Learning By Doing: Capturing the STEM Students' Experiences in Science Laboratory Experiments: A Lebenswelt

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Abstract: Background: As the advancement of today's technology, the important use of the school science laboratory has been greatly needed over the past years especially for the STEM students. Although other studies have gone over the importance of science laboratories, this paper presents a clear understanding of the lived experience of grade 12 students under the STEM strand in conducting experiments in the school science laboratory. Methods: This qualitative study utilized the phenomenological approach to fully understand the lived experiences of the Grade 12 STEM students concerning the central question: "How do laboratory experiments reinforce the academic development of STEM students?" The necessary data set was obtained through semi-structured interviews with twenty-seven (27) questions and formulated themes from the responses of the participants. Findings: Findings have shown the lived experiences of the Grade 12 Senior High School STEM students in conducting experiments in the school Science Laboratory. It comprises three major themes with three sub-themes each: Cognitive Application with the sub-themes Critical Thinking, Outcome-Based Approach, and Experiential Learning; Affective Implication with the sub-themes Personal Satisfaction, Collaboration, and Responsibility; and Psychomotor Intensification with the sub-themes Manipulation, Proficiency, and Adaptation. Conclusion: The students' learning experiences in the school science laboratory had been impactful in the development of the three domains of learning in relation to Bloom's Taxonomy. Students are able to nurture their cognitive, affective and psychomotor skills through the conduct of laboratory experiments. Recommendations: The researchers recommend that laboratory experimentation be given more emphasis in any Science course more than other performance tasks. To fill in the gaps in this study, it is suggested that the future researchers diversify the respondents' profile by locale, age, and strand. In addition, the researchers recommended conducting further analysis of the students' learning experiences on conducting science laboratory experiments.

Keywords: Laboratory Experiments, STEM, Cognitive, Affective, Psychomotor

1. Introduction

Today's technologically advancing society increases the demand in the workforce for jobs requiring proficiency related to science, engineering, technology, and mathematics (STEM) centered skills. Accordingly, the K-12 curriculum provides specialized strands and core subjects that aim to narrow the focus of academics and align it with the prospective career plans of the students. As Kennedy and Odell (2012) reported, "Engaging students in high-quality STEM education requires programs to include rigorous curriculum, instruction, and assessment, integrate

technology and engineering into the science and mathematics curriculum and also promote scientific inquiry and the engineering design process" [51]. Essential components of the effective delivery of learning competencies under the STEM strand include practical real-world applications through interactive activities on top of verbal delivery of content through lectures. Identifying connections among STEM disciplines from the scope of education will help students be familiar with the nature of work conducted by scientists, technologists, engineers, and mathematicians themselves and allow them to make more informed decisions about their desired STEM-related career pathways (Kelley & Knowles, 2016) [50]. Choosing the STEM strand and learning from core subjects and specialized activities will help students become equipped as they begin preparing for their future careers. STEM-related activities, such as laboratory activities, provide students with subject knowledge, cultivating their academic and social development. The participation of students in science laboratory activities has significantly impacted their perceptions of the Science laboratory environment, which in turn boosts their science learning self-efficacy (Lee et al., 2019) [59]. Science laboratory activities foster innovative abilities and reasoning skills and help students learn to deal with the challenges of observing the nature of existence. Science laboratories have played an essential role in advancing teaching and learning over the years, as laboratory work has been at the heart of involving students in processing investigations and discoveries. Science laboratory subjects continue to influence students' learning and decisions significantly; however, in today's modern technological age, acquiring knowledge and experience from laboratory practices can guarantee students a wide variety of STEM occupations of their choice. The workplace where technology-based education is unavoidable is waiting for individuals to be producers and inventors; this means that they can combine knowledge in the fields of Science, Technology, Engineering, and Mathematics (STEM) to enable individuals to demonstrate their efficiency (Sarac, 2018) [79]. The science curriculum is an inquiry-based, learner-centered subject that aligns with the objectives and characteristics of the Philippine K–12 Curriculum and equips students with the skills they need to succeed in society and the workplace. The Senior High School STEM curriculum was created by the Department of Education (DepEd) to develop students' skills from simple to complex problems in the country and the world in terms of science, technology, engineering, and mathematics concepts (Abas & Marasigan, 2020) [1]. In order to increase scientific literacy and help students improve their scientific skills, K–12 encourages students to use scientific laboratories. Laboratory activities and the use of science laboratories is a way of allowing students to learn with understanding and to engage in the process of constructing knowledge by practicing real-life applications of lessons. Integrated STEM education is a catalyst for preparing productive and innovative generations and promoting a country's economic growth (Karpudewan, 2019) [46]. School science laboratories allow students to participate in study and inquiry while utilizing various ideas, procedures, and experiments. Students in the STEM strand, especially in Qatar, need constant engagement and activities in the school science laboratories to meet the high-job demands in the STEM field. It will help not only Qatar but also the student's ability to be able to learn more and be more productive in their future career paths. The high demand for work-related jobs related to the STEM field is most noticeable in Qatar (Sellami et al., 2016) [82]. Combining many academic areas into one comprehensive course will aid in developing students who are not only knowledgeable, competent, and able to use the principles in their daily lives. The learning process is necessary to improve the student's understanding of the material, improve the learning environment through experiments, and aid the student in developing a clear understanding of significant issues. A research gap exists in STEM students' lived experiences conducting science laboratory experiments. In this regard, this research aims to establish whether science laboratory activities impact the academic development of STEM students. The analysis of lived experiences through this research study allows the students, teachers, and school administrators to be familiar with the status of the strand learning competencies and the areas of improvement to increase the efficacy of teaching STEM students using science laboratories. The present study aims to understand the learning experiences of Grade 12 students under the STEM strand based on conducting science laboratory experiments in school according to the K-12 curriculum. The researchers aim to discover the highlights of the experiences about the three domains of Bloom's Taxonomy about laboratory experiments. Specifically, it tries to answer the central question: "How do laboratory experiments reinforce the academic development of STEM students?" Additionally, the specific question to be answered is: "What are the lived experiences of the senior high school students when conducting experiments in the science laboratory?" These questions were analyzed to specify the preliminary inquiry to gather more detailed responses.

