and that school training be better aligned with industrial needs (Business World, 2019). The author of the news report, Aguinaldo (2019), stated that one of the Senators announced after the panel assessed the execution of the Enhanced Basic Education Law, which has been in effect for six years. Mr. Gatchalian cited data from the Department of Education (DepEd) that showed a decrease in the overall NAT average of the students since 2013-2014 (Business World, 2019) and in the subject Biology for the year 2016-2017 (BEA-EAD, 2019). Gatchalian (2019) claimed that they would go over the K-12 Curriculum and examine if the practical ability taught in the said curriculum are the skills that the industry requires. That means there might have a misalignment between what the real-world needs and what is taught in the existing K-12 curriculum.

The Manila Times (2020) published an article about the deterioration of the quality of education in the Philippines. Filipino students were at the bottom of the pack in math and science proficiency in the 2019 TIMMS (Manila Times, 2020). The article also stated that the Philippines got scores of 297 for Mathematics and 249 for the subject Science, correspondingly, the lowest marks among students from the 58 countries who took part in the research. This signifies the need for solid educational planning among the educational administrators and specialists to develop an intermediary to improve the quality of education the country already is facing (Alcuizer, 2016).

Biology as a Difficult Subject. Various scholars throughout the world have investigated students' difficulties in learning biology. According to the analysis of data conducted by Cimer (2016), there are five primary reasons: the topic's nature, teacher's style, and teaching strategies, students' learning styles and study habits, and lack of resources. Cimer (2016) also added that the primary reasons behind this were that biology has many concepts and many biological processes and phenomena that are not visible to the human eye. Some notions are too conceptual, and there are many foreign words. Furthermore, Biology covers many concepts and problems that students must understand. A lot of international research has produced similar conclusions. Tekkaya et al. (2018) and Durmaz (2017) found out that the biology curriculum and textbooks in Turkish secondary schools also featured profound knowledge and covered themes or concepts that were difficult to acquire and use in their daily lives.

Aside from the problematic concepts found in Biology textbooks, students also added that this subject demands memorization skills to learn some biological information (Zeidan, 2014). This means that students used memorization as a learning approach. This claim was supported by Turkish researchers Cimer (2016) and Ozcan (2014), stating that memorization is a typical biology-learning approach among secondary students. One possible reason for this decision is the way Biology is taught. Students may believe biology to be a discipline that only needs the memory of factual knowledge if books and classroom activities do not appear to be relevant to students' daily lives and do not contain practical work or experiments (Cimer, 2016).

Apart from the reason that Biology demands heavy memorization skills, another factor that affects students' understanding of biology concepts was how it was imparted. Biology lessons are mainly delivered through professors' lectures and classified as teacher-centered lessons (Tekkaya et al., 2018). It was known that Biology classes must only employ practical work and student-centered activities in biology classes (Braund & Reiss, 2015). The lack of a connection between what was taught in biology class and the participants' daily lives was another sub-factor connected to how biology is taught. The respondents of Tekkaya et al. (2018) claimed that the biology classes or teachers could not assist them in making connections between what they learned in class and their daily lives. This showed that lecturers in biology classes only talk and impart theoretical or abstract knowledge, with no applications from everyday life. A local study in the Philippines had the same findings where students couldn't grasp why they were learning such biology topics or concepts as they couldn't connect them to their everyday life (Bug-os et al., 2021). Specific adaptations such as an integrated curriculum may be required for such reasons

Conventional Teaching Approaches. By far the most popular teaching method is the Conventional Teaching Approach (Teachnology, Inc, n.d). Recent studies have cast doubt on its effectiveness, but it has been empirically proven to raise a school's average test scores consistently (Carnine et al., 2004). As a result, the teaching method has been a success and is widely used in classrooms. According to Eigelmann and Becker (1960), when used correctly, can help students improve their academic performance and other affective behaviors. Because of its advantages, many teachers continue to employ the conventional teaching method. According to Education Summary (2022), this form of teaching method includes expectations for students to adhere to a set of rules

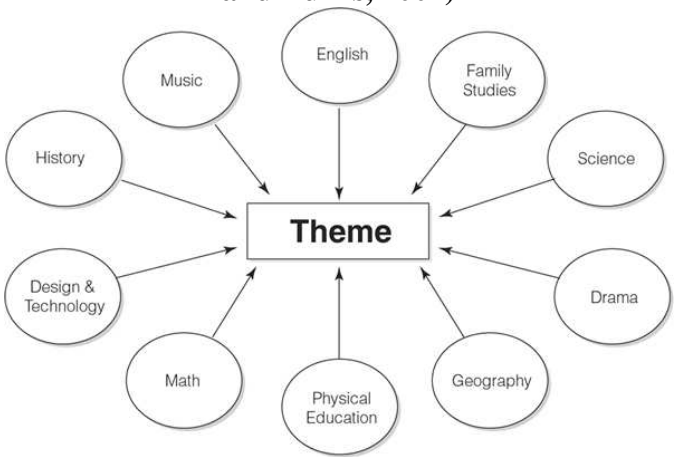
and regulations that help develop discipline in them. Salim (2019) further mentioned that it is a structured form of education where students must show up to class at a specific time and location, developing discipline in the learners. Students will learn how to act in society, how to communicate with others appropriately, and other important life lessons (Salim, 2019).

However, in the current times, because learners are also evolving, some teachers regard the use of scripted lessons with explicit Conventional Teaching Approach as a poor practice. Because Conventional Teaching Approach is usually associated with lecture-style method in classrooms, it produced passive learners obediently sitting on chairs and taking notes (Kelly, 2019). It appears to teachers and education reformers to be outdated, or inadequately meeting student learning needs (Main, 2009). With this situation, there is a need to innovate and incorporate teaching methods that make students feel like they are a part of the class because students are also growing in terms of their learning capacities.

Contemporary Integration Approaches. UNESCO has been active in activities beyond the mono-disciplinary perspective as a multi-sectoral organization. "Multidisciplinary," "interdisciplinary," and now "transdisciplinary" have all been used to describe these modalities (UNESCO, 2018). According to the journal published by Bimpitsos (2012), boundaries, analogies, and distinctions between these contemporary integration approaches have scarcely been explained. Kim (2018), UNESCO's Director for the Division of Philosophy and Ethics, tries to explain a distinction that isn't always obvious regarding the differences between "multi-," "inter-," and "trans-disciplinary" approaches to academic concepts and problem-solving.

"Integration" is the cardinal term for increasing comprehension in an academic world characterized by many separate disciplines. Multidisciplinary integration approaches focus primarily on the disciplines (Drake & Burns, 2004). Teachers who use this approach organize standards from the disciplines around a theme. **Figure 4** shows the relationship of different subjects to each other and to a common theme.

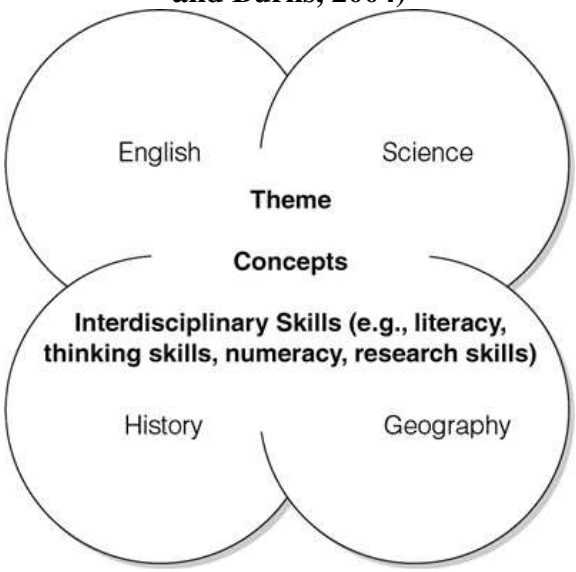
Figure 4 Multidisciplinary Integration (Drake and Burns, 2004)



According to Drake and Burns (2004), there are many ways to create multidisciplinary curriculum, and they tend to differ in the level of intensity of the integration effort. The first one is the intradisciplinary strategy in which teachers can integrate subdisciplines within a subject area. For example, is integrating reading, writing, and oral communication in language arts (Drake & Burns, 2004). Another example is integrating history, geography, economics, and government in an interdisciplinary social studies program. Integrated science integrates the perspectives of subdisciplines such as biology, chemistry, physics, and earth/space science. Through this integration, teachers expect students to understand the connections between the different subdisciplines. Another multidisciplinary perspective is through fusion strategy where teachers can fuse skills, knowledge, or even attitudes into regular school curriculum (Bimbitsos, 2012). Fusion can involve basic skills emphasizing positive work habits in each subject area (Bimbitsos, 2012). An example is when educators fuse technology across the curriculum with computer skills integrated into every subject area.

