International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Assessing the Experiential Learning and Scientific Process Skills of Senior High School STEM Students: A Literature Review

Dave M. Conchas, April Rose Y. Montilla, Kesia Dian C. Romblon, Michelle P. Torion, Jose Javier R. Reyes, Ariel O. Tinapay
[1, 2,3,4,5,6]College Teacher of Education, Cebu Roosevelt Memorial Colleges, Bogo City, Cebu, Philippines
[1]daveconchas69@gmail.com, [2] roseemontilla@gmail.com, [3]kesiaromblon2002@gmail.com, [4]michelle.torion.90@gmail.com, [5]jhavierreyes1@gmail.com, [6]arieltinapay288@gmail.com

Abstract—*This review of related literature provides understanding on experiential learning and scientific process skills. It serves as the foundation for the research design, methodology, and data analysis in the subsequent phases, contributing to the advancement and informing educational practices and policies. This highlights the studies obtained from the literature. The review assesses the scientific process skills in senior high school STEM students. Also, to bridge previous works on individual practices to group activities, and to explore the effectiveness of scientific process skills in science education. Furthermore, the review will explore any existing gaps or areas of contention within the literature. By critically evaluating the findings and methodologies of previous studies, the review aims to identify research gaps that this current study seeks to address. The gaps include specific populations or subject areas that have not been adequately explored, methodological limitations, or contradictory findings that require further investigation*.

Keywords— *A literature review, experiential learning, senior high school, stem students, scientific process skills.*

I. INTRODUCTION

Based on the K to 12 science curriculum framework that was established through the Department of Education (DepEd) Order No. 31, series of 2012, In order for students to become informed, engaged citizens who can make decisions about how to use scientific knowledge that may have social, health, or environmental ramifications, science education attempts to develop students' scientific literacy. The civic, personal, social, economic, moral, and ethical elements of life all combine science and technology. It is organized on the three components of learning science: understanding and applying scientific knowledge, performing scientific procedures, and exhibiting scientific aptitude. (Bybee, 2014).

According to (Ryan & Deci, 2000) when students have a personal stake in their education, they are more likely to persevere, seek deeper understanding, and apply knowledge in meaningful ways. Experiential learning cultivates a sense of ownership and investment in the educational experience. By actively participating in their own learning, students become more motivated, engaged, and interested in the content being studied (Walker et al., 2006; Linn et al., 2015. Experiential learning therefore generates a lively and engaging learning environment that sparks curiosity and encourages a sustained interest in science. Students need to develop their scientific process skills in addition to achieving that proficiency through experiential learning if they want to become proficient in the scientific method. Skills necessary for the scientific process include the capacity to construct hypotheses, plan experiments, gather and evaluate data, draw conclusions, and convey findings. The skills covered here help students develop their scientific literacy while also giving them transferable abilities that they can use in a variety of academic and professional settings. Students must possess a number of abilities related to the scientific process in order to conduct scientific research successfully.

According to research, students need clear guidance and practice developing hypotheses, planning experiments, gathering and analyzing data, and coming to conclusions based on the results. (Bell et al., 2003; Lederman et al., 2002). By actively developing proficiency in the scientific process, students acquire a systematic approach to knowledge acquisition and problem-solving.

II. DISCUSSIONS/LITERATURE REVIEWS

Science education equips students with the necessary to understand and engage with the world around them. Traditional teaching methods often rely on rote memorization and textbook-based learning, which may hinder skills, abilities, and scientific process skills. Studies have shown that passive learning approaches, such as lectures and information transmission, do not effectively engage students or promote deep understanding (Linn et al., 2008). This approach can result in surface-level learning, where students merely memorize facts without grasping the underlying principles or being able to use contexts.

In contrast, experiential learning offers a different strategy for teaching science that solves the limitations of traditional teaching. This approach emphasizes active student engagement, hands-on experiences, and authentic scientific investigations. Numerous studies have highlighted the benefits of experiential learning in science education. For instance, Bybee (2015) emphasized that students are encouraged to actively generate their understanding, develop their problem-solving abilities, and engage in scientific inquiry through experiential learning. Experiential learning, according to research, improves students' motivation, interest, and understanding of scientific ideas (Fortus et al., 2005; Kuhn, 2005).

Science Process

Developing students' skills in research, inquiry, and critical thinking as well as their potential for lifelong learning is one of the fundamental objectives of teaching science. Therefore, science process skills (SPS, from now on) are particularly crucial in the instruction of pupils who possess these qualities. According to (Farsakoglu, 2012), SPS is regarded as an essential and fundamental part of science instruction. SPS mostly refers to the mental processes that scientists use to acquire knowledge in order to analyze, formulate solutions, and solve difficulties (Ozgelen, et al, 2012). In a similar line, NRC (2000) suggests using learning that is based on study and investigation to enhance SPS. The NRC (2000) suggests that improving science process skills (SPS) should involve learning based on research and investigation. Students' utilization of these skills, which enable them to organize scientific information, not only helps them process new information through hands-on experiences but also enhances their understanding (Abd-El-Khalick, et al, 2010).

Scientific Process Skills can be categorized into groups: Basic Science Process Skills (BSPS) include observation, classification, and measurement. While Integrated Science Process Skills (ISPS) encompass identifying and controlling variables, defining operationally, formulating hypotheses, experimenting, interpreting data and drawing conclusions (Ozgelen, et al, 2012). BSPS can be seen as more related to the empirical aspect of science. In contrast, ISPS places a greater emphasis on the analytical side, particularly with regard to experiment confirmation SPS and real experiment design and implementation SPS. Due to their active involvement in the process of information acquisition and independent knowledge structuring under the direction of their teachers, people with developed SPS tend to have more persistent and correct knowledge bases (Sen, et al., 2012).

