International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental Skills of Senior High School Students on Academic Performance in Chemistry

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A B S T R A C T

This study aimed to address the gap in understanding and assess the experimental skills of Grade 12 STEM students in relation to their academic performance in General Chemistry 1. By exploring key mechanisms and developing an actionable plan, the research emphasizes critical skill areas, including data analysis, hypothesis testing, and scientific inquiry. The study involved 229 student respondents selected through RaoSoft Calculator and proportionate stratification, comprising 24 students from John J. Russel Memorial High School (JJRMHS), 119 from San Miguel National High School (SMNHS), and 43 each from Vedasto R. Santiago High School (VRSHS) and San Ildefonso National High School (SINHS). Teacher respondents were selected using total enumeration. The research was conducted during the first quarter of the school year 2024–2025.

A sequential explanatory mixed-method research design, combining quantitative and qualitative approaches, was employed to examine the relationship between experimental skills and academic performance. Results revealed discrepancies in how teachers and students assessed experimental skills. Teachers consistently rated students' skills as "Very High" across dimensions. Conversely, students generally rated their skills as "High" in most areas. The findings showed that experimental skills were predominantly rated as "Very High" by teachers and "High" by students. Students achieved an average academic performance in General Chemistry 1, with a general weighted mean of 89.80 during the first quarter. While no significant difference was observed between teachers' and students' perceptions of experimental skills, a positive correlation (r = 0.282, p = 0.000) was identified, indicating a significant relationship between experimental skills and academic performance.

Keywords: *Cognitive and Processing Abilities, Academic Performance, Communication and Reporting of Scientific Work, Experimental skills, Health and Safety*

Introduction

In the world of science, the heart of discovery is situated in the laboratory. Here, students explore beyond what they learn in books and classes, using equipment and chemicals to turn theories into real experiments. It is not only about what to find out, but the whole investigative experience. They face uncertainty when testing ideas and feel excitement when things work as expected. Collaboration is key as they work with others to solve problems and share thoughts, especially in senior high school.

Students were introduced to more advanced scientific principles and methodologies specifically, in General Chemistry 1. As one of the specialized subjects under the Science, Technology, Engineering, and Mathematics (STEM) strand in the senior high school curriculum, it elaborates chemical concepts which requires them to not only comprehend theoretical frameworks but also to develop proficiency in experimental skills. The laboratory plays a key role in sparking students' interest in science by gradually introducing them to materials and teaching them how to use them (Usarov, 2024). When teachers use a learning approach that embraces the evolving nature of science and encourages creativity, it can boost students' academic success, spark their creativity, and deepen their understanding of what science truly is (Eroğlu and Bektaş, 2022).

As the Enhanced Basic Education Act of 2013, known as Republic Act No. 10533, is concerned, science education seeks to cultivate scientific literacy in students, equipping them to be knowledgeable and engaged citizens capable of making informed decisions about the societal, health, or environmental implications of scientific knowledge applications. The curriculum acknowledges the significance of science and technology in everyday life, integrating them into various aspects such as social, economic, personal, and ethical domains. Furthermore, it fosters a close connection between science and technology, encompassing indigenous technological practices, thereby safeguarding the cultural heritage of our nation (Department of Education, 2016).

On the other hand, performing laboratory experiments reinforces the theoretical concepts taught in chemistry lectures. Through hands-on activities, students gain a deeper understanding of chemical principles, reactions, and properties, which can enhance their comprehension and retention of course material. The findings by Sulyman et al. (2022) revealed that there was a significant main effect of hands-on activities on student's academic performance in basic science. Additionally, hands-on activities play a crucial role across all levels of inquiry-based learning in science education to develop student's knowledge and skills (Trnova and Trna, 2011). This also reconfirms that enhancing interest could lead to better learning outcomes and its evidence-based methodology could be equally applied when introducing them to other difficult concepts of science as cited by Tolly and Kallery, (2021).

The research of Jumali et al. (2021) highlighted that most students thought that laboratory activity may increase their knowledge and comprehension of the subject and inspire them to study related material. Moreover, doing the laboratory work could help develop and improve other professional abilities including teamwork, experimental skill and communication as well as practical hands-on skills.

However, a significant research gap persists regarding the experimental skills of senior high school students in the Philippines. Data from the 2022 Programme for International Student Assessment (PISA) reveal that Filipino students exhibit limited competency in scientific inquiry, problem-solving, and data interpretation, ranking at the bottom among participating countries in science (Chi, 2023). These findings are corroborated by Bernardo et al. (2023), who highlighted that many students struggle to design and conduct experiments effectively. This is a crucial shortfall, as experimental skills underpin the ability to apply theoretical knowledge in practical contexts.

Further, Rogayan et al. (2021) identified that Filipino students face multiple barriers to learning STEM subjects, including challenges related to experimental skills, personal motivation, and socio-cultural factors. This underscores the pressing need to enhance their capacity for hands-on learning and scientific inquiry. The rapid evolution of Education 4.0, characterized by technologies such as artificial intelligence and robotics, further amplifies these challenges, calling for adaptive teaching strategies that align with modern scientific practices (De La Cruz, 2022).

There is a lack of localized studies exploring how experimental skills influence the academic performance of Filipino Grade 12 STEM students in General Chemistry 1. Current literature predominantly focuses on broad educational frameworks or isolated interventions, leaving a void in understanding the specific mechanisms that shape students' experimental competencies. Additionally, while hands-on activities are widely acknowledged as beneficial, there is insufficient evidence detailing how these activities can be tailored to address the unique challenges faced by Filipino students in resource-constrained environments.

At its core, this study aimed to bridge the gap and identify experimental skills of Grade 12 – STEM students on their academic performance in General Chemistry 1. This research endeavored to uncover the mechanisms and action plan through which students develop critical skills such as data analysis, hypothesis testing, and scientific inquiry.

Literature Review

As part of the quality basic education reform plan and a step towards globalizing the quality of Philippine basic education, the country is very vocal in its aspiration in elevating the scientific skills of every Filipino child. Since 2018, the country participates in the Programme for International Student Assessment (PISA) of the Organization for Economic Co-operation and Development (OECD) to have a visual representation of the country's current academic status – in science, mathematics, and literacy. Hence, the 2022 result placed the Philippines at 77th out of 81 countries globally in the student assessment conducted by the OECD for 15-year-old students. It can be gleaned that we are at less than the OECD average in mathematics, reading, and science (Inez, 2023).