Interdisciplinarity, built on bringing together different points of view, has its roots in fragmented disciplines. As a result, it falls short of the coherence it seeks (Puig & Froelich, 2021). Drake and Burns (2004) argued that interdisciplinary approach to integration provides the teachers with opportunities to organize the lesson around common learnings across disciplines; however, the integration is limited to the disciplines where common learnings are embedded in the disciplines to emphasize interdisciplinary skills and concepts, such as literacy, thinking skills, numeracy, research skills, among others. The disciplines are identifiable, but they assume less importance than in the multidisciplinary approach. Figure 5 illustrates the interdisciplinary approach.

Figure 5 Interdisciplinary Integration (Drake and Burns, 2004)



The third contemporary approach to integration is the Transdisciplinary approach. Teachers organize curriculum around student questions and concerns (Drake and Burns, 2004). Students develop like skills as they apply interdisciplinary and disciplinary skills in a real-life context (Scott, 2015). Drake and Burns (2004) emphasized that transdisciplinary approach to integration is focused on project-based learning wherein students tackle a local problem. In this approach, the teacher also finds out what the students already know and helps them generate questions to explore. Scott (2015) also added that in this approach, the teacher provides resources for students and opportunities to work in the field. Another perspective of transdisciplinary approach is to give students the opportunity to share their work with others in a culminating activity. Students display the results of their exploration and review and evaluate the project (OECD, 2019). Figure 6 displays the transdisciplinary integration.

Figure 6 Transdisciplinary Integration (Drake and Burns, 2004)

Interactions between the contemporary integrated approaches help connect and integrate different parts of information and each learner's ability to adapt and apply what they know to a real changing context (Augustine, 2018).

Transdisciplinary Approach. Transdisciplinarity is concerned with interactions between, across, and beyond disciplines. Its goal is to comprehend the contemporary world. One of its tenets is knowledge unification, with the sole purpose of "fixing the problem by combining and integrating scientific disciplines and blending them" (Nicolescu, 2011; Hoffman et al., 2017). McGregor (2019) added that transdisciplinarity is a prevailing system of conventional terms and principles that, like anthropology, which is interpreted as "human science," seeks to provide a broader view to disciplines and to solve problems that require a larger perspective than that of other disciplines by combining them. As a result, it aims to discover the truth by combining scientific, philosophical, and epistemological viewpoints. It's a novel technique for generating and integrating complex situations. There are suggested strategies on the application transdisciplinary approach to classroom discussion. Examples are incorporating news to the lesson, reading real-life situations and histories, inviting guest speakers, using realias as instructional materials, having a field trip, simulating real-life experiences and giving students real and tangible life problems to solve (McGregor, 2019; Drake & Burns. 2004; Nicolescu, 2011; Hoffman et al., 2017).

Polk (2015) defines the transdisciplinary approach as one that recognizes mutual learning among a range of participants through deliberate reflexive processes – "ongoing evaluation of the choices made when attempting to determine and integrate diverse preferences, values, competence, values, and knowledge". This is why transdisciplinary inquiry draws people from many academic disciplines, professions, and community stakeholders. It takes place in a specific location over time; it incorporates methods; it promotes the development of mutual understanding; it is highly engaging and collaborative; it recognizes differing views, and it tries to address societal problems while contributing to academic performance. (Toomey et al., 2015; Fam et al., 2018; Klein, 2018).

Isanmann et al. (2016) viewed transdisciplinarity as a notion of addressing challenges from an academic standpoint. This means it isn't a characteristic of a problem in and of itself but rather a method for dealing with contemporary issues or pertinent problems per academic norms. For these ideas, a

difficult undertaking regarding educational issues, especially in the 21st century, necessitates collaborative administration and educational planning (John et al., 2015). Nicolescu (2011) recommended that Transdisciplinarity should be taught in each discipline. This viewpoint was also supported by Jurgena & Cedere (2018). They stated that applying a transdisciplinary approach to solve pressing issues in education and its long-term development can provide new avenues for understanding and explaining the complicated issue of learners' cognitive interest development.

By overcoming the limitations of disciplinary segmentation of knowledge, Rostoka et al. (2021) believed that the transdisciplinary method is a general and valuable means of understanding the content of the information system. According to Jantch (2014), understanding reasons and values, assessing risks from joint activities of multiple cognitive processes, and determining their relevance to modern culture and civilization are all required to adopt a transdisciplinary approach. Jantch (2014) also added that a transdisciplinary approach aims to achieve a synergistic effect in the system of cognition of the world around us.

Related Studies

Conventional Teaching Approach in the Field of Education. Traditional education is a basic kind of education that many educators continue to choose. In a typical classroom, learners congregate at a set time and location beneath a roof. Traditional education uses a teacher-driven teaching method where the instructor's knowledge determines the learner's level of understanding. Because this is one of the most popular teaching approaches, several studies focused on this approach were also conducted. In the study conducted by Abah (2020) which is focused on enhancing conventional teaching, this approach entails improving the way that instruction is delivered by taking into account all viable options and methods well suited for circumstances and provide the highest chance of achieving predetermined goals. A traditional teacher is one who can effortlessly switch between tactics in accordance with the needs of the students and the overall instructional environment (Abah, 2020). Based on the results of their study, Strobel and Barneveld (2009) concluded that traditional teaching methods are more successful for short-term retention as assessed by standardized board tests. Traditional education has been used for many years and is the least expensive in terms of money, time, and effort. This makes it more stable (Barros, 1986; Khan, 2001). Eisentaedt et al. (1990) and Howard et al. (1993) claimed that students continuously get advantages from subject specialists and pick up factual knowledge of the relevant subject. As a result, they score better on tests. There are reports of better performance in concern to diagnostic skills, basic mechanism of disease process and that reflected in post-course examinations (Eisentaedt et al., 1990; Allison et al., 2002; Coulson, 1983).

Studies also declared that there are demerits in using this approach. Some conventional teachers don't provide a conducive learning environment due to their prejudice in favor of the selection and change of information retrieved through books. Additionally, some students may not speak during the lesson, unable to comprehend a word the teacher has said in class because teachers and students are not equally involved in this system (Al Ameen, 2010). According to the findings of Abdul (2019), some students have complained that some teachers don't appreciate questions that relate to the subjects they are teaching. Some students may not use additional resources in conventional institutions since some teachers dictate notes, which frequently overloads learners with information. Critical issues are not being given importance or attention, evaluation, clinical reasoning, independent study, or problem-solving, as well abilities in systems thinking (Abdul, 2019). As a result, when presented a problem, students in traditional schools exploited basic science inferences irresponsibly (Finch, 1999; Shahabudin, 1997). Moreover, one of the most undervalued skills is cooperation. It uses a non-interactive lecture model for instruction. Students frequently remark "non-relevant, passive, and uninteresting" terms of their prior medical training (Finch, 1999; Shahabudin, 1997). As a result, learners experience stress and worry, which is a warning environment for health.

Integrated Curriculum. Curriculum integration is a student-centered pedagogical approach that focuses on real-life challenges drawn from various topic areas. Students are fully involved in planning as they undertake and evaluate their learning (Etim, 2015). An integrated curriculum is not a novel educational technique. According to Progressives such as Jean-Jacques Rousseau and John Dewey, learning in school should be interconnected to the actual world. And school activities should respond to the student's interests. (Ozer, 2010).

According to the study conducted by Drake (2007), learners in integrated curricula achieve much higher academic accomplishment. Though there were few pieces of research on the relationship between integrated curriculum and standardized examinations, Drake (2007) claimed numerous benefits. Integrated curricula can improve learning, promote personal growth, boost self-motivation, increase capacity to

apply concepts, improve student knowledge of science concepts, and increase higher thinking skills.