In addition to the physical abilities required for inquiry and investigation, ISPS involves heavily relies on cognitive abilities (Aslan et al., 2016). Therefore, it is often emphasized that the development of ISPS relies on a prerequisite understanding of BSPS (AlRabaani, 2014).

Identifying and controlling variables

Identifying and controlling variables are fundamental skills that enable students to formulate testable hypotheses, design-controlled experiments, and draw valid conclusions. These skills are critical for students to understand cause-and-effect relationships, recognize confounding factors, and make evidence-based claims. Students gain scientific knowledge and the capacity to assess scientific information by learning variable identification and control (Smith, J., 2018). This section acknowledges the challenges students face in developing proficiency in identifying and controlling variables. These challenges include difficulty in recognizing relevant variables, understanding the interplay between variables, and designing experiments that effectively manipulate variables while maintaining control. Additionally, misconceptions and cognitive biases can hinder students' ability to accurately identify and control variables. By identifying the variables, every potential impact on an experiment's outcome are determined. In general, there are three types of variables: independent, dependent, and control. Clearly identifying the experiment's data will be more valid and reliable if there are correlations between these three variables. Students must learn how to recognize the variables that affect results (Celik, 2013). Identification of dependent, independent, and control variables is crucial for conducting a controlled experiment (Saat, 2004). Depending on the purpose of the study, just one independent variable's impact on the dependent variable must be investigated during an experiment (Padilla, 1990; Abruscato, 2000:45; Martin, 2003).

According to Gabel (1993), in order to conduct an experiment, test hypotheses or confirm presumptions must be able to control every factor that will have an impact on the experiment's results. It must first determine the factors that are responding and being changed. Afterward, a factor is purposefully altered, which causes the other variable to change. Changing one variable (the manipulated variable) and then observing changes in the other variable (the response variable) is the method used to manipulate and control variables. Numerous other variables (controlled variables) must also be established and maintained constant at the same time.

This is the case that there is a chance that these factors will have an impact on the outcomes. The experiment's outcome is unreliable if multiple variables are modified at once (Carin & Bass, 2001). Bailer et al, (1995), connected the process of generating hypotheses with that of identifying and controlling variables. Based on this, a hypothesis is a type of claim that predicts how one variable will affect another.

Formulating hypotheses

Formulating hypotheses involves generating tentative explanations or predictions based on existing knowledge and observations (Johnson & Smith, 2018). This section explores the relationship between hypothesis formulation and scientific inquiry, highlighting how hypotheses guide the process of investigation and discovery. The review of hypotheses in guiding experiments, data collection, and interpretation.A hypothesis is a claim based on a reasonable assumption that results from previous understanding and continuous observations (Ostlund, 1992). It serves as an implied justification for an observation, providing a starting point for scientific investigation. In order for a scientific theory to explain observable occurrences, it must meet certain criteria, including verifiability and testability (Ostlund, 1992). The formulation of hypotheses is essential to scientific investigation because it provides a framework for conducting experiments and gathering evidence.

Mastery of hypothesis formulation is key to gaining conceptual knowledge (Lawson, 2001). Individuals who have developed the ability to formulate hypotheses find it easier to understand and interpret scientific concepts. By formulating hypotheses, students engage in critical thinking and make logical connections between observed phenomena and potential explanations (Lawson, 2001). This process promotes deeper understanding. A hypothesis can be seen as a suppositional description of potential study results. It serves as a guide for the researcher, outlining the expected relationship between variables and providing a direction for data collection and analysis. The formulation of a hypothesis helps researchers articulate their expectations and formulate research questions to explore the phenomenon of interest.

Experimenting

Students who engage in inquiry-based learning must use higher-order thinking abilities to make decisions based on facts. They must quickly use a number of scientific process skills in this process, including data collection, variable identification, and hypothesis formulation. Experimentation, in particular, encompasses a significant portion of these scientific process skills and should be emphasized for in-depth exploration when conducting multiple experiments (Martin, 2012). However, teachers need to understand that significant advancements in experimentation skills may not occur after just a few attempts (Padilla, 1990). Students need multiple opportunities to develop and refine their experimentation skills in diverse contexts, rather than relying on a single instance. By providing students to engage in experimentation, educators can foster scientific reasoning abilities (Martin, 2012).

An experiment is a purposeful and deliberate action conducted in the real world to test conclusions drawn from theories or hypotheses (Abrahams & Millar, 2008). Through experimentation, students gain hands-on experience in designing and conducting their own investigations to create and test hypotheses (Aslan et al., 2016). This process allows students to actively apply the scientific method, fostering scientific principles (Aslan et al., 2016).

The prior idea was strengthened by conducting an easy experiment as part of the investigative process. According to Samatowa (2016), it was related to observation, experience, arranging an idea through an experiment, and encouraging the students. Science was just a subject; it was also a method for creating new knowledge (El Islami & Nuangchalerm, 2020). Practical activities, experiments, and projects were the most effective methods for imparting knowledge of scientific process skills (Mustafa et al., 2021). Participating in a practicum was one of the elements that influenced students' science process skills. The construction of certain skill activities, such as the development in the study, research, and interest, were expected to be supported by practicum (Duda & Susilo, 2019). Students who were skilled in the scientific method could produce information more successfully in this process. In relation to a case or event, students performed observations and measurements, gathered data, analyzed the data, and developed generalizations based on the data (Gültekin & Altun, 2022). From the perspective of learning, science process skills are essential tools for enabling students to interact with the world and take cognitive control of it through the development of concepts and scientific thinking (Mungandi, 2005; Harlen, 2000). Chiappetta and Koballa (2002) make a compelling case that acquiring and regularly using these abilities might better prepare students to handle challenges, pursue independent learning, and be passionate about science.