2 Method

This study aims to understand the participants' lived experiences, making it a phenomenological research design in general. Making new, significant distinctions due to getting closer to the phenomenon under study improves scientific understanding through the iterative qualitative research process (Aspers & Corte, 2019) [9]. This study's objective is to comprehend the participants' experiences and perceptions. Hence, a phenomenological research approach will be used in this study. According to Deakin's University, phenomenology is a powerful method for dispelling long-held beliefs and upending received wisdom, gaining insights into people's actions and motivations, and comprehending subjective experience. It might help create new theories, policy modifications, or response adjustments. As Neubauer et al. (2019) reported, the study of a person's experiences in the world is the primary goal of the qualitative research method known as phenomenology [70]. The approach of this method examines human experience in daily life while putting aside the researchers' preconceived notions about the phenomenon. In other words, phenomenological research investigates actual experiences to learn more about how people interpret them. Besides this, this strategy is based on the lessons discovered from the participants' experiences.

2.1. Research Local & Sample

This research was carried out in the Philippine School Doha (PSD), notably in the Messaimer District (Zone, 56),

Al Khuaifat Al Jadeeda Street, in Doha, State of Qatar (St. 1011). The participants are available, allowing the researchers to carry out their study. Hence this research was carried out in this location in addition to the fact that the researchers are students at this school and spend most of their time there.

2.2. Data Collection and Ethical Consideration

The process of gathering data started with creating a list of questions that would be included in the questionnaire that the participants would respond to during the interview. Selected students with applicable backgrounds will be given the questionnaire to validate it. The selected participants will receive emails with consent forms inviting them to participate in the study. The participants' availability determined the time and location of the interviews. Moreover, the interview was conducted through zoom, and the information was gathered through the interviews. The participants will express their first-hand experiences with the researchers with the aid of the robotfoto and interview guide. An orientation will be presented to the participants before the interviews to provide a background and understanding of the procedures to be the pattern for the data gathering. The qualitative research process will extensively use data treatment, interpretation, and analysis in addition to transcribing the oral responses.

2.3. Data Analysis

The opinions and experiences of the participants will be directly gathered and used as data in this study. The research progression will then be observed from their responses obtained through the planned questionnaire by using the following data analysis steps: (1) Emic data transcription; (2) Emic to Etic data transcriptions; (3) Cool to warm analysis; (4) Identifying and analyzing themes through dendrogram tool; and (5) the inclusion of these themes into the simulacrum of this research. The study of this research will result in a detailed and colossal understanding using the systematic procedure, analyzing the experience of the Senior High school student in the laboratory using thematic analysis. The generalizations drawn from the interviews will be returned to the participants for clarification and elaboration after the researchers have finished all these steps to improve the accuracy and validity. Answers will be organized to avoid the participants' biases or misunderstandings on the topic, and those with irrelevant points will be avoided. Once the member verification has been completed, along with the data collection, and cross-examination, the researchers will stop conducting interviews, and the method used to collect data will then end.

3 Results

This phenomenological study aims to describe the learning experience of the Grade 12 Senior High School students in conducting experiments in the Science Laboratory, specifically those who were enrolled in the STEM Strand in Grades 11 and 12 relatives to the specific question: "**What are the lived experiences of the senior high school students when conducting experiments in the science laboratory?**" Furthermore, the study focuses on the central question: "**How do laboratory experiments reinforce the academic development of STEM students?** Indeed, laboratory experiments provide students with experiential learning beyond classroom borders, deepening their understanding of the theories learned. It allows students to work in groups, thus establishing social relationships. Furthermore, students can use different laboratory tools and equipment to enhance their motor functions. Figure 2 shows the simulacrum focused on three major themes: Cognitive Application, Affective Motivation, and Psychomotor Intensification. These themes show what the students in specialized STEM subjects can experience when conducting experiments in science laboratories. Based on the results, students apply theories in the classroom using critical thinking considering the outcome-based approach used during laboratory experiments that later provided experiential learning, encapsulated in the central theme of Cognitive Application. Exposure to laboratory experiments developed their affective domain, which induced personal satisfaction, collaboration, and responsibility. Psychomotor intensification was accomplished through Manipulation, proficiency, and adaptation.

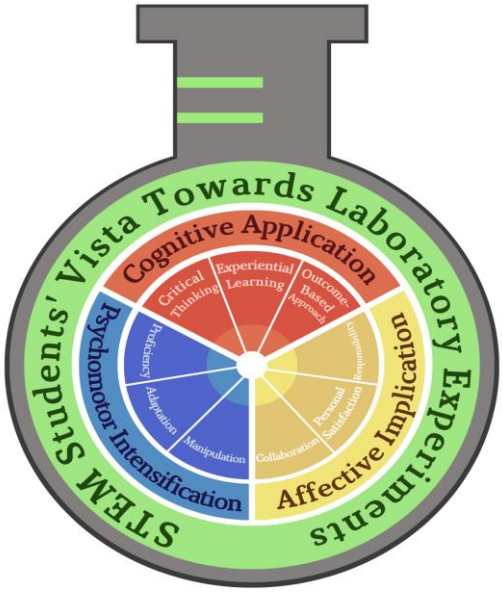

Figure 1: Showing the Impact of Laboratory Experiments

3.1. Cognitive Application

The first major theme is one of the essential parts of conducting experiments in the school science laboratory. It is the act of acquiring knowledge and understanding through cognitive thinking. It is one of the critical components in understanding theories that were part of the lecture sessions inside the classroom and applying them to real-life procedures to establish a known fact.

