Development of Practical Laboratory-Based Activities in General Chemistry for Grade 11 Students

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ABSTRACT

This study aimed to develop Practical Laboratory-Based Activities in General Chemistry for Grade 11 Students for the School Year 2022-2023. The developed learning materials included activities on the topics of Gas Laws, ideal gas law, and Dalton's law. These topics were selected based on the results of a diagnostic test taken by the Grade 11 students, which is considered the least mastered competency in General Chemistry I. This study employed the research and development method, involving the planning, development, and evaluation of materials anchored to the ADDIE model. Ten expert evaluators in the field of science evaluated the learning material, considering its content, format, presentation, organization, accuracy, and the currency of information, utilizing an adapted evaluation rating sheet designed for print resources provided by Learning Resource Management and Development System (LRMDS) of the Department of Education (DepEd). To ensure alignment with its intended learners, the Flesh-Kincaid Grade Level was employed to determine the readability level of the developed learning material.

The results of the study revealed that the following competencies were identified as the least mastered in General Chemistry 1, namely: Use the gas laws to determine the pressure, volume, or temperature of a gas under certain conditions of change (41.44%), Use the ideal gas equation to calculate pressure, volume, Temperature, or number of moles of a gas (31.57%) and Use Dalton's law of partial pressures to relate mole fraction and partial pressure of gases in a mixture (27.14%). A practical laboratory-based activity material was developed to address the least mastered competencies. The developed learning material contains two activities in each topic: Charles, Boyles, Gay-Lusssac, Dalton and Ideal Gas Law. Based on the evaluation of the science experts, the developed practical laboratory-based activity material obtained a passing score along content (27.60), format (67.80), presentation and organization (18.20), and accuracy and up-to-datedness of information (24.00). Likewise, with a readability level of 51.5, the developed material is suited for grades 10th and 12th.

It is therefore recommended that the teachers explore alternative interventions to address the least mastered competencies in General Chemistry I, and teacher developers should endeavor to create other types of learning materials to accommodate various student learning preferences and styles. Moreover, the utilization of the developed practical laboratory-based activity material in lower-year secondary schools is encouraged to determine its readability across different grade levels. Furthermore, Science teachers can utilize this material in their classes to identify potential issues learners may encounter, and it can be used by teachers to address learning difficulties, especially in General Chemistry I.

Keywords; Instructional material, Research and Development Method, ADDIE Model, General Chemistry, Practical Laboratory-Based Activities.

INTRODUCTION

The Problem

Enhancement of critical thinking, problem-solving abilities, and a more profound comprehension of the natural world are all greatly enhanced by science education. Among the various scientific disciplines, chemistry stands as a fundamental subject, providing valuable insights across different scientific fields. Looking towards equipping the future generation with the knowledge and skills necessary for scientific advancement, it becomes imperative to enhance the teaching and learning of general chemistry at the secondary education level.

The transition to the K to 12 programs in the Philippines significantly changed the curriculum, emphasizing a learner-centred and competency-based approach. Nonetheless, one central area of concern is the availability and sufficiency of practical laboratory-based activities, which are essential to science education and enable students to put their theoretical knowledge into practice, observe real-world occurrences, and gain a deeper understanding of scientific principles.

Countries worldwide have embraced a Global Goal as a foundational principle aimed at transforming the world. According to the United Nations (2018), one of these goals is centred on quality education, which is recognized as essential for establishing a robust foundation for sustainable development and achieving the broader Sustainable Development Goals set by the United Nations. They provided quality education to all, particularly impoverished and marginalized communities. To ensure this goal is obtained, countries worldwide participate in international assessments conducted by organizations such as PISA and TIMSS to evaluate students' academic achievements across different major subjects. Of all the major subjects, the consistently low academic achievement in Science among Filipino students has become a pressing concern for the educational system. Despite efforts to improve science education, recent international assessments highlight the Philippines' underperformance compared to other nations. According to the 2019 findings from two reputable international assessment organizations, PISA (Programme for International Student Assessment) and TISSM, the country's science proficiency score stood at a mere 249, ranking significantly below the international benchmark in the assessment of 58 participating nations.

Furthermore, the PISA statistics released in December 2019 revealed that the Philippines scored a modest 357 in Science, indicating the country's students performed among the lowest out of the 70 participating countries. These figures demonstrate a substantial disparity in science education and proficiency between the Philippines and its global counterparts. It is clear that Filipino students needed help to obtain the necessary learning competencies from these core subjects, resulting in low performances in different international assessments. These results are very alarming, especially on the part of the Department of Education.

Several factors contribute to this persistent issue, such as the need for more laboratory materials and facilities and effective teaching strategies. It has stunted and prevented the students from effectively learning chemistry (Sagcal, 2017). For one, it is necessary to acknowledge how the education system in the country should be improved. There is a need to address the gaps in addressing inequalities and improving the quality of education in the Philippines. Secondly, students cannot only do laboratory work and activities because of the lack of skills and capacity but also because of the availability of adequate, appropriate materials and tools. (De Borja & Marasigan 2020) It was also heavily emphasized that there needs to be more laboratory resources, apparatus, and even rooms available to match the class size and time available in the classes in the Philippines.

Moreover, in the study conducted by Mercado (2018), results showed that the prevailing challenges that need to be addressed in the laboratory class were the lack of updated instructional materials such as laboratory manuals and laboratory equipment, old laboratory apparatus that gives inaccurate, data and the least learned competencies. In addition, this study also suggested making use of contextualized, localized, and indigenized material in the development of laboratory learning materials in the Philippines. Laboratory learning materials are the tools teachers use to gather and assess the students' learnings in a particular science concept. However, some of the available materials in school failed to achieve their purpose in the learning process.

On the other hand, the education sector is giving teachers time to collaborate and improve themselves professionally through the help of the Learning Action Cell. These are mandated in the DepEd Order No. 35, Series of 2016, which emphasizes the Learning Action Cell (LAC) as a crucial School-Based Continuing Professional Development Strategy for enhancing teaching and learning in the curriculum. It is also essential to emphasize LAC sessions on the development and usage of student-centred and hands-on activities for the learners, especially on science subjects. It also encourages modifying teacher guides and learners' materials to accommodate practical and engaging laboratory experiences for science education.

The educational system in the Philippines has faced a wide range of gaps and deficiencies, especially in chemistry. It is essential to examine, assess, and address these concerns and issues and what can be done to improve how chemistry is taught within the Philippine curriculum. Thus, it is necessary to have a study that will address these challenges in the Philippine education system, especially in the science field. Moreover, this research aims to address the problem and establish solutions that can help improve the pedagogical practices of general chemistry in the Philippines. Furthermore, aside from the gaps in learning materials and resources, it is also essential to look into the pedagogical practices of Science, especially among chemistry teachers in the country. More than a traditional lecture-based teaching strategy would be required to teach the learners chemistry effectively.

However, the approach should be a mix of lecture hands-on and context-based teaching strategies. The study done by Rose (2012) has discussed these and the attempts to address these deficiencies and gaps and a method to shift to a more context-based kind of learning. It takes a more hands-on approach and process, examining how these ideas and theories might be used in real-life situations. It suggests that given the challenges students currently face in the science curriculum, teachers must address these concerns. One effective method is to develop learning materials tailored to assist students in overcoming these challenges.

Since the 1960s, one widely recognized approach applicable to developing learning materials is practical work. This method allows students to connect conceptual ideas with real-life situations, enabling them to apply their learning to daily tasks and activities. Oliveira and Bonito (2023) support this approach, highlighting the benefits of practical work in nurturing both fundamental conceptual understanding and practical skills in scientific processes. It can be accomplished by integrating hands-on and minds-on approaches in activity creation. On the other hand, In order to improve the state of teaching and learning chemistry, it is essential to assess these particular issues at a more comprehensive level.

Improving teachers' and students' current education conditions is necessary, providing a better learning environment for everyone. Due to budget constraints, laboratory activities need to be improved while working within the budget provided by government institutions. Aside from the request for the government to provide more funding support for chemistry laboratories, there could have been better laboratory activities that can be done and developed to reach optimum learning and development for the students and to understand further and appreciate the concepts in chemistry.

The researcher intends to address these issues and find a plausible solution that can bridge and aid in learning chemistry among the learners and students in this country. With that, the researcher aims to examine these issues and gaps in learning chemistry. Specifically, the researcher will look into and focus on how practical learning chemistry is for Grade 11 General Chemistry students. Due to certain limitations and to have a more focused scope in pursuing this study, the researcher will only have a sample of Grade 11 students under the STEM strand who are taking a General Chemistry I subject at Ilocos Sur National High School.

The researcher decided to pursue this particular study for various reasons. One is the need for more critical discourses and studies that address these gaps and concerns of learning chemistry in regional contexts. With this in mind, the researcher hopes that this study can contribute to providing more recent research that examines and explores these gaps in learning chemistry, especially in Ilocos Sur National High School. Moreover, it is essential to study the difficulty level of the topics in general chemistry and assess the challenges the students face. Once these are done, the researcher aims to develop and improve practical laboratory-based activities that can be efficiently utilized and applied within the local curriculum despite the lack of standard materials and resources, which, by extension, can enhance the teaching and learning of chemistry.

Statement of The Problem

The study aimed to develop practical laboratory-based activities in General Chemistry for Grade 11 students.

Specifically, it sought to answer the following questions:

What is/are the least mastered competencies in grade 11 General Chemistry 1 of the Basic Education Curriculum

a. Gas Laws,

b. Ideal Gas Law, and
c. Dalton's Law?

What practical laboratory-based activities can be developed in grade 11 general chemistry 1?

What is the evaluation of the developed practical laboratory-based activities in Grade 11 students along the following:

a. Content,
b. Format,
c. Presentation and organization, and
d. Accuracy and up-to-datedness of the information?

4. What is the readability level of the developed practical laboratory-based activities in Grade 11 students

Scope and Delimitation

The study focused on the development of practical laboratory-based activities in General Chemistry for Grade 11 STEM students at Ilocos Sur National High School, Division of Vigan City, Ilocos Sur, during the academic year 2022-2023. It employed the research and development method. The ADDIE Model was utilized in the construction of learning materials, but the evaluation was limited to the Analysis, Design, and Development of the material. However, the developed materials were evaluated in terms of content, format, presentation, organization, accuracy, and currency of information using the tool provided by the Learning Resource Management and Development System (LRMDS) of the Department of Education (DepEd).

The topics covered in this study were determined based on the competencies with the lowest percentage of mastery found in the result of the diagnostic test held in the first quarter of General Chemistry I for the School Year 2022-2023.

Ten experts (five male and five female) from selected secondary public schools in Vigan City and the Ilocos Sur division were purposively selected to evaluate the learning material. The schools included were Ilocos Sur National High School, Vigan National High School East, Lussoc National High School, San Juan National High School, and Magsingal National High School. The following statistical tools were used in the analysis of data gathered: percentage, mean, and Flesch Read Ease Score.

Theoretical Framework

This chapter included the results of previous research and challenges that the researchers believe were relevant to the current topic. The basic definitions used and the research questions or subtopics were thoroughly discussed by comparing this study to previous ones. The primary objective of creating this framework was to give researchers a strong foundation on which to build insightful studies on the state of the world and to provide a credible framework that future researchers can use as a guide.

Educational Theories

The Theory of Constructivism by Jean Piaget, Zone of Proximal Development by Vygotsky, and the Theory of Experiential Learning by David Kolbs served as the foundation for this study. The four educational theories were demonstrated in order for a teacher to achieve meaningful learning through the use of practical laboratory-based activities, he must be aware of the student's learning styles. Teachers must be mindful of the intelligence level of their students.

Constructivism

The constructivism theory of Tuerah (2019) is a teaching method based on the idea that individuals actively formulate their own knowledge via experience. The constructivist framework encourages the teacher to act as a facilitator and depends on the students to be in charge of their knowledge acquisition. Furthermore, A

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constructivist approach in a lab environment can enhance the learning and meaningfulness of the experience. (Exploring Exemplary Science Teaching, 2019). Therefore, the direct participation of the students in the learning process will allow them to observe, perform, and provide solutions to the problem presented in the activity. It develops collaborative skills and critical thinking. Practical laboratory-based activities encourage the students to explore and discover things in their own way with less guidance from the teacher.

Building upon previous evidence, Shana and Abulibdeh (2020) recommended that, considering chemistry as an applied science, researchers should incorporate practical exercises to illustrate the majority of its principles. Some concepts will be discovered once they are involved in real-life scenarios. Additionally, certain ideas lack practical applicability, necessitating further study to enhance the approachability and engagement of science topics, especially within chemistry. Students who engage in such practices may discover increased motivation to study rigorously and achieve a more profound comprehension of chemistry.

Experiential Learning

Another theory that can serve as the foundation for this research study, as highlighted by Habib (2021), is the Theory of Experiential Learning. This theory emphasizes that students should actively engage in the learning process, guided by their experiences. It assists students in recognizing their abilities and skills and understanding adaption demands, allowing them to put the required adjustments into practice for better and increased performance. According to the study conducted by Bangoy (2022), findings illustrate the advantageous impact of employing the practical work method on students' performance and creativity. These studies confirmed that incorporating performance-based activities such as laboratory work stimulates the students' interest, allowing them to involve themselves in the learning process and enabling them to connect their own experiences to the concepts for a better understanding of the lesson.

The researchers strongly advocate for educators to adopt this approach in investigating various topics or objectives. By implementing practical work methodologies, teachers can facilitate more effective acquisition of scientific knowledge. This method inspires students to be creative, ingenious, and focused, thereby capturing their interest and enjoyment while also fostering the development of their objectivity and open-mindedness.

It suggests that for learners to grasp a concept in chemistry effectively, they need to experience and explore the idea personally. This process allows them to observe and formulate their hypotheses and provides opportunities to test these hypotheses through practical laboratory work. In addition, teamwork and collaboration between members of the group are also observed to promote a conducive learning environment.

Zone of Proximal Development

Based on the study conducted by Taber (2018), the zone of proximal development proposed that students should learn new knowledge through collaboration with their peers. The teacher will no longer teach the students step by step. Instead, the teacher will only facilitate the students' learning. Therefore, the best way to apply this theory is to develop practical laboratory-based activities to engage the students to learn with less assistance from their teacher. According to the study conducted by Grin (2022), The purpose of practical work has two main goals: first, to spark students' interest in the subject and enhance their understanding of the topics taught in science classes. Second, practical work is renowned for aiding students in retaining information while often serving as a catalyst for igniting their curiosity and enthusiasm. Moreover, engaging in practical activities fosters the development of numerous transferable skills.

A similar study conducted by Mwangi (2018) stated that the quality of practical work must be considered to teach chemistry effectively and enhance knowledge acquisition. Teachers aiming to improve their students' performance in chemistry should consistently plan and utilize high-quality, practical methods. It necessitates educators to possess implicit knowledge of executing practical tasks. Results indicate that employing high-quality, experimental work successfully enhances students' performance in secondary school chemistry classes.

This means that when creating educational materials, particularly when addressing concepts that students find challenging to comprehend in the field of chemistry, it is important to consider practical activities since they promote a positive outcome to the student's learning process and develop the student's critical thinking skills by performing various task for the success of their work.

The ADDIE Model

Selecting an appropriate design ensures alignment with learning objectives and engages learners effectively. By integrating this design as a foundation, the teacher developer can streamline the creation process, ensuring coherence and relevance in the learning materials and ultimately enhancing their educational impact. In this study, the researcher used the instructional design method to come up with practical laboratory-based activity material intended to address topics that are difficult for learners to understand mainly in General Chemistry 1. Parikh (2023) stated that the process of planning and producing educational resources to enhance the learning process is known as instructional design. In addition, to determine the desired learning outcomes, instructional designers frequently begin by evaluating the learners' requirements. It indicates that by employing this kind of design, developers may carry out the systematic procedure in the creation of educational resources, minimizing the possible errors in the process.

The study conducted by Ali (2021) highlights how instructional design models facilitate real-world application and aid instructional designers in making sense of abstract learning theory. To assist instructional designers in the process of developing lessons, instructional design models arrange and illustrate learning theories and concepts. Learning material development may be framed by using instructional design models. This is also supported by the study conducted by Sison et al. (2023). The instructional model design is instrumental in the development of excellent educational courses and resources for students. It is regarded as a guiding framework for the creation of well-designed courses. Widely adopted for its established methodology in crafting understandable and beneficial educational resources, it is employed to assist students in achieving specific learning goals. Its prevalence extends across various professional environments, encompassing corporate offices, college lecture halls, and kindergarten classrooms. This implies that adopting an instructional design model provides a clear overview of the development process of Practical Laboratory Material. Moreover, it guarantees that the material serves its main purpose and ensures that the learning competencies are obtained by the students at the end of each activity.