Practical activities are one type of educational experience that might offer learning opportunities (Lepiyanto, 2014). Additionally, according to Roberts (2004), it can develop scientific skills in the utilization of experiment activities. A learning activity called an experiment gives students the chance to verify and put into practice a theory while utilizing lab equipment and outside of the lab (Rustaman, et al 2005). Wartono (2003) also found that experiment-based learning can help students comprehend science's idea and nature as a process and end result.

Interpreting data and drawing conclusions

Interpreting data and analysis in the formulation of hypotheses by facilitating the identification of patterns or trends that can lead to assumptions or hypotheses (Padilla, 1990). The process of interpreting data involves drawing inferences from observations and systematically analyzing empirical data. However, it is important to recognize that the interpretation of data can be influenced by minor variations being analyzed.

To effectively interpret and make informed judgments, students should utilize tables and graphs as valuable sources of information (Arthur, 1993). Tables and graphs provide visual representations that allow for the analysis and synthesis of data, enabling students to identify patterns, relationships, and trends. By engaging with visual representations of data, students can develop a deeper understanding of the information and draw meaningful conclusions.

Padilla (1990) highlights the importance of using tables and graphs to analyze and interpret data in science education. These visual representations serve as tools for organizing data, identifying patterns, and making data-driven inferences. Students can actively engage in analyzing data by visually representing it and extracting meaningful information, which in turn supports the formulation of hypotheses and scientific reasoning.

Furthermore, Yldrm and Simsek (2013) emphasize the role of tables and graphs in facilitating data interpretation and analysis. They suggest that these visual representations enhance students' ability to make sense of complex data sets, identify trends, and support evidence-based reasoning. By using tables and graphs, students can effectively organize, summarize, and compare data, enabling them to draw meaningful conclusions and develop hypotheses based on the patterns observed.

The term "experiential learning," which is known as "learning based on experiences," refers to a process by the firsthand of students may be put to productive use in order to achieve learning that is both effective and sustained. Students begin to build their metacognitive abilities via action, research, discovery, and active engagement in both individual and group projects. These talents will be valuable to them not just over the course of their education but also in the rest of their lives (Tinapay et al., 2021).

The theories that have been developed in this area have attempted to explain a variety of viewpoints regarding the

Dave M. Conchas, April Rose Y. Montilla, Kesia Dian C. Romblon, Michelle P. Torion, Jose Javier R. Reyes, and Ariel O. Tinapay, "Assessing the Experiential Learning and Scientific Process Skills of Senior High School STEM Students: A Literature Review," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 2, pp. 81-90, 2023.

manner in which; however, has led to development of a number of different conceptions that is both practical and efficient. The constructivist theory that underpins this kind of activity that summed up succinctly concept.This theory forms foundation of the activity that based on experience.

The core tenet of the constructivist approach to education is that students should be seen as active participants in their own education, with prior knowledge serving as the bedrock upon which new information should be constructed. In addition to this, the learning that takes place via effective activities is tied to the actual world assigned vital to experience. This is significant when taking into consideration essential key obtain that one seeks writings, emphasized the importance of a forward-thinking approach to education, one that makes beneficial use of the uniqueness and specificity of each student while also allowing them the freedom to experiment and make discoveries in order to arrive at a predetermined goal and an unmistakable conclusion that can be observed in real life. According to Dewey, learning from experience necessitates progressing through a series of mental processes or stages, including things like seeing an occurrence, recalling a past experience that was analogous to the current one, and commenting on or assessing the significance of the experience. Learning is accomplished (as a process, in the brain) through psychological processes that include organizing and structuring newly acquired information into related idea networks. The newly acquired information is connected to previously acquired process of learning, also known as schemes, in which information is reorganized. More deeply established knowledge is easier to recall and apply in new circumstances because there are greater connections between new information and information that already exists (Wirth & Perkins, 2008)

According to Kolb (1984), learning starts at the time when the learner interacts with the environment and, as a result of this interaction, has a distinct through experience goes through a four-stage cycle: beginning with the concrete experience, then moving on to the generalizations. As a result, one stage is dependent on the one that came before it.

A day-to-day activities and situations of life, it is dependent on the understanding that is obtained from conscious unknowing relationship information that was previously there. In accordance to Boydell (1976), experiential learning is equivalent with learning by discovery.

This kind of learning allows the student to pick and reorganize his views about the activities. The individual discovers possibilities that cannot be obvious in any other way than by directly experiencing them. On a psychical level, one may become aware of the beneficial aspects of experiential learning, particularly via the cultivation of unique settings designed to ease the process of learning. According to (Ambrose et al., 2010), learning via experience fosters greater levels of independence in the learner. Students participate in experiential learning when they are put in unfamiliar settings and given tasks to do in a real-world setting.

In order for the students to do those duties, they need to become aware of what it is that they already know, what it is that they do not know, and how to learn. Because of this, it is necessary for prior delve via past learning is transferred into new settings and how the students demonstrate mastery of the material (Tirol, 2021). Last but not least, having these abilities enables students to become self-directed learners throughout their whole lives.

Laboratories are recognized as practical learning homes in schools, they should be constructed in current times for science lectures. Laboratory activities appeal to learn with understanding while also engaging in a process of constructing knowledge by doing science." The instructor is obligated to acknowledge and promote the potential for solving problems with interactive computer simulations, as well as to engage the students in challenging scenarios and the process of experimentation. The instructor assists the students in seeing the links between different contexts, as well as to take initiative in their own learning (Tinapay & Tirol, 2021).