Other educational studies have concluded that an integrated curriculum fosters intellectual curiosity, enhances attitudes toward school, improves problem-solving skills, and leads to improved academic accomplishment. In the views of Barefield (2015), students in alternative programs perform at least as well, if not better, on standardized examinations than students in traditional programs. They believe that by including added features, teaching and learning will become a more interesting and engaging endeavor. More empirical studies such as integrating teaching approaches are likely to be added to the knowledge base in the era of data-driven decision-making.

Transdisciplinary Approach in the Field of Education. Studies conducted over previous years had projected significant changes in the educational system. These studies show that the educational landscape is shifting drastically, necessitating a new paradigm (Flogie & Abreek, 2015). As a result, the choice to embrace transdisciplinary approach to education's long-term growth has emerged as a feasible answer that can provide a fresh open perspective for understanding and interpreting the complicated issue for long-term stability.

What distinguishes transdisciplinarity from other approaches and ensures its relevance in 21st-century education is its embrace and focus on the intrinsic complexity of reality that emerges when examining an issue or situation from multiple perspectives and aspects to uncover hidden connections between disciplines (Madni, 2007, p. 3). Baumber et al. (2019) investigated how a transdisciplinary approach might be utilized to understand better and promote student-teacher collaborations. The teacher and students come from different disciplinary backgrounds and have different levels of expertise. It was discovered that there is a growing body of data demonstrating how incorporating student viewpoints into the design and delivery of educational programs may improve higher education experiences and learning in ways that benefit both students and faculty and the entire institution.

Button (2009) conducted a study among STEM students and observed that students could develop a more expansive disposition for thinking and learning, becoming metacognitive because their assignments were actual performance tasks that allowed them to link to real-world circumstances. It was also known that Transdisciplinary inquiry is a type of professional learning that is widely available in the public school system (Geres-Smith, 2020). According to Crinall and Henry's (2018) findings, this form of integrated contemporary approach may be more helpful in assisting instructors in implementing new concepts in the classroom, increasing sentiments of educator connectedness, and generating more inclusive environments, especially in public schools where there is a large population of students per classroom.

Krause (2015) research findings suggest that learning took place not through the use of complicated electronic equipment but rather through face-to-face encounters between caring yet varied human individuals and the application of the information in a real-world setting. This shows that transdisciplinary approach as a method of professional learning could be a powerful, efficient, and exciting way to equip educators with the transformative learning experiences they want and need to adapt to changing times and effectively support students' learning quickly. Casey (2009), on the other hand, came to the opposite conclusion, claiming that transdisciplinary approach leads to integration confusion, and the preparation of the curriculum is time-consuming. To have a better implementation, teachers should be well-trained for this approach (Casey, 2009).

UNESCO (2018) promoted the integration of the said approach. Guimaraes et al. (2019) claimed that engaging through a transdisciplinary approach has allowed interaction between university disciplines, connecting information, breaking, and modifying preconceptions among students. This signifies that we should create the circumstances and environments in which education takes place to bring about this shift in perception as teachers. However, the researcher also argues that this can only transpire if educators construct transdisciplinary learning environments. As other studies have found, using this approach promotes authentic experiences by connecting one discipline to the real-world setting (Tobias et al., 2018).

The study of Kovesi et al. (2012) demonstrated the importance of using a transdisciplinary approach to create cutting-edge instructional materials for the training of modern holistic engineers. However, Kovesi et al. (2012) highlighted the challenges in using a transdisciplinary approach when creating teaching materials. Their research showed that a key challenge in their design process was choosing real-world examples for the scenario construction. In a similar study conducted by Ertas et al. (2003), the need for new engineers in the industry and the contribution of business to the creation of transdisciplinary engineering curricula have been discussed. According to the authors, the transdisciplinary approach can help educational programs overcome many of the challenges brought

on by the quick pace of technological change in today's world.

In the field of natural sciences, there are few literatures about the integration of the transdisciplinary approach in a classroom setting. One of them is a study conducted by Jurgena and Cedere (2018), which found that it is insufficient for students to acquire knowledge and skills in several disciplines. They also need more experience using them and the tools to solve problems in their daily life. In other context, there were no distinct disciplines in real life. The ability to perform and solve challenges is based on integrating knowledge and skills, or their integration in a specific life scenario with a particular purpose at a particular time (La Porte, 2015). It implies that the new educational paradigm should be elevated to a higher degree. As a result, transdisciplinarity must be considered in the teaching/learning process, which entails investigating some real-world issues and combining the perspectives of several disciplines so that students can apply their new knowledge and understanding to real-world situations.

In most of these studies, the commonly cited transdisciplinary method remains descriptive rather than pragmatic at this time. As a result, the researcher believes that transdisciplinarity should be introduced as a living experience that brings participants together from various backgrounds to break the barriers between disciplines and real- world context to demonstrate explicitly the combination of technical fields that make up this fast-paced educational system.

To have a clearer conceptual view of this research, a theoretical-conceptual framework is shown and described on the following page, which is steered by the above-mentioned related theories, pieces of literature, and studies.

Theoretical Conceptual Framework

The theoretical-conceptual framework of the study is presented below.

Figure 7 Schematic Diagram of the Theoretical-Conceptual Framework of the Study

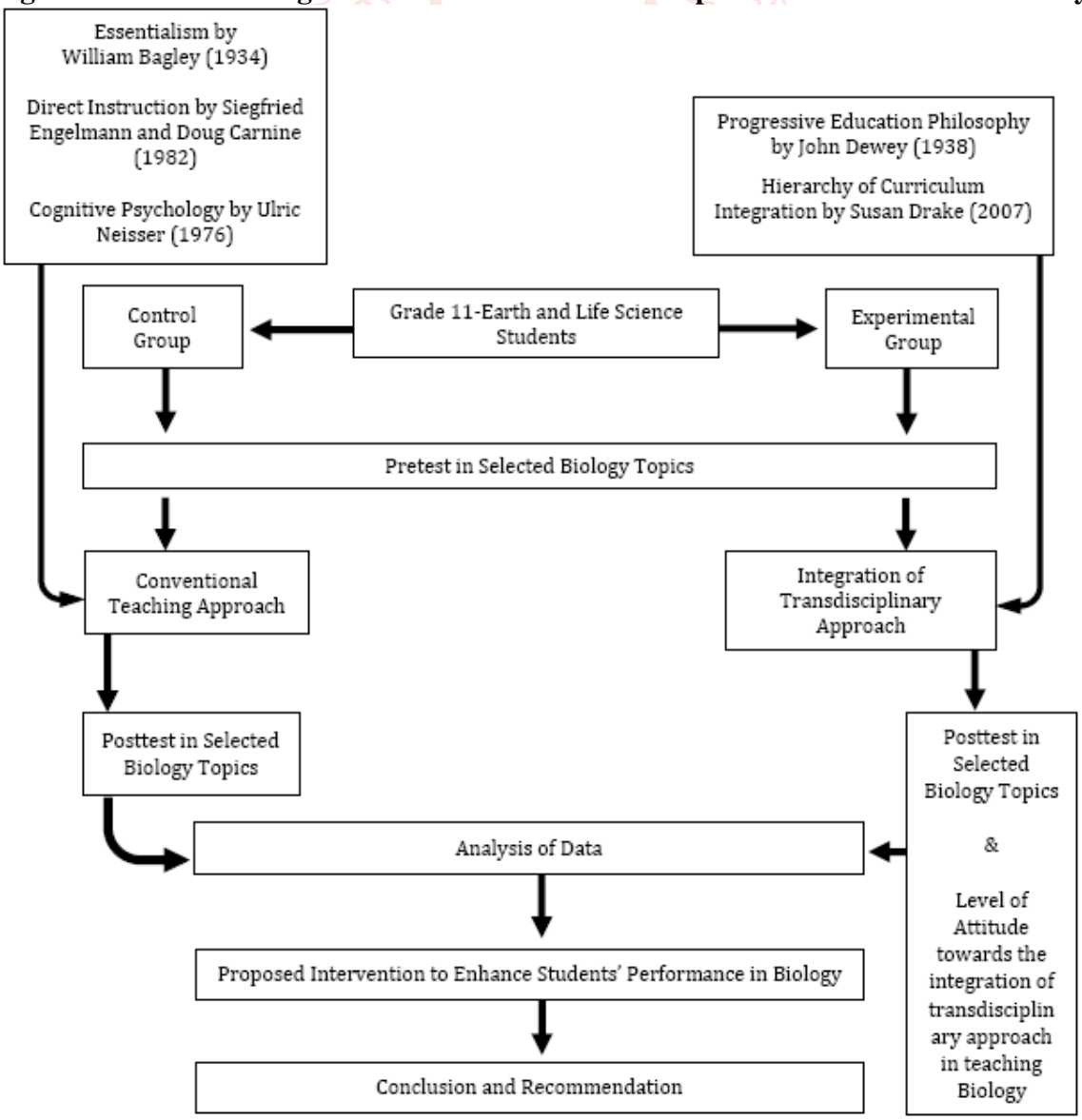


Figure 7 presents the study's theoretical-conceptual framework. The educational philosophy of Essentialism of William Bagley, Direct Instruction by Siegfried Engelmann and Doug Carnine and Cognitive Psychology by Ulric Neisser underpins conventional teaching approach. On the other hand, Progressive Education Philosophy of John Dewey and Susan Drake's Curriculum Integration Hierarchy are the philosophies and theories which serve as the foundation for the study's intervention.