On The other hand, instructional design models have various types, one of which is the ADDIE Model. This model consists of five steps: analysis, design, development, implementation, and evaluation. According to Spatioti et al. (2022), The ADDIE model is a widely accepted approach for creating and evaluating educational programs, learning experiences, and materials. This model is founded on the overall system theory and analysis, ensuring a logical and seamless task analysis process. However, the relatively rigid and hierarchical structure of the ADDIE model, being linear, could impede the creative thinking of both programmers and teachers. It features distinct and extensive stages, following a rigorous linear structure, where the success of each stage is deemed crucial for the subsequent one. While adhering to a strict workflow can be beneficial in maintaining consistency, it also poses a limitation on flexibility.

This suggests that while there exists flexibility in transitioning from one stage to the next, the process remains circular. Consequently, it proves ineffective when executed without predetermined materials and thorough prior study. Additionally, it imposes constraints, especially on teachers who may not endorse the notion that students require strict adherence to rigorous guidelines for effective studying. Nevertheless, its simplicity, adaptability, and structural integrity render it suitable for this investigation.

The study conducted by Widyastuti and Susiana (2019) claimed that the theoretical underpinnings of learning design serve as the basis for this model's methodical development. This approach is designed to address learning challenges pertaining to learning materials that align with students' needs and characteristics. It is planned and programmed with sequences of systematic exercises. It highlights the advantages of using the ADDIE paradigm for creating instructional materials since it allows teachers to provide content that supports students' learning in a predetermined amount of time. Furthermore, a material in General chemistry was developed applying the ADDIE model conducted by Lee (2018); the data revealed that after using the developed material, The course's student points were improved, and the failure rate was lowered, according to the results. In addition, The process of developing instructional materials and courses that are effective for the audience is guided by this paradigm. It is a model of instructional design that has endured over time. It means that the ADDIE Model has proven beneficial in crafting learning materials that cater to students' needs effectively. It also suggests that utilizing such models could be advantageous in educational settings, enabling educators to create more effective and tailored learning experiences.

On Science Curriculum

To provide the necessary scientific knowledge and abilities to the students, the science curriculum of the K–12 Basic Education Program is improved and expanded. The program's science core learning requirements are designed to show learners that they grasp fundamental scientific principles and how to use scientific inquiry techniques. The students are expected to demonstrate scientific attitudes and values to solve problems critically, develop valuable products, conserve the environment and resources, improve people's integrity and well-being, make wise decisions, and participate in discussions of pertinent issues involving Science, technology, and the environment. (K-12 CG for Science, 2013).

The K–12 Basic Education Program uses a spiral progression strategy throughout topics, elaborating on ideas that were first formed at the primary level as they become more sophisticated and complicated. According to Dunton & Co (2019), The Spiral Curriculum is a design framework that helps science teachers build lessons, activities, or projects aimed at developing non-identifying thinking skills and dispositions. It includes progress and continuation in the study of Science. The progression describes a student's educational journey and how to acquire, apply, and develop skills, knowledge, and understanding in increasingly challenging situations. The spiral development method for teaching competencies is demanded of all teachers. Education is anticipated to improve with the use of the spiral progression strategy in the curriculum. 1) avoid disjunctions between stages of schooling, 2) allow learners to learn topics and skills appropriate to their developmental and cognitive stages, and 3) improve comprehension and understanding of subjects and skills as they are reviewed and integrated. (DepEd Order No. 31, s. 2012).

As the K to 12 science program is fully established in the education system in the country continues, development and improvement of learning materials and other learning resources are needed to address the competencies that are considered to be the least mastered in science curriculum, especially in chemistry same as with the other branches of Science.

Development of Practical Laboratory-Based Activities

According to the website Royal Society of Chemistry (2021), chemistry is a laboratory subject that can only be adequately taught for middle and high school students with extensive laboratory experience. Laboratory equipment identification, manipulation, and general use are critical components of the topic. A laboratory in a school should be equipped to undertake instructive displays and experiments. Accessible to all students and maintained with safety in mind, the laboratory environment must be well-kept. The study conducted by Santos et al. (2021) proposed that teachers should take precautions to protect themselves and their children during any laboratory experiment. The most effective technique for ensuring that students obtain basic science abilities is instruction that emphasizes laboratory demonstrations and experiments and is student-centred. Therefore, involving the students in laboratory activities and different practical works helps them appreciate the importance of the concept being taught to them and apply this knowledge in real life. Aside from that, teachers can also utilize laboratory activities to deal with the least mastered competencies in the subject matter, especially in chemistry subject. It is also supported by the study conducted by Seda Cetin et al. (2018); they claim that if students have the chance to participate in learning that covers a wide range of scientific methods, the impact of laboratory instruction can significantly increase their proficiency in chemistry.

Laboratory activities are considered to be a student-centred and inquiry-based earning approach that allows the student to involve themself in learning physically with the help of laboratory apparatuses and equipment and relate their learning to real-life applications. It also gives the students the opportunity to perform and observe the procedures and results of the experiment. Halawa et al. (2020) found that guided inquiry-based science instruction benefits students' science learning in terms of conceptual understanding and procedural abilities. In addition, Heindl (2019) showed a tendency for better learning outcomes due to inquiry-based learning as opposed to conventional methods. In secondary school, as opposed to elementary, the benefits of inquiry-based learning were more pronounced. In addition, in the study by Duban et al. (2019), he stated that students who engage in inquiry-based experiments become more involved in their learning environment and the problem-solving process. Particularly, classroom teachers are anticipated to be more engaged in the laboratory setting. Practical laboratory-based activities are both guided by these learning approaches, and many studies prove that they enhance students' mastery of science-related concepts.

According to Meng et al. (2022), laboratory practice serves multiple functions in the process of learning. It develops students' aptitude for practical skills, enables the recognition of technical advancements and their application in experimental situations, and promotes the growth of scientific thinking. Furthermore, the study by Horrigan (2018) suggested that laboratory work plays many different roles in acquiring physiological information, bridges the gap between fundamental medical knowledge and clinical application, and develops students' clinical abilities, creativity, and critical thinking. On the other hand, In conventional didactic lectures, there are few opportunities for students to engage in critical thought about the subject at hand. Instead, they are expected to emulate their lecturers' demonstrations through observation and conformity to rules. Due to obstructions in the line of sight, the quality of observation during lab sessions may be restricted. The amount of class time also limits opportunities for active class discussion and practical use of laboratory techniques.

Royal Society of Chemistry, (2022), The mainstay of undergraduate chemistry education is still laboratory work. RSC and the ACS, two professional organizations, have standards for certified courses that reflect their recognition of the value of laboratory work. For The Royal Society of Chemistry (RSC) certification, students must complete at least 400 hours in addition to a research project for a master's degree and at least 300 hours of practical training for a bachelor's degree. According to the findings of Cornejo (2022), In order to improve the level of performance of Grade 12 Senior High School learners in the STEM (Science, Technology, Engineering, and Mathematics) strand and to supplement and augment the delivery of instruction during the pandemic, the researcher suggests utilizing the developed learning materials. Using the designed learning modules in a real classroom context, science teachers may examine how the module affects students' attitudes toward learning the material and determine their strengths and flaws. Last, but not least, it is advised that school administrators give faculty training and seminars on how to create study materials for Physics and other science topics suited for senior high school students during the sufficient pandemic.

According to Akani (2015), This study aims to investigate the influence of the laboratory on the academic success of chemistry students in secondary schools in the Nigerian state of Ebonyi. Four research questions and two hypotheses led the study. The study utilized a sample of 240 students recruited from 10 secondary schools in the three Education Zones of Ebonyi State. A research questionnaire was crafted by the researcher to be utilized. Three specialists, one from measurement and evaluation and the other two from chemical education, validated the device. The acquired data was examined using the statistical measures of mean and standard deviation. The hypotheses were tested using the t-test. The results demonstrated that the usage of the laboratory helps students acquire scientific attitudes toward the study of chemistry, efficiency, and scientific problem-solving skills. Some recommendations were offered in light of the findings: chemistry should be taught in a laboratory, the government should construct and equip science laboratories, and the secondary education system should employ more qualified chemistry teachers.

American Chemical Society (2022). Laboratory scientific experiences are essential to the learning process in all areas of study, beginning in kindergarten and extending through college. According to research, students who participate in well-designed laboratory experiences improve problem-solving and critical-thinking skills and gain exposure to laboratory processes, materials, and equipment. Consistent investments in hands-on experiences encourage students to pursue higher education and prepare them for high-technology employment by cultivating the skills desired by potential employers. When created and facilitated by qualified instructors, hands-on experiences dramatically enhance science teaching at all levels. During hands-on chemistry activities, students use laboratory gear and devices to examine chemical characteristics and reactions directly and safely. These activities are crucial for studying chemistry and enhancing scientific literacy. Web-based and computersimulated activities may expand student exposure to chemistry, save expenses, and minimize hazardous waste and safety concerns. However, they cannot be regarded as equivalent replacements for laboratory experiences. The Society believes there is no substitute for hands-on activities in which materials and equipment are utilized responsibly and student experiences are facilitated. The Society endorses ongoing investments to provide the facilities, equipment, curricula, and professional development required for compelling hands-on laboratory scientific experiences from kindergarten through college.

Tafa (2012), The primary goal of this research was to present an overview of the situation of the practical organic chemistry I course at Haramaya University. As the primary data source, all second-semester first-year chemistry students, laboratory instructors, and Practical Organic Chemistry I course materials were utilized. The primary instruments used to obtain the required data were questionnaires and course content analyses. The observation was another data collection method. Qualitative and quantitative methodologies were utilized to assess data. The majority of the activities have a lower inquiry level of one, and the majority of the practical work described is of the demonstration variety. In addition, laboratory instructors and students ranked the demonstration of lecture-taught materials as the manual's least important purpose. Based on these findings, specific recommendations were made.

Kennepohl (2021) states that chemistry laboratories are essential for teaching and learning, but providing one when courses and programmes are offered virtually or remotely can be difficult. Multiple studies have demonstrated that alternative laboratory modes can result in comparable student performance compared to in-person encounters. In this research review, analyze five laboratory delivery methods (i.e., face-to-face, virtual, remote control, home-study kits, and, to a lesser extent, self-guided field visits) that may be considered for providing excellent practical laboratory activities to accompany online studies. Each mode has its unique advantages and disadvantages and can be utilized singly or in combination. The selection and integration of these modes, which are influenced by learning outcomes and other factors, are evaluated as part of the design process. Lastly, the design of future laboratories will incorporate new technologies, open educational resources, learning analytics, universal design, and citizen science.

It was stated by USA LAB (2022) in its article that Science is taught differently than any other educational subject. Observe any scientific classroom, and you will immediately see the difference. Rather than rows of desks, science classrooms have tiny clusters of tables with sinks, burners, and other learning-assist equipment. The question is raised as to why Science is taught using apparatus, whereas all other courses are taught using textbooks and lectures. Science laboratory equipment enables students to do experiments rather than only read about them. Rather than taking mundane notes, they might observe and conduct intriguing experiments. This type of experiential education frequently facilitates comprehension of complex theories and concepts. As a result, students can gain a greater appreciation for the sciences and become more involved in their coursework. As stated previously, science lab devices enable students to engage directly with the material they are studying. By actively participating in their coursework, students frequently demonstrate excellent retention. While a student may need to reread difficult material multiple times before retaining the information, conducting a single experiment and observing the outcomes firsthand can make the information considerably more memorable. Many pupils would only be able to engage in such activities or retain such knowledge in the presence of adequate science equipment in classrooms. Students are able to practice conducting experiments, which is another reason why science lab equipment is essential in schools. You wouldn't expect someone to be able to drive a car successfully if they've read about automobiles and never practised behind the wheel. The same applies to Science. If students choose to pursue a science-based career in the future, they are required to conduct experiments and engage in hands-on activities. The shift from reading about the sciences to applying them to real-world situations would be facilitated by having done a few experiments in school. Consequently, giving students the necessary laboratory supplies is crucial so they may practise doing experiments.

Springer (2021) states that individual or group observation, practice, and experimentation with tangible objects, equipment, observable results, and concepts constitute laboratory-based learning. This type of learning can occur not just in a traditional laboratory setting but also in other environments, such as the e-LMS and computer simulation. In a laboratory, there are several ways that learning might take place: viewing a case or phenomenon, doing experiments, or taking part in experiential learning. The fundamental objective of arranging laboratory instruction for students is cultivating their practical expertise in their respective fields of concentration. Laboratory instruction allows students to apply and reinforce the theoretical principles presented in the classroom. In addition, a variety of learning goals, including experiential learning, are targeted.

According to Sagcal (2017), The primary objective of this study is to enhance the practical and laboratory skills of junior public high school students in grade ten by creating and validating context-based laboratory activities and inexpensive chemistry kits. These kits and activities during the fourth quarter (December 2016 – March 2017). Using descriptive and quasi-experimental approaches, 24 science teachers, one junior high school principal, and 30 student respondents evaluated and measured the usefulness of these instructional resources. The control group consisted of 30 students who were instructed to utilize standard lecture-based methods. Standardized multiple-choice pre- and post-tests containing 65 items were administered to both groups of pupils in order to calculate their mean gain scores. The purpose of the pre-test was to determine the topics that pupils had the slightest command of. Stoichiometry and the ideal gas law were the least comprehended subjects for these groups. In addition, a post-test was delivered to both groups to assess their comprehension of these topics based on their mean gain scores. According to the data collected, teachers and student responders rated the context-based activities and low-cost kits as successful and highly acceptable (4.79 on a scale of 5 weighted mean). Hake's mean gain scores were 0.63 in the other group and 0.25 in the control group, with a substantial rise in the experimental group. Students in the experimental group who used these materials had considerably higher mean scores and levels of mastery than those in the control group.

According to Amolins (2015), The development of good scientific educators has been a longstanding goal of the education sector as a whole. Numerous studies have advocated subject matter expertise and a breadth of professional development based on constructivist concepts to facilitate successful student-centred and inquiry-based instruction. As a feasible method of professional development, however, only some programs have addressed the integration of the scientific research laboratory into the science classroom. In addition, while sporadic laboratory training programs have appeared in recent years, many of them need a component for converting acquired abilities into classroom change. In light of the enormous growth and demand for competent staff and an educated populace in the biotech and medical industries during the past few years, it is beneficial for the physiology and broader science education groups to examine this topic. This study aimed to evaluate the efficacy of a laboratory-based professional development program centred on incorporating reformed teaching methods into secondary teachers' classrooms. It was judged by the program's capacity to teach elevated academic performance and classroom satisfaction in its participants. The findings revealed an increase in the use of student-centred instruction and other reformed approaches by program participants and self-efficacy, confidence, and work satisfaction.

In addition, a reluctance to modify established teaching procedures was identified. The combination of these results enabled the development of an experience framework for professional development in applied science education that promotes a classroom culture of transformation.

Importance of using Practical Laboratory Activities in teaching chemistry

Instructional materials encompass a wide range of resources and tools that educators utilize to enhance the teaching and learning experience. Their primary purpose is to support and enrich education by making complex concepts more accessible and understandable for students. These resources support a variety of learning styles and topic areas by providing a range of formats and presentations, which fosters an inclusive and productive learning environment. It was discovered in a study by Adalikwu and Iorkpilgh (2013) that students who were taught using instructional materials performed academically much better than those who were not. Additionally, using instructional materials was frequently linked to enhancing students' conceptual comprehension, which resulted in tremendous academic success. Similar findings were found in the study carried out by Ibe et al. (2021). According to the study, students who were taught chemistry using creative instructional methods outperformed those who used traditional teaching resources. The information retention of the students who used improvised materials was likewise higher than that of the non-users. Interestingly, the researchers found no evidence of a relationship between gender, the kind of teaching materials utilized, and students' retention in chemistry.

One of the effective instructional materials to be explicitly used in chemistry is practical laboratory activities that apply the student-centred approach suggested by the curriculum, allowing learners to explore concepts through hands-on work. Given the practical and real-world applications of chemistry and biology, Shana and Abulibdeh's research (2020) highlights the importance of practical work for getting a complete understanding of these ideas. The researchers underline the importance of experiential learning for enhancing understanding of these scientific areas. While more study is needed to clarify complex concepts and make Science more approachable and appealing, practical application is essential for understanding some concepts. Students can become more motivated, exert more effort, and comprehend concepts better by incorporating practical work.