Furthermore, the country's average performance was 356 points, ranking third to last globally in mean science performance among participating countries, and still lower than the OECD average of 485 points. As an intervention, the Department of Education takes everything one step at a time in order to uplift the holistic academic advancement of the students by implementing variety of strategies one of which is the National Learning Recovery Program (NLRP). This program under the DepEd Order No. 13, s. 2023 aims to close learning gaps and aid K to 12 students in all public elementary and secondary schools nationwide in attaining learning standards. The success of each program still depends on the quality of teaching deliveries, motivation from the students, and support from all walks of stakeholders, especially in the context of science education. Key factors from the intrinsic and extrinsic aspects of learning play a critical role.

Motivation, a crucial role in students' learning experiences, including in the field of science. When students perceive science as relevant to their lives, they are more likely to be motivated to learn. Teachers can enhance relevance by connecting science concepts to real-world phenomena, current events, and students' interests. In this case, students may approach science learning with curiosity and enthusiasm, viewing challenges as opportunities for growth rather than obstacles. They may be more likely to engage in inquiry-based learning and exploration, which can deepen their understanding of scientific concepts.

Additionally, students may be more proactive in seeking out resources, asking questions, and taking ownership of their learning in science. They may be better able to manage their time and resources, allowing them to dedicate sufficient effort to science learning both inside and outside the classroom. As a result, students may perceive science learning as personally meaningful and rewarding, leading to deeper engagement and persistence in the face of challenges. They may also be more likely to participate in extracurricular science activities or pursue further education and careers in scientific fields. Indeed, students who have high levels of life orientation, life effectiveness and life satisfaction obtain high grades in science as supported by Pangilinan (2022).

Motivation serves as a catalyst for the development of critical thinking skills in science learning by promoting engagement, curiosity, problem-solving abilities, intrinsic interest, collaborative discourse, and metacognitive awareness. As cited by Montalbo (2022), there is a significant relationship between the students critical thinking disposition and their academic achievement in science. The higher the critical thinking disposition of students, the higher their grades in science. On top of that, there is also a significant relationship between students learning styles in terms of visual, auditory, and kinesthetic and their academic achievement in science.

According to the findings of Villangca (2022), students are able to interact and communicate well, both when speaking and writing; good at rationalization, recognizing patterns, and logically analyzing problems; and are more in tune with nature and are often engaged in cultivating, exploring the environment, and acquiring knowledge about other species. They will have greater interest and motivation in studying science which eventually results in higher learning outcomes in the subject. Students who chose STEM had a positive attitude toward science and higher levels of multiple intelligence. Respondents state that when they have a positive feeling about science, they will become more motivated and engaged in studying the subject which will result to higher academic achievement in the subject.

Likewise, students' perception in learning Senior High School chemistry (Mendoza, 2022) strategies such as web-based learning, class wide peer tutoring, paired peer tutoring and contextualized laboratory resources or also known as 21st century approaches help the students understand the lesson in chemistry. These pedagogies allow the students to develop their skills such as communication, collaboration, critical thinking, and creativity skills. According to his study, the use of 21st century approaches was effective, helpful, and relevant as an intervention to develop the 4C's of the Senior High School students as well as it improves their academic performance. This study is corroborated by Calakhan (2022) which concludes that the students performed significantly better after exposing them in web-based learning (PhET virtual simulations).

Meanwhile, the impact of teachers in learning science is profound, shaping students' attitudes, knowledge, and skills in the subject and preparing them to become scientifically literate and informed citizens. Effective science teaching requires not only expertise in the subject matter but also a commitment to fostering curiosity, critical thinking, and a lifelong love of learning in students. Mellona (2022) states that there is a significant relationship between the teachers' soft skills and student science process capabilities. The more the teachers utilize their soft skills, the higher is the level of student science process capabilities. Furthermore, there is a significant relationship between the teacher's soft skills and students' academic performance.

In the context of student view on this matter, they understand how crucial it is to have a working science lab. Students struggle with science-related tasks, particularly with physics, biology, and chemical experiments. Students that participate in the STEM strand rarely conduct experiments in science labs. Conversely, the students discovered that functional science laboratories were a useful resource, particularly for those enrolled in college courses related to medicine. As a result, without the utilization of science laboratories, students enrolled in the STEM strand find it difficult to understand their specialized courses, as per the study of Arnejo (2021). Furthermore, Jabello (2021) cites that students who are able to conduct experiments are more equipped to explore and apply the concepts offered in science classes because of the experience that these abilities provide. It was also said that students who participate in experiments or hands-on activities on a regular basis are able to learn more than those who are only exposed to discussions of the issues since they have the opportunity to interact, reflect, and debate the material.

Rogayan et al. (2021) brought attention to the difficulties Filipino students face when learning STEM. The three main types of obstacles that the students faced were course-related challenges, individual challenges, and socio-cultural challenges. The difficulties that the students raised could operate as a roadmap for STEM educators, legislators, and other stakeholders in education to reconsider and recast their procedures, practices, and policies when it comes to instructing kids in STEM subjects. It is advised that STEM curricula be reviewed and redesigned to better meet the needs of the new industrial revolution and Society 5.0. Schools should keep reviewing and rethinking the curriculum to make sure it is in line with the needs of the present and future, particularly in the post-COVID-19 era. It is also necessary to incorporate into the program performance activities that are pertinent, interesting, and contextualized. It may be investigated to provide academic and financial support to worthy but financially disadvantaged STEM students to encourage more students to enroll in STEM academic strands. For STEM teachers to connect their methodology with pupils who are naturally tech-savvy and skilled across all generations, professional development programs and ongoing retooling are essential.

A new way to teach is with Experiment-Based Learning and Creativity Worksheets (LKPD) developed by Ngaji in 2023. These worksheets have been shown to really help students understand scientific ideas better. When these worksheets were used, students' education got a lot better. Teaching quality went up, students had more interesting lessons, and they became much better at understanding science.

