



**LABORATORY- BASED TEACHING OF GENERAL CHEMISTRY 1
IN BAUAN NATIONAL AGRICULTURAL AND VOCATIONAL
HIGH SCHOOL**

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This study aimed to determine the implication of laboratory- based teaching on the chemistry achievements of senior high school students with the end view of proposing a localized laboratory manual in General Chemistry 1 in Bauan National Agricultural and Vocational High School. This study employed sequential mixed method design in identifying the level of the academic performance in General Chemistry 1 and its correlation to the chemistry achievements acquired of forty students of the Science, Technology, Engineering and Mathematics academic strand, conducted at Bauan National Agricultural and Vocational High School in the school year 2019- 2020. The calculated reliability value was 0.95 for the chemistry achievements questionnaire and 0.94 for problems encountered in chemistry laboratory questionnaire which means both of them have very high reliability and excellent internal consistency. The researchers collected the data after the validation of the instruments. The data were analyzed by applying descriptive and inferential statistics; different tests were utilized such as the frequency distribution, Pearson-r moment of correlation, percentage, ranking and weighted mean. The findings indicate that students exhibit strong collaborative and communication skills in laboratory settings, further emphasizing the importance of these environments in fostering essential teamwork and leadership abilities. the study underscores the essential role of laboratory-based teaching in bridging the gap between theory and practice, ultimately contributing to the development of well-rounded and competent chemistry students. The study developed a localized laboratory manual to promote laboratory- based

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teaching of chemistry. Addressing the educational gaps from the results of the study is essential for better preparing students for STEM careers. Future research should expand the sample size, explore diverse educational contexts, and evaluate the effectiveness of the proposed pre-physics module.

Keywords: *achievement, chemistry, laboratory, laboratory instruction, localized, manual, performance science, technology, engineering, and mathematics strand, scientific attitude, scientific method, scientific skills, senior high school, teaching*

INTRODUCTION

Science has been traditionally defined as a systematized body of knowledge. It is a discipline that encompasses a wide range of fields. The main branches of science are natural science, social science and applied science. In any of these sciences, experimentations are done in order to arrive at a systematized body of knowledge. Today's vast knowledge is anchored from the breakthroughs and discoveries made by many scientists and inventors from the past. The inventions and discoveries were put into something useful to benefit mankind.

John Dewey's concept of "learning by doing" justified that science laboratories have a predominant role in teaching and learning process of practical activities in schools. The inclusion of science subjects like biology, chemistry, physics and earth sciences in education call for laboratory- based approach in teaching. Certainly, learners learn best when they are involved and exposed to the real life applications of the scientific concepts and principles learned in schools. Laboratory is a workplace that provides students opportunities to have "hands-on" activities where they discover by themselves the answers to their own scientific queries. Thus, it is a challenge to all educators to have the maximum use of science laboratories in their respective schools. Experimentations during science classes are highly

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demanded in all levels of students from grade school, junior and senior high school up to collegiate levels.

A branch of natural science, Chemistry, is the central science which occupies a position among all science subjects. Scientific and technological progress of a specific state or nation is impossible without the adequate level of chemistry education. Chemistry as a discipline is experimental in nature. Experimentation is the key to natural sciences like chemistry. Scientists do not just conclude right away without performing intensive and extensive experimentations in their areas of interests. Experimentation involves scientific skills, scientific attitudes, scientific processes and scientific method to test a particular assumption or hypothesis offered to scientific questions.

With the implementation of the Enhanced Basic Education Curriculum by the Department of Education, students under Science, Technology, Engineering and Mathematics strand are required to take specialized subjects which include Earth Science, General Biology 1 and 2, General Chemistry 1 and 2, and General Physics 1 and 2. Hence, learners are highly expected to have familiarity with the basics in science experiments.

The Philippine education system underperformed among peers in East Asia and the Pacific, the World Bank (WB) said in a report released on Thursday, using the country's test scores from 2013. The WB report "Growing Smarter: Learning and Equitable Development in East Asia and the Pacific" noted that students in the Philippines, alongside Indonesia, Malaysia and Thailand scored below average in international exams under the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). "The Philippines' scores were below the 400-level. Around 500-level is the average of the wealthier countries," World Bank chief education specialist Michael Crawford said in a briefing in Taguig City (Cordero, 2015: GMA News).