In the study conducted by Oliveira and Bonito (2023), three advantages of practical work in science education were identified. Firstly, it fosters the development of practical skills in scientific processes, concurrently promoting a deeper conceptual understanding. Secondly, practical work is crucial in improving students' scientific literacy and their comprehension of scientific concepts and phenomena. Lastly, practical work facilitates the growth of research skills, immersing students in processes similar to those performed by scientists.

Additionally, as experiments make up a significant portion of Chemistry study, laboratory work and hands-on activities are essential parts of Chemistry teaching. Teachers frequently use chemistry demonstrations as a teaching strategy to increase student interest in the topic and encourage them to comprehend chemical principles. Surprisingly, actively engaging students in chemistry presentations can increase motivation and comprehension just as well as or better than traditional experiments (Vinko et al., 2020). Results from a different study also suggest that practical work provides an excellent platform for enhancing students' motivation and comprehension. Students who participate in practical activities show greater attention, acquire new knowledge, feel more enthusiastic, and comprehend concepts better. Moreover, it encourages collaboration with peers, boosts confidence, and improves their ability to answer questions and create graphs compared to traditional teaching methods, which yield a different level of motivation and understanding in students (Lee & Sulaiman, 2018). Both of these studies emphasize that teaching chemistry in the form of practical activities or performance tasks allows the students to engage effectively in the learning process because it involves tangible materials that they can manipulate and control, allowing them to explore various results of their activity, enhancing the student's creativity and decision-making.

Despite the recognized advantages of integrating instructional materials in education, the global education sector continues to grapple with shortages and inadequate funding, especially in the provision of instructional materials to public schools. Maradun (2023) emphasizes the urgent need to improve the quality of teaching resources used in secondary schools to teach and study chemistry. These materials offer distinctive benefits that can significantly assist teachers in their instructional approaches. However, public schools must be granted sufficient funding to ensure seamless operations of laboratories and other educational activities. The current lack of financial support has resulted in a decline in students' performance in chemistry due to the ineffective utilization of instructional materials, hampering the overall teaching and learning process. As a result, it is crucial to prioritize allocating resources and attention toward improving instructional material usage in chemistry education.

Additionally, by making investments in ongoing professional development, educators can become more proficient and effective educators, which will enhance the educational experience for students. Concurrently, given the limitations imposed by the department's limited resources, it is imperative to guarantee that students have access to an abundance of educational materials and tools. Teachers are given an extra degree of accountability in light of these constraints, which motivates them to actively participate in the development of educational resources. This diverse method aims to establish a synergistic learning environment in which students with rich educational resources work with empowered teachers who have expanded skills, supporting an ideal learning ecosystem despite resource constraints.

Conceptual Framework

To illustrate the study, a research paradigm on the Input-Process-Output Model was used to visualize the process in the development of practical laboratory-based activities in General Chemistry for Grade 11 students, as presented below:

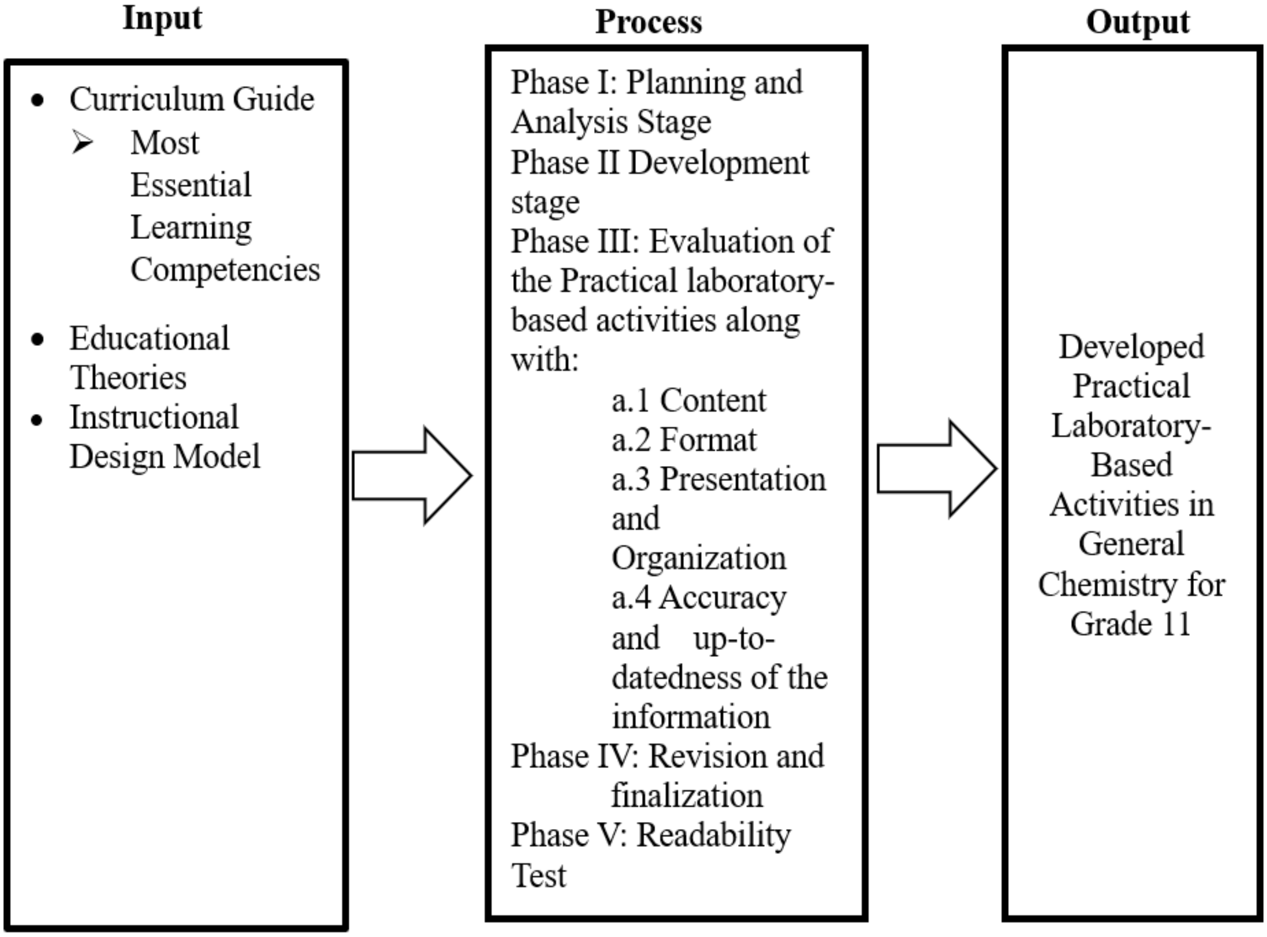

Fig. 1 Research Paradigm

The input entails the CG followed by the MELC in General Chemistry I for Grade 11 subjects identified through a diagnostic test administered during the first quarter, along with the Educational Theories that provided the framework for the development of the material.

The process involves the development of practical laboratory-based activities for students in Grade 11. This process has five phases: planning and analysis, development, evaluation, revision, finalization, and readability test of the material. The ten experts from selected schools in Vigan and Ilocos Sur Division evaluated the developed practical laboratory-based activities. They underwent revisions based on the solicited comments and suggestions of the experts written in the evaluation form, leading to the finalization and improvement of the learning material.

The output of the study was developed and evaluated practical laboratory-based activity material in General Chemistry 1 for Grade 11 students.

Operational Definition of Terms

To ensure comprehension and clarity, the following terms were defined according to their usage in this study:

Curriculum Guide (CG). It referred to the compilation of most essential learning competencies in general chemistry 1, which is used as a basis for the least mastered competencies.

Educational Theories. It pertained to the pedagogical theories used as a foundation in the development of the learning material, such as constructivism, experiential learning, and Zone of Proximal Development.

Instructional Design Model. It pertained to the model used as a guide in the process of the development of the learning material.

Planning and Analysis Stage. It referred to the process of devising practical activities included in the learning material and reviewing the curriculum guide, textbooks, and other learning materials to identify emphasized essential concepts and propose additional ideas and strategies.

Revision and Finalization. It pertained to the act of enhancing the developed material by integrating suggestions and comments from evaluators.

Development Stage. It referred to a process of improving the practical laboratory-based activities from the existing material used in teaching instruction.

Practical Laboratory-Based Activities. It referred to the teacher-made learning material mainly focused on laboratory-based activities in General Chemistry I. The activities are performed inside the laboratory room using different laboratory apparatuses and equipment.

Most Essential Learning Competency (MELC). It pertained to the learning objective that the DepEd outlined in the K-12 Curriculum in the specialized subject under General Chemistry 1 and provided the framework for creating the instructional materials for the learners.

Readability Test. It refers to determining the text's reading difficulty in the first reading.

Evaluation stage. It referred to the screening of the developed practical laboratory-based activities by the experts.

Assumptions

The study was premised on the following assumptions in the conduct of the study:

1. The evaluators did their best to provide enough time to read the material and evaluate to offer helpful suggestions for improving the practical laboratory-based activities for grade 11 students.
2. Evaluators are expected to provide sincere assessments of the practical laboratory exercises, drawing upon their expertise, to collaboratively enhance the quality of the learning materials by offering valuable insight.
3. The diagnostic test and evaluation tool are valid and reliable.

RESEARCH METHODOLOGY

This chapter presented the population, sampling strategy, sample size, research instrument, assessment, readability, method of data collecting, data analysis, and ethical considerations.

Research Design

The method that the researcher of this study used was a research and developmental research method. The descriptive research strategy aimed to identify the least-learned competencies in General Chemistry 1 among grade 11 students during the first quarter. It was also developmental in that it aimed to develop practical laboratory-based activities. The process involved in the development of the material begins with the planning and analysis of the existing learning materials.

Second, the development of the actual material. Third, the evaluation of the material in terms of its content, format, presentation, organization, accuracy, and up-to-date information. Fourth is the revision and finalization of the material, incorporating all the evaluators' suggestions. Lastly, readability to assess if the material suits the intended user.

Population and Sample

The population of this study consisted of (10) secondary public school teachers from the School Division of Vigan City and Ilocos Sur Division during the school year 2022-2023. The method utilized to choose the respondents was purposive sampling. The inclusion criteria were as follows: (a) Secondary public-school

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teachers who were master's degree holders with specialization in Science, (b) had at least five years of teaching experience, and (c) were willing to sign the informed consent as a respondent. Table 1 presents the distribution of respondents.

Table 1 Distribution of the Population

School	Population
Ilocos Sur National High School	4
Vigan National High School East	2
San Jun National High School	1
Magsingal National High School	1
Lussoc National High School	2
Total:	10

A diagnostic test was administered to 325 Grade 11 students from eight (8) sections of the (STEM) strand at Ilocos Sur National High School to identify the competencies with the lowest percentage of mastery in General Chemistry I.

Data Gathering Instrument

The principal device the researchers used to collect the needed data comprised two parts: The research study utilized a Diagnostic test adopted from Ilocos Sur National High School Division of Vigan City and was administered to Grade 11 students to identify the least mastered competencies in General Chemistry I subject. The results from the diagnostic test were analyzed to determine the least mastered competency in General Chemistry 1 for Grade 11 students.

The norms for interpreting the level of proficiency were adapted from those of DepED, as shown below:

Score	**Descriptive Rating**
90-100	Highly Proficient (HP)
75-89	Proficient (P)
50-74	Nearly Proficient (NP)
25-49	Low Proficient (LP)
0-24	Not Proficient (NP)

The evaluation of the development of practical laboratory-based activities for Grade 11 General Chemistry 1 used the evaluation-rating sheet for print materials. This rating sheet was adopted from the Learning Resources Management and Development System (LRMDS) of the Department of Education. It included indicators on content, instruction, design, accuracy, and up-to-dateness of the information.

A 4-point Likert scale was used, with the following interpretations: 1-Not Satisfactory, 2-Poor, 3-Satisfactory, and 4-Very Satisfactory, to evaluate the developed practical laboratory-based activities in General Chemistry for Grade 11 students. For content, format, presentation, and organization of the developed practical laboratory-based activities, the following criteria were used:

Mean Rating	**Descriptive Rating**
3.26 - 4.00	Very Satisfactory

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2.51 - 3.25	Satisfactory
1.76-2.50	Poor
1.00 - 1.75	Not Satisfactory

For accuracy and up-to-dateness of information on the developed practical laboratory-based activities, the following were used:

Mean Rating	**Descriptive Rating**
3.26 - 4.00	No error
2.51 - 3.25	Presence of an error but very minor and must be fixed
1.76 - 2.50	Presence of error and requires significant revision
1.00 - 1.75	Poor

Moreover, to analyze and interpret whether the developed practical laboratory-based activities for Grade 11 students passed or failed the evaluation criterion for printed materials, the following were used:

Passing Scores

Factor 1: At least 21 points out of a maximum of 28 points

Factor 2: At least 54 points out of a maximum of 72 points

Factor 3: At least 15 points out of a maximum of 20 points

Factor 4: At least 24 points out of a maximum of 24 points

The second part was the readability test, which was used to determine the minimum grade level at which the developed practical laboratory-based activities could be understood at the first reading. To calculate the text difficulty, reading age, and average grade level of the developed practical laboratory-based activities, the following were used:

Flesch Reading Ease Score	**Level Flesh Kincaid**	**Grade Level**
90-100	Very Easy	5th Grade
80-89	Easy	6th Grade
70 79	Fairly easy	7th-grade
60 69	Standard	8th and 9th Grade
50 59	Fairly difficult	10th to 12th Grade
30- 49	Difficult	in College
0- 29	Very Difficult	College Graduate

Data Gathering Procedure

The researcher personally visited the Ilocos Sur National High School to ask permission to conduct the research

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study. The researcher selected Teacher evaluators from different public secondary schools in the Vigan City and Ilocos Sur Divisions. The researcher also consulted the internet, books, and tutorials that were conducive to developing the learning material. The researcher visited the library for detailed research and read different materials relevant to the study.

After the professor approved the developed learning material, copies were distributed to the ten evaluators in the selected schools. The evaluators were given enough time to respond, and then the researchers collected the evaluation checklists the next working day. The data gathered from this research instrument were tallied and computed for interpretation according to the mean rating of the items checked by the evaluators.

Below is the step-by-step procedure followed by the researcher.

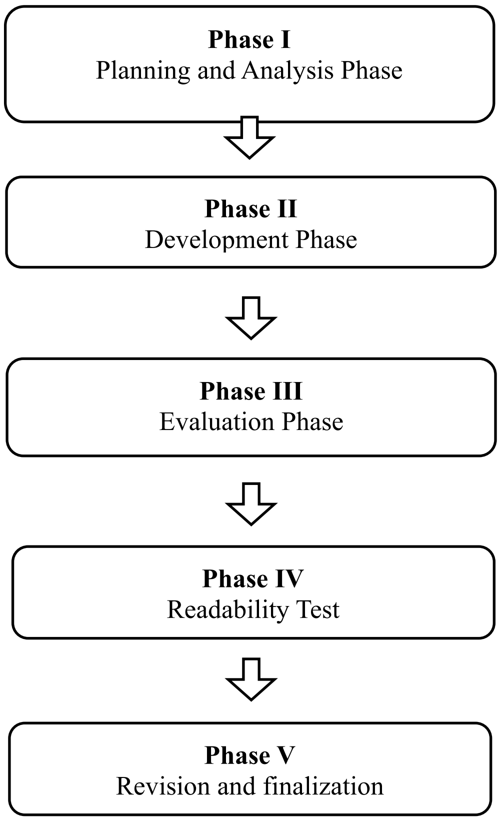

Fig. 2 Flowchart on the planning, development, and evaluation of the material

Phase I: Planning and Analysis stage

Step 1: Analysis and revisiting the Grade 11 General Chemistry curriculum guide. The researcher reviewed the General Chemistry curriculum guide to identify the essential concepts that were emphasized and to propose additional ideas and strategies. It was done to improve student learning, engagement, experience, and outcomes.

The researcher analyzes the content of the different learning materials, including curriculum guides, teacher's guides, and other relevant resources that could be used to construct practical laboratory-based activities. Likewise, the researcher reviewed and selected general chemistry books published in the Philippines as part of the needs assessment. The developed learning material underwent evaluation and readability to guarantee its quality. Different experts in the field of Science were invited to evaluate the material.