The study's chosen subjects were the pre-selected sections of Grade 11-HUMSS students from a public high school in Carmen, Cebu. This group of Senior High School (SHS) students were the chosen subjects because aside that they are taking Biology subject, Bone and Reid (2010) argued that SHS students especially the Grade 11 were facing transition issues resulting to having poor Science academic performance. The subjects were divided into two groups, experimental group and control group. The experimental group was exposed to the integration of the transdisciplinary approach, and the control group was taught only using a conventional teaching approach. Each group answered the pretest and posttest on selected Biology topics, specifically, the Digestive System, Respiratory System, Circulatory System, Immune System, and Nervous System. The researcher chose these topics because, in addition to being covered in the Earth and Life Science competencies, the Human Organ System was considered by students to be one of the most difficult biology topics to learn (Tekkaya et al., 2018). The experimental group took the Survey toward Attitude on the Integration of Transdisciplinary Approach. Afterwards, data analysis was done using statistical tools, and instructional intervention to improve students' performance in Biology classes was proposed. After the analysis of data, conclusions and recommendations were drawn.

Significance of the Study

The findings of this study would be beneficial to the following:

the **school administrators** and curriculum experts could be provided with new teaching interventions that could be integrated into the existing curriculum that fosters students' intellectual curiosity, enhances attitudes toward school, improves problem-solving skills, and leads to improved academic accomplishment;

the **biology educators and subject teachers** could be guided on how to improve their teaching strategies and methods and to provide learners with a broader view to disciplines and to solve problems that require a more extensive perspective;

the **students** could enhance their pragmatic learning, to apply the skills that the industry requires, to understand the real-world situations and they will also appreciate how useful learning Biology in our daily living;

the **parents** could be made aware of the academic performance of their children and would be guided on the practices that will support and enhance their children's ability to comprehend, and interpret knowledge and skills in various settings; and

the **future researchers** could be provided with further reference to pursue related studies and could be given a basis in developing better and more comprehensive research regarding integrated curriculum.

Scope and Delimitation of the Study

The study aimed to test the effectiveness of integrating Transdisciplinary Approach in Biology Instruction in comparison with the Conventional Teaching Approach. Furthermore, the Biology topics that were taught were: (1) Digestive System, (2) Reproductive System, (3) Respiratory System, (4) Circulatory System, and (5)

Nervous System, wherein these are part of the lessons by which the students are taking up from their Earth and Life Science subject. Students belonged to control and experimental group were discussed with the same Biology topics.

The researcher conducted the study on the first two weeks of the First Grading of the School Year 2022-2023. The subjects of the study were the Grade 11-Humanities and Social Sciences Strand students at a public high school in the municipality of Carmen, Cebu. There were two sections involved in this study; one was the experimental group, and the other represented the control group. The experimental group was exposed to class activities that were integrated with the transdisciplinary approach. In contrast, the control group was given the conventional class by which no intervention was utilized. A questionnaire on attitude towards the integration of the Transdisciplinary Approach was administered to the experimental group.

Definition of Terms

The following terms were used in the study;

Conventional Teaching Approach. In this study, this approach is also known as traditional way of teaching where the teacher is the source of all the knowledge and characterized by pure lecture and knowledge-based discussion.

Integrated Curriculum. In the study, this refers to establishing connections for students, allowing them

to participate in relevant, meaningful activities that are relevant to their everyday lives.

Transdisciplinary Approach. In the study, it refers to the intervention to be tested on the experimental group. The Human Organ Systems, specifically the *Digestive System, Respiratory System, Circulatory System, Immune System, and Nervous System*, were discussed during the intervention.

2. RESEARCH METHODOLOGY

This section describes the research methodology, which includes the research design, research environment, research subjects, research instruments, research sampling, data collection procedure, pedagogical approach, research ethics consideration, data management plan and statistical data treatment.

Research Design

The study employed the quasi-experimental method since the research respondents were pre-selected. This study grouped the participants into control and treatment groups for comparison. Mainly, this study employed a pretest-posttest design with respondents receiving the same assessment measures. The research design is shown in the diagram below.

G1	**O1**	**-**	**O2**
G2	**O3**	**X**	**O4**

where:
G1 is the control group that was exposed to conventional teaching approach,
G2 is the experimental group that was exposed to the integration of transdisciplinary approach,
X is the experimental intervention which is the integration of transdisciplinary approach,
O1 is the pretest of the control group,
O2 is the posttest of the control group,
O3 is the pretest of the experimental group, and,
O4 is the posttest of the experimental group.

Research Environment

The study was conducted at a public high school in the Municipality of Carmen, northern Cebu. This school is situated near the river and the provincial road going to the upper barangays of Carmen. The school has a land area of 1 hectare donated by the municipality of Carmen. Its operation started in the School Year 1996-1997. The land is basically flat. Most of the people living near the school's vicinity are farmers, others are construction workers, government employees, and small to medium business owners.

The school serves the people of the upper barangays of Carmen since it is the nearest school located in the vicinity. It is viewed as a great help in the locality because children of financially hard-up families are accommodated in this school. Moreover, it brought education nearer to the people. Before, dedicated students would travel far and pass into undeveloped roads to earn a secondary education. Now, because of the presence of the school, the distance of quality education was cut short. Thus, more students can acquire education with less difficulty. The school is a complete secondary school manned by a Principal offering both Junior and Senior High schools. It has 24 Junior High School teachers with national items and 6 Senior High School teachers with division items. It has a total student population of 1377 enrolled students for the school year 2021-2022, wherein 1083 are Junior High School students, and 294 are Senior High School students.

The school is one of the chosen schools of the Cebu Province Division to conduct the expanded limited face-to-face classes. Prior to this implementation, the school utilized the printed module modality as part of its Learning Continuity Plan because most of the students had issues with their internet connectivity. Senior high school students were the first to take advantage of the expanded limited face-to-face classes.

Research Subjects

This study was conducted on Grade 11-HUMSS students enrolled in the school year 2022-2023. This group of Senior High School (SHS) students were the chosen subjects because aside that they are taking Biology subject, Bone and Reid (2010) argued that SHS students especially the Grade 11 were facing transition issues resulting to having poor Science academic performance. The researcher would like to determine the effectivity of the intervention to students with transition concerns. Aside from that, Umar et al. (2018) also proclaimed that there has been a worrying decrease in the percentage of public senior secondary school students who passed biology as a subject in examinations, as well as a steep increase in the percentage of failures documented. This situation prompted the researcher to choose this set of students. The students who attended the face-to-face classes were the subjects of the study. A total of 36 students were selected as the research participants. There were 18 students from Grade 11-HUMSS Set A, and another 18 students were involved from Grade 11-HUMSS Set B, all of which are taking Earth and Life Science as one of their core subjects. There was homogeneity among the respondents because they all came from the same track and strand. Moreover, Sets A and B used to be in the same section but they were divided into two because the maximum number of students in a classroom in the new normal face-to-face classes was only 20. Students from Grade 11-

HUMSS Set A were exposed to the integration of the Transdisciplinary Approach on their Earth and Life Science lesson, while the student belonging to Grade 11-HUMSS Set B were exposed to the conventional class.