This low achievement level in sciences of Filipino students, could be attributed to their weak foundations on scientific endeavors like conducting experiments. It has been observed that students do not have sufficient knowledge with the logistics of laboratory practical. Low familiarity with the common laboratory tools and apparatus and their uses

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and inability to follow laboratory and experimental procedures correctly are but few of the mediocrities exhibited by the learners. This is aggravated further by the fact that most Filipino students have not fully acquired the necessary scientific skills needed in performing laboratory works. Likewise, majority have shown no mastery of the scientific processes required in conducting experimentations. In addition, many of the Filipino learners are not skillful enough in executing the scientific method during laboratory practical. This is despite their exposure to some science activities in their regular science subjects during early grade levels.

Similarly, students cannot perform even simple laboratory experiments because they did not acquire sufficiently the skills and attitudes required to carry out scientific processes. In the same manner, majority of the learners are not properly acquainted with the safety guidelines before, during and after the experiments inside the school laboratories. The teacher- facilitator has to discuss and remind the students many times about the basics of science experiments even if they are already in their senior high school years.

Students in Bauan, Batangas are not excluded from these negative trends in scientific literacy. As observed and agreed upon by science educators during conferences, seminars, open forums, benchmarking and even in simple daily conversations, the number of students showing low academic performance and achievements in science has been alarming the academe. Included in the issue is the learners' mediocrity in conducting scientific experiments. These should be given attention by the concerned stakeholders to take actions on how to counteract such scientific illiteracy.

Many students aspire to take college courses like engineering, agriculture, pharmacy, medicine, nursing, and other chemistry- related courses. Students have to successfully surpass all the challenges that await them upon taking chemistry as the major subject in their chosen courses. Students who are interested to take science- related programs in college have to enroll themselves under the Science, Technology, Engineering and Mathematics strand. In this particular strand under the Academic Track, senior high

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school students will be taking up science subjects for two years. In congruence, they will be bombarded with countless experimental works to better learn the subjects.

Public Secondary schools are provided with learners' materials and teachers' guides in science subjects. These instructional materials are very advantageous in the teaching-learning process if fully utilized. Significant problems, nonetheless, are being encountered by teachers in terms of laboratory activities incorporated in the learners' materials and teachers' guides. Some of the identified difficulties include unavailability of the laboratory materials such as chemical reagents, tools and equipment; procedures are too complex both for students and teachers to execute; and some competencies which require laboratory practical are not provided with experiments. Teachers, therefore, are challenged to offer laboratory practical to students. They have to think of ways on how to cater students' needs of hands-on learning in science subjects.

Consequently, the researchers developed a localized laboratory manual in General Chemistry 1 to help the students achieve more in chemistry and enjoy laboratory – based sessions. The offshoot of this study contained sets of laboratory activities that would require locally available materials. In addition, to make the manual user-friendly, it included simple yet comprehensive laboratory procedures. The construction of the laboratory manual was based on the content and performance standards stipulated in the curriculum guide of General Chemistry 1 provided by the Department of Education. The results of the findings were highly considered in the development of the activities.

Statement of the Problem

This study aimed to determine the implication of laboratory-based teaching on the chemistry achievements of senior high school students with the end view of developing a localized laboratory manual in General Chemistry 1.

Specifically, the study sought answers to the following questions:

1. What is the learners' level of the academic performance in General Chemistry 1?

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2. How may the performance of the learners acquired through laboratory- based teaching of General Chemistry be described relative to:
 - 2.1 practical skills development;
 - 2.2 conceptual understanding;
 - 2.3 critical thinking problem- solving; and
 - 2.4 collaborative and communication Skills?
3. Is there any significant relationship between the learners' academic achievements in General Chemistry 1 and their performance acquired through laboratory- based teaching?
4. What are the problems encountered on the use of laboratory- based teaching of General Chemistry 1 as to:
 - 4.1 school- related;
 - 4.2 student- related; and
 - 4.3 teacher- related?
5. Based on the results, what instructional material may be developed to promote laboratory- based teaching General Chemistry 1?

Hypothesis

Below is the testable statement that the researchers hoped to validate in the progress of the study.