Step 2: Identification of the least mastered competencies: The researcher adopted the 2022-2023 diagnostic test results in General Chemistry 1 for Grade 11 Science Technology, Engineering, and Mathematics students at Ilocos Sur National High School in the first quarter. The researcher secured all the necessary communication letters and documents for the use of the data in the study. It was done to identify the least learned competencies in General Chemistry 1, which became the basis for the activities included in the learning material. The data served as the foundation for selecting the topics and drafting the activities included in the learning material.

Step 3: Planning and organizing the learning competencies. The researcher ensured that the activities in the practical laboratory-based activities were hands-on and student-centred laboratory activities designed to address the identified least mastered competencies in General Chemistry. The learning objectives in each activity were aligned with the identified least mastered competencies in General Chemistry.

Phase II: Development stage

Step 4: Designing the Practical Laboratory-Based Activities. The instructional materials developed were used to address the topics that are difficult for learners to understand. Each material had eight parts: the Introduction, objective, materials, procedures, results and discussion, guide questions, conclusions, and references. The components of this learning material were based on existing laboratory worksheets, manuals, and other learning resources. However, some modifications were made to achieve the intended competencies in each of the topics, and each activity utilized practical materials in the laboratory work.

The learning resources were created to support students' growth in subject-matter expertise, scientific reasoning abilities, awareness of the ambiguity and complexity of empirical work, practical skill development, understanding of the nature of science, encouragement of a love of science and science education, and improvement of teamwork abilities.

Step 5: Preparation of the first draft of practical laboratory-based activities

The first drafts of the learning material undergo informal evaluation. The number of activities in the learning material was aligned with the learning competencies of the identified least mastered topic in General Chemistry. Each developed practical laboratory-based activity was utilized and tested by the students in one of the STEM classes in order for the researcher to pre-assess each one of them. Subsequently, the researcher will present the practical laboratory-based activities to the adviser and colleagues. After this, the experts' insights were processed to determine the strong and weak points of the developed learning materials. Comments and suggestions were considered for the improvement of the material.

Step 6: Revising It involves modifying the development of practical laboratory-based activities based on the comments and suggestions of the expert evaluators.

Phase III: Evaluation Phase

Step 7*:* Evaluation. It involved ten experts who evaluated the developed practical laboratory-based activities using an evaluation-rating sheet for print materials. This rating sheet was adopted from the Learning Resource Management and Development System of the Department of Education. It included indicators on content, format, presentation, accuracy, and up-to-dateness of information. The results were analyzed, and all evaluators' suggestions were noted and followed to improve and enhance the developed practical laboratory-based activities.

Phase IV. Readability Test

The final step was to run readability tests to determine the text's reading difficulty. It entailed putting the developed practical laboratory-based activities for Grade 11 General Chemistry 1 through readability tests, utilizing seven readability formulae to determine the level of reading difficulty using the Flesch Read Ease Score. The readability constructs Flesh Kincaid Grade Level determined the average grade level of students who could understand the text in its first reading.

Phase V. Revision and finalization

It involves the final touches on the practical laboratory-based activities based on the comments and suggestions by the evaluators before its printing.

Ethical Consideration

These encompass the fundamental rules guiding ethical research procedures, ensuring the protection of respondents' rights, integrity, and well-being during the study's conduct. These considerations are underpinned by an ethical approval number A-2023-173, issued by the University of Northern Philippines Ethics Review Committee on the 19th of July, 2023. They outline the parameters that researchers must operate within to negotiate complex ethical and legal requirements in order to carry out investigations that uphold the most significant levels of honesty and consideration for all persons concerned.

The researcher provided the evaluators with complete information regarding the study's main objective and their specific responsibility within it. Before the study, the evaluators were given comprehensive information and a consent form, giving them the option to accept or reject participation. They had the option to withdraw at any moment, in which case their data would be destroyed in order to protect privacy. Once it was confirmed that evaluators were voluntarily involved, that anonymity would be maintained, and that appropriate data gathering procedure had been followed, informed permission was secured.

In addition, although the study's evaluators weren't members of the vulnerable group, the researcher prioritized their rights and welfare. Their rights were respected, and measures were taken to keep them safe. No monetary compensation was given, but a token of appreciation was provided to the school for participation. The researcher and the thesis technical committee decided on particular criteria, which were met by the evaluators who were selected by purposive sampling. They included science master's degree-holding teachers with five years of teaching experience from public or private schools willing to sign informed consent to evaluate the researcher's learning material. Since all participants were adults, their participation did not need their permission.

Evaluators in the research faced only minor risks, with the possibility of mild cognitive disturbance during the evaluation of laboratory-based tasks. In order to lessen this, the researcher made sure that the evaluation form was intelligible and provided enough time to accomplish the form without interfering with regular activities. Encouraging participants to seek clarification and providing them with complete flexibility about leaving the research at no cost meant that their comfort and autonomy were maintained throughout.

The researcher ensured unauthorized access to the data to maintain the evaluator's anonymity and unauthorized confidentiality. It was addressed and supported through, but not limited to, the following: (a) assigning code names/numbers for the evaluators on all research notes and documents and (b)storing survey questionnaires and any additional personally identifiable information of respondents in a secured filing cabinet. The researcher ensured anonymity by removing identifying data from the analyzed information. Results were reported anonymously to prevent associating responses with individuals. All data were stored securely for a year, accessible only to authorized personnel. After dissemination and publication, all records were securely destroyed.

Statistical Treatment of Data

To attain the objectives set for this study, the following statistical tools were used to treat the data gathered:

Mean – is used to determine the evaluation of the developed practical laboratory-based activities in terms of content, instruction, design, and up-to-dateness.

Percentage – it is used to describe the mastery level of the students in all the learning competencies in General Chemistry I

Flesch Read Ease Score – it is used to identify the readability level of the developed practical laboratory-based activities in Grade 11 students.

Presentation, Analysis, And Interpretation Of Data

This chapter presents the analyses and interpretations made on the gathered in the study to answer the problems raised in the previous chapter.

Problem 1. What is/are the least mastered competencies in grade 11 General Chemistry 1 of the Basic Education Curriculum?

a. **Gases Laws,**

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b. Ideal Gas Law, and

c. Dalton's Law?

This section presents the least mastered competencies in grade 11 General Chemistry 1. The least mastered competencies were determined through the learners' diagnostic tests. The first table shows all the learning competencies in General Chemistry 1 for grade 11 students under the academic strand of Science, Technology, Engineering and Mathematics (STEM). The data presented herein represents the adopted result of the diagnostic test that was administered during the first quarter of the school year 2022-2023. Table 2 revealed that specific competencies were least mastered, indicating the lowest level of proficiency among all the competencies assessed. It suggests that students encountered difficulties in achieving these particular competencies, highlighting a gap in their understanding of the subject of chemistry. Consequently, there arises a need to develop practical laboratory activities that promote collaborative learning and enhance their comprehension of these topics.

The data revealed that three competencies were categorized as the least mastered within General Chemistry 1. These competencies include the ability to 'apply gas laws to determine the pressure, volume, or temperature of a gas under certain conditions of changes' with a mastery percentage of 41.44,

Table II Least Mastered Competencies In Grade 11 General Chemistry 1

No	Competencies	% of Mastery	Interpretation
1	Use properties of matter to identify substances and to separate them. STEM_GC11MPIa-b-5	75.31	Proficient
2	Recognize the formulas of common chemical substances. STEM_GC11MPIa-b-9	72.51	Nearly Proficient
3	Compare consumer products on the basis of their components for use, safety, quality, and cost. STEM_GC11MPIa-b-11	72.92	Nearly Proficient
4	Describe various simple separation techniques such as distillation, chromatography STEM_GC11MPIa-b-12	75.49	Proficient
5	Recognize common isotopes and their uses. STEM_GC11AMIc-e-19	76.62	Proficient
6	Represent compounds using chemical formulas, structural formulas, and models. STEM_GC11AMIc-e-21	80.92	Proficient
7	Name compounds given their formula and write a formula given the name of the compound. STEM_GC11AMIc-e-23	60.19	Nearly Proficient
8	Calculate the empirical formula from the percent composition of a compoundSTEM_GC11PCIf-32	77.23	Proficient
9	Calculate molecular formula given molar mass STEM_GC11PCIf-33	75.54	Proficient
10	Write and balance chemical equationsSTEM_GC11CRIf-g-37	76.15	Proficient
11	Construct mole or mass ratios for a reaction in order to calculate the amount of reactant needed or the amount of product formed in terms of moles or mass STEM_GC11MRIg-h-38	76.44	Proficient
12	Calculate the percent yield and theoretical yield of the reaction STEM_GC11MRIg-h-39	75.62	Proficient
13	Explain the concept of limiting reagent in a chemical reaction;	75.38	Proficient

	identify the excess reagent(s)STEM_GC11MRIg-h-40		
14	(LAB) Determine mass relationship in a chemical reactionSTEM_GC11MRIg-h-42	75.79	Proficient
15	Define pressure and give the common units of pressureSTEM_GC11G-Ihi-43	73.38	Nearly Proficient
16	Use the gas laws to determine the pressure, volume, or temperature of a gas under certain conditions of changeSTEM_GC11G-Ihi-45	41.44	Low Proficient
17	Use the ideal gas equation to calculate pressure, volume, Temperature, or number of moles of a gasSTEM_GC11G-Ihi-46	31.57	Low Proficient
18	Use Dalton's law of partial pressures to relate mole fraction and partial pressure of gases in a mixtureSTEM_GC11DLIi-47	27.14	Low Proficient
19	Apply the principles of stoichiometry to determine the amounts (volume, number of moles, or mass) of gaseous reactants and productsSTEM_GC11GSIi-j-48	54.00	Nearly Proficient
20	Relate the rate of gas effusion with molar massSTEM_GC11KMTIj-50	57.23	Nearly Proficient
Average:		66.54	Nearly Proficient

Legend: 90-100 **Highly Proficient (HP);** 75-89 **Proficient (P)** 50-74 **Nearly Proficient (NP)**; 25-49 **Low Proficient (LP)**; 0-24 **Not Proficient (NP).**

Utilize the ideal gas equations to calculate pressure, volume, temperature, or the number of moles of a gas' with a mastery percentage of 31.57, and 'apply Dalton's law of partial pressure to relate mole fraction and pressure of gases in a mixture,' which had a mastery percentage of 27.14. These competencies mainly fall within the Gas Laws, covering Boyle's, Charles', Gay-Lussac's, Dalton's, and the Ideal Gas Laws. It emphasizes the challenges learners face with competencies associated with Gas Laws. The development of practical laboratory materials specifically tailored to this topic is necessary to address this issue.

Furthermore, several learning competencies exhibited near proficiency, with a percentage of mastery ranging between 50-74. Conversely, as presented in the table, certain competencies demonstrated that learners successfully achieved the required objectives, signifying their proficiency, with a percentage of mastery ranging between 75 and 89. Despite the variation in proficiency levels among these competencies, this study primarily focused on those that needed to be mastered.

The study conducted by Acosta (2020) suggested that teachers should use the least-mastered competencies of the students to create instructional materials. Building upon this suggestion, Akani (2015) noted that utilizing laboratory experiments plays a vital role in promoting scientific attitudes and enhancing problem-solving skills among students, particularly in practical chemistry. In response to these findings, he suggested solutions to tackle this issue, one of which was to ensure that schools have access to modern and updated teaching materials.

In light of the findings by Ghani et al. (2017), the utilization of concept maps as an assessment tool within laboratory-based learning activities influenced students' comprehension favourably. It catalyzed elevating their higher-order thinking skills (HOTS).

A similar study conducted by Timilsena et al. (2022) revealed that offering laboratory work activities, implementing learner-centred teaching strategies in science classrooms, connecting chemistry in practical life situations, and bridging gaps in horizontal linkage within the science curriculum were identified as potential solutions to address learning challenges in the field of chemistry within science education.

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Problem 2. What Practical Laboratory-based activities can be developed in grade 11 General Chemistry I?

The diagnostic test results unveiled the challenges that Grade 11 students were facing, particularly within the domain of Gas Laws, including Charles's, Boyle's, Gay-Lussac's, Dalton's, and the ideal gas law, under the subject of General Chemistry 1. In response to these challenges, the researcher embarked on developing a learning material to assist students in overcoming these competencies.

The material was carefully designed to create engaging and meaningful learning experiences by integrating practical activities, particularly through experiments that can be done not only inside the laboratory school but also in their own houses due to the use of practical material that can be found in any place. By doing so, students could effectively connect their classroom knowledge to real-life experiences, reinforcing their understanding of the subject matter.

Furthermore, the experiments offered in this learning material were hands-on activities. Through this approach, students were able to connect their classroom theory with practical experiences. Consequently, students not only theoretically understood the subject matter but also got the chance to apply what they had learned in a useful, concrete way. It also promotes collaboration and exploration among students, enhancing their comprehension and application of the topics addressed in the experiments.

The researcher developed Practical Laboratory-Based Activity material in General Chemistry for Grade 11 students. The title of this material was "I Lab Gases." The molecular structures of the five common gases found in the Earth's atmosphere: nitrogen (N), oxygen (O), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are illustrated on the material's cover page. Different colours represent each element from these gases to make the material more attractive to the users.

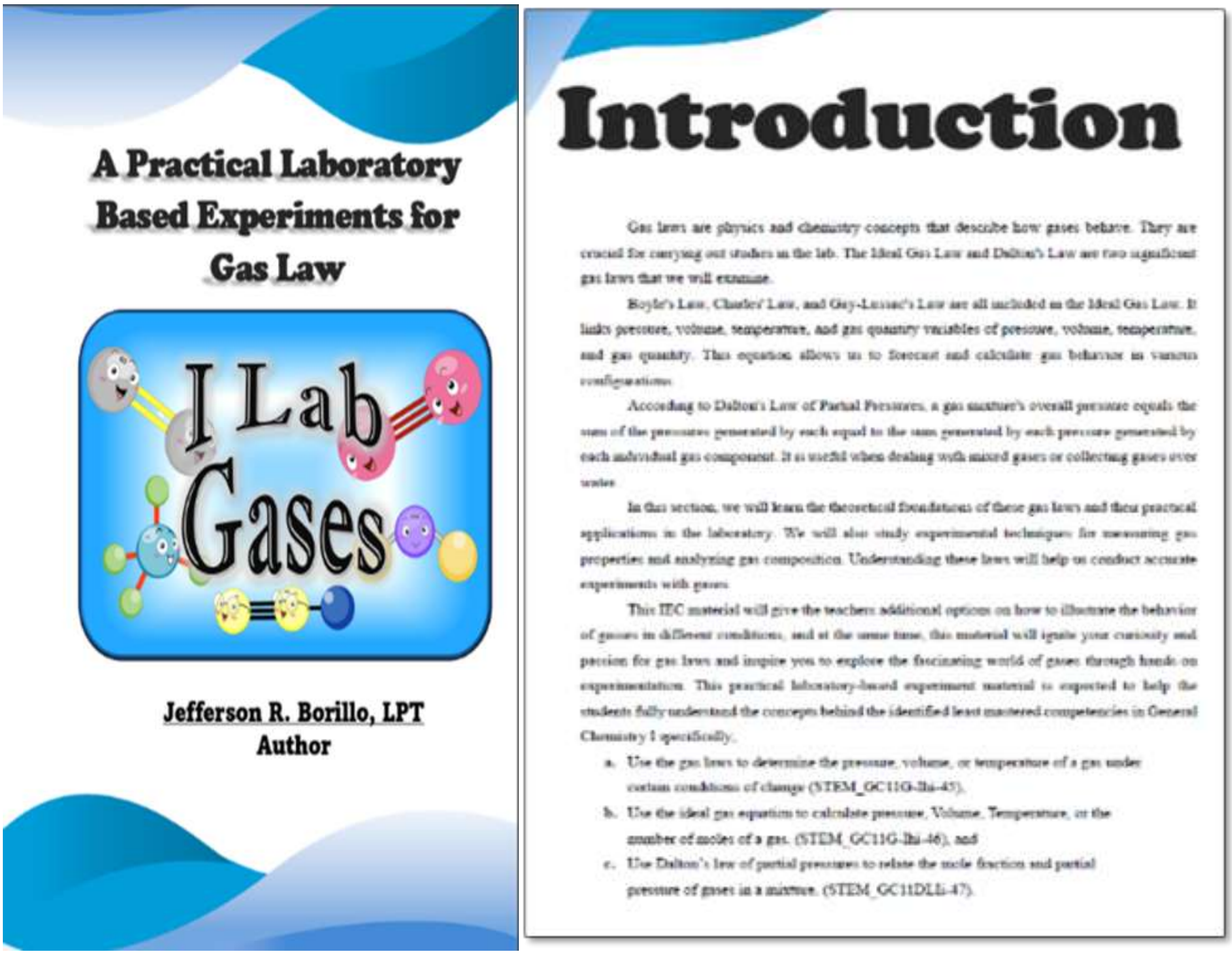

Fig. 3 Cover page and Introduction of the learning material with the identified least mastered competencies