Methods like as dialogue, acting, ways for working in groups, etc., may all be utilized effectively. The instructor has a responsibility to choose experiences with a high potential for learning carefully. These are the situations that give opportunity delve that support. In context of experiential learning, the function of the instructor focuses on directing, facilitating, and providing assistance to students. The act of reflecting on what was learned, both during and after exposure to new situations, is an important and fundamental of learning which in turn generates high value, and improves both critical thinking and the capacities to synthesize information (Boud, Cohen & Walker, 1993). The students have a better understanding of theoretical components and are able to notice the practical use of those components in actual life scenarios as a result of their participation in the experiment.

The pupils are engaged on several levels, including cognitively causes significant multiple levels, including cognitive, affective, and social acquisitions. The connections between the pupils get deeper and more meaningful as time goes on. The students utilize their prior knowledge as a foundation to build their understanding of the new material being presented to them. In other words, the student is the primary recipient of the benefits gained. This assigns instructor rather than encourages responsibility and motivation among the student body (Grageda et al., 2022).

Basic Scientific Process Skills

Smith and Johnson (2019) propose that in order to foster a deep comprehension of scientific subjects and principles, it is imperative for students to acquire a set of scientific process skills that encompass a range of abilities including keen observation, sustained interest, intuitive insight, hands-on experimentation, meticulous data analysis, and sound judgment. Through the cultivation of these skills, students not only enhance their capacity to think critically but also elevate their problem-solving acumen, enabling them to navigate complex scientific concepts and phenomena with greater proficiency and intellectual agility.

SPS has continued to be an important component of research over the past ten years (Coil, et al., 2014). They have long been at the center of discussions on processes and content. The basic SPS comprises observation, categorization,

Dave M. Conchas, April Rose Y. Montilla, Kesia Dian C. Romblon, Michelle P. Torion, Jose Javier R. Reyes, and Ariel O. Tinapay, "Assessing the Experiential Learning and Scientific Process Skills of Senior High School STEM Students: A Literature Review," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 2, pp. 81-90, 2023.

communication, measurement and use of numbers, prediction, drawing conclusions, and use of space-time relations.

According to Turiman et al. (2012), in order to enhance critical thinking and acquire the essential learning skills needed for the 21st century, it is crucial to develop each of these abilities. The instruction of effective knowledge acquisition and meaningful learning is greatly enhanced by the utilization of fundamental Scientific Process Skills (SPS). It is imperative to establish fundamental SPSs that enable the integration of existing knowledge with novel ideas, thereby deepening our comprehension of scientific phenomena. (Harlen, 1999).

Integrated Scientific Process Skills

The integrated SPS includes identification and control of variables, formulation of hypotheses, interpretation of data, and experimentation. Higher levels of secondary and tertiary education use integrated SPS because they are more complex and involve higher-order cognitive processes (National Institute for Education, 2014).

These abilities, which are frequently paired with basic SPS, may be useful in developing ideas, prediction, and information synthesis. The limited development of integrated SPS is a challenge for engaging in research at higher levels and comprehending scientific topics. The integration of scientific process skills within science education has become a critical focus in recent years.

Scientific process skills encompass a range of capabilities that empower students to actively participate in scientific inquiry, problem-solving, critical thinking, and data analysis. These skills comprise activities such as observation, measurement, classification, inference, prediction, communication, and experimentation. Literature highlights the significance of integrating these skills across science education to cultivate scientific literacy, enhance conceptual understanding, and nurture students' scientific thinking abilities (Bybee, R. W., 2006, "Scientific literacy, ecological literacy, and the teaching of science," Science Education, 90(2), 224-240).

Numerous frameworks and models have been proposed to guide the integration of scientific process skills into science education. For instance, the 5E learning cycle (Engage, Explore, Explain, Elaborate, and Evaluate) offers a framework that incorporates scientific process skills throughout each stage of the instructional sequence. Additional models, such as the Science Writing Heuristic and the Inquiry-Based Science Education model, also underscore the integration of process skills in science teaching and learning (Bybee, R. W., 2014, "The BSCS 5E instructional model: Personal reflections and contemporary implications," Science and Children). Assessing integrated scientific process skills presents challenges due to their complex and dynamic nature.

Traditional assessment methods, such as multiple-choice tests, may not capture students' ability to apply process skills effectively. Consequently, alternative assessment approaches, including performance assessments, portfolios, and rubrics, have been suggested to better evaluate students' mastery of these skills (Krajcik, J. S., & Shin, N. (2014). Project-based learning. In R. K. Sawyer (Ed.), The Cambridge handbook of the learning sciences (2nd ed., pp. 398-417). Cambridge University Press). Despite the acknowledgment of the significance of incorporating scientific process skills in a cohesive manner, several challenges exist in implementing them in science education. These challenges include the limited training and confidence of teachers, the time constraints of curriculum coverage, and the need for appropriate instructional resources (Tinapay & Tirol, 2021).

Future research should focus on developing effective teacher professional development programs, designing curriculum materials that embed process skills, and investigating the impact of technology in supporting integrated skill development (Luera, G. R., & Callahan, J. L. (2019). Challenges and opportunities for integrating science practices in elementary classrooms. Science Education, 103(4), 855-880).

Academic performance of students

Students who lack scientific process skills may struggle in science education. They could have difficulties with activities like problem-solving, conducting experiments, analyzing data, and communicating scientific concepts. A significant component of the work of the scientific education research community has been the examination of students' attitudes toward studying science. The evidence that young people are becoming less interested in pursuing scientific jobs is now amplifying its significance (Department for Education 1994; Smithers and Robinson 1988).

In the early years of the twenty-first century, a significant challenge confronting scientific instruction is the practical application of science and technology to address societal needs and demands. Science education plays a vital role in reshaping students' cognitive frameworks, enhancing their academic performance, and facilitating the acquisition of desired skills, including subject-specific expertise and transferable scientific knowledge (Lavigne, Vallerand, & Miquelon, 2007; Bautista, 2012).