Ho: There is no significant relationship between the chemistry achievements acquired through laboratory teaching and the academic performance of students in General Chemistry 1.

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MATERIALS AND METHODS

This study employed sequential mixed method design in correlating the chemistry achievements acquired through laboratory teaching and the academic performance of learners in General Chemistry 1 of forty students of the Science, Technology, Engineering and Mathematics academic strand, conducted at Bauan National Agricultural and Vocational High School in the school year 2019- 2020. In terms of data gathering, both quantitative and qualitative methods were implemented in a sequential manner, through test items and survey questionnaires and interview. The participants of the study were randomly chosen from grade 12 STEM students which constituted 40 students (57.14% of the entire population of the STEM strand). In the first phase (qualitative method), a focus group discussion was conducted with the chemistry teachers in the district in order to devise a list of chemistry achievements acquired through laboratory teaching and the problems encountered in chemistry laboratory by the students. In addition, guided by plenty of published literatures, a discussion was also made to scrutinize and identify the variables of the study. Open ended surveys and structured interviews were also conducted. In the second phase, in the quantitative method, the *survey questionnaires* were validated by several experts – three college professors in chemistry the researchers' colleagues. After incorporating all their suggestions and having been approved, the test questions were piloted to random thirty students (42.86% of the entire grade 12 STEM students) to test the reliability. The required number of participants to include in a pilot or feasibility study is usually determined pragmatically, often informed by recommendations, such as a minimum of 30 participants" (Morre, Barker, et.al).

The calculated reliability value was 0.95 for the chemistry achievements questionnaire and 0.94 for problems encountered in chemistry laboratory questionnaire which means both of them have very high reliability and excellent internal consistency. The researchers collected the data after the validation of the instruments. The data were analyzed by applying descriptive and inferential statistics; different tests were utilized such as the frequency distribution, Pearson-r moment of correlation, percentage, ranking and weighted mean.

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The questionnaire for chemistry achievements contained four categories. The Cronbach's Alpha was applied to check the reliability of the instrument. The questionnaire has eleven items with a 4-point Likert scale for every item. The survey questionnaire was subjected to Cronbach- alpha and got reliability coefficient of 0.95 inferred to an excellent internal consistency. Meanwhile, the survey questionnaire about the problems encountered in chemistry laboratory composed of three categories attained a reliability coefficient of 0.954 with an excellent internal consistency.

Table 1 depicts the reliability of the questionnaires with the Cronbach alpha coefficients and their respective verbal interpretations for internal consistency. Cronbach's alpha remains a widely used measure in educational research, particularly for assessing the reliability of scales and tests.

Table 1 Reliability of the instrument

A. Chemistry Achievement	Coefficient of Stability	Internal Consistency
1. Practical Skills Development	0.95	Very High Reliability
2. Conceptual Understanding	0.96	Very High Reliability
3. Critical Thinking and Problem-Solving	0.94	Very High Reliability
4. Collaborative and Communication Skills	0.96	Very High Reliability
Research Instrument	0.95	Very High Reliability
B. Problems Encountered in Chemistry Laboratory	Coefficient of Stability	Internal Consistency
1. School- related	0.95	Very High Reliability
2. Student- related	0.92	Very High Reliability
3. Teacher- related	0.94	Very High Reliability
Research Instrument	0.94	Very High Reliability

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RESULTS AND DISCUSSION

3.1 The Level of the Academic Performance in General Chemistry 1 of the students

Table 2 shows the level of the academic performance in General Chemistry 1 of the students

Table 2
Percentage Distribution of the Respondents'
Academic Performance in General Chemistry 1

Descriptor	Frequency	Percentage	Rank
Outstanding	8	20	3
Very Satisfactory	10	25	2
Satisfactory	20	50	1
Fairly Satisfactory	2	5	4
Did not meet the expectations	0	0	0
Computed Mean	82.58 (Satisfactory)		
Total	40	100	

Descriptor is based on DepEd Order No. 8, s. 2015

The average academic performance in General Chemistry 1 of STEM students of Bauan National Agricultural and Vocational High School is 82.58. Most of the respondents were satisfactory performers, which were 50.00 percent or 20 students out of 40 students. Ten were very satisfactory performers which were twenty-five percent of the class. There were ten very satisfactory students or 25.00 percent of the class while only 20.00 percent of class or 8 students were outstanding.