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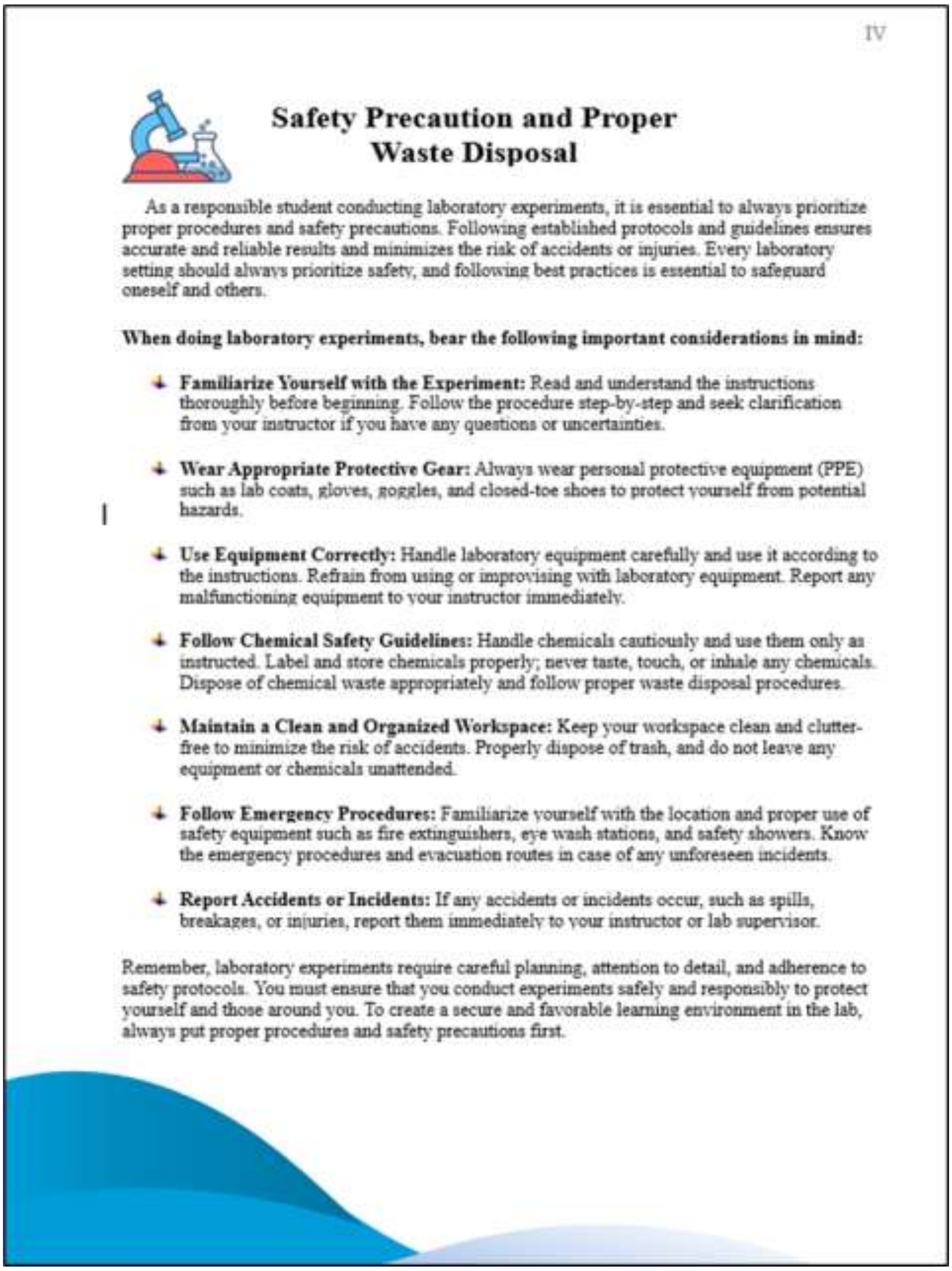
This material encompasses the Gas Laws, including Boyle's, Charles's, Gay-Lussac's, Dalton's, and the Ideal Gas Laws. It comprises a series of engaging experiments related to these topics, offering various hands-on activities designed to help students explore these concepts. The primary aim is to address topics that are difficult for learners to understand mainly within the scope of General Chemistry 1.



IV

Safety Precaution and Proper Waste Disposal

As a responsible student conducting laboratory experiments, it is essential to always prioritize proper procedures and safety precautions. Following established protocols and guidelines ensures accurate and reliable results and minimizes the risk of accidents or injuries. Every laboratory setting should always prioritize safety, and following best practices is essential to safeguard oneself and others.

When doing laboratory experiments, bear the following important considerations in mind:

- **Familiarize Yourself with the Experiment:** Read and understand the instructions thoroughly before beginning. Follow the procedure step-by-step and seek clarification from your instructor if you have any questions or uncertainties.
- **Wear Appropriate Protective Gear:** Always wear personal protective equipment (PPE) such as lab coats, gloves, goggles, and closed-toe shoes to protect yourself from potential hazards.
- **Use Equipment Correctly:** Handle laboratory equipment carefully and use it according to the instructions. Refrain from using or improvising with laboratory equipment. Report any malfunctioning equipment to your instructor immediately.
- **Follow Chemical Safety Guidelines:** Handle chemicals cautiously and use them only as instructed. Label and store chemicals properly; never taste, touch, or inhale any chemicals. Dispose of chemical waste appropriately and follow proper waste disposal procedures.
- **Maintain a Clean and Organized Workspace:** Keep your workspace clean and clutter-free to minimize the risk of accidents. Properly dispose of trash, and do not leave any equipment or chemicals unattended.
- **Follow Emergency Procedures:** Familiarize yourself with the location and proper use of safety equipment such as fire extinguishers, eye wash stations, and safety showers. Know the emergency procedures and evacuation routes in case of any unforeseen incidents.
- **Report Accidents or Incidents:** If any accidents or incidents occur, such as spills, breakages, or injuries, report them immediately to your instructor or lab supervisor.

Remember, laboratory experiments require careful planning, attention to detail, and adherence to safety protocols. You must ensure that you conduct experiments safely and responsibly to protect yourself and those around you. To create a secure and favorable learning environment in the lab, always put proper procedures and safety precautions first.

Fig. 4 Detailed safety precautions and proper disposal procedures for conducting different experiments.

Each experiment in this material promotes students' critical thinking and problem-solving skills, utilizing readily available household materials. This approach enables learners to relate each concept to their daily lives, fostering real-life learning experiences. Additionally, these experiments empower students to make keen observations, develop hypotheses, and draw meaningful conclusions from the data they collect, further enhancing their understanding of scientific principles.

Safety Precaution and Proper Waste Disposal. The following procedures and rules were set for the students to follow before, during, and after each experiment to ensure accurate and dependable results and minimize any potential mishaps or injuries in the working area. The provided guidelines covered the following: Familiarization with the experiment, use of protective gear, correct use of equipment, organization of the working area, following the emergency procedures, and reporting for any accident or incident. These guidelines will also help teachers easily monitor each student's safety.

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Introduction and The Most Essential Learning Competency (MELC). It provides users with a relatable experience, prompting intriguing questions and introducing the concept of gas laws. An outline of the idea is given, including the variables that were employed in the experiment. Additionally, it includes the Most Essential Learning Competency (MELC) that students must acquire before progressing to the next topic**.**

Lab Partners: ______________________ **Date:** __________

Grade and Section: ______________________ **Score:** __________

Experiment No. 1

Title: Unpredictable Tire

Introduction

Whether it happened while driving or simply when finding a flat tire in the parking lot, we have all the experience of a tire suddenly deflating. Even while it could be a hassle, the science underlying this occurrence is quite intriguing. Charles's Law, which outlines the link between a gas's volume and temperature, is one crucial scientific concept at play when a tire deflates. It explains how changes in temperature affect the properties of the air inside your tires, similar to how it governs the behavior of gases. Let's explore the intriguing connection between Charles's Law and your tire's performance. We will discover how this scientific concept impacts tire pressure, handling, and your driving experience. Charles' Law can be written mathematically as follows:

Figure 1.1. A driver experiencing a flat tire on the road.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \text{ or } \frac{V}{T} = k$$

Where V is the volume of the gas, T is the gas's absolute temperature, and k is a constant. This equation can be rearranged to solve for any of the variables.

Most Essential Learning Competency: Use the gas laws to determine the pressure, volume, or temperature of a gas under certain conditions of change (*STEM_GC11G-Ihi-45*)

Lab Partners: ______________________ **Date:** __________

Grade and Section: ______________________ **Score:** __________

Experiment No. 6

Title: Heat Wave

Introduction

Around the world, pressure cookers are frequently used in kitchens to prepare meals rapidly and effectively. But have you ever thought about how these tools relate to the intriguing realm of chemistry? One key scientific principle that can be applied to pressure cookers is Gay-Lussac's Law, also known as the pressure-temperature relationship. This fundamental law sheds light on how gases behave and explains why pressure cookers operate differently from other cooking appliances. In order to better understand how Gay-Lussac's Law relates to pressure cookers, let's carry out a quick experiment that demonstrates gas flow inside a system.

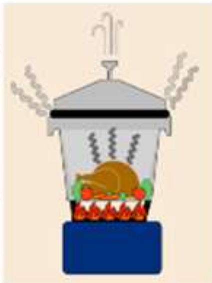

Figure 6.1 Cooking chicken in a pressure cooker.

Most Essential Learning Competency: Use the gas laws to determine pressure, volume, or temperature of a gas under certain conditions of change (*STEM_GC11G-Ihi-45*)

I. LEARNING OBJECTIVES:

- Demonstrate a double displacement reaction in the setup.
- Calculate the pressure, volume, temperature, or the number of moles of a gas.
- Examine the relationships between pressure, volume, temperature, and the number of moles (n) of gas in a system.

II. MATERIALS

- Baking powder
- Vinegar
- Triple Beam Balance
- Plastic Bottle
- Balloon
- Tape Measure
- Scissor and Market
- Spatula

Fig. 5 Sample introduction, learning objectives, and materials for one of the experiments

Learning Objectives and Materials. At the start of each experiment, measurable learning objectives are provided, which students should achieve by the experiment's end. These objectives serve as a guide for both students and teachers, outlining the activity's purpose. Following this, the materials to be used during the experiment are introduced. These materials are commonly found in households and have practical applications in our daily activities at home.

Procedure. It offers clear, step-by-step instructions organized chronologically for gathering data. It also provides a visual representation of the experiment's arrangement, which guides students in carrying out the experiment. This visual aid helps students perform each procedure accurately, aided by the accompanying pictures.

III. PROCEDURE

1. Get a clear plastic bottle and clean it, removing any labels or stickers.
2. Create a small hole in the center of the plastic cup and tightly fit a tire valve into it.
3. Use a glue gun to secure the tire valve in place and check for any leaks.
4. Place a thermometer inside the bottle and screw the cup onto the bottle.
5. Connect an air pump to the tire valve.
6. Pump the bottle twice and check the thermometer for any temperature change.
7. Use a pressure gauge meter to measure the pressure inside the bottle and record the data.
8. Repeat the process for additional trials, adding two pumps each time and recording temperature and pressure changes.
9. Continue adding two pumps until you reach Trial E (a total of 10 pumps).
10. If the pressure becomes too high and the bottle cannot contain the gas, seek assistance from your teacher to assess the situation and prevent any untoward incidents.

Figure 6.2. measuring the air pressure inside the bottle using pressure gauge. *Figure 6.3. Thermometer inside a plastic bottle.*

IV. RESULT AND DISCUSSION

Data Table	
Amount of 3% Peroxide used (mL)	
Mass of peroxide solution used (g)	
Volume of Oxygen Collected (mL)	
Temperature of Water (°C)	
Barometric Pressure (atm) (provided by instructor)	
Water vapor pressure from table (torr)	
Water vapor pressure (atm)	

Compute the following:

A. Pressure of the oxygen (atm)?

B. Volume of Oxygen collected (L)?

C. Temperature of oxygen (K)?

D. Moles of Oxygen collected (mol)?

E. Moles of H_2O_2 in the sample (mol)?

F. Mass of peroxide in sample (g)?

G. % hydrogen peroxide in solution (%)?

Fig. 6 Image of the step-by-step procedure for conducting the experiments in the learning material.

RESULT AND DISCUSSION.

It presents the experiment's findings and results using tables and graphs. It explains the unexpected outcome and how it affected the data acquired and analyzed. It analyzes the strengths and weaknesses of the experiment's design and compares your findings with those of other studies of a similar nature.

V. GUIDE QUESTIONS

1. Considering that catalysts are not consumed in the reaction, do you think increasing the amount of catalyst would affect the reaction rate for the decomposition of hydrogen peroxide? Why or why not?
2. Would there be a change in the value of "n" if the sample of gas used in the experiment is not CO_2?
3. Would the balloon's volume still be the same if you changed the amount of chemicals added in the experiment instead of the pressure? Explain your answer.
4. Compare the size of your balloon with other groups and observe if there is a difference between them. If there is explain some factors that cause these differences
5. How does Ideal Gas Law demonstrate the behavior of gases in different environmental conditions?

VI. CONCLUSION

Direction: In the space provided below, formulate your conclusion by summarizing the key findings and results of the experiment, and discuss the implications or significance of these findings.

Fig. 7 Sample guide questions and the conclusion part of the learning material.

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The Conclusion. It enables the learners to present the overall result based on experimental readings and observations made throughout the experiment. It describes the findings, encountered errors that could have occurred, and real-world applications of the experiment.


Name: ____________ Date: ____________
Grade and Section: ____________ Score: ____________

Enrichment Activity

DIRECTION: Carefully read the problem and use Ideal Gas law to solve the question below. Show your solution in the space provided.

1. A weather balloon is inflated with 4 moles of helium gas at a pressure of 1 atm and a temperature of 25 degrees Celsius. If the balloon rises to an altitude where the pressure is only 0.5 atmospheres and the temperature is -10 °C, what will be the new volume of the balloon?

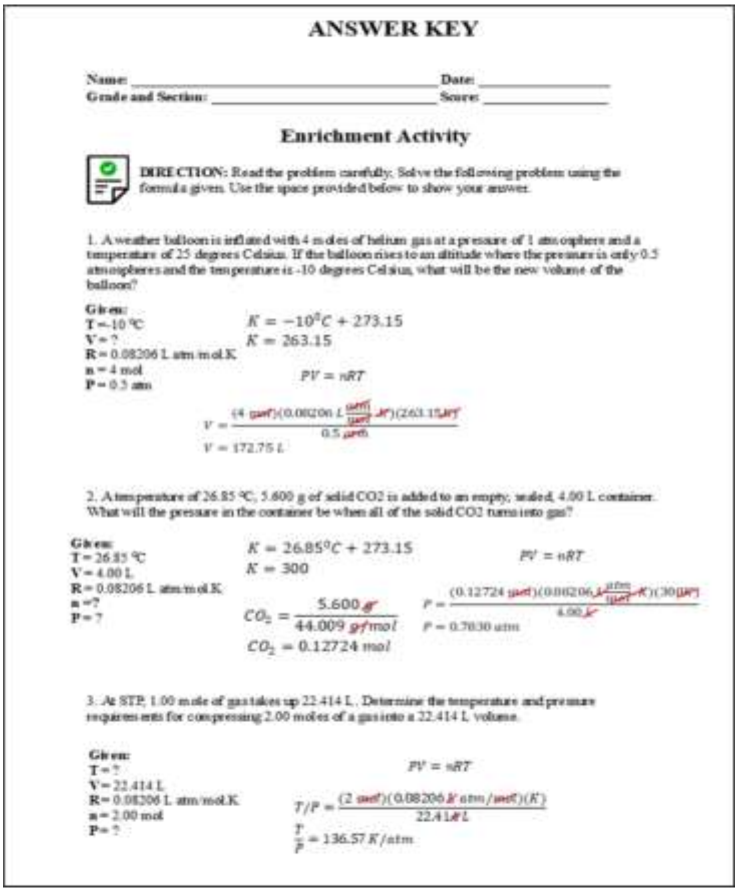
2. A temperature of 26.85 °C, 5.600 g of solid CO_2 is added to an empty, sealed, 4.00 L container. What will the pressure in the container be when all of the solid CO_2 turns into gas?