Structuring the educational process to make it engaging for students is essential to boost their interest in science and achieving better learning outcomes (Slekiene and Lamanauskas, 2020). By using inquiry-based learning, students' curiosity is piqued, interest in the subject is promoted, and their experimental abilities and skills are fostered. Experimental training activity is an essential and contemporary component of education. Students can be given instructional materials in an engaging format through the experiment, which stimulates their interest in the subject. A popular teaching approach in scientific education is inquiry-based instruction, which is seen to be a useful way to help students develop their procedural and epistemic knowledge about inquiry processes in addition to their comprehension of science material as cited by Vorholzer et al. (2022). Research has consistently demonstrated that to effectively assist students' learning, inquiry-related activities should be paired with instruction that specifically addresses procedural and epistemic knowledge.

Based on the discussions of Dewi et al. (2022), there are concurrent differences in science process skills between students who are taught senior high school chemistry material using conventional learning methods and verification experiments (trying-out the experiments to prove theories, concepts, principles, and laws that have been studied previously). The verification experimental method operates concurrently to support students' learning objectives. There are differences in the students 'learning outcomes taught using verification experimental methods and conventional learning methods in high school chemistry material. Students 'learning achievement taught using verification experimental methods was superior to groups of students taught using conventional learning methods.

Fahmidani and Rohaeti (2023) inferred that students' scientific attitudes are still classified as low to medium, necessitating the use of a range of strategies to encourage them. To solve this issue, educational strategies that encourage student participation and develop their scientific mindsets must be implemented. Affective variables have not gotten as much attention in chemistry research as cognitive and metacognitive determinants of accomplishment (Thangavel and Selvan, 2024). Moreover, Khaparde and Shaker (2020) strongly recognized that students psycho-motor, cognitive and affective abilities and skills are essential because the tasks, methods, contents and learning processes involved in the effective development of these skills and abilities are different and should be appropriately emphasized during the designing of a laboratory course and strategy for instruction and assessment.

In contrast to labs that reinforce lecture concepts, Walsh et al. (2022) find that labs that emphasize the development of experimental skills enhance students' critical thinking abilities and experimentation perspectives. Skills-based labs have a more positive influence on these outcomes than concepts-based labs, regardless of the gender, color, or ethnicity of the students. According to their research, while modeling activities have a minimal impact on performance, activities that assist students' decision-making and communication account for more than half and one-third, respectively, of the effect of skills-based labs on students' critical thinking abilities and experimentation views.

In accordance with Kalthoff et al. (2018), students should learn experimental skills at both school and university. There are a number of strategies that fall between implicit and explicit education to support experimental skills. Hence, the type of instruction does not significantly influence the acquisition of experimental and content-related skills in this target group but by trend as cited by Vorholzer et al. (2022). Through research tasks, experimental skills are formed and developed better, because they are absorbed meaningfully in the process of carrying out an activity. Our observations show that the research approach is the best way for students to get closer to the work of scientists, to understand "how" science works and how the knowledge that is described in their textbooks is obtained (Ivanova and Zhelyazka, 2023).

In conformity with Fitriyana et al. (2023), chemistry teachers must be frequent in making learning innovations through the application of student-centered learning approach and the introduction of contextual chemistry learning. Therefore, the teacher should design meaningful chemistry learning with special effort on each characteristic of the materials in order to reduce students' difficulties towards chemistry subject.

The studies of Bernardo et al. (2023) and Rogayan et al. (2021) bring attention to the limited scientific inquiry skills and STEM-related challenges among Filipino students. While these studies focus broadly on the obstacles in science education, this research zeroes in on the experimental skills gap in General Chemistry 1. By doing so, it sought to provide a localized perspective on improving hands-on learning in a resource-constrained environment.

This study drew heavily from the established understanding of the benefits of hands-on learning and group-based laboratory activities, as highlighted in previous research, while introducing new dimensions. It aimed to identify specific mechanisms through which experimental skills influence academic performance, particularly in a Filipino STEM education setting. By contextualizing findings within local challenges and opportunities, this study not only validates prior research but also extends its applicability, providing practical recommendations for curriculum improvement and policy implementation.

Theoretical Framework

A comprehension of pertinent ideas that direct and oversee the entire research process is provided in this part.

Radical Constructivism Theory suggests that knowledge is actively constructed by individuals based on their experiences and interactions with the world. This theory is useful in elevating the experimental skills of senior high school students. In the context of active learning, students engage directly with the material through experimentation and inquiry. By actively participating in laboratory experiments and constructing their own understanding of chemical concepts, students develop a grasp of the subject matter. Each individual constructs his/her own unique understanding of the world. This means that students can approach laboratory experiments in a way that is personally meaningful to them.

By allowing students to explore their own interests and perspectives, Radical Constructivism supports personalized learning. Lastly, in Radical Constructivism, learning is an ongoing process of construction and reconstruction. Laboratory experiments provide students with opportunities to test their hypotheses, make observations, and refine their understanding based on feedback from the results. By encouraging students to reflect on their experiences and revise their conceptual frameworks, Radical Constructivism supports continuous learning and improvement.

On the other hand, a theory of knowing known as radical constructivism (Glasersfeld, 1974) offers a practical solution to issues pertaining to language, reality, truth, and human understanding. It introduces a shift in many fundamental concepts, which has a significant impact on how we generally view the world. The new orientation frees the individual from specious tethers and demonstrates that we are ultimately in charge of our thoughts and actions by raising awareness of the thinker's active participation in developing notions. According to the book, teaching educators the craft of creating knowledge rather than prepackaged content is what matters most.

Acquisition of Other 3Rs Model (Sternberg, 2004) that focuses on critical problem-solving abilities such as thinking, resilience, and accountability can enhance students' academic performance and equip them with general life success techniques. Scientists generally believe that students can acquire these talents and that teachers can impart them. The findings by Gonzales (2020) demonstrated that although teachers are quite prepared and relevant to become change agents in education, they find it difficult to be useful resources. It has also been demonstrated that teachers' ability to become fully realized change agents is largely dependent on school preparedness, relevance, and resources.

The Philippines' Department of Education is innovative, relevant, and equipped for the twenty-first century thanks to professionally trained instructors and 21st-century school supplies. It is advised that the school offer training to raise the proficiency of the instructors and equip them with enough resources for the twenty-first century. This comes with a clearer and smooth execution of laboratory activities in enhancing experimental skills of every student.

Inquiry-based learning, as proposed by Dewey in 1933, focuses on encouraging students to learn through inquiry, putting them at the center of the learning process, and promoting self-directed and active learning. This approach is best for helping students understand how knowledge is created and for developing their research skills.