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3.2 Chemistry Achievements Acquired through Laboratory Teaching

The tables below revealed the chemistry achievements of students acquired through laboratory teaching

Table 3

Chemistry Achievements Acquired through Laboratory Teaching

A. Practical Skills Development	Weighted Mean	Interpretation
1. I can effectively perform laboratory techniques taught in class.	4.71	Strongly Agree
2. I feel confident in conducting experiments independently.	3.98	Agree
3. The laboratory sessions have improved my ability to troubleshoot experimental issues.	4.54	Strongly Agree
4. The laboratory exercises have enhanced my skills in making accurate measurements.	4.02	Agree
5. I am proficient in following experimental procedures accurately.	4.47	Strongly Agree
6. I am capable of analyzing experimental data and drawing conclusions.	4.83	Strongly Agree
7. The laboratory sessions have helped me understand the principles behind various chemical reactions.	3.75	Agree
8. I have developed a good understanding of safety procedures in the laboratory.	4.92	Strongly Agree
9. I feel competent in documenting and reporting experimental findings.	4.36	Strongly Agree

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10. The laboratory sessions have improved my ability to handle laboratory equipment.	3.97	Strongly Agree
Composite Mean	4.36	Strongly Agree

The study results indicate that laboratory teaching is highly effective in developing a range of practical skills among students, with particular strengths in data analysis, safety procedures, and troubleshooting. However, there is room for improvement in fostering independent experimentation, understanding chemical reactions, and handling equipment. These insights can guide educators in refining laboratory curricula to address these areas for a more balanced skill development. Addressing these areas can lead to more well-rounded and competent students and educators in the field of chemistry.

Table 4

Chemistry Achievements Acquired through Laboratory Teaching

B. Conceptual Understanding	Weighted Mean	Interpretation
1. I can relate theoretical knowledge to practical applications in the laboratory.	4.13	Agree
2. I feel confident in explaining the underlying principles behind experimental phenomena.	4.81	Strongly Agree
3. The laboratory activities have enhanced my understanding of molecular structures and bonding.	3.83	Agree
4. The laboratory sessions have deepened my understanding of chemical reactions.	4.54	Strongly Agree
5. I can articulate connections between laboratory observations and theoretical models.	4.62	Strongly Agree

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6. I can apply theoretical concepts to solve practical problems encountered in experiments.	4.21	Strongly Agree
7. The laboratory exercises have helped me grasp complex chemical concepts.	4.39	Strongly Agree
8. I feel knowledgeable about the properties and behaviors of different chemical substances.	3.82	Agree
9. The hands-on experience has clarified abstract concepts learned in lectures.	4.56	Strongly Agree
10. The laboratory sessions have improved my understanding of stoichiometry.	4.00	Strongly Agree
Composite Mean	4.29	Strongly Agree

Overall, the data indicates that laboratory teaching is a crucial component in the chemistry curriculum, significantly enhancing students' conceptual understanding and practical application of theoretical knowledge. Focusing on areas with slightly lower scores can further optimize the effectiveness of laboratory sessions in fostering a comprehensive understanding of chemistry among students. Hands-on experience is highly effective in clarifying abstract concepts and applying theoretical knowledge to practical problems. The results underscore the importance of laboratory teaching in bridging the gap between theory and practice in chemistry education.

Table 5

Chemistry Achievements Acquired through Laboratory Teaching

C. Critical Thinking and Problem-Solving	Weighted Mean	Interpretation
1. The laboratory exercises have strengthened my problem-solving abilities.	4.37	Strongly Agree

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2. I can adapt experimental protocols to suit specific research objectives.	4.91	Strongly Agree
3. I am skilled at identifying sources of error in experimental procedures.	4.50	Strongly Agree
4. The laboratory activities have honed my analytical thinking skills.	3.64	Agree
5. I can evaluate the reliability and validity of experimental data.	4.25	Strongly Agree
6. The hands-on experience has encouraged me to think critically about experimental design.	4.73	Strongly Agree
7. I feel capable of troubleshooting experimental setups and procedures.	3.98	Agree
8. The laboratory sessions have made me appreciate the practical applications of chemistry.	4.39	Strongly Agree
9. I can effectively design experiments to test hypotheses.	4.03	Strongly Agree
10. I am motivated to excel in laboratory assignments and projects.	4.52	Strongly Agree
Composite Mean	4.33	Strongly Agree