Research Sampling

The participants of the study were chosen through purposive sampling, specifically homogenous sampling, which is a type of nonprobability sample. The researcher selected the sample based on the researcher's knowledge about the study and population. Since the study utilized the quasi-experimental design, this study sought to achieve a homogenous sample.

Research Ethics Consideration

A letter was addressed to the principal of the chosen high school to see if they school would allow the conduct of study with their Grade 11-HUMSS students to be the research respondents. The identification of the prospective respondents was only permitted if approved by the school's principal. The researcher presented a research proposal to the school's review committee to check if the research objectives and designs are ethical and follow the school's code of conduct. When the respondents were already chosen, they were informed about the study and asked to sign a consent form if they decide to engage and participate. The study also ensured that participants received and comprehended all the information they require to make an informed decision, including the study's benefits, risks, institutional approval, and data collection process.

Because the study requires voluntary participation, research participants were free to choose whether or not to participate. All participants have the option to withdraw from or leave the research process at any time without feeling obligated to do so. Moreover, participants were not required to give a reason for leaving the study. The researcher emphasized that there will be no negative repercussions for their refusal to engage.

In the study, confidentiality was displayed. All identifying information provided by respondents, such as names, contact information, physical characteristics, and scores, were managed with strict confidentiality and were not made public.

Data Management Plan

The collected data will only be kept in public access for a maximum of two years. It may be helpful during research revisions, conferences, and publications or as a reference in questions and inquiries related to the study. To ensure data security, the researcher created an electronic copy of it, which was saved on the researcher's external hard drive and sent to the researcher's institutional email account. The processed data were also censored to protect the respondents' anonymity. To comply with the Data Privacy Act of 2012, hardcopies of residual questionnaires, survey forms, and activity sheets were shredded after processing and interpreting the data to ensure data confidentiality.

Data Collection Procedure

Before the data gathering, the researcher applied for Research Ethics Review and accomplished the Research Ethics procedures for Human Investigations. In addition, the researcher sent a request letter to the authors of the Questionnaire on Scientific Attitude via email, requesting permission to adapt and revise their standardized tool based on the research objectives (see Appendix C). For the data gathering, the following stages were included in this study: research permission, pretest administration, experimentation, posttest administration, and an attitude inventory regarding the incorporation of transdisciplinary approach in Biology instruction.

A permission letter was forwarded to the school's principal to respectfully ask permission to start the conduct of the study to the said school (see Appendix A). The request letter was approved and signed by the school's principal and a consent form was given directly to the participating students since the respondents are already 18 years old and above (see Appendix B). The purpose, duration, procedure, and confidentiality of the data obtained during the research process were explained thoroughly to the students. The researcher emphasized to the respondents that participation in the aforementioned study is entirely voluntary and have no bearing on their Earth and Life Science grades. There were no emotional or physical abuse or expenses involved and risk of violating the government's health protocols, data privacy, and child protection policy.

The study was administered in the first two weeks of the First Quarter of the school year 2022-2023. It was done through face-to-face classes. The study was consisted of two groups, the experimental group composed of Grade 11-HUMSS Set A students and the control group consisting of Grade 11-HUMSS Set B students. Before the experimentation phase, the researcher conducted a validated pretest for both the experimental and control group. The coverage for the exam focused on human organ systems, particularly (1) Digestive System, (2) Respiratory System, (3) Circulatory System, (4) Immune System, and the (5) Nervous System. Each topic have 10 items, for a total of 50 items given to participating students in the form of multiple-choice questions.

Following the administration of the pretest, experimentation was carried out. The experimental group was exposed to the integration of the transdisciplinary approach, whereas the control group was exposed to traditional teaching methods. Each topic was taught on different days. After the experimentation phase, a posttest of 50 multiple-choice questions with the same coverage and competency as the pretest was administered to both groups. After the administration of the posttest, the experimental group answered a survey to determine their attitude towards the integration of the transdisciplinary approach during their Earth and Life Science class. The collected data was analyzed.

Pedagogical Approach

This study utilized two forms of pedagogies to teach the Human Organ Systems to the Grade 11-HUMSS students. The first pedagogy was an integration method, and the other was a traditional teaching method. The organ systems were taught in the experiment group through incorporating the intervention, while the organ systems were introduced to the control group through a conventional way of teaching.

Control Group

The control group took a validated 50-item multiple-choice pretest before the experimentation to diagnose their prior learnings on human organ systems. The control group was exposed to a conventional class. The topics were taught using a simple PowerPoint presentation with no interventions involved and no activities involving real- world scenarios. The class was purely teacher-centered, where the source of all the information is the teacher. After the discussion of all the organ systems, a posttest was taken by the control group (see Appendix F, Part I).

Experimental Group

The treatment group also took a validated 50-item multiple-choice pretest prior to the experimentation. The group was exposed to the integration of the Transdisciplinary Approach during the Earth and Life Science class which was the intervention of the study. This group was exposed to activities incorporating real-world scenarios but still adhering to the health protocols. Because the students were directly involved in the teaching-learning process, this was not a teacher-centered class but rather a student-centered class.

To ensure effective delivery of Transdisciplinary Approach as an intervention, the constructivist's 5 E's was used as an instructional design, which focuses on the learners' capability to build or construct new ideas on top of their old ideas (see Appendix F, Part II). The 5 E's can be applied with students of all ages, including adults. Each of the 5 E's describes a phase of learning, and each phase begins with the letter "E": Engage, Explore, Explain, Elaborate, and Evaluate. The 5 E's allows students and teachers to experience common activities, to use and build on prior knowledge and experience, to construct meaning, and to continually assess their understanding of a concept.

Engage. This phase of the 5 E's starts the process. An "engage" activity should make connections between past and present learning experiences; anticipate activities and focus students' thinking on the learning outcomes of current activities; and students should become mentally engaged in the concept, process, or skill to be learned. This phase allows the teachers to provide situations or open-ended thinking activities that will arouse the learner's interest and differentiated activities that will lead them to engage in the teaching-learning process explicitly and implicitly. During this phase, students actively explore their environment or manipulate materials.

Explore. This phase of the 5 E's provides students with a common base of experiences. They identify local problems and scenarios, and develop concepts, processes, and skills. In this phase, the activities require both the teacher and the student to do things differently. There is a shift in who controls the learning. The learner becomes the leader, and the teacher plays the very important role as learning facilitator.

Table 1 Role of teacher and students during the Explore Phase (Division of Cebu Province, 2019)

What the teacher does	What the learner does
Acts as facilitator Observes and listens Asks probing questions Provides time for learners to solve problems Encourages cooperative learning	Conducts investigation Forms predictions and hypotheses Records observations and ideas Shares thinking with others Performs individual tasks contributory to the achievement of group output

(Examples of exploration activities are experimentation or experimental modeling, solving word problems, reading stories, simulation, investigation, etc.)

Explain. This phase of the 5 E's helps students explain the concepts they have been exploring. They have opportunities to verbalize their conceptual understanding or to demonstrate new skills or behaviors. This phase also provides opportunities for teachers to introduce formal terms, definitions, and explanations and expound the importance of the content to the real-world context.

Elaborate. This phase of the 5 E's extends students' conceptual understanding and allows them to practice skills and behaviors. Through new and old real-world experiences, the learners develop deeper and broader understanding of major concepts, obtain more information about areas of interest, and refine their skills.

Evaluate. This phase of the 5 E's encourages learners to assess their understanding and abilities and lets teachers evaluate students' understanding of key concepts and skill development. The teacher assesses learners understanding by giving different types of project-based performance tasks.

The experimental group took a posttest after the discussion of all the topics. The group were also asked to complete a survey adapted from Montclare et al. (2019) to assess their attitudes toward the intervention.

Research Instrument

The researcher utilized a validated teacher-constructed questionnaires as a pretest and posttest (see Appendix G). The questionnaire was comprised of 50 multiple choice questions for the pretest and another 50 items for the posttest (see Appendix D). Questions on the pretest were not repeated nor rephrased on the posttest. However, questions were based on the same competencies. The researcher created a table of specification to maintain the level of difficulty. For the 50-item exam, 10 questions were asked about the digestive system, another 10 for the respiratory system, 10 about the circulatory system, 10 for the immune system, and another 10 for the nervous system. The researcher ensured that for each topic, the number of questions for each cognitive processes were balanced for both pretest and posttest. Three qualified Biology teachers and professors who are experts in their respective schools validated the questionnaires. Following expert validation, the questionnaires were pilot tested to 40 Grade 10 students from the same school. The data collected from the pilot test were analyzed using a statistical tool for reliability (see Appendix I).