3.1.1 Critical Thinking

The capacity of the learner to critically assess data during science laboratory experiments that lead to effectively analyze procedures and perform with utmost accuracy. The respondents claimed that:

> *"I am gaining proficiency in conducting science experiments by observation. I try to look closely, analyze the causes, and the effects of our experiments. I look at other angles of experiments unlike if I did not do the experiment…" (P1)*

It can be inferred that the individual is making a concerted effort to enhance their proficiency in conducting science experiments by means of observation. Particularly, they diligently scrutinize their experiments' causes and effects

while exploring them from diverse perspectives, implying a thoughtful and analytical approach to their work.

"...we also learn to be great problem solvers as we learn to actively think or figure out things through these experiments." (P6)

It is deduced that the individual holds the belief that conducting experiments can serve as a catalyst in fostering the acquisition of problem-solving skills. The statement suggests that through the process of active thinking and strategic problem-solving during experimentation, individuals can improve their capacity for solving problems.

"It could also be problem solving since you're working with certain issues from time to time and different harmful circumstances, so you somewhat develop that sense of initiative of solving problems."(P8)

Ostensibly, the person believes that taking part in activities that require handling problems and harmful circumstances might help people enhance their problem-solving abilities. The remark implies that these encounters can foster a sense of initiative and the capacity to handle challenges effectively. The respondents emphasized the advantages of scientific laboratory experiments for the growth of critical thinking and problem-solving abilities. They expressed their dedication to analyzing experiment data from various angles and approaching their work thoughtfully and analytically. It has been pointed out that experimentation can improve one's capacity for problem-solving, encouraging initiative in the face of difficult circumstances. The statements suggest that science laboratory experiments can serve as a valuable platform for developing critical thinking and problem-solving skills, thereby improving one's analytical acumen and capacity for effective decision-making.

3.1.2 Outcome-based Approach

Outcome-based approach refers to setting a clear expectation of what needs to be accomplished at the end of the experiment. This approach is used by teachers to guide students to concentrate on the goal and achieve desired outcomes through student-centric activities. Students will see the outcome of an experiment after it has been conducted. As the participants claimed:

"It's the product that I look forward to the most. And the lesson that I would gain from that, and the experience that I would gain from conducting the experiment." (P2)

It can be extrapolated from the statement that the person places a high priority on the outcome of doing an experiment. The statement implies a desire to participate in careful contemplation and analysis of the results, indicating a desire to learn important lessons and experiences from the testing process. Thus, it can be concluded that the individual is motivated by a combination of the potential insights to be gained from conducting experiments and the excitement of producing a tangible product as the final outcome.

"The most memorable part when conducting an experiment is mostly when you get the result of the experiment itself since that's where you see how things work out, after the process of the experiment itself." (P4)

The statement suggests that the individual finds the result of an experiment to be the most memorable aspect of the process, as it provides insight into how things worked out after the experiment was conducted. From this, it may be inferred that the individual places great value on the outcome of the experiment, and is motivated by the potential insights that can be gained from analyzing the results. In conclusion, the statement suggests that the individual's interest lies in the process of conducting an experiment, with a particular focus on the potential outcomes and the insights that can be gained from them.

"...the most interesting part is seeing the outcome of the experiment... certain things react with each other, and that's really something not you've seen in- or that's not something that you would normally learn." (P7)

The individual finds the outcome of an experiment to be the most fascinating aspect of the process. They have a particular interest in monitoring the interactions between various elements, which offers a special learning opportunity that cannot be obtained using conventional techniques. This statement implies that the individual values the experiential learning that comes from conducting experiments and is motivated by the potential discoveries that can be made through this process.

The evidence presented by the participants supports the conclusion that an outcome-based approach is an effective strategy to motivate students in conducting experiments. The emphasis on achieving clear goals and desired outcomes through student-centered activities can foster a desire to learn important lessons and gain valuable experiences from the testing process. The participants' statements suggest a particular focus on the potential insights and tangible products that can be gained from conducting experiments, indicating a strong motivation to engage in careful analysis of the results.

3.1.3. Experiential Learning

The process of learning from experience is known as experiential learning. Students are better able to relate concepts and information taught in the classroom to actual conditions when they are involved in practical activities and reflection:

"I can find that conducting science experiments could be the practical application of the concepts we learn." (P5)

The statement implies that concepts apply to real-world applications through science laboratory experiments.

"I think because of the experiments you get the practical knowledge which is not usually found in a classroom, because in the classroom you only usually have that theoretical knowledge you don't apply it so you really don't know if you will have the right outcome until you do it in the laboratory and observe it with your own eyes and senses." (P6)

Performing experiments provides real-world knowledge that students would not gain in a classroom. Students frequently learn theory inside the class but do not put it

into practice or apply it in real life. If they only study it in class, they would not be able to see the results of their experiments with their own eyes or experience it with their senses.