In General Chemistry 1 for senior high school students, inquiry-based learning can greatly improve their experimental skills. This is done by encouraging active participation, problem-solving, applying learning to real-world situations, independent and collaborative learning, curiosity, and creativity. Through hands-on, inquiry-driven learning, students gain the skills and confidence needed not only for experiments but also for future endeavors.

Collectively, the three pedagogical frameworks offer valuable insights into the complex interplay between experimental skills of senior high school STEM students towards their academic achievement in General Chemistry 1. In this case, the researcher, combining these models in the context of General Chemistry 1 could create a powerful learning environment that fosters the development of experimental skills and academic achievement among senior high school STEM students. By emphasizing critical thinking, active engagement, and hands-on exploration, students are better equipped to succeed in their chemistry studies and beyond.

Conceptual Framework

The relationships between important variables, ideas, and constructions pertinent to the study are explained in an organized manner in this part.

It can be asserted (Slekiene and Lamanauskas, 2020) that to enhance student's interest in science and attain improved learning outcomes, it is crucial to structure the educational process in a manner that engages students. Implementing inquiry-based learning fosters the development of their experimental abilities and skills, stimulates their curiosity, and nurtures their interest in the subject. The cultivation of new, favored activities among them holds significant importance for achieving better learning outcomes. This has a positive effect on their conceptual understanding and new literacy (Asrizal et al., 2023). Moreover, the research presented by Nursyahidah et al. (2023) indicated that a series of activities STEM-based designed through lesson study can make them understand material actively, joyfully, and meaningfully.

Fundamentally, this study sought to narrow the divide between Experimental Skills of Grade 12 – STEM Students and Academic Performance in General Chemistry 1. Through an exploration of both cognitive and pedagogical aspects of experimental learning, this study aimed to reveal how students acquire experimental skills such as data analysis, hypothesis testing, and scientific inquiry.

Figure 1.

Paradigm of the study

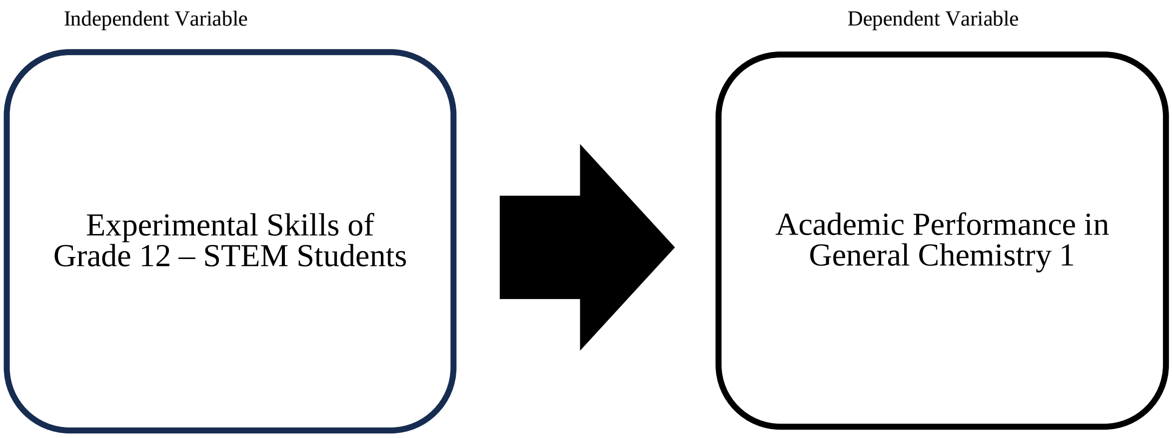

Figure 1 exhibits the guiding framework of the study which involved investigating the relationship between various independent variables related to experimental skills of Grade 12 – STEM Students and General Chemistry 1 Teachers and the dependent variable of students' academic performance, specifically their first-quarter grade in General Chemistry 1. To put it into context, the independent variable is Experimental Skills which includes the following: (a.) Knowledge and Theoretical Understanding that refer to the understanding and comprehension of the theoretical principles and concepts underlying experimental procedures in chemistry. It may include understanding key scientific theories, principles, and concepts relevant to chemistry experiments; (b.) Psycho-Motor Skills that encompass the physical skills and dexterity required to perform laboratory tasks effectively and accurately. It includes activities such as using laboratory equipment, handling chemicals, and conducting experiments safely and efficiently; (c.) Health and Safety that focuses on the knowledge and adherence to safety protocols and practices in laboratory settings. It involves understanding potential hazards, proper handling of chemicals, use of safety equipment, and overall awareness of safety measures to prevent accidents or injuries.; (d.) Information about Measurements, Instruments, Methods, and Processes that pertain to the understanding and proficiency in using various instruments, techniques, and methods for conducting experiments and making measurements accurately. It includes knowledge of instrumentation, calibration procedures, experimental protocols, and data analysis methods.; (e.) Cognitive and Processing Abilities that involve cognitive skills such as problem-solving, critical thinking, and analytical reasoning that are essential for interpreting experimental results, troubleshooting issues, and drawing conclusions from data obtained during experiments; and lastly, (f.) Communication and Reporting of Scientific Work that relates to the ability to effectively communicate experimental procedures, findings, and conclusions through written reports, presentations, or other forms of communication. It includes skills such as writing scientific reports, presenting data visually, and articulating findings clearly and accurately.

Following this, the dependent variable of this study is the Students' Academic Performance: This refers to the students' overall achievement or success in their General Chemistry 1 course during the first quarter, typically measured by their grades. It serves as an indicator of how well students have mastered the material and performed in various assessments such as exams, quizzes, and laboratory assignments.

This framework shapes every aspect of the research process, from conceptualization to interpretation of findings. It aids the researchers in structuring their inquiry, making methodological decisions, and interpreting the results within a theoretical context.

Statement of the Problem

This study determined the relationship between the experimental skills of Grade 12 STEM students on their academic performance in general chemistry 1 for First Quarter of School Year 2024 - 2025.