In determining the level of attitude of the experimental group toward the integration of transdisciplinary approach in Biology instruction, a standardized questionnaire by Montclare et al. (2019) was adapted and modified to be appropriate for the research problem (see Appendix E).

Statistical Data Treatment

The collected data was analyzed using the following statistical tools:

1. The t-test of small and single sample was used in this study to determine the pretest and posttest performance of the control and experimental groups in the subject Earth and Life Science, as shown below:

$$t = \frac{|H.M. - A.M.|}{\frac{SD}{\sqrt{n}}}$$

where:
t = computed t-test value;
H.M. = hypothetical mean (60% of the total score);
A.M. = actual mean of each group;
SD = standard deviation, and
n = sample size.

2. The paired sample t-test was used in this study to calculate the mean gain from pretest to posttest performance of both the control and experimental groups, as shown below:

$$t = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}}$$

where:
t = computed t-test value;
$\bar{d}$ = mean of differences;
$S\bar{d}$ = standard deviation of the difference, and
n = sample size.

3. The t-test of two independent samples was used in this study to find out the difference in mean gain between the control and experimental groups. The formula is shown below:

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_{d1}^2}{n_1}} + \sqrt{\frac{s_{d2}^2}{n_2}}}$$

where:
t = computed t-test value;
$\bar{x1}$ = mean of the experimental group;
$\bar{x2}$ = mean of the control group;
$S\bar{d}1$ = standard deviation of the experimental group;
$S\bar{d}2$ = standard deviation of the control group;
$n1$ = sample size of the experimental group, and
$n2$ = sample size of the control group.

4. The weighted mean was utilized to evaluate the attitude level of the experimental group toward the integration of transdisciplinary approach in Biology instruction, as shown below:

$$WM = \frac{\sum x\, W}{\sum W}$$

where:
WM = weighted mean;
x = each of the item value;
W = weight of each item, and
"Σ" = the sum of.

All tests were set at 5% level of significance.

3. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter presents, analyzes, and interprets the data gathered to answer the problems of the study.

Performance Level of Grade 11-HUMSS Students in Biology

Table 2 shows the pretest performance of the two groups in Biology (see Appendix H).

Table 2 Pretest Performance of Grade 11-HUMSS Students in Biology

Group	n	H.M.a	A.M.	SD	Test Statistics		Qualitative Description
					Computed t	*p value*	
Control (exposed to conventional teaching)	18	30	18.44	3.32	14.77	< .001*	Below Average
Experimental (exposed to the integration of Transdisciplinary Approach)	18	30	18.44	2.99	16.44	< .001*	Below Average

H.M.[a] = 60% of the test items; for significance p value < ∝. *Significant at a=.05

Table 2 showed the pretest performance level of the Grade 11-HUMSS students in Biology. The table revealed that the control group exposed to conventional teaching with an actual mean of 18.44 and SD of 3.32, and the experimental group with an actual mean of 18.44 and SD of 2.99 displayed significantly lower scores than the hypothetical mean, t(17) = 14.77, p < .001 and t(17) = 16.44, p < .001 which are less than α = .05 respectively. These were significant, hence, HO1 was therefore rejected for both groups. This meant that there were significant differences between the hypothetical mean and the actual mean of the two groups' pretest performances. Both groups performed **Below Average** on the pretest. The control and experimental groups did not achieve the standard passing percentage for public schools which is 60%. The low pretest scores may indicate that Grade 11-HUMSS students have less prior knowledge or may have forgotten some of the basic organ system concepts. Another reason could be the two-year gap of having remote learning because these students were only using the modular modality at the time. This finding supported the claim of Lazarowitz and Lieb (2006), who stated that low pretest scores are expected because students still have misconceptions, naive knowledge, and preconceptions at the start of the discussion, affecting their scores, and also according to Zuckerman et al. (2021), remote learning during the COVID-19 crises impacted students, worsening the learning gaps in Biology. The outcome of the pretest was predictable since the topics had not yet been discussed.

The posttest performance of the Grade 11-HUMSS students in Biology is showed in Table 3.

Table 3 Posttest Performance of Grade 11-HUMSS Students in Biology

Group	n	H.M.a	A.M.	SD	Test Statistics		Qualitative Description
					Computed t	p value	
Control (exposed to conventional teaching)	18	30	20.22	4.40	9.43	< .001*	Below Average
Experimental (exposed to the integration of Transdisciplinary Approach)	18	30	28.78	6.38	0.81	0.429	Average

H.M.[a] = 60% of the test items; for significance p value < ∝. *Significant at a=.05

The control group taught using the conventional way of teaching and without any intervention displayed lower scores than the hypothetical mean with an actual mean of 20.22 and an SD of 4.40, t(17)= 9.43, p < .001, which is less than α = .05. This was significant, thus rejected HO1 which meant that there was still a significant difference between the hypothetical mean and the actual mean of the control group's posttest performance. The control group's achievement in the posttest is still considered **Below Average.** This also showed that group failed to meet the school's standard passing requirement of 60%.

The below average performance of the control group might be attributed to the conventional class given to the group. The class was conducted solely through traditional discussion with only a PowerPoint presentation, and

the contents were taught to the group of students without any reference to real-life scenarios. The teacher discussed the contents purely knowledge based, and the students are just passive receivers of the information. This was in line with Main (2009) finding, stating that this approach is no longer effective particularly in Biology instruction, because learners are evolving, and this method will just produce passive learners obediently sitting on chairs and taking notes. The findings of the study also supported Cimer (2016) argument stating that this approach is already regarded as poor practice because it fails to meet the needs of students, resulting in low grades and performance.

On the other hand, the experimental group with a (M=28.78, SD=6.38) demonstrated comparably with the hypothetical mean, t(17)=0.81, p=.429, which was greater than the significance level. This failed to reject HO1 which meant that there was no significant difference between the hypothetical mean and actual mean of the posttest performance of the Grade 11 students in the experimental group who were exposed to the integration of Transdisciplinary approach. The achievement of the experimental group was **Average**. The group just barely reached the 60% passing criterion set by the school.

The experimental group's average posttest performance might be attributed to the group's exposure to the integration of the intervention which is transdisciplinary approach. Aside from a PowerPoint presentation, a human torso model was used as an instructional tool in this study so that students could gain a better understanding of what the organs would look like in real life. Aside from that, the contents on the various organ systems were linked to real-life examples, such as introducing situations that they may have already encountered. In that way, they could easily relate to the topic and incorporate their learnings to real-life situations. The achievement of the experimental group supported the study of Flogie and Abreek (2015), which stated that incorporating transdisciplinary approach in sciences projected significant changes in the performance of the students and showed long-term growth. Furthermore, other findings which shared similar thoughts and opinion were also corroborated by these results and these were as follows: Integrating transdisciplinary approach is also suited in 21st-century education since it embraces and focuses on the intrinsic complexity of reality that emerges when examining an issue or situation from multiple perspectives (Madni, 2007, p. 3). According to Baumber et al. (2019), this approach allows students to better visualize and remember the lessons because they can relate to them or have possibly experienced them before. Button (2009) observed that students could develop a more expansive disposition for thinking and learning, becoming metacognitive because their activities were actual performance tasks that allowed them to link to real-world circumstances.

However, the experimental group was not able to have an above average performance despite the intervention applied to the group. This may indicate that students still find it challenging and difficult for them to relate the lessons to actual situations. This finding may also be influenced by the students' lack of critical thinking and problem-solving skills when given tasks requiring the use of real-world experiences. This may also suggest that the teacher still lacks the capability of delivering the lesson effectively through transdisciplinary approach. The following assumptions were opined by the following: according to the study of Ertas (2003), the difficulty of transdisciplinary education is possible because students are not conditioned to massive knowledge expansion especially when the lesson is connected to other disciplines. The finding was also supported by the study of Nelson (2001) who argued that there is still significant gap in connecting knowledge areas to real-world themes because even the teachers were struggling in creating activities that are transdisciplinary-focused. This suggested that teachers need to receive the proper training on how to run classes that are transdisciplinary integrated.