"I'd say that the actual experience of forming the experiment is a great benefit since with the classroom setting it's all about just learning it in theory, but in the laboratory, you actually get to put that knowledge in to use." (P3)

An efficient method to apply knowledge is to engage in a laboratory experiment. Instead of simply studying it in theory, it is beneficial for the students to see and do it in action. Beyond enhancing theoretical learning, laboratory experiments have further advantages. While laboratory work gives students the opportunity to obtain practical experience and build the practical skills necessary for scientific inquiry, classroom learning lays the groundwork for understanding scientific principles.

Experiential learning through laboratory experiments is a valuable approach for students to apply theoretical knowledge in real-world settings and gain practical skills for scientific inquiry. By engaging in hands-on activities and reflecting on their experiences, students can enhance their understanding of concepts and improve their ability to relate them to actual conditions.

Through experiential learning, students can bridge the gap between theory and practice and acquire a deeper understanding of the subject matter. Furthermore, experiential learning can also foster creativity, problem-solving, and critical thinking skills in students, as they are encouraged to develop their own experiments and analyze their results. It is essential for educators to incorporate experiential learning opportunities in their teaching methods to provide students with a well-rounded education that equips them with both theoretical knowledge and practical skills.

3.2 Affective Implication

The second major theme includes the manner of dealing things emotionally in relation to their experiences during the conduct of laboratory experiments. Affection plays a key role in developing a fondness in doing experiments which brings forth essential values.

3.2.1. Personal Satisfaction

The students feel a sense of fulfillment after completing an experiment, especially in school science laboratories, as they have experienced the practical Application of the lessons, they learned from their science classes. It is also from operating the experiment with the satisfaction of the outcome. As the participants stated:

"...even if you don't get what you expect, I still feel very fulfilled when finishing an experiment." (P2)

The satisfaction of completing a task or activity can be rewarding to the student, even if the outcome does not align with one's expectations.

"... you would feel a sense of fulfillment because you were able to do the procedure right, you were able to get the instructions right, and then you got the most favorable end result, and even if there were a bit of obstacles in the way, I think you can always learn a lesson from that, you will know what not to do in the next experiment." (P6)

The importance of following procedures and instructions in achieving favorable outcomes in experiments, as well as the valuable lessons that can be learned from any obstacles encountered along the way. Through the process of experimentation, the students can gain a sense of fulfillment from successfully completing tasks and learning from their experiences.

"... so obviously it would be something that is accomplishing once you complete an experiment successfully since you applied everything you learned, you listen to all of this, and it takes a lot of preparation, a lot of energy, a lot of thinking when you're doing all of these experiments, so genuinely it would be accomplishing." (P8)

Successfully conducting an experiment can be a rewarding experience to students because it takes a lot of planning, effort, and critical thought. Given that it entails using the knowledge and skills acquired during the process, it can be considered a success and a crucial turning point in the learning process.

Personal satisfaction can be an essential factor in the learning process for students engaged in science laboratory work. Students can be encouraged and inspired to continue their scientific endeavors by having the opportunity to feel a feeling of accomplishment and joy after finishing an experiment, regardless of the results. Through the practical application of lessons learned in the classroom, following procedures and instructions, and encountering and learning from obstacles, students can gain valuable experience, knowledge, and skills that they can carry with them throughout their lives.

3.2.2 Collaboration

Collaboration refers to the student's actions when working with someone; it is the essence of teamwork and cooperation in completing a task. It will allow students to improve their educational experience by working together.

"What we do with our classmates and friends, it makes it more fun and the way the teacher does it with us and it develops our relationship with the teacher." (P1)

Through collaborative and interactive learning experiences with classmates and friends, students find learning more enjoyable and engaging. Moreover, teachers who incorporate such methods into their lessons create a positive classroom atmosphere and strengthen their relationship with their students. The integration of these techniques not only enhances the learning experience but also facilitates the development of social and interpersonal skills, which can be beneficial in various aspects of life.

"...Something that really stuck to me has to be the socializing and cooperation aspect of it all. I get to communicate with more people than I normally do." (P7)

The experience of socializing and cooperating with others is a notable aspect of the activity, as it allows the students

to interact with a broader range of individuals than they typically would. This indicates a willingness to engage with others and collaborate on shared goals, which is a valuable skill that can be applied in various areas of life.

"When you're working with people, I feel like that's when you really develop those certain values and certain mindsets, because you're working hand in hand with someone, and sometimes you're trying to adjust with each other." (P8)

Working collaboratively with others provides a unique opportunity to develop essential values and mindsets that are crucial to success. Through the process of adjustment and cooperation, individuals are able to hone their interpersonal skills and build strong relationships with their colleagues. These experiences can help individuals grow and develop as professionals, and may even translate to other aspects of their personal and professional lives.

Collaboration is a powerful tool for improving the educational experience and fostering the growth of crucial social and interpersonal skills. Through collaborative learning activities, students can work together, communicate more effectively, and develop a sense of camaraderie with their peers and teachers. These encounters can promote professional and personal development by educating people on fundamental principles and ways of thinking professional and personal development by educating people on fundamental principles and ways of thinking that they can use throughout their lives.

3.2.3 Responsibility

Responsibility is when students can display behavior about one's ability to act independently with utmost accountability. It shows independence and reliability through one's own volition in completing tasks.

"So being in a science laboratory and conducting science experiments helped me be more cautious not only in the lab but outside of school and in the things, I do in general." (P5)

Engaging in science laboratory work and conducting experiments require a high level of caution and attentiveness to detail, which can be transferable skills outside of the laboratory setting.