Specifically, it sought to answer to the following questions:

1. How may the assessment of teachers and students on experimental skills of Grade 12 STEM students be described in terms of:
   1.1. Knowledge and theoretical understanding;
   1.2. Psycho-Motor skills;
   1.3. Health and safety;
   1.4. Information about measurements, instruments, methods, and processes;
   1.5. Cognitive and processing abilities; and
   1.6. Communication and reporting of scientific work?
2. How may the academic performance of Grade 12 STEM students be described in terms of their First Quarter grade in General Chemistry 1?
3. Is there a significant difference between the assessments of the two respondents with regards to student's experimental skills?
4. Is there a significant relationship between experimental skills and academic performance of STEM students?
5. What are the challenges faced by the students that hindered the enhancement of their experimental skills?
6. What school action plan may be crafted based on the result of the study?

Hypothesis

Based on the problems presented, the following null hypotheses are made:

1. There is no significant difference between the assessments of the respondents with regards to student's experimental skills.
2. There is no significant relationship between experimental skills and academic performance of STEM students.

Methodology

Research Design

The study employed a sequential explanatory mixed-method research design to investigate the correlation between senior high school students' experimental skills and their academic performance. By integrating multiple data sources, mixed methods can effectively study complex topics according to Giri et al. (2021). In order to identify potential qualitative questions to be asked during the following phase, the modified survey questionnaire was used initially.

In particular, the researcher did not intervene in the presentation or summary of quantitative data using statistics; instead, the descriptive correlational research approach was utilized to investigate the relationships between variables of interest. This study approach determined the connection between senior high school experimental talents and their academic achievement. In accordance with the quantitative result from the survey, 6 qualitative modified interview questions were administered to chosen STEM student-respondents for the qualitative data that was used to fully explore the quantitative study results.

Sampling and Respondents

The respondents of the study were Grade 12 – STEM students at 4 public secondary schools in the municipality of San Miguel and San Ildefonso in Bulacan having a total population of 564 students. To determine the recommended sample size, RaoSoft Calculator was used to calculate the minimum sample size needed to estimate a statistic based on an acceptable margin of error (0.05).

In research settings, RaoSoft Calculator plays a pivotal role in data analysis, offering researchers the means to assess the significance of findings, determine sample sizes for experiments, and interpret survey data with precision. By automating tedious calculations, it empowers researchers to focus on data interpretation and hypothesis testing (Professional Regulation Commission, 2024). Moreover, proportionate stratification determines the exact number of respondents per school.

Table 1.

Respondents of the Study per School

Name of Public Secondary Schools	Grade 12 – STEM Total Population	Student-Respondents	Teacher-Respondents
John J. Russel Memorial High School	59	24	1
San Miguel National High School	294	119	1
Vedasto R. Santiago High School	106	43	1
San Ildefonso National High School	105	43	1
TOTAL	564	229	4

With the implementation of RaoSoft Calculator, Table 1 shows the respondents of the study per school and their associated total population. It can be gleaned that 229 out of 564 total population were identified as the total number of respondents. The researcher selected 24 respondents from John J Russel Memorial High School, 119 from San Miguel National High School, and 43 apiece from Vedasto R. Santiago High School and San Ildefonso National High School. Also, they were requested to answer the adopted questionnaire for quantitative data collection.

For the collection of qualitative data, the researcher randomly selected 5% (11) out of the 229-sample student-respondents who answered the questions freely that were subjected to their personal perception. Total enumeration sampling was implemented for teachers having a total of 4 teacher-respondents. Furthermore, the questions were crafted based on the result of the quantitative survey questionnaire. The chosen respondents received the information about the subjects to be covered during the interview ahead of time to be ready.

Locale of the Study

Figure 2.

This study was conducted in the four public secondary schools in the municipalities of San Miguel and San Ildefonso, province of Bulacan. These schools are John J. Russell Memorial High School (Sibul, San Miguel, Bulacan), San Miguel National High School (San Juan, San Miguel, Bulacan), Vedasto R. Santiago High School (Salacot, San Miguel, Bulacan), and San Ildefonso National High School (Poblacion, San Ildefonso, Bulacan).

Instruments

Depending on the kind of data being collected and the nature of the research, instruments can take many different forms. An adopted survey questionnaire from Khaparde and Shaker (2020) and a 6 qualitative modified interview questions was used in this study to ascertain the association between senior high school students' academic performance in General Chemistry 1 and their experimental skills. On the other hand, an official request of questionnaire modification was made via email to the questionnaire's authors to comply with Republic Act No. 10173, often known as the Data Privacy Act of 2012.

The questionnaire was designed to capture various aspects of experimental skills, such as laboratory techniques, safety practices, problem-solving abilities, and data analysis skills. It incorporated a 5-point Likert rating scale to measure the frequency or extent of agreement with the statements related to experimental skills. The scale ranged from 1 to 5, with 1 representing "Very Low," and 5 representing "Very High." Respondents were asked to indicate their level of agreement or disagreement with each statement by selecting the corresponding number on the scale.

The Likert rating scale was used to gauge how frequently or commonly students engage in behaviors or demonstrate skills related to experimental practices in chemistry. The statements included in the questionnaire likely cover a range of activities or behaviors relevant to experimental skills, such as conducting experiments, recording data, following safety protocols, and analyzing results. The purpose of assessing the frequency of use of statements about experimental skills is to understand how these skills may influence students' academic performance in chemistry. By gathering data on students' self-reported engagement in experimental activities, the researcher was able to examine potential correlations between the frequency of use of experimental skills and students' grades or performance in chemistry courses.

A 6-item modified interview questionnaire was created specifically to gather information about the experimental skills of senior high school students in the context of their academic performance in chemistry after the analysis of the survey. This is to further the understanding on the relationship between senior high school students' experimental skills and their academic performance in General Chemistry 1. The researcher performed a modified interview with 5% (11) of the student-respondents and total enumeration (with 4) for teacher-respondents for the qualitative section of this study.

Data Gathering Techniques

Prior to gathering data, the researcher secured an approval from the Bulacan Schools Division Superintendent to carry out the study in the four public secondary schools located in San Miguel and San Ildefonso. The researcher coordinated with the principals, assistant principals, head teachers, focal persons, teachers, and students at the schools to arrange the data collection schedule after obtaining the approval letter. The researcher personally administered the questionnaire in order to answer any additional questions and provide clarifications on the subject matter.