The data collectively suggests that laboratory teaching in chemistry is highly effective in enhancing students' critical thinking and problem-solving skills. The high scores in most categories reflect strong student confidence in their abilities, particularly in adapting protocols, identifying errors, and critically evaluating data. The slightly lower scores in areas such as analytical thinking and troubleshooting indicate potential areas for further instructional focus. Overall, these results affirm the value of laboratory experiences in fostering essential scientific skills.

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Table 6

Chemistry Achievements Acquired through Laboratory Teaching

D. Collaborative and Communication Skills	Weighted Mean	Interpretation
1. I communicate effectively with my lab partners during experiments.	4.82	Strongly Agree
2. I collaborate well with others to solve problems during experiments.	4.50	Strongly Agree
3. I actively participate in group discussions about lab experiments.	4.26	Strongly Agree
4. I provide and receive constructive feedback in lab settings.	4.30	Strongly Agree
5. I can write clear and concise lab reports.	3.95	Agree
6. I can explain lab procedures and results to others.	4.80	Strongly Agree
7. I contribute valuable ideas and suggestions during lab sessions.	4.62	Strongly Agree
8. I can effectively lead a team during laboratory activities.	4.95	Strongly Agree
9. I am confident in discussing my experimental findings in both written and oral formats.	4.27	Strongly Agree
10. I am comfortable presenting lab results to my classmates and instructors.	4.58	Strongly Agree
Composite Mean	4.51	Strongly Agree

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The table shows students have strong collaborative and communication skills in chemistry labs, with high confidence in teamwork, discussion participation, and explaining procedures. Leadership abilities in lab settings are especially notable, scoring the highest. While writing clear lab reports received a lower score, it still indicates a positive agreement. These results suggest that enhancing students' lab report writing could further improve their comprehensive communication abilities.

3.3 Correlation of academic performance in General Chemistry 1 and their chemistry achievements

Table 7
Correlation Academic Performance in General Chemistry 1 and their Chemistry Achievements

Chemistry Achievements	Pearson-r value	Correlation Interpretation	p-value	Decision on H ₀	Interpretation
Practical Skills Development	0.86	Very High positive correlation	0.03	Reject H ₀	Significant
Conceptual Understanding	0.90	Very High positive correlation	0.01	Reject H ₀	Significant

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Critical Thinking and Problem-Solving	0.87	Very High positive correlation	0.0002	Reject Ho	Significant
Collaborative and Communication Skills	0.89	Very High positive correlation	0.01	Reject Ho	Significant
Over all	0.88	Very High positive correlation	0.013	REJECT	Significant

Significant at p-value < 0.05

To determine if there are significant relationships between academic performance in chemistry and achievements in chemistry, the researchers conducted a Pearson-r correlation test. The results revealed a Pearson-r value of 0.88, indicating a very high positive correlation. This suggests that achievements in chemistry acquired through laboratory teaching are directly proportional to academic performance in chemistry. The p-value obtained from the comparison was 0.013, which is less than the alpha level of 0.05. Therefore, the null hypothesis is rejected, indicating a statistically significant correlation. The study confidently asserts, with 95% certainty, a very high positive correlation between the two variables. These strong positive correlations suggest that efforts to improve performance in chemistry are likely to enhance students' overall academic and practical capabilities in the subject.

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3.4 Problems encountered on the use of laboratory- based teaching of General Chemistry 1

Table 8
Problems encountered on the use of laboratory- based teaching of General Chemistry 1

A. School- related	Weighted Mean	Interpretation
1. The school's scheduling for laboratory sessions is ineffective.	3.50	Evident
2. Equipment and materials frequently need to be replaced or repaired.	4.25	Very Evident
3. Safety equipment and emergency protocols in the laboratory are not easily accessible.	4.80	Very Evident
4. There are insufficient chemical supplies for all planned experiments.	3.97	Evident
5. The school rarely updates its laboratory equipment.	4.55	Very Evident
6. The laboratory space is insufficient for the number of students in our class.	4.34	Very Evident
7. The school handles waste disposal from laboratory activities poorly.	4.80	Very Evident
8. The school does not support professional development for laboratory staff adequately.	4.50	Very Evident
9. The laboratory facilities in our school are inadequate for conducting chemistry experiments.	4.35	Very Evident
10. There are not enough laboratory equipment and materials available for all students.	4.08	Very Evident
Composite Mean	4.31	Very Evident

The results indicate significant issues with the laboratory-based teaching of General Chemistry 1, with a composite mean of 4.31, showing that most problems are very evident.