"...I developed that sense of attentiveness, mindfulness, patience, I get to develop that." (P8)

Developing a sense of attentiveness, mindfulness, and patience is a crucial aspect of personal growth and development. This can be achieved through various experiences, including laboratory work and scientific experimentation.

"It teaches you to be more careful… so it teaches us to pay more attention, not just to be careful of what we're doing and how it can affect others." (P4)

A vital skill that may be cultivated through a variety of activities, including those in scientific laboratories, is the ability to be cautious and pay attention. As a result, developing this skill can help students be more conscious of their behaviors and how they affect others.

Responsibility is a valuable skill for students to develop, as it demonstrates independence and accountability in completing tasks. Engaging in activities that require caution and attentiveness, such as science laboratory work, can foster these qualities in students. Furthermore, the development of attentiveness, mindfulness, and patience through such experiences can contribute to personal growth and development. Ultimately, learning to be more careful and mindful of one's actions can help students better understand how their behavior impacts themselves and those around them.

3.3 Psychomotor Intensification

The third central theme refers to the mental processes related to the student's physical movement. It refers to how students can make decisions through the use of both the psychological and physical aspects of the body. It is conveyed by how they process and complete an experiment.

3.3.1 Manipulation

It refers to the student's ability to manipulate the laboratory tools and equipment while gaining control over the experiment practically and skillfully to their own advantage. Students claimed:

"…we have all the materials and tools that we need to do the experiment. We would learn more by doing that and we have the experience and the hands-on activities we do in the laboratory." (P1)

The participants assert that they possess all the necessary materials and tools to conduct the experiment, and that performing the experiment would lead to a greater understanding of the subject matter. They value the hands-on experience and practical activities that are available in the laboratory. From this, it can be inferred that the participants place great importance on active learning, with a focus on engaging with the subject matter through experimentation. This indicates a desire to gain a deeper understanding of the material, as well as an interest in developing practical skills and knowledge through direct experience.

"A major thing that helps me understand the lesson more is seeing the concepts that you read on paper actually in front of your eyes and being able to put your hands on it." (P5)

The participant expresses a preference for hands-on learning in their statement, highlighting the importance of seeing and interacting with concepts rather than simply reading about them. They suggest that seeing the concepts in action and physically interacting with them can enhance the learning experience. Thus, the individual seeks out opportunities to apply theoretical concepts in a practical setting.

"…we were tasked to use the microscope in looking for onion and cheek cells…this activity marked my first time seeing what plant and animal cells look like from my own eyes." (P10)

The individual had the opportunity to use a microscope to observe onion and cheek cells for the first time. This activity offered the chance to visualize plant and animal cells in a way that is not possible through other methods. As a result, they were able to expand their comprehension of the subject and obtain useful practical experience.

In summary, based on the participants' statements, it can be concluded that the ability to manipulate laboratory tools and equipment is an essential aspect of active learning. The participants value the hands-on experience and practical activities available in the laboratory, and see experimentation as a means to gain a deeper understanding of the subject matter. They express a preference for hands-on learning and the opportunity to see theoretical concepts in action, indicating a desire to develop practical skills and knowledge through direct experience. The use of tools such as microscopes offers a unique opportunity for visualization and practical experience, which can enhance the learning experience and expand comprehension of the subject matter.

3.3.2 Proficiency

The ability of the learner to be able to execute an experiment in a precise manner. It shows that the students can develop proficiency in analyzing scientific concepts due to exposure to laboratory experimentations where they can utilize equipment and learn proficiency through this:

"I make sure to work efficiently this time while trying to get the correct measurements to see if I would still have the same result or I would have a similar result now to my groupmates or classmates." (P6)

In order to compare their results to those of their peers, the student recognizes efficiency in their work and aims to achieve precise measurements. They are eager to exert the necessary effort because they are driven to accomplish the same result as their peers. It can be assumed that the person is goal-oriented and works to get the greatest outcomes. This reveals a dedication to learning and development as well as a willingness to advance their knowledge and abilities through practical application.

"My proficiency in measuring, computing, and analyzing developed." (P2)

The student has become more proficient at measuring, computing, and analyzing, most likely as a result of regular practice and interaction with the requisite skills and concepts.

"...with all those experiences put into me now, I have not only improved but also established necessary skills to conduct experiments proficiently such as reading and following the instructions and providing cautiously what was asked." (P7)

Through previous laboratory experiences, the student has acquired and developed important skills in conducting experiments, such as closely following instructions and providing precise responses to requirements. As a result, they have not only improved their proficiency in laboratory work but also acquired essential skills that are necessary for conducting experiments efficiently and effectively. These skills are valuable assets that can aid the individual in their future laboratory work and studies.

Laboratory experimentation plays a significant role in the development of students' proficiency in executing experiments precisely and analyzing scientific concepts. The accounts provided by the students illustrate their dedication to achieving accurate results and improving their skills in measuring, computing, and analyzing. As they gain more experience, they develop essential skills such as following instructions closely and providing precise responses to requirements. These skills are critical for conducting experiments efficiently and effectively, and they will undoubtedly serve the students well in their future laboratory work and studies.

3.3.3 Adaptation

The student can adjust when they are in a dire situation. It refers to their ability to think quickly about unexpected problems during the experiment. Students can adjust to unavoidable circumstances when necessary:

"I would look around and search for other tools that I can use as an alternative for the experiment. If it's just something minor and can be replaced with any other materials as long as it can achieve the same effect, then I would just try to find a replacement." (P3)

This statement demonstrates a willingness to seek alternative methods and materials in the event that the necessary tools are unavailable. They express a practical approach to problem-solving, prioritizing the achievement of the desired outcome over adhering strictly to the prescribed methods. It indicates adaptability in the face of challenges, qualities that are valuable in a laboratory setting where unexpected circumstances can arise.