According to several studies (Osborne & Collins, 2001; Jegede, 2007; Barmby, Kind & Jones, 2008), academic achievement in science is associated with students' motivation and interest in their academic endeavors, as well as the level of scientific understanding they are exposed to within the educational setting. Additionally, another study (Beal & Stevens, 2011) defines motivation as the factors that contribute to a student's interests, willingness, and voluntary engagement.

In this context, it is widely believed that motivation plays a pivotal role in enhancing outcomes in science education. Specifically, extrinsic motivation and intrinsic motivation are recognized as key motivational factors in science learning. Other factors that contribute to motivation in science education include test anxiety, self-efficacy, task value, beliefs regarding control over one's own learning, and self-efficacy (Tuana, Chin, & Shieh, 2005; Bautista, 2012).

Uno (2012) defines motivation as the fundamental drive that guides behavior. Motivation plays a vital role in the learning process and is essential for achieving improved

Dave M. Conchas, April Rose Y. Montilla, Kesia Dian C. Romblon, Michelle P. Torion, Jose Javier R. Reyes, and Ariel O. Tinapay, "Assessing the Experiential Learning and Scientific Process Skills of Senior High School STEM Students: A Literature Review," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 2, pp. 81-90, 2023.

academic performance (Christiana, 2009; Awan et al., 2011; Singh, 2011). As per the results of numerous studies conducted by various researchers, student learning motivation is a significant factor that influences the effectiveness of achieving learning objectives (Supriyatin et al., 2017; Azrai et al., 2016). Furthermore, according to Christiana (2009), teachers' motivation is a key aspect in student learning because a lack of desire for teaching might result in a low degree of teaching efficiency (Knoell, 2012) research supports and agrees that learning occurs best in an atmosphere with positive interpersonal interactions because it has the capacity to empower classrooms with a climate in which learners feel appreciated, acknowledged, and respected. A psychologically healthy teacher is responsible for creating a good, supporting, motivating, and intellectually engaging environment for the teaching-learning process (Oliver & Reschly, 2007; Christiana 2009). Hughes and Kwok (2007) concluded in one of their studies that students who have a close and supportive relationship with their teacher are more engaged with their academics, work effectively in school settings, encourage self-initiated learning, and show determination when encountering challenges.

Students who engage actively in their learning process and display interest in their academic education are more likely to achieve higher levels of learning (Wang et al., 2021). Higher education institutions promote the utilization of students' strengths and provide learning opportunities and resources that facilitate active participation (Broido et al., 2021). On the other hand, low engagement in academic activities contributes to students' dissatisfaction, boredom, negative experiences, and attrition (Derakhshan et al., 2021).

It has been established that engagement is linked to intelligence, curiosity, motivation, and enjoyment in various academic subjects, resulting in improved learning outcomes (Yin, 2018). Engagement is a construct that involves intricate relationships between ideas, emotions, and motivation, aligning with the development of self-determination theory in the realm of motivation (Mercer and Dörnyei, 2020). The motivation of students is a crucial aspect in fostering learning and enhancing the value of higher education, as highly motivated students are more likely to succeed in their endeavors (Derakhshan et al., 2020; Halif et al., 2020).

Teaching Methods in Science Education

In order to teach science to students in an effective manner, it is crucial to create meaningful learning environments that consistently offer challenges. According to Adesoji and Olatunbosun (2008), greatness in science and technology can be attained through efficient science teaching. The application of inappropriate ineffective teaching methods was one of the reasons identified as hindering students' understanding of success in the science disciplines (Nwagbo, 2001). The majority of scientific teachers lack the background knowledge necessary for activity-based learning, and the lecture approach to instruction has been the most common (Nwosu, 2004). The adoption of various innovative teaching methods has become prevalent due to the need to cover diverse topics and foster the development of various skills. Teachers have devised numerous creative strategies to actively engage students in the teaching and learning process. It is widely recognized as highly significant to incorporate these teaching methods into classrooms (Slavin, 2005; Leikin & Zaslavsky, 1997).

The recommended approach for implementing the school curriculum highlighted the importance of field research, guided discovery, laboratory skills, and conceptual thinking. Additionally, other methods such as models, demonstrations, field trips, discussions, group work, and project work were suggested. These approaches were recommended based on the specified objectives, curriculum materials, and contextual considerations by the Nigeria Educational Research and Development Council (NERDC, 2009).

According to the current curriculum, science teachers are expected to cover specific content within a designated timeframe. However, teachers often face challenges in effectively conveying the necessary knowledge to students. These challenges can arise from time constraints, lack of materials, or uncertainty about which strategies to employ. Additionally, certain teaching methods have been found to be more effective than others, with effectiveness varying depending on the subject or topic being taught (Barbosa, Jofili, & Watta, 2004; Longjohn, 2009; Umoren & Ogong, 2007). Therefore, it is necessary to employ one or more innovative approaches that are suitable for specific science topics or content in order to achieve effective teaching.

Multiple studies suggest that the instructional methods employed in the classroom, rather than teachers' experience and educational qualifications, may have a more significant impact on students' performance and attitudes towards science (Kloser, 2014; Rockoff, 2004; Seidel and Shavelson, 2007). The actions teachers take within the classroom can either engage or disengage students in the subject of science. This highlights the importance of identifying effective teaching strategies that positively influence students' scientific performance and attitudes.

Significant efforts have been made globally to enhance science education, including curriculum modifications and the development of science teachers' skills. In particular, teachers have been encouraged to incorporate inquiry-based approaches into their science instruction. The roots of science inquiry can be traced back to renowned theorists such as Jean Piaget, Lev Vygotsky, and David Ausubel, who explored the nature of learning and instruction. Their work in learning theory became known as constructivism (Cakir, 2008; Minner, Levy, and Century, 2010).