Additionally, the respondents were asked to sign an informed consent form beforehand. This includes the total number of participants, the methods, the confidentiality and safety measures, the advantages, the contact details, the voluntary involvement, and the participant's agreement to participate in the study. Grade 12 – STEM students who are younger than eighteen were required to sign an agreement form, which was sent to their parents or guardians. The consent and assent forms' contents were expressed in simple terms so that respondents could understand.

A modified survey questionnaire was used in this study to provide a quantitative description of senior high school students' experimental abilities and their academic performance in General Chemistry 1. The same questionnaire was also administered to all General Chemistry 1 teachers. After analyzing the result of the quantitative data, a 6-item modified interview questionnaire was accomplished to gather qualitative information, comprehensive comprehension of the quantitative results.

Only the researcher had the access to the safe location where the respondent data was kept. The gathered data was sorted, then tabulated in preparation for statistical analysis. The Data Privacy Act of 2012, also known as Republic Act 10173, is a law that protects individual personal information in information and communications systems used by the government and the private sector. It creates a National Privacy Commission and serves other purposes. In addition, all responses were treated with the utmost confidentiality and used only for the study.

Following Memorandum No. 9 s. 2021, the researcher shred the paper records to remove any prospective data.

Data Analysis

Descriptive statistics was used to arrange, tabulate, total, and analyze the quantitative results from the survey questionnaires that have been gathered.

The experimental skills of Grade 12 STEM students in senior high school are described by descriptive statistics such as weighted mean and standard deviation.

In the meantime, Pearson R was used to established whether senior high school students' academic performance in chemistry and their experimental talents was significantly correlated.

The qualitative information gathered from the 6-item modified interview questionnaire was subjected to direct analysis. It permits the investigation and finding of perspectives in addition to the recognition of respondent similarities and differences, offering a more specific understanding of the factors under investigation in the study.

Ethical Considerations

Before agreeing to participate, respondents were fully informed about the study's objective, procedures, risks, benefits, and their rights. The researcher acquired voluntary and informed permission forms from educators and students who participate in the survey. Participants were provided with the freedom to inquire about study procedures and discontinue participation at any moment without fear of negative repercussions.

Strict precautions were taken to protect the confidentiality and privacy of the personal data provided by the respondents. These cover protecting data throughout transmission, storage, and use. The data was anonymized to avoid identifying specific respondents.

Considering this, the researcher carried out the investigation in an open, sincere, and moral manner. This includes ensuring that the survey was conducted in a safe and controlled environment, providing adequate supervision and support, and offering resources or referrals for participants who may experience distress or adverse effects because of their participation. Any wrongdoing, including data falsification and manipulation, shall be strongly prohibited. Additionally, the researcher makes sure that all applicable laws, rules, and ethical principles guiding the study's conduct are strictly adhered to.

The researcher ensured fair treatment of all participants, regardless of demographic characteristics such as age, gender, ethnicity, or socioeconomic status. All identified participants had equal opportunities to participate in the study and receive any benefits or interventions offered as part of the research. In contrary, participants have been free to decline participation or withdraw from the study without fear of reprisal or negative consequences. Moreover, the researcher gave respect to the autonomy and decision-making capacity of participants, particularly in cases involving minors or vulnerable populations. Parents or legal guardians provided consent on behalf of minors, but the researcher also considered the preferences and interests of the minors themselves when obtaining assent.

Results and Discussion

Table 1.

Academic Performance of Grade 12 STEM students in their First Quarter Grade in General Chemistry 1

General Average	f	%
98-100	1	0.44
95-97	19	8.30
90-94	100	43.67
85-89	92	40.17
80-84	17	7.42
75-79	0	0.00
Below 75	0	0.00
Standard Deviation	3.53	
General Average	89.80	
Verbal Interpretation	Average	

Legend: below 75 "Failed", 75-79 "Poor", 80-84 "Below Average", 85-89 "Average", 90-94 "Above average", 95-97 "Good", and 98-100 "Excellent"

It can be gleaned from Table 1 that most student-respondents scored in the 90-94 range (43.67%), with a general average of 89.80, interpreted as "Average" during the First Quarter of the First Semester, School Year 2024 – 2025. Meanwhile, there were 40.17 % "Below Average", 8.30 % "Above Average", 7.42% "Good", and a 0.44% "Excellent".

Significant Difference Between the Assessments of General Chemistry 1 Teachers and Grade 12 STEM Students on Senior High School Students' Experimental Skills

A t-test analysis was performed to determine whether a significant difference existed between the assessments of the two groups of respondents on Senior High School Students' Experimental skills.

Table 9 exhibits the results of correlational analysis on significant difference between General Chemistry 1 Teachers and Grade 12 STEM Students' Assessments on their Experimental skills.

Table 2.

Results of Correlational Analysis on Significant difference between General Chemistry 1 Teachers and Grade 12 STEM Students on Senior High School Student's Experimental skills

Variable	t-value	p-value	Decision	Verbal Interpretation
Senior High School Student's Experimental Skills	-1.764	0.079	Accept H_o	Not Significant

Legend: α = 0.01

As shown in Table 2, there is no significant difference between significant difference existed between the assessments of the two groups of respondents on senior high school students' experimental skills as the t-value denotes a -1.764, whereas the p-value with 0.079. The t-value and p-value (0.079) suggest no significant difference, meaning teachers' and students' ratings were not statistically different. In this case, the lack of significant difference could suggest that both teachers and students generally align in their evaluation of experimental skills.

According to Chiu (2021) who examined the impact of virtual laboratories on high school students' performance, finding revealed no significant difference in learning outcomes between the experimental and control groups. Similarly, Chiu noted that students and teachers shared similar views on the effectiveness of certain teaching approaches in enhancing laboratory skills, reinforcing the idea that both parties may have aligned assessments of student competence. This supports the finding that teachers and students could be on the same page regarding experimental skill evaluations, as noted in this study.

However, these findings underscore the potential discrepancies between teachers' and students' perspectives on key variables. Such differences may reveal gaps in perception that can serve as a foundation for future discussions, aiming to align expectations and experiences. These conversations could foster a deeper understanding of how both teachers and students perceive the learning process, ultimately enhancing collaboration and improving the overall educational experience in science classrooms.

Significant Relationship Between Experimental Skills and Academic Performance of Grade 12 STEM students

Table 10 exhibits the results of the correlation analysis which was performed to determine whether a significant relationship existed between the experimental skills and academic performance of Grade 12 STEM students

Table 3.