"Just be adaptable; it comes down to how you utilize the things you're given." (P4)

In instances where the students might not have all the resources they need, adaptability is a vital trait that can aid people in succeeding. By being adaptable, individuals can make the most of the tools and resources available to them, and find creative solutions to problems. No matter the circumstance, success ultimately depends on one's capacity to utilize the available resources wisely.

One of the most important aspects of laboratory work is the capacity to adjust to unforeseen circumstances and make the most of available resources. Students who can adjust to new situations and handle problems practically are more likely to succeed in obtaining their goals. This emphasizes the value of encouraging a mindset in the laboratory setting that stresses adaptability and creative thinking. Ultimately, the ability to adapt can lead to greater success and a deeper understanding of the subject matter.

4 Discussion

Using school science laboratories has always been significant to students continued academic development. This phenomenological study implies how STEM students engage with school science laboratory experiments. The findings indicate that science laboratory activities can positively impact senior high school students' sense of fulfillment. Such activities enhance students' sense of accomplishment, enjoyment, and interest in science and

develop essential skills such as problem-solving, critical thinking, and collaboration. A study by Barros, A. G., Barros, D. B., & Gandra, M. (2019) shows that laboratory activities have a positive impact on students' learning outcomes, including knowledge acquisition, conceptual understanding, problem-solving, and inquiry skills [14]. In addition, many studies have indicated that laboratory activities can increase students' motivation and interest in science and improve their attitudes towards science. For example, a study by (Chang, et al. 2017) found that laboratory activities helped students understand the practical relevance of scientific knowledge, while another study reported that students enjoyed and engaged more with science as a result of laboratory activities [21]. Overall, the evidence suggests that laboratory activities can enhance students' learning experiences and contribute to the development of important scientific knowledge, skills, and attitudes.

The discussion is assisted by studies emphasizing the importance of hands-on laboratory activities in science education. Engaging in school science laboratory activities can significantly impact senior high school students' sense of fulfillment, and laboratory activities can enhance students' accomplishment and satisfaction with their learning experiences (Basilio et al., 2018) [15]. In addition to this, students also reported feeling a sense of enjoyment and interest in science due to laboratory activities. This finding is assisted by research conducted by R. Azmitia, who found that students who participate in laboratory activities are more likely to find science enjoyable and engaging (Azmitia, 2011)[13].

4.1 Cognitive Application

Cognitive Application is utilizing knowledge and understanding of the world through mental processes such as perception, memory, attention, and reasoning. Laboratory activities are essential for promoting cognitive development in students as they provide opportunities for hands-on exploration and experimentation, promote critical thinking and reasoning, and help students develop their working memory capacity. Battista and Clements (1996) conducted a study that showed that laboratory activities improve cognitive development in science among high school students [16]. The study found that students who engaged in laboratory activities had better critical thinking, problem-solving, and reasoning skills than those who received only traditional lecture-based instruction. The study found that students who engaged in laboratory activities had better critical thinking, problem-solving, and reasoning skills than those who received only traditional lecture-based instruction. In a more recent study by Pratama and Rusilowati (2017), it was found that laboratory activities could improve students' cognitive skills, such as analysis, evaluation, and synthesis, which are essential for scientific inquiry [73]. Additionally, another study by Jovanovic and King (2019) showed that laboratory activities can enhance students' cognitive learning experiences in science and promote the development of their cognitive skills, including attention, memory, and executive functioning [45]. Overall, these studies suggest that laboratory activities play an important role in promoting cognitive development and enhancing students' cognitive skills in science education.

4.1.1 Critical Thinking

The learner's capacity to critically assess data during science laboratory experiments involves using reasoning, logic, and evidence to assess and understand complex ideas or problems and generate new knowledge and insights. Critical thinking requires identifying biases, assumptions, and fallacies in arguments and questioning assumptions and preconceptions—the ability to assess arguments and draw conclusions through evaluating. To generate well-informed students, or students who grasp significant, useful, beautiful, and powerful ideas, is one of education's major goals. Another is to develop students who are eager to think logically and critically and who will apply what they learn to improve their own lives and society Iyer L. (2019) [43].

4.1.2 Outcome-Based Approach

The outcome-based approach focuses on analyzing the impact of a program or intervention by examining its results or accomplishments rather than merely the inputs or processes. The strategy strongly emphasizes the value of establishing clear, quantifiable goals and using data to assess their level of achievement. The study by Abdi and Crippen (2017) used an outcome-based methodology to study the efficacy of an inquiry-based learning program in a science education center connected to a university [2]. The study evaluated the program's outcomes, including students' attitudes toward science, capacity for scientific inquiry, and comprehension of scientific ideas. The outcomes demonstrated that the curriculum successfully enhanced students' attitudes toward science and their capacity for scientific inquiry. This study emphasizes the importance of evaluating science education initiatives in school science labs regarding their effects on students' learning outcomes.

4.1.3 Experiential Learning

Experiential learning is a learning process that emphasizes hands-on activities and real-world experiences that promote reflection, critical thinking, and problem-solving. It effectively enhances learning outcomes in various subjects, including science and mathematics. Students' conscious, active participation in opportunities for learning by doing and reflection on those experiences equips them to apply their theoretical understanding to practical activities in various situations both within and beyond the classroom. It enables them to gain more understanding of what they have learned from their science classes by experiencing its applications firsthand. The benefits of experiential learning are evident on a psychical level, mainly when unique learning environments are. Because the students better understand the connections between the theoretical concepts and their relevance, knowledge acquisition is created simpler Gorghiua & Santi (2016) [31].