It is important for students to develop a critical approach to science by engaging in scientific inquiry. This involves gaining a deep understanding of a subject, developing a logical scientific method, and ultimately providing an accurate response to the question being examined (Crawford, 2007). However, implementing inquiry-based science teaching presents several challenges.

One challenge revolves around the definition of inquiry-based teaching. Different practices such as minimally guided discovery, project-based learning, and inquiry learning are often grouped together, despite variations in the level of teacher involvement. Consequently, broad criticisms are applied to approaches that, in practice, differ significantly from one another (Hmelo-Silver, Duncan, and Chinn, 2007). The lack of a standardized definition, along with the constant evolution of that definition, highlights the difficulties in establishing a clear understanding of what constitutes scientific inquiry (Duschl et al., 2007; Furtak et al., 2012). In terms of unguided exploration, critics have highlighted the lack of structure in knowledge construction.

Critics argue that novice students lack the extensive knowledge and training that experienced scientists possess. When scientists formulate a hypothesis, they draw upon a body of knowledge accumulated over time. In contrast, students lack this expertise and rely on fragmented understanding of scientific principles and short-term memory, which can become overwhelmed with newly acquired information (J. Sweller, 2003, 2004)

According to Fagen and Mazur (2003), "lecture method causes students to have a reading habit. Students taught in lecture-based classes learn less than those taught using activity-based reform methods." The lecture method is frequently a one-way process without discussion, questioning, or immediate practice, making it a poor teaching method" (Hatim, 2001; Al-Rawi, 2013). "In the lecture method, the teacher tells the students what to do rather than activating them to discover for themselves" (Al-Rawi, 2013). "In the lecture method, the teacher tells the students what to do rather than activating them to explore for themselves" (Miles, 2015). The demonstration teaching style is also beneficial to students' knowledge and retention (McKee, Williamson, & Ruebush, 2007). Al Rawi, (2013) "The demonstration is effective in teaching skills of using tools and laboratory experiments in science, but the time available to perform this demonstration in a classroom setting is very limited." "Consequently, a demonstration is often intended for students to make findings rather than through hands-on laboratory" (McKee, Williamson, & Ruebush, 2007).

Since we cannot teach everything, teaching others how to learn is the fastest and most logical solution (Çakır & Sarkaya, 2018). In this case, the constructivist method takes center stage. Using one's own knowledge and experiences, the individual will be able to mold the new information that they have learned.

According to the constructivist approach in this situation, the student will take an active role in learning activities and be at the center of the learning process (Alavi & Dufner, 2005). In this method, the teacher serves as the mentor and actively controls the academic activities of the students. In other words, the focus of education has shifted from being teacher-centered to being student-centered. Yet, this circumstance motivates students to study more effectively. Because students learn about the connections between scientific concepts. Students engage more fully in class activities when they become aware of these circumstances (Erbaş & Demirer, 2019).

Furthermore, science is learned in a classroom environment. As a result, it is predicted that the success of a particular teaching approach will be determined by its contextual responsiveness. To achieve successful inquiry-based learning, various factors come into play. These include the presence of a positive school environment, discipline, access to appropriate equipment and personnel, sufficient teaching time, and supportive school leadership that encourages scientific inquiry. Additionally, well-trained teachers who possess the capability and willingness to implement this instructional approach are crucial. In contrast, teacher-directed instruction may require fewer equipment and resources. The implementation of inquiry-based science instruction involves the teacher relinquishing some control of the classroom to the students (Tirol, 2022).

Implementing inquiry-based learning requires a distinct set of skills and attitudes compared to teacher-led lectures. A lecture is akin to a rehearsed performance, whereas inquiry-based learning demands flexibility and adaptability. Therefore, the successful implementation of these practices relies on teachers' capability and willingness to adopt inquiry-based teaching approaches (McGinnis, Parker, and Graeber, 2004; Newman et al., 2004), their attitudes towards these practices (Windschitl, 2003), and the presence of a school culture that promotes scientific inquiry (McGinnis, Parker, and Graeber, 2004).

Impact on group activities

Students have the chance to participate in an active role in small-group activities that involve analysis, brainstorming, and discussion while working toward a common objective through collaborative learning. Following assessment, feedback is provided to individual group members and the group as a collective in order to identify those who may require additional support (Laal et al., 2013) group member bears responsibility for their designated role.

In response to the growing societal need for collective problem-solving, there has been a shift from individual efforts to group work, reflecting the trend of collaboration in the 21st century (Laal et al., 2013). When students engage in group work and engage in discussions to achieve a shared objective, it represents a significant departure from the conventional teacher-centered or lecture-centered approach in the classroom. This approach showcases the management of respectful relationships with others and fosters mutual connections and support that extend beyond academic settings (Majid et al., 2013).

Another study that was conducted also highlighted abilities, accomplishments, duties, and respect for other people's perspectives of group members. Consensus-building through the agreement of group members is the foundation of collaborative learning that impact on group activities (Laal & Laal, 2012). Favorable attitudes towards student group work encompass the belief that it enhances learning, promotes effective time utilization, and aids in knowledge retention. Students express contentment with group work, considering it to be more enjoyable and engaging than working individually. Additionally, desired attitudes include perceiving group work as manageable and having confidence in one's ability to contribute meaningfully to the outcomes of the group (Cantwell and Andres, 2002). Positive attitudes towards group work have been associated with increased socialization, reduced social stress, greater mastery of performance goals, and enhanced educational understanding (Cantwell and Andrews, 2002).