Mean Improvement of the Grade 11-HUMSS Students in Biology from the Pretest to Posttest

It was hypothesized in this study that there is no significant improvement of the Grade 11-HUMSS students' academic performance in Biology from the pretest to the posttest. Table 4 presents the control and experimental group's mean improvement in Biology from pretest to posttest.

Table 4 Mean Improvement from Pretest to Posttest of the Control and Experimental Group

Group	n	Pre-test Mean	Post-test Mean	$\bar{d}$	Sd	Test Statistics	
						Computed t	*p value*
Control (exposed to conventional teaching)	18	18.44	20.22	1.78	4.95	1.53	.144
Experimental (exposed to the integration of Transdisciplinary Approach)	18	18.44	28.78	10.33	6.70	6.54	< .001*

*Significant at a=.05

Table 4 displayed the mean gains for both groups. The control group had a mean gain of 1.78, t(17)=1.53, *p*=.144, hence, not significant. This failed to reject Ho2, which means that there was no significant mean improvement in the academic performance of the control group from the pretest to posttest in Biology.

The control group's no improvement in terms of their performance from pretest to posttest might be attributed to the conventional teaching approach in which they were exposed to. Since the approach is just a plain discussion and does not incorporate any intervention, the students just passively listen to the discussion and may become bored along the way. This may suggest for a need of an intervention, where activities are more student-centered, and students participate actively during the discussion. This finding supported Kaufmann et al. (2000), which claimed that traditional classroom settings create passive learners who simply listen and read the material without further reflection, leading to high levels of disengagement and students becoming shy in voicing their queries. As a result, it would take longer for the students to understand the new content or may have completely misunderstood the lesson. UNESCO-IBE (1995) added that since learners are just a passive receiver of knowledge, the lack of motivation is possible and may result to poor academic performance.

On the contrary, the experimental group with a mean gain of 10.33, t(17)=6.54, $p < .001$ showed significant result. This rejected Ho2 which meant that the group manifested significant improvements in their academic performance in Biology from pretest to posttest. The intervention being used is most likely the reason why the experimental group's pretest-posttest performance in Biology showed a significant mean gain. This suggested that integrating transdisciplinary approach can effectively improve and enhance students' learning. This finding was consistent with the following studies: Tekkaya et al. (2018) stated that the connection between what was taught in biology class and the participants' daily lives was a factor in improved academic performance. Learning is more meaningful when students can relate the topics to their own experiences and are more involved during the discussion (Tekkaya et al., 2018). Jurgena and Cedere (2018) also agree with this claim stating that students remember the discussion longer when they can incorporate it with several disciplines. The use of the human torso model as an instructional material may also have contributed to the experimental group's improvement. According to Akpeli (2019), the used of models contribute to an authentic science education. This means that models aid in the simplification and clarification of complex ideas and the structure of a complex phenomenon by reducing it to simpler and more familiar images, thereby promoting retention.

Comparison Between the Control and Experimental Groups in Terms of their Performance in Biology

This study hypothesized that there is no significant difference in the mean improvement between the control and experimental groups' academic performance. Table 5 displays the difference in the mean gains between the two groups.

Table 5 Differences in Mean Improvements Between Control and Experimental Groups

Group	n	Mean Gain	*Sd*	Difference Between the Means	Test Statistics	
					Computed t	p value
Control (exposed to conventional teaching)	18	1.78	4.95	8.55	3.11	.006*
Experimental (exposed to the integration of Transdisciplinary Approach)	18	10.33	6.70			

***Significant at *a*=.05**

Table 5 shows a difference of 8.55 between the mean gains in favor of the experimental group. There was a significant difference in the mean gains between the control and experimental groups, t(34)=3.11, *p*=.006. This rejected the Ho3 which means that the experimental group performed better in Biology than the control group. The integration of transdisciplinary approach is an effective intervention in terms of improving the students' academic performance in Biology. This may imply that students exposed to this intervention might have been actively involved and engaged in the discussion. The students were asked on scenarios involving diseases, medical procedures, and health practices that they had probably encountered or heard about throughout their lives. Students and the teacher were actively involved in an intellectual discourse in this manner. Additionally, students engaged in activities where they acted as organs, simulating bodily functions such as respiration and immunological response. This finding supported the Hierarchy of Curriculum Integration of Susan Drake (2007). Drake (2007) argued that making connections between real-life situations and academic content areas is more effective in molding lifelong learners than simply exposing students to traditional lectures. Students can use what they have learned in practical settings. As a result, it improves their academic performance in Biology and develop positive perceptions towards the subject (Drake, 2007). Furthermore, this result also agreed with the

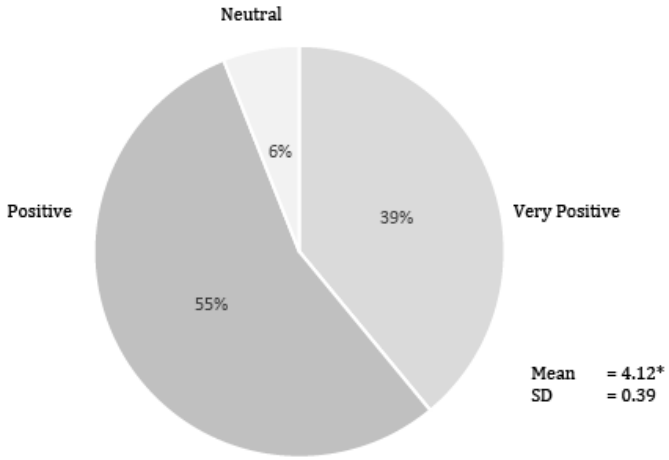
following contentions: Drake and Reid (2018) who asserted that students will not be competitive in the future if they simply memorize a series of facts in order to pass an exam. They must be lifelong learners capable of managing and interpreting large amounts of data as well as problem-solving complex issues of the day. Students need the ability to navigate life in an ever-changing and increasingly complex environment (Dorn et al., 2021).

On the other hand, the control group's poor performance could be attributed to a lack of practical work and student-centered activities in class. The students are listening passively on the discussion that is purely knowledge based. The teacher did not give any scenarios that the students could relate to using their own experiences, nor the teacher asked the class questions about real-life circumstances. This result supported the study of Tekkaya et al. (2018), who claimed that a lack of connection between what was taught in biology class and participants' daily lives was a contributing factor to poor Science performance. As a result, students may not understand why they were learning such topics or concepts because they could not relate them to their daily lives and may find the discussion of the topics irrelevant. Specific adaptations such as an integrated curriculum may be required for such reasons.

Attitude of the Experimental Group Towards the Integration of Transdisciplinary Approach

The experimental group was assessed in terms of their attitude towards the integration of the transdisciplinary approach. The results are presented in Figure 8.

Figure 8 Attitude of the Experimental Group Towards the Integration of Transdisciplinary Approach



As seen in Figure 8, 10 students, or 55% of the experimental group, demonstrated a **Positive** attitude towards the integration of the Transdisciplinary Approach during their Earth and Life Science classes. This means that most of the group exhibited a favorable response towards the used of the intervention of the study. Thirty-nine percent (39%) or 7 students of the experimental group showed a **Very Positive** attitude in response to their experience in attending classes integrated with Transdisciplinary Approach. Meanwhile, only 1 (6%) student manifested a **Neutral** response regarding the intervention. The results were based on a five-point Likert scale attitude survey adapted from Montclare et al. (2019). With a mean score of 4.12 and a standard deviation of 0.39 for the entire group, the attitude was categorized as **Positive** which means that the students exposed to the intervention would like to learn Biology that relates more to real-world scenarios and to their own experiences. The results also showed that relating the topic to the students' experiences help them better understand the topic about organ systems. Additionally, most students strongly agreed that the activities promoted high levels of retention. It is also easier for them to learn Biology if the teaching is contextualized and presented in a way that they can also expressed their own thoughts and relate into it.

This finding corroborated the following studies: Dorn et al (2021) study also revealed that students are more interested and engaged with classes integrated with life experiences than a boring, traditional lecture class. Dorn et al. (2021) added that learning cannot be genuinely authentic unless it is based on experiences outside the classroom. Drake (2007) also claimed positive supports on the integration of the transdisciplinary approach. This approach can improve learning, promote personal growth, boost self-motivation, increase capacity to apply concepts, improve student knowledge of science concepts, and increase higher thinking skills. Hence, integrating transdisciplinary approach in Biology classes would have positive outcomes and would be beneficial to the students. The findings of the survey affirmed Dewey's Philosophy of Progressive Education (1956) which states that the most crucial aspect is removing the assumption that the educational experience is limited to the classroom setting and recognizing the need to integrate education into daily life. Because through this, students would be able to regularly let their experience shape their education and social consciousness.