Results of the Correlational Analysis on the Significant relationship between experimental skills and academic performance of Grade 12 STEM students.

Variable		r-value	p-value	Decision	Verbal Interpretation
Experimental Skills	Academic Performance	0.282	0.000	Reject H_o	Significant

Legend: α = 0.01

Table 10 indicates that a positive correlation was found (r = 0.282, p = 0.000), suggesting a significant relationship between experimental skills and academic performance of Grade 12 STEM students.

Recent research highlights a clear link between experimental skills and academic performance among STEM students, particularly in chemistry. Wang et al. (2022) found that students engaged in interactive, game-based learning in STEM subjects like science and math tend to perform better academically. Similarly, Rebulanan and Samala (2021) conducted a meta-analysis revealing that students who develop essential science process skills—like experimentation and data analysis—show significant gains in their academic success.

These findings suggest that experimental skills, such as data collection, analysis, and communication, are fundamental not only for lab work but also for improving overall academic achievement. By building these skills through hands-on and interactive activities, students gain critical tools that help them excel in both scientific and academic environments.

Action Plan Based on the Results of the Study

Results of this study revealed that the experimental skills of senior high school students are interconnected with their academic performance in chemistry.

From the assessments and perceptions of General Chemistry 1 teachers and Grade 12 STEM students, the sub-variables consisting of Health and Safety, Information about Measurements, Instruments, Methods and Processes and Communication and Reporting of Scientific Work got the highest results. However, sub-variables composed of Knowledge and Theoretical Understanding, Psycho-Motor Skills, and Cognitive and Processing Abilities obtained the lowest results.

From these results, the researcher crafted a program of activities which aims to further strengthen and improve the experimental skills of the senior high school students, and their academic performance as presented in Table 11.

Table 4.

Action Plan of Activities

Oective	**Action**	**Timeline**	**Person Involved**	**Expected Outcome**
For Teachers: **To optimize existing resources to teach experimental skills and enhance teaching strategies to encourage hands-on learning.**	Implementation of Project ALERT: Applying Laboratory Experimentation with Resourceful Techniques	First and Second Quarter of S.Y. 2025-2026	Grade 12 STEM Students Science Teachers Master Teachers Head Teachers School Head	Teachers can design effective experiments using available resources and provide interactive experiment options.
For students: **To encourage independent learning and problem-solving and enhance teamwork and**	Implementation of Project EQUIP: Enhancing Quality and Upgraded Innovation Projects	First and Second Quarter of S.Y. 2025-2026	Grade 12 STEM Students Science Teachers Master Teachers Head Teachers School Head	Students enhance creativity and critical thinking through hands-on activities and develop teamwork and practical skills in resource-limited settings.

innovation in experimental tasks.	

See Appendix H and Appendix I

This action plan of activities, developed by the researcher, offers a comprehensive and practical framework to address the gaps identified in this study. By outlining targeted strategies and initiatives, the plan not only bridges theoretical findings with actionable solutions but also ensures that the interventions are both meaningful and impactful for the intended beneficiaries.

To further understand the proposed activities and their implementation, please refer to Appendix H and I, which contains a detailed Project Proposal. This document elaborates on the project's objectives, methodologies, and expected outcomes, ensuring a clear and actionable path forward for addressing the research findings.

Findings

This study determined the relationship between experimental skills of senior high school students and their academic performance in chemistry within the municipality of San Miguel and San Ildefonso, Bulacan, for the first semester and first quarter of School Year 2024 – 2025.

Following the procedures outlined in the previous chapter, the answers to the questions posed in this study were determined and summarized as follows:

The findings revealed that the teachers assessed their students' experimental skills in terms of knowledge and theoretical understanding as "Very High" as compared to the students' perception marking it as "High".

Teachers' assessed students' experimental skills in terms of Psycho-Motor Skills as "Very High" lower than the students' perception marking it as "High".

Both General Chemistry 1 teachers and Grade 12 STEM students agreed that senior high school students have a "Very High" capabilities in their experimental skills in terms of health and safety.

The experimental skills of students in terms of Information about measurements, instruments, methods and processes were considered as "Very High" of the teacher-respondents while gaining "High" marks as per the students' assessment.

It was highlighted in this research that the experimental skills in terms of cognitive and processing abilities of the senior high school students were perceived by the teachers and students as "Very High" and "High" respectively.

Meanwhile, the experimental skills in terms of communication and reporting of scientific work were described as "Very High" by the teachers and "High" by the students.

The experimental skills of senior high school students were generally described as "Very High".

Based on the findings, majority of the students' academic performance during the first quarter of the first semester of School Year 2024 – 2025 was described as average gaining 89.80 general weighted mean.

There was no significant difference found between General Chemistry 1 Teachers and Grade 12 STEM Students perceptions on Senior High School Student's Experimental skills.

Hence, there is a positive correlation found ($r = 0.282$, $p = 0.000$), suggesting a significant relationship between experimental skills and academic performance of Grade 12 STEM students.

Conclusions and Recommendations

Conclusions

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

Teachers perceived their students to have higher experimental skills compared to how students rated their own abilities. This discrepancy highlights a need for better communication and alignment of expectations between teachers and students. Additionally, both General Chemistry 1 teachers and Grade 12 STEM students agreed that students possess high experimental skills. This mutual assessment indicates a solid foundation in experimental competencies.

Students achieved an average mark in their first quarter grades in General Chemistry 1, suggesting room for improvement in connecting experimental skills to theoretical knowledge.

A significant relationship was identified between experimental skills and academic performance. Students with stronger experimental skills were more likely to achieve higher grades in General Chemistry, underscoring the importance of hands-on learning in STEM education.

While outdated tools and limited resources posed challenges, these were considered minor obstacles. Both teachers and students demonstrated remarkable flexibility and resourcefulness, enabling them to address these issues effectively and maintain high levels of experimental learning.

These findings affirm the critical role of experimental skills in academic success and highlight the resilience of teachers and students in optimizing available resources to enhance learning outcomes. This underscores the importance of initiatives like the Project EQUIP (Enhancing Quality and Upgraded Innovation Projects) in bridging gaps and fostering excellence in STEM education.