This study sheds light on how environmental, motivational, and experiential factors influence group work activities. Personality traits have also been found to be connected to attitudes towards group work in various studies. Thompson, Anitsal, and Barrett (2008) conducted a study demonstrating that individualistic versus collectivistic tendencies, as well as group members' comfort and satisfaction with working collaboratively rather than individually, influence their orientation towards group work.

According to Cantwell and Andrews (2002), higher levels of sociability were associated with lower levels of social anxiety, increased desire for group work, improved group task performance, and reduced levels of depression. Additionally, research has indicated that personality traits mediate the relationship between achievement orientation and participation in competitive versus collaborative activities (Ross, Rausch, Canada, 2003).

There has been significant theoretical and practical interest in group activities and the benefits of interactive learning in the classroom (Cowie and Berdondini, 2001; Duran and Monereo, 2005; Hänze and Berger, 2007). The use of these initiatives appears to vary across different societies (e.g., Tobin, Wu, and Davidson, 1989; Clarke-Stewart et al., 2006). This interest stems from two main sources (Colomina and Onrubia, 2001). Firstly, studies have shown that cooperative group activities enhance learning and socialization more than competitive or individualistic situations. Secondly, there is a shift in research towards considering school-based learning as a fundamentally social process that involves communication and interaction. This perspective suggests that peers can play a significant role in the learning that takes place within the school context.

Influence of technology

Technology has made a significant impact on science education by introducing innovative methods to educate and discover. These technologies not only make learning more interesting and dynamic, but they also allow students to examine topics and theories in a way that is interactive. Today, the rapid advancement of technology has enhanced the importance of science (Grunberg & Grunberg, 2011). In this regard, several countries place importance on science education in order to remain technological innovators or maintain their dominance (Ayas, 1995; Elçiçek, 2016; Ünal, 2003). According to Roblyer (2003), "educational technology is a combination of processes and tools in addressing educational needs and problems, with an emphasis on applying the most current tools: computers and their related technologies." As a result, instructional technology is said to contain two components.

Processes encompass the learning activities necessary to accomplish a learning objective, while resources are utilized to facilitate the learning process. According to Smaldino, Russell, Heinich, and Molenda (2005), many individuals associate technology with products such as computers and CD players, and they state that when employed for instructional purposes, this type of technology is referred to as instructional technology. Traditionally, science education has been more conservative compared to other subjects in the curriculum. However, technological advancements have made an impact on science education, which is equally crucial. Science education encounters its own concerns and challenges, but technological progress can assist science teachers in addressing these issues. Both teachers and students in science education have access to a variety of valuable resources made available through information technology (Tinapay et al., 2023).

The Internet, simulations, and other developing information technologies can also be included. Roblyer and Edwards (2000) define hypermedia as "software/video resources and probe ware. The Internet is one technological product that can be used extensively in science teaching. Simulators can also be used by science professors to teach science. A simulator is a device that simulates actual equipment operating characteristics (Gagne et al., 1988). Simulations can help students get experience in applications that would be risky to try in real-life settings.

It is critical for students to engage in authentic science problems that are solved collaboratively in order to build a knowledge of the nature of scientific inquiry (Crawford, 2000). These activities differ significantly from more traditional teaching methods, and their implementation is challenging. Windschitl (2003) and Haug (2014) consider it complex.

As a result, it has not been widely adopted by instructors, and a variety of perspectives and teaching methodologies exist (Crawford, 2000, 2007). According to research, inquiry learning is frequently conflated with hands-on activities and "experiments" that focus on getting the "right" answer and are frequently unrelated to substantial science subject (Crawford, 2000; Gengarelly & Abrams, 2008; National Research Council, 2000). These activities frequently lack integration with other classroom activities and tend to focus on procedures rather than analysis and comprehension activities. Similar criticism is leveled toward depictions of inquiry as an ordered process, which leads to misunderstandings of a universal scientific approach (Crawford, et al, 200). Critiques of traditional approaches to teaching Scientific Process Skills highlight the tendency for these activities to be isolated from broader classroom contexts, emphasizing procedural aspects over analytical and comprehensive engagement, and failing to acknowledge the diverse and dynamic nature of scientific inquiry, as suggested by researchers such as Crawford (2000), Windschitl (2003), Abrams (2008).

III. Conclusion

Drawing upon constructivist theory, experiential learning emphasizes the active involvement of students in hands-on activities and immersive participation, thereby facilitating effective and enduring learning experiences that seamlessly connect theoretical concepts with real-world applications, while also nurturing the development of metacognitive skills.

To foster in-depth learning and the acquisition of essential skills, educators assume a pivotal role by strategically designing interactive learning environments, leveraging the utilization of laboratories, and employing a diverse array of instructional techniques tailored to individual and collective needs. However, within the realm of higher education, the cultivation of integrated scientific process abilities becomes a pressing imperative, as the absence of their adequate development poses significant barriers that hinder students' active engagement in research-based endeavors. Furthermore, the attainment of academic success in science education is intricately intertwined with factors such as motivation, student engagement, and the creation of a supportive and nurturing learning milieu that empowers learners to flourish. While collaborative group activities foster cooperation and peer interaction, the integration of innovative teaching strategies, such as inquiry-based instruction and the seamless incorporation of technology, holds immense potential for optimizing learning outcomes. Nevertheless, the effective implementation of these strategies is not without its challenges, as it necessitates overcoming various obstacles that can impede the seamless integration and execution of such transformative approaches within the educational landscape.