Proposed Guidelines on The Integration of Transdisciplinary Approach In Biology Instruction

Introduction

Transdisciplinary Approach is an approach to curriculum integration which breaks the boundaries between the traditional disciplines and centers teaching and learning around the creation of meaning

within the context of real-world issues or themes. The integration of the students' real-world experiences is the focus of the teaching and learning process. According to the findings of the study, integrating transdisciplinary approach enhances students' long-term retention of biology lessons. Through pragmatic way of teaching, students have the opportunity to include personal experiences in class discussions. Students can also use what they have learned in practical settings. As a result, it improves their academic performance in Biology and develop positive perceptions towards the subject.

Objectives

These proposed guidelines on the integration of Transdisciplinary Approach aims to:

A. provide teachers with knowledge on how to properly integrate Transdisciplinary Approach in Biology Instruction
B. enhance classroom instruction through pragmatic learning

Instructional Plan in Biology

Learning Area: Earth and Life Science – Biology

Content/Topic: Immune System

Minimum Desired Learning Competencies

- Identify the different parts of the immune system
- Explain the functions of the parts of the immune system
- Emphasize the significance of having an immune system
- Simulate the features and functions of the immune system through association to certain societal position
- Relate the function of the immune system to real-life situations

Methodology

Engage

As an application to transdisciplinary approach, the following questions related in having a healthy lifestyle will be asked by the teacher to the students.

Q1. Do you wash your hands regularly to avoid infections?
Q2. Do you always eat nutritious food?
Q3. Do you get plenty of exercise?
Q4. Do you get adequate among of sleep every day?
Q5. Do you visit your doctor regularly?

Explore

As an integration of transdisciplinary approach, the teacher will ask the students to list three (3) serious diseases they have personally experienced or have learned about throughout their lives. For each, students should write one or two sentences to describe how they think these diseases can be prevented. On the board, the teacher will list and tally responses. The teacher will count how many students mentioned vaccines or vaccination in their descriptions. After tallying the responses, the teacher will then ask the students what they think is the lesson. The teacher will explain to the students that they will learn about adaptive immune system, which is the basis for vaccination.

Let the students discuss how they think vaccination works after experiencing the health crisis cause by the COVID-19 pandemic. If needed, prompt students by reminding them that vaccination is also called ***'immunization'.***

Explain

On this part, the students can verbalize their conceptual understanding and to demonstrate new skills or behaviors. The teacher will let the students create a graphic organizer such as a flowchart or concept map that models the immune system using the activity sheet **"FUNCTION OF THE ADAPTIVE IMMUNE SYSTEM".**

Activity 1
Function of the Adaptive Immune System
Using resources suggested by your teacher, research the function of each of the adaptive immune system's components. Then work with your group to create a simple graphical model that explains the adaptive immune system. Sketch your model in the space below.

Source: https://media.chop.edu/data/files/pdfs/vec-unit1.3-student-worksheet.pdf

Students discuss their models with others. During their presentation, students can expound the importance of the content to the real-world context. Students will give examples of situations they have already encountered in which functions of the adaptive immune system were evident. Afterwards, the students could also enumerate the different ways to have a strong immune system.

Elaborate

The teacher will then hold a class discussion to address any questions or misconceptions. If needed, guide the students with prompt questions:

A. How does your model represent the real immune system?
B. Are some parts of the immune system more important than other?
C. Why is an adaptive system needed if we have an innate immune system?

To integrate transdisciplinary approach, the teacher will present some information on the status of the Philippines during the COVID-19 pandemic. It will also be covered how important it is to always have a strong immune system, not just during pandemic.

Evaluation

One of the example strategies of integrating transdisciplinary approach is simulating real-life experience. To assess their associating abilities, the class will be divided into 4-5 groups. The students will simulate the features and functions of the adaptive immune system by associating it to certain societal positions. After which, they will then explain the relatedness of the two situations.

Example*: A terrorist invading a country being compared to a new antigen entering the human body stimulating an immune response.*

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of the study, findings drawn from analyzing the gathered data, conclusions, and suggested recommendations which can be the basis for further researches.

Summary

This study employed a quasi-experimental method following a two-group pretest-posttest design. The two groups were given the same assessment measures but were exposed to different teaching methods to determine the effectiveness of integrating Transdisciplinary Approach in biology instruction. The study was conducted to Grade 11-HUMSS students at a public high school in Carmen, Cebu. The experimental group composed of 18 students were exposed to the integration of Transdisciplinary Approach. In comparison, the control group composed as well of 18 students, were taught using the conventional teaching method. Specifically, the study answered the following questions:

1. What is the pretest and posttest performance of the Grade 11 students in the:

1.1. control group (exposed to conventional teaching approach) and;

1.2. experimental group (exposed to the integration of transdisciplinary approach)?

2. Is there a significant mean improvement in the academic performance from the pretest to posttest of the Grade 11 students in the:

2.1. control group, and;

2.2. experimental group?

3. Is there a significant difference in the mean improvement in the academic performance between the control group and the experimental group?

4. What is the level of attitude of the experimental group toward the integration of transdisciplinary approach in teaching Biology?

5. What intervention may be proposed to enhance the performance of the students in Biology?

Findings

These were the findings of the study,

1. Both the experimental group which was taught using a transdisciplinary approach, and the control group, which was taught using a traditional teaching strategy, performed Below Average in the pretest. In the posttest, the performance of the control group was still Below Average. However, the experimental group showed an Average performance in their posttest.
2. There was no significant mean improvement in the academic performance of the control group from the pretest to posttest. On the contrary, the experimental group manifested significant mean gains in their academic performance in Biology from pretest to posttest.
3. There was a significant difference between the mean improvement of the control and experimental groups' academic performances. The experimental group exposed to Transdisciplinary Approach performed significantly better compared to the control group taught using the conventional teaching approach.
4. The experimental group manifested Positive attitude towards the use of transdisciplinary approach in their biology class.
5. A sample instructional plan with an integration of Transdisciplinary Approach was proposed for Biology instruction.

Conclusions

Biology is considered a difficult subject by most students because of the concepts that are too abstract and its nature that forces them to memorize facts (Tekkaya et al., 2018). The lack of connection between what was taught in biology class and the students' daily lives was a major factor to this difficulty. Specific interventions such as integrating Transdisciplinary Approach may be required for such reasons. Hence, the use of Transdisciplinary Approach was assessed to see its effectiveness in improving the students' academic performance.

Based on the findings of this study, the integration of Transdisciplinary Approach was proven to be more effective than the traditional teaching approach in enhancing and improving the biology performance of the students as manifested by a significant improvement and the students' positive attitude towards transdisciplinary approach integration. This means that the group exhibited a favorable response towards the use of the intervention of the study. Integrating transdisciplinary approach enhances students' long-term retention since the students have the opportunity to include personal experiences in

class discussions. As a result, it improved their academic performance in Biology and develop positive perceptions towards the subject. Drake's (2007) Hierarchy of Curriculum Integration which stated that learners in integrated curricula achieve much higher academic accomplishments and Dewey's Philosophy of Progressive Education which argued that pragmatic learning helped the learners achieve significance and self-realization were all affirmed by the findings of the study.

Recommendations

Based on the findings and conclusions of this study, the following are the suggested recommendations, that:

1. basic and higher education administrators and curriculum specialists encourage and support the integration of a transdisciplinary approach not only in science instruction but also in other subject areas;
2. educational institutions provide trainings and seminars on how to effectively integrate transdisciplinary approach, as well as develop implementation manuals that will properly orient the teachers;
3. teachers focus more on pragmatic teaching rather than having conventional classes through integrating transdisciplinary approach in their respective subject areas; and,
4. future researchers carry out similar studies with a broader scope, ideally (a) involving larger number of participants, (b) involving more schools preferably both public and private schools, (c) determining the effectivity of transdisciplinary approach to other subject areas, and (d) determining the effectivity of other two approaches to integration in biology instruction namely the multidisciplinary approach and interdisciplinary approach.

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