3. At STP, 1.00 mole of gas takes up 22.414 L. Determine the temperature and pressure requirements for compressing 2.00 moles of a gas into a 22.414 L volume.

Fig. 8 A sample enrichment activity for one of the topics

Enrichment Activity. It offers more stimulating avenues for students to solve problems, enabling them to use the knowledge they gained from the experiment and deepen their understanding of the main idea.

Answer Key. It provides students with correct answers, enabling independent checking of their work and allowing them to see how the problem is solved in a step-by-step process.


ANSWER KEY

Name: ____________ Date: ____________
Grade and Section: ____________ Score: ____________

Enrichment Activity

DIRECTION: Read the problem carefully. Solve the following problem using the formula given. Use the space provided below to show your answer.

1. A weather balloon is inflated with 4 moles of helium gas at a pressure of 1 atmosphere and a temperature of 25 degrees Celsius. If the balloon rises to an altitude where the pressure is only 0.5 atmospheres and the temperature is -10 degrees Celsius, what will be the new volume of the balloon?

Given:
T=-10 °C
V=?
R=0.08206 L atm mol.K
n=4 mol
P=0.5 atm

$K = -10^0C + 273.15$
$K = 263.15$

$PV = nRT$

$V = \frac{(4\ mol)(0.08206\ L\ \frac{atm}{mol}\ K)(263.15\ K)}{0.5\ atm}$
$V = 172.75\ L$

2. A temperature of 26.85 °C, 5.600 g of solid CO2 is added to an empty, sealed, 4.00 L container. What will the pressure in the container be when all of the solid CO2 turns into gas?

Given:
T=26.85 °C
V=4.00 L
R=0.08206 L atm/mol.K
n=?
P=?

$K = 26.85^0C + 273.15$
$K = 300$

$CO_2 = \frac{5.600\ g}{44.009\ g/mol}$
$CO_2 = 0.12724\ mol$

$PV = nRT$

$P = \frac{(0.12724\ mol)(0.08206\ L\frac{atm}{mol}\ K)(300\ K)}{4.00\ L}$
$P = 0.7830\ atm$

3. At STP, 1.00 mole of gas takes up 22.414 L. Determine the temperature and pressure requirements for compressing 2.00 moles of a gas into a 22.414 L volume.

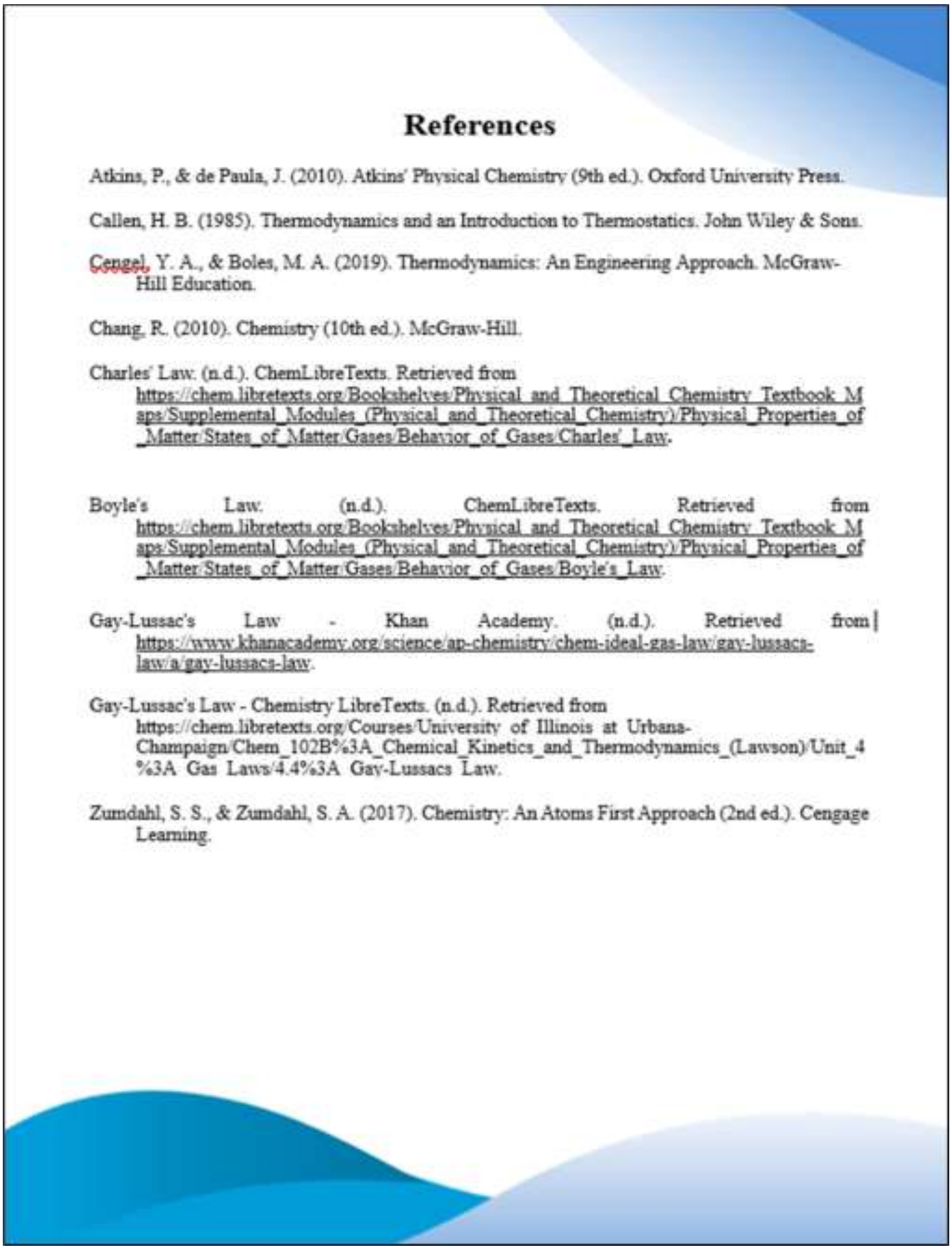
Given:
T=?
V=22.414 L
R=0.08206 L atm/mol.K
n=2.00 mol
P=?

$PV = nRT$

$T/P = \frac{(2\ mol)(0.08206\ L\ atm/mol)(K)}{22.414\ L}$
$\frac{T}{P} = 136.57\ K/atm$

Fig. 9. Detailed solution to one of the enrichment activities in the learning material.

Reference. Provides reading to the students. It is a carefully compiled list of resources the students used to reinforce the concepts and skills they learned.



References

Atkins, P., & de Paula, J. (2010). Atkins' Physical Chemistry (9th ed.). Oxford University Press.

Callen, H. B. (1985). Thermodynamics and an Introduction to Thermostatics. John Wiley & Sons.

Cengel, Y. A., & Boles, M. A. (2019). Thermodynamics: An Engineering Approach. McGraw-Hill Education.

Chang, R. (2010). Chemistry (10th ed.). McGraw-Hill.

Charles' Law. (n.d.). ChemLibreTexts. Retrieved from https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Gases/Behavior_of_Gases/Charles'_Law.

Boyle's Law. (n.d.). ChemLibreTexts. Retrieved from https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Gases/Behavior_of_Gases/Boyle's_Law.

Gay-Lussac's Law - Khan Academy. (n.d.). Retrieved from https://www.khanacademy.org/science/ap-chemistry/chem-ideal-gas-law/gay-lussacs-law/a/gay-lussacs-law.

Gay-Lussac's Law - Chemistry LibreTexts. (n.d.). Retrieved from https://chem.libretexts.org/Courses/University_of_Illinois_at_Urbana-Champaign/Chem_102B%3A_Chemical_Kinetics_and_Thermodynamics_(Lawson)/Unit_4%3A_Gas_Laws/4.4%3A_Gay-Lussacs_Law.

Zumdahl, S. S., & Zumdahl, S. A. (2017). Chemistry: An Atoms First Approach (2nd ed.). Cengage Learning.

Fig. 10. List of references used in crafting the content of the learning materials.

Additionally, it contains essential information that needs to be present in the books.

The researcher carefully crafts each part of the Practical Laboratory-Based Activity material to meet the standards of the Department of Education, providing opportunities for the students to explore the selected topics by integrating real-life scenarios and materials. This technique promotes practical application outside the theoretical domain and enhances learning by enabling students to understand complex concepts through hands-on inquiry.

Problem 3. What is the evaluation of the developed practical laboratory-based activities in Grade 11 students?

The next step involved creating and selecting the best practical activities suitable for the learning material. These activities were then evaluated by matching them with the areas of least mastery identified through the diagnostic

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test results. The aim was to address these issues specifically for Grade 11 students, using practical laboratory-based activities. Selected chemistry teachers carefully evaluated and reviewed these criteria to ensure the quality and appropriateness of the learning material. Tables 3, 4, 5, and 6 present the evaluation of the experts on the developed practical laboratory-based activities for Grade 11 along content, format, presentation, organization, accuracy, and Up-to-datedness of Information.

As Almanasreh et al. (2019) noted, the instrument development process depends heavily on evaluation procedures and the criteria that go with them. Thus, they should be regarded and reported with the same amount of priority as other evaluation techniques. Since the data gathered during this step is crucial for verifying the quality of the newly developed material, the evaluation method merits rigour. It recommends that in order to prove their quality, newly produced materials should be subjected to expert evaluation using a trusted instrument.

Table 3 shows the evaluation of the Developed Practical Laboratory-Based Activities in Grade 11 along content. This table provides crucial insights into these practical activities' quality and academic soundness, ensuring that they align effectively with the educational goals and curriculum requirements for Grade 11 students.

As presented in the table, the evaluation of the Developed Practical Laboratory-Based Activities for Grade 11 students, along with the content, yields a passing score of 27.60, leading to the decision of "Passed." This outcome emphasizes that the material's content has successfully surpassed the requisite standards and criteria. The developed learning material succeeds in several areas, highlighting its remarkable quality. It is carefully adjusted to match the students' developmental stage, perfectly meeting their interests. The content's effectiveness is further demonstrated by its crucial role in meeting grade/year level goals and particular subject area objectives. It distinguishes itself, in particular, by encouraging the growth of higher cognitive abilities like creativity, active learning, and problem-solving. It upholds an admirable dedication to objectivity, free from ideological, cultural, religious, racial, or gender prejudices, and delivers a fair and unbiased educational experience.

Table III the evaluation of the developed practical laboratory-based activities in grade 11 along content

Factor 1 Content	$\bar{x}$	**DR**
1. Content is suitable to the student's level of development.	4.00	VS
2. Material contributes to the achievement of specific objectives of the subject area and grade/year level for which it is intended.	4.00	VS
3 Material provides for the development of higher cognitive skills such as critical thinking, creativity, learning by doing, inquiry, problem-solving, etc.	4.00	VS
4. Material is free of ideological, cultural, religious, racial, and gender biases and prejudices.	4.00	VS
5. Material enhances the development of desirable values and traits such as: (Put a check ***(√)*** mark only to the applicable values and traits)	3.60	VS
6. Material has the potential to arouse the interest of the target reader.	4.00	VS
7. Adequate warning/cautionary notes are provided in topics and activities where safety and health are of concern.	4.00	VS
Decision	27.60 (Passed)	

Note: Resource must score **at least 21 points** out of a maximum of **28 points** to pass this criterion. Please put a checkmark **(√)** on the appropriate box.

Mean Rating	**Descriptive Rating**
3.26 - 4.00	Very Satisfactory
2.51 - 3.25	Satisfactory

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1.76-2.50	Poor
1.00 - 1.75	Not Satisfactory

Additionally, it has a unique talent for engrossing and captivating its target audience, earning a mean rating of 4.00 (Very satisfactory). These findings have been supported by a comment from one of the evaluators, emphasizing that the content of the developed material is very substantial and informative. Learners can easily relate to the concept since they already learned it in grade 10. This indicates that the material has been customized to the student's level, successfully meeting nearly all the indicators specific to this factor, thereby indicating the presence of high-quality content within the developed material. On the other hand, the deficiency in the learning materials becomes evident when it comes to fostering desirable values and traits, as indicated by a mean rating of 3.60 (Very Satisfactory). These materials should strengthen patriotism and encourage the expression of love and respect for the country.

Additionally, it should also impart essential qualities to students, including productivity, a scientific attitude, and sound reasoning skills. Hence, incorporating some desirable traits and values in the part of the introduction is also added to the learning material. Understanding the evaluation of these activities, especially concerning their content, is essential for enhancing the overall educational experience and the successful achievement of learning outcomes. According to Membrebe and Anadia (2015), it is suggested that the contents of supplementary learning materials must be carefully assessed following the content criterion provided by the DepEd so it can be used as instructional material to improve science teaching, facilitate the learning process, and, most importantly, to improve student achievement on least mastered competencies. The study conducted by Funa & Ricafort (2019) suggested that educational materials should incorporate objectives explicitly outlined as specific, quantifiable, achievable, dependable, and time-sensitive. These materials should also encompass easily handled, logically structured, and effectively sequenced activities, all geared towards facilitating learners in comprehending and applying subject-area concepts. Additionally, evaluations should be designed to enhance learners' grasp of concepts and align with the behavioural objectives set for each activity.

On the other hand, Mijares (2023) stated that instructional materials should emphasize embedding skills and knowledge in holistic and realistic contexts. Anchored contexts support complex and ill-structured problems in which learners generate new knowledge and subproblems while determining how and when knowledge is used. Furthermore, the study conducted by Tolentino et al. (2023) emphasized that the learning materials should adhere to specific criteria to benefit learners and improve the learning experience.

It suggests that it must consider factors such as language, content, format, activities, and organization when creating high-quality learning material. There needs to be more than evaluation in terms of its content to ensure the quality of the learning material. It is also important to evaluate the activities with respect to their format. It is essential to ensure that they are designed in a manner that optimally supports the educational goals and learning experiences of Grade 11 students.

Table 4 presents the evaluation of the Developed Practical Laboratory-Based Activities in Grade 11 along Format.

Based on the table, the format got an overall score of 67.80 points, indicating a "Passed" decision. This score easily exceeds the criterion's minimal point requirement of at least 54 points. This suggests that the learning material was crafted following the requirements established by the Department of Education, allowing the intended users to use the materials effortlessly due to their portability, high-quality printing, durability, and appealing text and illustrations.

Table IV The Evaluation of The Developed Practical Laboratory-Based Activities In Grade 11 Along Format

Factor 2: Format	$\bar{x}$	DR
Prints		

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1.1 The size of letters is appropriate to the intended user.	4.00	VS
1.2 Spaces between letters and words facilitate reading.	3.70	VS
1.3 Font is easy to read.	4.00	VS
1.4 Printing is of good quality (i.e., no broken letters, even density, correct alignment, properly placed screen registration).	3.60	VS
Illustrations		
2.1 Simple and easily recognizable.	4.00	VS
2.2 Clarify and supplement the text.	3.80	VS
2.3 Properly labelled or captioned (if applicable)	3.10	S
2.4 Realistic/appropriate colors.	3.90	VS
2.5 Attractive and appealing.	3.50	VS
2.6 Culturally relevant.	3.60	VS
Design and Layout		
3.1 Attractive and pleasing to look at.	3.90	VS
3.2 Simple (i.e., does not distract the attention of the reader).	4.00	VS
3.3 Adequate illustration in relation to text.	3.20	S
3.4. Harmonious blending of elements (e.g., illustrations and text).	3.50	VS
Paper and Binding		
4.1 The paper used contributes to easy reading.	4.00	VS
4.2 Durable binding to withstand frequent use.	4.00	VS
Size and Weight of Resource		
5.1 Easy to handle.	4.00	VS
5.2 Relatively light.	4.00	VS
Decision	67.80 (Passed)	

Note: Resource must score **at least 54 points** out of a maximum of **72 points** to pass this criterion. Please put a checkmark on the appropriate box.