4.2 Affective Implication

Affective implication refers to the emergence of the emotional capacity to experience, recognize and express varied emotions when conducting experiments with peers. It focuses on how emotions affect students, including feelings, emotions to express, emotions to control, empathy, and emotional intelligence. The study by Denham et al. (2014) explores children's socialization of

emotional competence and emphasizes the importance of emotional competence for children's well-being [22]. Another study by Lee and Kahveci (2019) examined the effect of a science laboratory program on students' emotional engagement, finding that laboratory experiences positively influenced students' emotional engagement and motivation towards science learning [59]. The authors suggest that the emotional experiences gained through laboratory activities can be harnessed to promote students' interest and engagement in science.

4.2.1 Personal Satisfaction

Personal satisfaction pertains to an individual's experience of fulfillment when completing tasks successfully when conducting laboratory experiments. The study by Hsu et al. (2017) investigated college students' attitudes, personal satisfaction, and confidence toward laboratory learning environments with participants enrolled in science laboratory courses [38]. The results indicated that students generally had positive attitudes towards laboratory learning, and their personal satisfaction and confidence were positively correlated with their attitudes. The authors conclude that laboratory learning environments play a crucial role in shaping students' attitudes and perceptions of science learning, and it is also from being able to operate the experiment resulting in a satisfactory outcome.

In a study by Kilinc et al. (2020), the impact of laboratory activities on the satisfaction of pre-service science teachers was investigated [53]. The findings showed that laboratory activities had a positive effect on participants' satisfaction and increased their confidence in teaching science.In conclusion, laboratory activities in science education have a positive impact not only on students' learning outcomes but also on their personal satisfaction, enjoyment, and confidence in science. The studies reviewed in this discussion suggest that laboratory activities enhance students' interest and motivation in science, promote their critical thinking, problem-solving, and inquiry skills, and contribute to their conceptual understanding of scientific phenomena. Additionally, laboratory activities also play a crucial role in shaping pre-service teachers' attitudes and perceptions towards science education. Therefore, incorporating laboratory activities into science education is essential for the development of students' scientific knowledge, skills, attitudes, and personal satisfaction, as well as for the improvement of science teacher education.

4.2.2 Collaboration

Collaboration is when individuals work cooperatively to perform an activity (Lai, 2011) [57]. It is the essence of teamwork and cooperation in completing a task. The sense of responsibility and fulfillment support the practices experienced by the participants. In a study by Yoon et al. (2015), the researchers investigated the effects of communication on group formation and cooperation in laboratory experiments with student participants [91]. They found that communication improved group formation and increased cooperation, mainly when participants could communicate face-to-face rather than via text messaging. The study suggests that effective communication can enhance cooperation in social dilemmas.

4.2.3 Responsibility

In addition, the participants also execute responsibility through punctual operation and the development of senses of attentiveness, mindfulness, and patience. It shows independence and reliability through one's own volition in completing tasks. In order to ensure that everything is done in the participant's best interest, in a study called "Student Responsibility and Performance in Undergraduate Science Laboratories" by Rodger and Walker (2018), results of the study showed that students who reported taking more responsibility for their learning in the laboratory had higher final course grades compared to those who reported taking less responsibility [75]. Additionally, students who reported higher levels of responsibility were more likely to engage in productive learning behaviors, such as asking questions and seeking help from instructors and peers.

4.3 Psychomotor Intensification

The psychomotor domain focuses on manual tasks that require the Manipulation of objects and physical activities (Merrit, 2008) [67]. According to Zaghloul (2001) and Merrit (2008), the human mind and body are attached while performing those activities [92]. Practical skills involve psychomotor development, as the students typically handle chemicals, glassware, and instrumentation. Laboratory work promotes students' cognitive development and psychomotor skills, enhancing their scientific attitude and enjoyment of science laboratories (Vincent &Lunetta, 2003) [87]. There is a need for more studies on developing assessments focusing on psychomotor or integrated skills and establishing standard criteria to evaluate the effectiveness of laboratory activities (Ma & Nickerson, 2006) to help reveal the variety of possible benefits that technology can bring to improving students' learning in science laboratories [65].

4.3.1 Manipulation

The usage and handling of chemical substances and scientific equipment during laboratory research are emphasized by manipulative skills in science. Developing manipulative skills is a critical aim of practical work (Abrahams et al. 2013) [3]. Manipulative skills involve using the hands or feet to move or use an object to accomplish a task or reach a goal. An object might be a pencil or a button for fine motor skills. The item could be a plaything or sporting equipment like a bat, ball, racquet, or jump rope for developing gross motor skills, but in this case, it is science laboratory experiments.

4.3.2 Execution

Execution means the ability to experiment successfully and precisely as it is essential when conducting experiments in the school science laboratory. It is shown that physical experience with science-related activities in the laboratory can execute and enhance the student's performance, primarily through their previous experience (Kontra, et al. 2015) [55]. It meant the importance of the students being able to perform and execute the experiments since they would be able to learn and adapt to different tasks assigned to them. Proper execution of laboratory experiments is necessary to get the desired results for the students.