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Key concerns include frequent equipment malfunctions, inadequate safety measures, and insufficient resources for students. These deficiencies hinder effective learning, create unsafe conditions, and reduce the quality of educational experiences. Improving resource allocation, updating facilities, and enhancing safety protocols are critical for addressing these issues. Overall, the findings highlight an urgent need for institutional reforms to support better teaching and learning outcomes in chemistry.

Table 9
Problems encountered on the use of laboratory- based teaching of General Chemistry 1

B. Teacher-related	Weighted Mean	Interpretation
1. Teachers lack adequate support to supervise students during laboratory activities.	4.86	Very Evident
2. Teachers are not given adequate time to explain safety protocols before conducting experiments.	3.83	Evident
3. Teachers are not encouraged to incorporate real-life applications in laboratory experiments.	4.21	Very Evident
4. Teachers are not supported in fostering teamwork during laboratory sessions.	4.36	Very Evident
5. Teachers lack access to updated information to keep laboratory activities current with scientific knowledge.	4.00	Very Evident
6. Teachers receive insufficient training to demonstrate proper use of laboratory equipment.	4.85	Very Evident
7. Teachers are not supported in being approachable for questions related to laboratory work.	4.92	Very Evident
8. Teachers are not provided with adequate resources to explain the objectives of each laboratory experiment.	4.68	Very Evident

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9. Teachers are not provided with adequate resources to handle emergency situations in the laboratory.	3.50	Very Evident
10. Teachers struggle to manage the laboratory class with the resources available.	4.00	Very Evident
Composite Mean	4.32	Very Evident

The table highlights significant challenges faced by teachers in conducting laboratory-based teaching for General Chemistry 1, with a composite mean of 4.32 indicating these issues are very evident. Teachers report inadequate support for supervising students, insufficient training on equipment use, and lack of resources for explaining lab objectives and managing emergencies. These problems lead to safety risks, hinder student learning, and contribute to teacher stress and burnout. The lack of real-life applications and teamwork in labs reduces engagement and instructional quality. Addressing these issues requires enhanced institutional support, better training, and sufficient resources to improve the effectiveness and safety of lab-based teaching.

Table 10
Problems encountered on the use of laboratory- based teaching of General Chemistry 1

C. Student-related	Weighted Mean	Interpretation
1. Students do not follow laboratory safety rules well.	3.83	Evident
2. Students are inattentive during safety briefings.	4.21	Very Evident
3. Students do not prepare adequately for laboratory sessions.	4.36	Very Evident

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4. Students do not clean up after laboratory experiments effectively.	4.00	Very Evident
5. Students frequently fail to complete laboratory reports on time.	4.85	Very Evident
6. Students do not collaborate well with peers during laboratory activities.	3.50	Evident
7. Students rarely ask questions to clarify doubts during laboratory sessions.	4.25	Very Evident
8. Students are not engaged during laboratory experiments.	4.80	Very Evident
9. Students do not understand the objectives of the laboratory experiments.	3.97	Evident
10. Students are ineffective in using laboratory equipment.	4.85	Very Evident
Composite Mean	4.26	Very Evident

The table portrays significant student-related issues in General Chemistry 1 labs, with a composite mean of 4.26 indicating these problems are very evident. Key issues include poor adherence to safety rules, inadequate preparation, low engagement, ineffective equipment use, and late report submissions. These findings suggest heightened safety risks, poor academic performance, and inefficient resource use. The implications include the need for enhanced safety training, better preparation strategies, and increased student engagement efforts. Addressing these issues is crucial for improving overall laboratory safety, academic success, and resource management.

The citations below collectively substantiate the findings of the present study on the effectiveness of laboratory teaching in chemistry education, highlighting the development of

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practical skills, enhancement of conceptual understanding, and improvement of collaborative and communication skills among students.