Under the prints, the developed material exhibited a positive rating on the size of the letters used, allowing each paragraph to be readable to the intended users. Because of this, it got the highest mean rating of 4.00 (very satisfactory). This proved that selecting the appropriate font size in printed materials is crucial as it directly impacts the readability of the material, ensuring the message will be effectively conveyed to the learners. Moreover, the printing quality of the material got the lowest mean rating of 3.60 (very satisfactory). The evaluator identified minor issues such as paragraph alignment inconsistencies, word density irregularities, and broken letters, resulting in incomplete messages. These results were supported by one of the comments written by the evaluator, reminding that the alignment of text on all pages must be observed. This comment highlighted the importance of text alignment for a better material appearance, which significantly affects its format. Moreover, this inferred the need for pre-printing quality checks to address minor faults, emphasizing the requirement for well-maintained, functional printing equipment to create high-quality prints and prevent such issues continuously.

Furthermore, In each activity from the material, a simple and easy-to-recognize illustration was included for the purpose of showing an overview of the setups that the students need to perform, same as with the concepts that they need to explore with this a mean rating of 4.00 (very satisfactory). On the other hand, teacher evaluators are satisfied with the illustrations included in the material. A few of them needed labels, which is essential in providing clarity and details about the illustrations presented, resulting in the lowest mean rating of 3.10 among all the items evaluated. These results were significantly influenced by the comments provided by some evaluators, emphasizing the necessity of including captions and labels in each picture, as well as citing the sources if the picture is not original. They emphasized citing sources when using non-original images, highlighting a commitment to ethical practices, and ensuring due credit and transparency in the materials presented. Similar comments from other evaluators also underscored the importance of having a caption for each picture. Therefore, citing sources and adding labels to the illustrations and pictures were included in the learning material to provide clarity and details to the illustrations.

This underscores the importance of including labels to provide students with insights into the content of an illustration. In the study conducted by Estacio (2015), he emphasized that instructional aids should be comprehensive, include explanatory labels, and strive for simplicity. The results of this study align with his recommendations, as respondents perceived the developed instructional material as complete, simple, and easy to understand. According to the study conducted by Givera (2023), In order to capture students' attention, the researcher should create instructional material that is visually appealing and engaging. All ideas have been contextualized and simplified simultaneously to keep readers' interest from the beginning until the end.

Planning an appropriate design and layout for any developed materials is an important decision; this is essential as it captures interest and leaves a favorable impression on the material's users. The developed learning material, characterized by its simplicity, is devoid of distractions for learners, and it has garnered the highest mean rating of 4.00 (very satisfactory). Remarkably, despite its simplicity, the material maintains an appealing and visually pleasing quality. Meanwhile, the evaluators noted that the materials lacked adequate illustrations relative to the text, receiving the lowest mean rating of 3.20 (Satisfactory). This implies that incorporating more illustrations into the materials could assist students in visualizing instructions and provide them with guidance to complete tasks effectively. Hence, additional illustrations/pictures were incorporated into the procedure of the activities for better visualization of the task needed to be performed. As Aquino (2018) suggests, illustrations can captivate attention, bolster retention, improve comprehension, and establish context.

On the other hand, the binding methods applied for assembling the learning materials ensure their durability and make them resilient enough to endure repeated handling by both learners and educators. Moreover, the high-quality paper used significantly contributes to the visual appeal and functionality of the learning materials due to its pleasing texture and the vivid, high-quality rendering of colours and text. These features facilitate ease of use and contribute to the learning materials' overall appeal. The evaluators find it convenient to carry these materials to various locations due to their lightweight design, which minimizes the physical burden of transporting them. It is evident from these characteristics that the evaluators are very satisfied with the outcome of the materials, gaining both criteria with a mean rating of 4.00. The combination of durable binding, exceptional paper quality, and user-friendly design collectively underscores the excellence of these learning materials. Several comments from the evaluators have been considered to enhance the developed material overall. Some of these recommendations include italicizing and bolding the Most Essential Learning Competency (MELC), ensuring consistency in capitalization for activity objectives, incorporating a grid section in the material where students can input data from their graphs, and providing a specific amount/length of time the material to be used by the user. Through the evaluation of various experts and integration of these suggestions, the researcher was able to improve the material further, surpassing the standards specified by the DepEd. This enhancement allows users to comprehend the topics presented in each experiment easily.

The following table shows the evaluation of how effectively these activities are arranged and presented. Such an analysis is crucial for educators and curriculum designers to ensure that these practical activities are academically sound, engaging, and well-structured, aiming for optimal student learning outcomes.

Table 5 presents the evaluation of the Developed Practical Laboratory-Based Activities in Grade 11, along Presentation and Organization.

As shown in the table, a total score of 18 points, resulting in a "Passed" decision for this factor, exceeds the required score of 15 points to pass this criterion. This indicates that the material is suitable for its intended

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educational purpose. Learners are provided with a well-structured and effective resource that enhances their understanding and engagement with practical laboratory activities. The success of this teaching material has been attributed to careful planning and attention to detail, which has eventually benefited both educators and students. The language and presentation of the instructional material are excellent in many ways. It expertly modifies its terminology to correspond with the experience and comprehension level of the intended reader, guaranteeing accessibility and interest.

Table V The Evaluation of The Developed Practical Laboratory-Based Activities in Grade 11, Along Presentation and Organization

Factor 3: Presentation and Organization	$\bar{x}$	DR
1. Presentation is engaging, interesting, and understandable.	3.50	VS
2. There is a logical and smooth flow of ideas.	3.50	VS
3. Vocabulary level is adapted to the target reader's likely experience and level of understanding.	3.60	VS
4. The length of sentences is suited to the comprehension level of the target reader.	3.90	VS
5. Sentences and paragraph structures are varied and interesting to the target reader.	3.70	VS
Decision	18.20 (Passed)	

Note: Resource must score **at least 15 points** out of a maximum of **20 points** to pass this criterion. Please put a checkmark on the appropriate box.

Moreover, it skillfully adjusts sentence length according to the reader's comprehension level to promote greater understanding. Notably, the content is distinguished by the use of stimulating and varied sentence and paragraph patterns, which improve readability and hold the reader's attention. It is a compelling instructional resource due to these factors taken together.

In addition, the importance of offering clear and comprehensive instructions during experimentation must be emphasized more. These instructions serve as a guide for learners, enabling them to navigate the experimental process with clarity and confidence. The outstanding mean rating of 3.90, signifying a high level of satisfaction among evaluators, underscores the fact that teacher evaluators found the instructions clear and suitable for lower grade levels. This achievement reflects meticulous consideration of the material's comprehensibility, ensuring that it aligns perfectly with the intended grade level and fostering a positive and productive learning experience. As suggested by Dizon & Villanueva (2022), incorporating more exciting and understandable sentences; organizing the lectures and activities, making the flow coherent; changing the unfamiliar words into more simple words; and revising some of the sentences, making it more stimulating and sensible for the intended learners. In the same study by Bugler et al. (2017), The quality of instructional materials is influenced by their usability, encompassing ease of use for teachers, students, and parents, as well as their comprehensiveness in providing clear instructions, materials, activities, and assessments.

There is potential for improvement in sustaining constant engagement, comprehensibility, and an orderly and seamless flow of ideas across the material, according to the results of the presentation and the organization of the content. Both of these aspects received the lowest mean rating of 3.50 (very satisfactory). It emphasizes how crucial it is to balance providing interesting information and ensuring students can readily follow the material's logical flow. Rogayan and Dollete (2019) stressed that the effectiveness of instructional materials becomes evident when they significantly impact learners, capturing their curiosity, piquing their interest, and holding their attention.

This aligns with the observations made by Cruz (2015), who highlighted the potential of instructional materials, such as laboratory manuals, to not only spark students' interest but also enhance their comprehension, ultimately aiding instructors in delivering more effective teaching. In order to address these concerns and refine the presentation, the researcher revises some of the procedures and instructions for better understanding and to ensure that the flow of ideas is in the correct organization. On the other hand, other activities in the learning material were improved and revised to make it more interesting for the reader. Enrichment activities, which contain five problem-solving activities, were also included in the learning material for the students to assess their mastery of the topic presented. Some animations and engaging questions were also incorporated to catch the students' attention, allowing them to think deeply about the activities. These adjustments were added to the learning material to improve its weaknesses, as seen in the experts' evaluation.

Table 6 presents the Evaluation of the Developed Practical Laboratory-Based Activities in Grade 11 along Accuracy and Up-to-datedness of Information.

As presented in the table, the developed practical laboratory-based activity material was able to obtain a perfect score of 24 points with a decision of "Passed," which suggested that the material is free from any form of errors, specifically on the computation, grammar, factual information and other aspect of the learning material. Furthermore, maintaining the currency of information is essential to guarantee that students are taught the most useful and relevant knowledge. Accuracy and up-to-date data empower educators and learners alike to engage effectively with the material, promoting a dynamic and reliable learning experience that equips individuals with trustworthy and current knowledge.

This thorough analysis ensures that students obtain up-to-date and accurate information to help their learning by providing insightful information about the quality and applicability of the practical activities utilized in Grade 11 education. The teacher evaluators ensure that all the given activities from the developed Practical Laboratory activities are reviewed individually to check for any errors that may occur, such as conceptual, factual, grammatical, computational, quality of information provided by the material, and even typographical errors. All of these were examined carefully by the evaluators.

Table VI The Evaluation Of The Developed Practical Laboratory-Based Activities In Grade 11 Along Accuracy And Up-To-Datedness Of Information

Factor 4: Accuracy and Up-to-datedness of Information	$\bar{x}$	DR
1. Conceptual errors.	4.00	No Error
2. Factual errors.	4.00	No Error
3. Grammatical errors.	4.00	No Error
4. Computational errors.	4.00	No Error
5. Obsolete information.	4.00	No Error
6. Typographical and other minor errors (e.g., inappropriate or unclear illustrations, missing labels, wrong captions, etc.).	4.00	No Error
Decision	24.00 (Passed)	

Note: Resource must score **24** out of a maximum of **24 points** to pass this criterion. Please put a checkmark on the appropriate box.

Mean Rating **Descriptive Rating**

3.26 - 4.00 No error

2.51 - 3.25 Presence of an error, but very minor and must be fixed

1.76 - 2.50 Presence of error and requires significant revision

1.00 - 1.75 Poor

The accuracy and up-to-dateness of information are fundamental pillars in the development of effective learning

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materials. Accuracy guarantees that the information being delivered is factually correct and based on reputable sources. When students come across reliable information, they may trust the text and create a solid foundation of knowledge. The results of this study closely mirror the research findings of Rochsun and Agustin (2020); their work highlighted the importance of the language utilized within instructional materials, emphasized the construction of contextual problems, and underscored the significance of the information included in the material. Lourdes & Tan (2019). In light of the fact that most instructors and students rely on these resources for their instruction and learning, the significance of error-free teaching materials was reiterated in order to reduce the likelihood of mistakes being made more frequently.

Furthermore, Ghani and Daud's (2018) thorough investigation reaffirms the critical significance of efficient instructional organization. According to their research, such structuring should be original and appropriate to the topic. This approach ensures learners are engaged, motivated, and better equipped to grasp complex concepts. These studies suggest that designing and implementing educational materials and methods significantly impacts students' learning experiences and outcomes. As such, educators should consider these insights when developing instructional strategies and materials to enhance the overall quality of education. A similar study conducted by Yadao (2022) concluded that in order to have accurate and updated learning material, it should be free from any form of error.

Table 7 presents the summary of the ratings of the Developed Practical Laboratory-Based Activities in General Chemistry for Grade 11.

Table VII Summary Of The Ratings Of The Developed Practical Laboratory-Based Activities In General Chemistry For Grade 11

Factors	**Rating**	**Remarks**
Factor 1: Content	27.60	Passed
Factor 2: Format	67.80	Passed
Factor 3: Presentation and Organization	18.20	Passed
Factor 4: Accuracy and Up-to-dateness of Information	24.00	Passed

Legend:

Factor 1: At least 21 points out of a maximum of 28 points

Factor 2: At least 54 points out of a maximum of 72 points

Factor 3: At least 15 points out of a maximum of 20 points

Factor 4: At least 24 points out of a maximum of 24 points

As shown in the table, the content evaluation across the four factors was given a 'Passed' rating, implying that it was evaluated positively and met the standards set by the Department of Education. Additionally, the learning material has been proven to be well-crafted, earning a 'Passed' remark from various experts in the field of science.

The content evaluation yielded a score of 27.60, with a decision as 'Passed.' This signifies that the learning material fosters desirable traits and values in students while also enhancing their higher-order thinking skills. These aspects stimulate students' interest in the subject matter. The alignment of learning objectives with the activities was evident to ensure that the specific competencies were addressed.

This supports the study of Troop et al. (2020) that the content of the learning material is essential for students' efficient acquisition of new knowledge and skills. It is ineffective to learn without credible content. Content, then, lies at the core of education.

Moreover, in terms of format, the developed practical laboratory-based activity material obtained an overall

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score of 67.80, exceeding the minimum requirement of 54 points to meet the criteria. This implies that the printed materials, illustrations, design, layout, paper quality, binding, size, and weight of resources demonstrate a high-quality appearance and durability, as evaluated by the expert. This suggests that the material is well-suited for the intended learners and can withstand the test of time.

Meanwhile, the presentation and organization of the material got an overall score of 18.20 with a decision of "Passed." This result implies that the material is easy to understand due to its logical flow of ideas combined with the use of vocabulary words that align with the student's level of comprehension. In addition, each paragraph was crafted to catch the user's attention.

Finally, the evaluators rated the Accuracy and Up-to-dateness of Information in the developed material with a perfect score of 24 points, indicating a decision of "Passed." This implies the materials are packed with current topics relevant to the concepts embedded in the material. Furthermore, it is also found that the material is free from any form of error. Parallel to the study of Hamora et al. (2022), he emphasized that teacher developers must carefully examine the learning materials' content before the distribution and utilization of the materials. The developer is responsible for making sure that there are no factual or grammatical errors in the material, not even mistakes in the calculations and formulas. This implies that the accuracy of the information and concept presented in a learning material helps the students to understand the topic better and, at the same, reduces the instances wherein the students get confused by the instructions or ideas that the material wants to inform the students. On the other hand, the inclusion of current events and issues in learning material allows students to be aware of the important events in their environment, allowing them to be part of society.

According to Ulfa and Trisno (2021), Learning materials are made to cater to the needs of both teachers and students; even though the resources are well-established and well-designed, some of their components might not satisfy the curriculum, core and essential competencies, or the demands of the students. Furthermore, there may still be discrepancies between the requirements of the curriculum and the elements of the materials. As a result, it's essential to evaluate the learning material. This collaborates with the findings of Olipas (2023), who stated that the evaluation of the instructional materials is necessary to improve the way the materials are used in the learning process. This implies that evaluation of developed learning materials is vital to determine their strengths and to improve their weaknesses, and also to prevent misunderstanding between the concepts taught, especially in science subjects.

Problem 4. What is the readability level of the Developed Practical Laboratory-Based Activities in Grade 11Students

Merely considering a material to be valid is insufficient when evaluating its suitability as effective learning material for our learners. It must also be clear and easy to understand by the learners. To assess this, the practical laboratory-based activity material underwent a readability test using the Flesch Reading Ease. This test aimed to determine if the material is suitable for the target grade level, which is Grade 11.

By utilizing this test, the researcher can determine the grade level to which the material belongs. This provides valuable insights into whether the material needs modification to suit the intended learners better. After subjecting the material to the readability test, the table below displays the test results.

Table 8 presents the readability level of Developed Practical Laboratory-Based Activities in Grade 11 Students.

Table VIII Readability Level Of Developed Practical Laboratory-Based Activities In Grade 11

Experiment Number	Flesch Reading Ease Score	Grade Level
1	55.6	10^{th} to 12^{th} Grade
2	47.0	In College
3	68.7	8^{th} and 9^{th} Grade
4	58.4	10^{th} to 12^{th} Grade

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5	44.2	In College
6	41.7	In College
7	50.0	10th to 12th Grade
8	48.2	In College
9	57.5	10th to 12th Grade
10	44.1	In College
As a Whole	**51.5**	**10th to 12th Grade**

Legend:

Flesch Reading Level Flesh Grade Level Ease Score Kincaid

90-100	Very Easy	5th Grade
80-89	Easy	6th Grade
70 79	Fairly easy	7th-grade
60 69	Standard	8th and 9th Grade
50 59	Fairly difficult	10th to 12th Grade
30- 49	Difficult	In college
0- 29	Very Difficult	College Graduate

The table reveals that the readability level of the developed Practical Laboratory Activity material is 51.5, which means that some high school students can comprehend the learning materials. Based on the Flesch Reading Ease theory, the texts can be easily understood and are suitable for 11th-grade senior high school students. This finding highlights the importance of crafting educational materials that align with the reading capabilities of the intended audience, promoting practical learning experiences and knowledge retention.