4.3.3 Adaptation

According to Rogala-Pwelczyk (2002), *adaptation* is described as a specific kind of human accommodation to a particular environment [76]. Such a definition describes adaptation as a process that prepares students to work effectively in a given environment. A student finds efficient and innovative ways to conduct experiments to optimize resources when necessary. In this way, the insufficiency of tools and equipment can be addressed.

5. Conclusion

Scientific activities and laboratory experiments have significantly contributed to the learners' learning and experience, especially seeing it hand in hand. It helps them improve their ability to conduct scientific theories and their effectiveness in understanding the lesson or experiment. Gericke et al. (2022) found that the essence of laboratory experiments can be distinguished as comprising various scientific practices, in other words, a collection of fundamental knowledge and skill elements used when conducting scientific studies [28]. Furthermore, the challenges and engagement they gain in the science laboratory help them improve their critical thinking and scientific problem reasoning.

Several studies support the notion that laboratory experiments promote scientific learning and development. For example, a study by Ainsworth and Loizou (2013) found that laboratory experiments are essential for promoting scientific understanding and skill development among students [5]. They suggest that laboratory experiments promote a more in-depth and lasting understanding of scientific concepts and principles than other forms of instruction. Similarly, a study by Kirschner et al. (2013) showed that laboratory experiments promote the development of scientific reasoning skills, such as hypothesis testing and experimental design [54]. They suggest that laboratory experiments should be an integral part of science education to promote scientific literacy and critical thinking skills among students. Another study by Staver and Lumpe (2015) found that laboratory experiments promote student engagement and interest in science [83]. The study suggests that laboratory experiments are an effective way to enhance student motivation and interest in science, leading to improved academic performance. In summary, laboratory experiments are an essential component of science education that promotes scientific learning, skill development, critical thinking, and student engagement. These studies provide valuable insights into the importance of laboratory experiments in science education and suggest that they should be a fundamental part of the curriculum.

The study investigated the lived experiences of Grade 12 STEM students about conducting experiments in the school science laboratory. It determined how students are developed through laboratory science experiments in line with the cognitive, affective, and psychomotor aspects. These results provide insight into how STEM students can learn holistically in a laboratory environment. It also gives us an understanding of what motivates them to do their best during experiments and how they can develop essential skills such as problem-solving, teamwork, and independence. The findings of this study may be used by teachers, education administrators, and curriculum designers to create better learning experiences for STEM students in the school science laboratory. This study is significant for science curriculum specialists in designing appropriate activities for Senior High School students to emphasize laboratory experiments. Moreover, this study can aid Science teachers in putting more weight on conducting experiments and planning valuable performance tasks for students that could be performed inside the laboratory.

The study has several limitations, including time constraints due to school activities and limited data sources due to the unique study area. The sample size is also limited to participants from one school, which may introduce selection bias and limit the generalizability of the findings. These limitations should be considered when interpreting and extending the results to other contexts.

The researchers advise future researchers to use this study as an introduction to students' learning experiences under the STEM strand on conducting science laboratory experiments. As this study focuses mainly on the respondents in the STEM strand, expanding it to students with access to laboratory experiments can also be explored to understand further the phases of the student's learning experiences in different grade levels. Since this study focuses primarily on students enrolled in Philippine School Doha, widening the scope of participants from other schools or countries can be considered. The researchers recommend further analyzing the students' learning experiences in conducting science laboratory experiments.

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Author Profile

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Margarett Paula S. Baltazar is from Meycuayan, Bulacan. She was born on April 13 2005. She is currently a grade 12 student under the STEM (Science, Technology, Engineering and Mathematics) strand. She was part of the top 10 in her section in grade 9. She accomplished many things such as, participating in the school intramurals during grade 7 to 9 and 12. She also participated in several art contests in the school. She always believed in the quote of "You only live once, use it to its fullest"

Lovely Catherine Joyce E. Implamado is from Batangas City. She was born on July 20, 2005. She is currently a grade 12 student under the STEM (Science, Technology, Engineering and Mathematics) strand. She has been part of the high honor students since she was grade 5 and she became the top 1 of class when she was grade 9. She also had been part of school volleyball varsity in 2019, she also won Ms. United Nations 2018, Vision and Mission Representative 2017, Champion in Art Contest 2019, and 2nd runner up in Recyclable Art Contest 2019. She always participates in school extra-curricular activities and she believes in the quote "It does not matter how slowly you go as long as you do not stop."

Alija Glaiehnn R. Manalili is a grade twelve student in Philippine School Doha under the Science, Technology, Engineering and Mathematics. She is a consistent honor from grade nine to eleven. She also won a poem competition multiple times in her last school. She believes in a quote of "I'm like a surfer, first you just paddle and fall off the board but as time goes by you can stand up on the bigger waves."

Eurica Isiah O. Dorado is from Nagcarlan, Laguna. She was born on January 27, 2005. She is currently a grade 12 student under the STEM (Science, Technology, Engineering, and Mathematics) strand. She achieved various things in her life such as being a consistent member of the Honor Roll during grade 10 and 11. Furthermore, she won first place in the UN Digital Arts Contest by Lyceum of The Philippines University-Batangas, she was also part of the Poster Making Competition hosted by the ArgiKonomiya 2022, and she is a National Competitor in the Philippine Taekwondo Association in junior of division under QMDK Sarangani. She believes in the saying "Through darkest times there will always be light that shines."

Salman Malic is from Jeddah, KSA. He was born on March 14 2005. He is currently a grade 12 student under the STEM (Science, Technology, Engineering and Mathematics) He received an award from his junior high career, including a team award for the Qatar National Scratch Coding Competition 2018 at the Qatar National Convention Center at the Qatar Foundation Center.

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