REFERENCES

[1]. Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). The BSCS 5E instructional model: Origins and effectiveness. Colorado Springs, CO: BSCS.
[2]. Duschl, R. A., & Grandy, R. E. (Eds.). (2008). Teaching scientific inquiry: Recommendations for research and implementation. Sense Publishers.
[3]. Kolb, D. A. (2014). Experiential learning: Experience as the source of learning and development (2nd ed.). Pearson.
[4]. Lederman, N. G., & Abell, S. K. (Eds.). (2014). Handbook of research on science education (Vol. II). Routledge.
[5]. Millar, R., & Osborne, J. (Eds.). (1998). Beyond 2000: Science education for the future. Routledge.
[6]. Minner, D. D., Levy, A. J., & Century, J. (Eds.). (2010). Inquiry-based science education: Applying it in the classroom. Teachers College Press.
[7]. Osborne, J., & Dillon, J. (Eds.). (2008). Good practice in science teaching: What research has to say (2nd ed.). Open University Press.
[8]. Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Making sense of inquiry-based instruction: A case study of Brian's conceptual change about electric circuits. Sense Publishers.
[9]. Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. Science Education, 82(4), 417-436.
[10]. Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction. The Science Teacher, 30-33
[11]. Bonwell, C. C., & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. ASHE-ERIC Higher Education Report No. 1. George Washington University, School of Education and Human Development.
[12]. Burwell, K. C., & Kaufman, D. M. (2018). Beyond the lecture: Experiential learning in medical education. Journal of General Internal Medicine, 33(7), 1110-1116.
[13]. Bybee, R. W. (2014). The case for STEM education: Challenges and opportunities. NSTA Press.
[14]. Bybee, R. W. (2014). The BSCS 5E instructional model and 21st century skills. BSCS.
[15]. Chinn, C. A., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. Science Education, 86(2), 175-218.
[16]. Dewey, J. (1938). Experience and education. Kappa Delta Pi.
[17]. Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. Science Education, 84(3), 287-312.
[18]. Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. Review of Educational Research, 300-329.
[19]. Grageda, C.N., Tinapay, A.O., Tirol, S.L., Abadiano, M.N. (2022). Socio-Cultural Theory in the Cognitive Development Perspective. NeuroQuantology, 20(16) 1482-1493 DOI: 10.14704/NQ.2022.20.16.NQ880145
[20]. Gilmore, A. (2009). The use of experiential learning in the development of business graduates' skills and competencies. Education + Training, 51(4), 272-292.
[21]. Hofstein, A., & Rosenfeld, S. (2016). Bridging the gap between formal and informal science learning. Studies in Science Education, 52(2), 135-163.
[22]. Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. Science Education, 88(1), 28-54.
[23]. Jarvis, P. (2010). Adult education and lifelong learning: Theory and practice. Routledge.
[24]. Jiménez-Aleixandre, M. P., Rodríguez, A. B., & Duschl, R. A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. Science Education, 84(6), 757-792.
[25]. Lederman, N. G., & Lederman, J. S. (2014). Research on teaching and learning nature of science. In Handbook of research on science education (Vol. II, pp. 600-620). Routledge.
[26]. Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). Classroom instruction that works: Research-based strategies for increasing student achievement. ASCD.
[27]. Moon, J. A. (2004). A handbook of reflective and experiential learning: Theory and practice. Routledge Falmer.
[28]. National Research Council. (2009). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. National Academies Press.
[29]. Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. Journal of Research in Science Teaching, 41(10), 994-1020.
[30]. Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. International Journal of Science Education, 25(9), 1049-1079.
[31]. Reid, K. A., & Kogut, G. (2018). Experiential learning in higher education: A research perspective. Studies in Higher Education, 43(2), 357-374.
[32]. Sinatra, G. M., Southerland, S. A., McConaughy, F., & Demastes, J. W. (2003). Intentions and beliefs in students' understanding and acceptance of biological evolution. Journal of Research in Science Teaching, 40(5), 510-528
[33]. Tinapay, A. O., & Tirol, S. L. (2021). Social Learning Perspectives in School Policies in a Higher Education Institution. Nat. Volatiles & Essent. Oils, 8(5), 9666-9686.
[34]. Tinapay, A. O., & Tirol, S. L. (2021). Teachers' Primary Roles in the New Normal: Through the E-Learning Perspective. International Journal of Innovative Science and Research Technology, 6(10), 90-91.
[35]. Tinapay, A., Tirol, S., Cortes, J. A., & Punay, M. (2021). Attitude of learners towards science and their science process skills in the case of the spiral curriculum: A. International Journal of Research, 10(15), 13-24.
[36]. Tinapay, A.O., Desabille, I.N., Tirol, S.L., Samillano, J.H. (2023). Practical Research Teachers' Technological, Pedagogical, and Content Knowledge (Tpack) and Competencies: A Literature Review. Eur. Chem. Bull. 12(4), 3140-3160
[37]. Tirol, S. L. (2021). Spiral Progression of Biology Content in the Philippine K to 12 Science Curriculum. International Journal of Multidisciplinary Research and Publications (IJMRAP), 4, 20-27.
[38]. Tirol, S. L. (2022). Spiral Progression Approach in the K to 12 Science Curriculum: A Literature Review. International Journal of Education (IJE), 10, 29-44. https://doi.org/10.5121/ije.2022.10403
[39]. Tirol, S.L. (2023). Science Teachers’ Competence on Model-Based Inquiry: A Review of Related Literature. Eur. Chem. Bull. 2023,12(5), 2886-2902

[40]. Warren, A. E., & Wakefield, J. S. (2006). Building bridges to experiential learning: A complete guide to organizing and delivering internships, cooperative education, and other experiences. Stylus Publishing.
[41]. Windschitl, M., Thompson, J., & Braaten, M. (2008). Beyond the scientific method: Model-based inquiry as a new paradigm of preference for school science investigations. Science Education, 92(5), 941-967.
[42]. Wurdinger, S. D., & Carlson, J. A. (2010). Teaching for experiential learning: Five approaches that work. Rowman & Littlefield Education.