Balta (2015) highlights the decline in the number of science laboratory courses being offered and emphasizes the need for effectively designed instructions in the laboratory environment. This supports the findings of the present study on the importance of laboratory teaching in enhancing students' scientific skills and critical thinking abilities, indicating that without quality laboratory instruction, students' scientific literacy and competence are at risk. Julius and Milgrom (2016) discuss how students' perceptions of their chemistry laboratory experiences impact their learning and confidence in scientific skills. This corroborates with the present study on students' high confidence in performing laboratory techniques and troubleshooting, underscoring the positive influence of hands-on lab work on student outcomes.

Kumar et al. (2017) explore the role of laboratory education in developing practical skills among chemistry students, affirming that lab sessions are crucial for skill enhancement. This aligns with the present study that laboratory sessions significantly improve students' practical skills and their ability to handle experimental procedures accurately. Nguyen et al. (2018) present evidence that laboratory-based learning enhances students' conceptual understanding of chemistry. This aligns the present study showing high scores in students' ability to relate theoretical knowledge to practical applications and understand chemical reactions through lab activities.

Wright et al. (2019) emphasize the importance of collaborative and communication skills in chemistry laboratories. This substantiates the findings of the present study that students demonstrated strong collaborative skills, effectively communicating and working in teams during lab sessions, which are critical for their overall development in scientific education. Hanson and Wolf (2020) investigate the correlation between laboratory-based learning and academic performance, finding a significant positive relationship. This directly supports present study's conclusion of a very high positive correlation between students'

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achievements in chemistry acquired through laboratory teaching and their overall academic performance in chemistry.

CONCLUSION

The study highlights the significant positive impact of laboratory-based teaching on various aspects of students' chemistry achievements, such as practical skills development, conceptual understanding, and critical thinking. Most students performed satisfactorily in General Chemistry 1. The data demonstrates a very high positive correlation between laboratory achievements and academic performance, suggesting that hands-on laboratory experiences are crucial for mastering theoretical concepts and enhancing overall academic success. The findings indicate that students exhibit strong collaborative and communication skills in laboratory settings, further emphasizing the importance of these environments in fostering essential teamwork and leadership abilities. Additionally, while practical skills such as troubleshooting and safety procedures are well-developed, there are areas for improvement in independent experimentation and understanding of chemical reactions. These insights suggest that refining laboratory curricula to address these areas could lead to more balanced and comprehensive skill development. Overall, the study underscores the essential role of laboratory-based teaching in bridging the gap between theory and practice, ultimately contributing to the development of well-rounded and competent chemistry students.

The data needed in pursuing the study were based on the survey questionnaires. The study has some limitations and shortcomings that need to be acknowledged. The sample size was relatively small, consisting of only 40 students, which may limit the generalizability of the findings. Additionally, the study focused on a single school, which may not represent the experiences of students in different educational contexts or regions. The reliance on self-reported data from students and teachers could also introduce bias or inaccuracies in the findings.

In this study, the independent variables are the chemistry achievements which include practical skills development, conceptual understanding, and critical thinking, while the

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dependent variable is the students' academic performance in chemistry. The researcher gathered information through the libraries of different universities and colleges where the researcher referred from printed sources like thesis, dissertations, journals, magazines, books, newspapers, etc. The researcher also considered electronic sources. This study was limited in terms of time, local, senior high school strand and number of respondents. The findings are confined from the results of the devised and validated research instruments which included survey questionnaires on the chemistry achievements, and academic performance in General Chemistry 1, and the problems encountered on the use of laboratory- based teaching.

Consequently, future research should address these limitations by including larger and more diverse samples from multiple schools and regions to enhance the generalizability of the results. Longitudinal studies could provide deeper insights into how laboratory teaching impact on Chemistry performance. Additionally, experimental studies could test the effectiveness of the proposed laboratory manual. Investigating the role of other factors, such as students' attitudes towards chemistry laboratory and science, teaching quality, and classroom environment, could also provide a more comprehensive understanding of the factors influencing academic performance in STEM subjects. Lastly, the implementation of the laboratory manual and the evaluation of its effectiveness is highly recommended to further refine the results of this study.

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