Recommendations

In light of the findings and conclusions of the study, the following recommendations are hereby offered:

1. The school may implement an action plan based on the study's results to address gaps and enhance the experimental skills of teachers and students.
2. Teachers should prioritize ongoing professional development to enhance their science teaching and experimental skills.
3. A regular feedback system between school heads and teachers can bridge assessment gaps, foster open communication, and ensure continuous improvement in teaching and learning practices.
4. Future researchers can expand this study by exploring additional variables, such as differences in teacher and student perspectives on experiments and the use of upgraded lab tools, to develop more effective interventions.

These recommendations provide a comprehensive framework for addressing the challenges highlighted by the study, promoting a culture of continuous improvement, and enhancing experimental skills among the school's STEM community.

Instruments Used in the Study

Survey Questionnaire for Grade 12 – STEM Student-Respondents

EXPERIMENTAL SKILLS OF SENIOR HIGH SCHOOL STUDENTS ON ACADEMIC PERFORMANCE IN CHEMISTRY

CONSENT

I hereby give my consent for the use of my data strictly for research purposes by JAY D. SAN GABRIEL whose taking MAED Science at Bulacan Agricultural State College in his study entitled "Experimental Skills of Senior High School Students on Academic Performance in Chemistry". I understand that the data collected from me will be used solely for academic and research purposes and will not be shared with any third parties or used for commercial gain.

I am aware that my participation is voluntary, and I have the right to withdraw from the study at any time without consequence. I understand that my responses will be anonymized and treated confidentially, with all identifying information removed to ensure privacy.

I acknowledge that the researcher is committed to complying with the Data Privacy Act of 2012 and will take all necessary measures to protect the confidentiality and security of my data. I understand that the results of the study may be published or disseminated in academic journals, presentations, or reports, but my identity will remain confidential.

☐ I affirm that I have read and understood the information provided, and I agree to participate in

the study under the terms outlined above.

I: Students' Demographic Profile

Instructions: This study aims to determine the Experimental Skills of Grade 12 – STEM Students and its relationship on their Academic Performance in General Chemistry 1 in Quarter I of School Year 2024 - 2025. Please provide the most accurate information by filling in the blank after the item or by putting a check mark (✔) on the box that corresponds to your answer. Please be advised that this study strictly follows the Data Privacy Act of 2012.

Name:____

Final Grade in General Chemistry 1 (Quarter I): ___________________________

II: Questionnaire for Grade 12 – STEM Student-Respondents

Adapted from, Khaparde and Shaker (2020)

Instructions: Please check (✔) the column describing your ability in a laboratory experiment as a STEM Student by checking the appropriate column which corresponds to the following scale:

5 – Very High	The behavior or response occurs consistently or frequently.
4 – High	The behavior or response occurs frequently but may not be consistent.
3 – Moderate	The behavior or response occurs occasionally or intermittently.
2 – Low	The behavior or response occurs infrequently or rarely.
1 – Very Low	The behavior or response never occurs or is extremely rare.

Item Statement **Knowledge and theoretical understanding**					
The student…	**5**	**4**	**3**	**2**	**1**
1. classify substances in objects on basis of differences and similarities.					
2. combine smaller facts into more comprehensive facts, ideas, and concepts.					
3. evaluate information (resources and data) for accuracy.					
4. produce tangible and original products that apply concepts and processes in chemistry.					
5. produce new ideas and problems that evolve from investigations (scientific method) and apply past experiences to a new situation.					
Psycho-Motor skills					
The student…	**5**	**4**	**3**	**2**	**1**
1. recognize the laboratory tools and materials.					

2. handle (pick, move and set down) the laboratory tools and materials and to handle objects without damage to either the object or other objects in its environment or hazard to any person.					
3. perform the basic and specific detail tasks such as to hold the tool appropriately for use or to set the tool in action in each experiment.					
4. fluently use the tools for performing a range of tasks of the kind for which the tools were designed.					
5. use tools rapidly, efficiently, effectively, and safely to perform experimental tasks on a regular basis.					
Health and safety					
The student…	**5**	**4**	**3**	**2**	**1**
1. follow the standard health and safety information given in the laboratory manual for experiments.					
2. handled and disposed chemicals safely in the laboratory.					
3. assess the risk of a particular situation in the laboratory and deal with it in a safe manner.					
4. work safely in the laboratory.					
5. clean all the laboratory glass wares, apparatus, and tools properly.					
Information about measurements, instruments, methods, and processes					
The student…	**5**	**4**	**3**	**2**	**1**
1. use arbitrary standards to measure compute and compare weight, area, volume, or pressure of substances.					
2. measure and record measurements from the collected information.					
3. make graphs, histograms, diagrams, or charts to record and compare information.					
4. test hypothesis and design a technique for taking measurement.					
5. use metric system to measure and compare distance, volume, weight, pressure, and temperature of substances.					
Cognitive and processing abilities					
The student…	**5**	**4**	**3**	**2**	**1**
1. make predictions from assembled data.					
2. select evidence that verifies a prediction or hypothesis from the experiment.					
3. construct several hypotheses for verification from the result of the experiment.					
4. design and conduct investigations to further the laboratory experiment.					
5. evaluate the purpose of a controlled variable in an experiment.					
Communication and reporting of scientific work					
The student…	**5**	**4**	**3**	**2**	**1**
1. collect data from simple experiments.					
2. expand collection of data to other sources.					
3. identify objects, processes, organisms observed in the environment.					
4. describe characteristics of objects and events observed.					
5. state questions inferred from variables and differences observed.					

III. Interview Questions for Grade 12 – STEM Student-Respondents

Instruction: These inquiries aim to provide a more thorough grasp of the connection between senior high school student's experimental skill and their academic performance in chemistry. To fulfill the purpose of this study, please read each question attentively and answer truthfully. To substantiate the accuracy and legitimacy of your responses, a portion of them may be cited and incorporated in the study report.

1. How do students perceive the importance of experimental skills in their academic studies and future careers?
2. Can you describe a recent laboratory experiment where you faced difficulties or encountered obstacles? What were these difficulties, and how did you address them?
3. How do students navigate safety concerns and protocols in laboratory settings, and what challenges do they face in adhering to these guidelines?
4. Do you think there is a need for an updated and new tool in measuring and recording data from the experiment to further student's current skills in handling measurements and data recording accurately?
5. What learning approach can enhance students' experimental skills in terms of cognitive and processing abilities?
6. In what instances does students show active engagement during the laboratory work?

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