On the other hand, the developed material can also be used by lower year levels, covering similar topics. The data suggests that it is suitable not only for grade 11 but also for some high school students, including learners from grades 7 to 10 in junior high school.

Taken individually, Experiment number 3, titled 'Air Compression,' achieved the highest score of 68.7, making it suitable for learners in grades 7 and 8. This demonstrates that a high readability score facilitates the easy understanding of text and instructions for the intended learners. It also applies to lower grade levels, starting at least grades 7 and 8. This experiment introduces the concept of Boyle's Law, enabling students to observe the relationship between pressure and volume. Moreover, the readability scores of experiments 1, 4, 7, and 9 fell within the range of 50-59, signifying their appropriateness for specific high school learners. This confirms that these experiments remained suitable for the target users. They offer diverse learning experiences, enabling learners to actively engage in, observe, and grasp the concepts behind gas laws.

On the other hand, the majority of the presented experiments had readability scores ranging between 30 and 49, specifically experiments number 2, 5, 6, 8, and 10. This indicates that the following activities are suitable for high school and some college students. Despite having the lowest readability score among the developed practical laboratory-based activity materials, it is still recommended for use with grade 11 senior high school learners, given that senior high school topics are somewhat similar and aligned with college-level content.

This analysis gauges the ease with which students can comprehend and engage with the materials, providing critical insights into the accessibility and effectiveness of the educational resources. Examining the readability of these activities is essential for tailoring educational content to the appropriate cognitive and literacy levels of Grade 11 students, ultimately enhancing their learning experience.

The Ministry of Education Book Centre (2018) emphasized that enrichment materials should be readable at various grade levels. This means that even if it surpasses the participants' grade level in terms of reading complexity, it still qualifies as enrichment as long as it meets the specified criteria for readability percentage. In line with this, Puspaningtyas et al. (2020) stressed that good readability is crucial for learning materials to be used independently by students. Yetti (2021) supported this idea by highlighting how assessing the readability level of reading texts enables teachers to align them with students' grade levels, providing appropriate reading materials that facilitate students' better comprehension of the content.

Furthermore, Dewi and Adijaya (2022) emphasized that readability is vital to assessing textbooks and learning materials. When the readability level does not match the students' cognitive level, it can significantly impact their ability to comprehend the content. Therefore, ensuring appropriate readability is essential for effective learning materials. With this evidence, conducting readability tests for newly developed learning materials is paramount. These tests ensure that the readability of the material aligns with the intended grade level and guarantees the overall quality of the educational resources.

A similar study conducted by Tolentino & Tacubanza (2020) suggested that regardless of whether they are in print or digital formats, instructional materials must carefully evaluate their readability and consider the terminology, grammar, vocabulary, and suitability for the targeted grade level.

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the study's findings, conclusion, and recommendations.

Findings

Based on the data generated and analyzed, the following are the salient findings of the study.

1. There are three least mastered competencies in General Chemistry I, namely; "apply gas laws to determine the pressure, volume, or temperature of a gas under certain conditions of changes, utilize the ideal gas equations to calculate pressure, volume, temperature, or the number of moles of a gas' and 'apply Dalton's law of partial pressure to relate mole fraction and pressure of gases in a mixture with a percentage mastery level of 41.44, 31.57 and 27.14 which implies low proficiency level.
2. A practical laboratory-based activity material was developed to address the least mastered competencies in General Chemistry I.
3. The evaluation of the developed learning material Passed all the criteria, specifically in terms of its content (27.60 points), format (67.80 points), presentation and organization (18.20 points), accuracy, and timeliness of information (24 points).
4. The mean readability of the developed Practical Laboratory-Based Activity material is 51.5, which is suitable for grade 10^{th} and 12^{th} levels.

Conclusion

After cautious analysis and interpretation of the data, the following conclusions are at this moment presented:

1. The result of the diagnostic test identified three least mastered competencies in Grade 11 General Chemistry I, namely: "apply gas laws to determine the pressure, volume, or temperature of a gas under certain conditions of changes, utilize the ideal gas equations to calculate pressure, volume, temperature, or the number of moles of a gas' and 'apply Dalton's law of partial pressure to relate mole fraction and pressure of gases in a mixture. The said competencies fall under the topic of Gas Laws.
2. A Practical Laboratory-Based Activity material that focuses on Charles, Boyles, Guy-lussac, Daltons, and the Ideal Gas Equation Law was developed for Grade 11 students.
3. The evaluation of the developed Practical Laboratory-Based Activity material, considering content, format, presentation, organization, accuracy, and currency, passed the criteria set by the Department of

Education, which implies that secondary schools in the Vigan City Division can utilize the material.

4. The readability level of the developed Practical Laboratory-Based Activity material is well suited for grade 11 learners and some high school students.

Recommendation

The following recommendations are given for consideration in light of the conclusions obtained:

1. The developed practical laboratory-based activity material is suggested for utilization as additional learning material in General Chemistry I for grade 11 students.
2. Science teachers may utilize this material in their classrooms to assess how well the learning materials are teaching General Chemistry I and also to identify potential issues that learners may encounter. Moreover, it can be used by teachers to address learning difficulties, especially in General Chemistry I, explicitly focusing on the topic of gas laws.
3. The teachers should explore alternative interventions, such as providing modules, worksheets, Intervention Material, peer tutoring, focus group discussions, and other teaching methods, to address the General Chemistry I competencies that students struggle with the most.
4. Teacher developers should create other types of learning materials to accommodate various student learning preferences and styles. This not only provides a chance for teachers to explore and acquire new knowledge from different learning materials but also supports students' diverse learning approaches.
5. Utilization of the developed practical laboratory-based activity material in lower-year secondary schools is encouraged to determine its readability across different grade levels.

REFERENCES

1. Abdul Ghani, M. T., & Wan Daud, W. A. (2018). Adaptation of Addie instructional model in developing educational website for Language learning. Global Journal al Thaqafah, 8(2), 7–16. https://doi.org/10.7187/gjat122018-1 Acosta, R. A. N. (2020). Developed and validated grade 10 science learning materials in selected secondary schools in District III, a division of Puerto Princesa City, Philippines. Journal of Educational Research in Developing Areas, https://doi.org/10.47434/JEREDA.1.3.2020.248
2. Adalikwu, S., & Iorkpilgh, I. (2013). The influence of instructional materials on academic performance of senior secondary school students in chemistry in Cross River State. Global Journal of Educational Research, 12(1). https://doi.org/10.4314/gjedr.v12i1.6
3. Akani, O. (2015). Laboratory Teaching: Implication on Students' Achievement In Chemistry In Secondary Schools In Ebonyi State of Nigeria. Journal of Education and Practice. https://files.eric.ed.gov/fulltext/EJ1081346.pdf
4. Akinoso, O. (2018). Effect of the Use of Multimedia on Students' Performance in Secondary School Mathematics. Global Media Journal, 16. https://www.researchgate.net/publication/341741472_effect-of-the-use-of-multimedia-on-students-performance-in-secondary-school-mathematics-
5. Ali, C. A. (2021). A comparative study of Sam and Addie Models in simulating STEM instruction. African Educational Research Journal, 9(4), 852–859. https://doi.org/10.30918/aerj.94.21.125
6. Almanasreh, E., Moles, R., & Chen, T. (2019). Evaluation of methods used for estimating content validity. Research in Social and Administrative Pharmacy, 15, 214–221. https://doi.org/10.1016/j.sapharm.2018.03.066.
7. Aquino, P. M. M. (2018). Development, Validation and Effectiveness of Enhancement Material in Science and Health V. Asian Journal of Multidisciplinary Studies, 1(1). https://www.academia.edu/es/74300505/Development_Validation_and_Effectiveness_of_Enhancement_Material_in_Science_and_Health_V
8. Bangoy, R. M. (2022). Practical Work Approach: A Tool to Improve the Creativity Skills of the Students in Recycling. Globus Journal of Progressive Education, 12(1). https://doi.org/10.46360/globus.edu.220221014
9. Bugler, D., Marple, S., Burr, E., Chen-Gaddini, M., & Finkelstein, N. (2017). How do teachers judge the quality of instructional materials? WestEd. https://www.wested.org/wp-content/uploads/2017/03/resource-selecting-instructional-materials-brief-1-quality.pdf

10. Brau, B. (2018). Constructivism. In R. Kimmons, The Students' Guide to Learning Design and Research. EdTech Books. Retrieved from https://edtechbooks.org/studentguide/constructivism
11. Bretz, S. L. (2019). Evidence for the importance of laboratory courses. Journal in Chemical Education 96, 193−195. https://doi.org/10.1021/acs.jchemed.8b00874
12. Cruz, E. D. (2014). Development and Validation of Worktext in Drawing 2. https://www.academia.edu/.https://www.academia.edu/8678769/Development_and_Validation_of_Worktext_in_Drawing_2
13. Chan, K. C. Y. (2012). Laboratory Learning. SpringerLink. https://link.springer.com/referenceworkentry/10.1007/978-1-4419-1428-6_966?error=cookies_not_supported&code=81b0745d-ded5-44f9-814b-561e772247c5
14. De Borja, J. M., & Marasigan, A. C. (2020). Status of Science Laboratory in a Public Junior High School. International Journal of Research Publications, 46(1).
15. Dewi, S., & Adijaya, N. (2022). Readability analysis of teaching materials of English courses class 2 and 6 elementary school. Journal of Languages and Education, 2, 121–124. https://alejournal.com/index.php/ladu/article/download/120/61
16. Dizon, K. M., & Villanueva, J. (2022). Development and validation of a basic sentence structure worktext. American Journal of Education and Technology, 1(1), 26–36. https://doi.org/10.54536/ajet.v1i1.328
17. Dunton, J. B., & Co, W. S. (2019). “Spiral progression approach in teaching science and the performance of learners in district I, Capiz.” Journal of Physics: Conference Series, 1254(1), 012045. https://doi.org/10.1088/1742-6596/1254/1/012045
18. Duban, N., Aydoğdu, B., & Yüksel, A. (2019). Classroom teachers' opinions on Science Laboratory practices. Universal Journal of Educational Research, 7(3), 772–780. https://doi.org/10.13189/ujer.2019.070317
19. Estacio, R. D. L. (2015). Development and validation of a Learning Assessment Tool and Instructional Material in Physics 1 (Mechanics). academia.edu. https://www.academia.edu/23726543/Development_and_Validation_of_a_Learning_Assessment_Tool_and_Instructional_Material_in_Physics_1_Mechanics
20. Funa, Aaron & Ricafort, Jhonner (2019). Developing Gamified Instructional Materials in Genetics for Grade 12 STEM. International Journal of Engineering Science and Computing 9 (3):20597-20600. https://philarchive.org/rec/FUNDGI
21. Ghani, I., Ibrahim, N., Yahaya, N., & Surif, J. (2017). Enhancing students' HOTS in laboratory educational activity by using a concept map as an alternative assessment tool. Chemistry Education Research and Practice, 18, 849-874. https://doi.org/10.1039/C7RP00120G.
22. Givera, A. G. (2023). Development and Validation of Contextualized Supplementary Worksheets in Grade 8 English. United International Journal for Research & Technology. https://uijrt.com/paper/development-validation-contextualized-supplementary-worksheets-grade-8-english
23. Habib, M. K., Nagata, F., & Watanabe, K. (2021). Mechatronics: Experiential learning and the stimulation of thinking skills. Education Sciences, 11(2), 46. https://doi.org/10.3390/educsci11020046
24. Hamora, L, Rabaya, “W Pentang, “ Pizaña, P & Gamozo, M.J. (2022). Students’ Evaluation of faculty-prepared instructional modules: Inferences for instructional materials Review and revision. Journal of Education, Management and Development Studies, 20-29. https//doi.org/10.52631jemds.v2i2109
25. Hernando-Malipot, M. (2022). DepEd cites the need to bolster science and technology education in K to 12. Manila Bulletin. Retrieved from https://mb.com.ph/2022/03/09/deped-cites-need-to-bolster-science-technology-education-in-k-to-12/.
26. Halawa, S., Hsu, Y.-S., Zhang, W.-X., Kuo, Y.-R., & Wu, J.-Y. (2020). Features and trends of teaching strategies for scientific practices from a 2008–2017 articles review. International Journal of Science Education, 42(7), 1183–1206. https://doi.org/10.1080/09500693.2020.1752415
27. Heindl, M. (2019). Inquiry-based learning and the pre-requisite for its use in science at school: A meta-analysis. Journal of Pedagogical Research, 3(2), 52–61. https://doi.org/10.33902/JPR.2019254160
28. Horrigan LA. Tackling the threshold concepts in physiology: what is the role of the laboratory class? Adv Physiol Educ 42: 507–515, 2018. doi:10.1152/advan.00123.2017
29. Ibe, N., Obikezie, M., & Chikendu, R. (2021). Effect of improvised instructional materials on chemistry students’ academic retention in Secondary School. International Journal of Research in Education and

Sustainable Development, 1(5), 19–31. https://doi.org/10.46654/ijresd.1520

30. Kennepohl, D. (2021). Laboratory Activities to Support Online Chemistry Courses: A Literature Review. https://cdnsciencepub.com/doi/10.1139/cjc-2020-0506
31. Kovacs, M., Jaquiery, M., Algermissen, J., Arriaga, P., Gau, R., Gokce, A., Grassi, M., Kouros, C. D., Yeung, S. K., & Aczel, B. (2022). Lab manuals for efficient and high-quality science in a happy and safe work environment. https://doi.org/10.31222/osf.io/bzcxg
32. Lee, M. C., & Sulaiman, F. (2018). The Effectiveness of Practical Work on Students‘Motivation and Understanding towards Learning Physics. International Journal of Humanities and Social Science Invention (IJHSSI), 7(8), 35–41.
33. Lee, T. T., Sharif, A. M., & Rahim, N. A. (2018). Designing E-Content for Teaching Basic Chemistry Concepts in Higher Education: A Needs Analysis. Journal of Turkish Science Education, 15(4). https://doi.org/10.12973/tused.10246a
34. Libretexts. (2022). Dalton's Law (Law of Partial Pressures). Chemistry Libre Texts. https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Properties_of_Gases/Gas_Laws/Dalton's_Law_(Law_of_Partial_Pressures)
35. Lina, R. A. (2006). A Proposed Development Plan in Chemistry and Physics Laboratories at Philippine State College of Aeronautics (thesis).
36. Lourdes, M., & Tan, G. (2019). An Evaluation of DepEd-produced Grade 7 Biology Modules by Biology Experts and Science Teachers. International Journal of Innovation in Science and Mathematics Education, 27(5), 27-42.https://openjournals.library.sydney.edu.au/index.php/CAL/article/download/12954/12666
37. Maradun, I. H. (2023). The Relevance of Instructional Materials in Teaching and Learning Chemistry (A Case Study of Selected Secondary School in Maradun Local Government Zamfara State). International Journal of Research Publication and Reviews, 4, 337–340. https://ijrpr.com/uploads/V4ISSUE2/IJRPR9905.pdf
38. Memebrebe. Nino Q. & AnadiaAiselle (2015) Improving Student Achievement for Science in Grade 7 using Strategic Intervention Material. Retrieved from www.iamsed.org/wp-content/uploads/2015/06//Science Education and Teaching
39. Mercado, J. C. (2020). Development of Laboratory Manual in Physics for Engineers. International Journal of Science and Research (IJSR), 9(10). https://doi.org/10.21275/SR201002120011
40. Marquez, E., & Garcia, S. (2020). Structuring student success: Incorporating a genre-based pedagogical method to improve the strength of the Materials Laboratory Manual. 2020 ASEE Virtual Annual Conference Content Access Proceedings. https://doi.org/10.18260/1-2--35217
41. Meng, X., Xu, X., Chen, H., and Zhang, L. (2022). The effectiveness of combining e-learning, peer teaching, and flipped classrooms for delivering a physiology laboratory course to nursing students. Adv. Physiol. Educ. 46, 21–26. doi: 10.1152/advan.00062.2020
42. Mijares , B. F. (2023). Development and Validation of a Supplementary Learning Material In Earth Science. Cosmos An International Journal of Art & Higher Education, 12(Jan-Jun 2023). https://doi.org/10.46360/cosmos.ahe.520231005
43. Mwangi, J. T. (2018). Effect of Quality of Chemistry Practical Work on Students' Performance in Chemistry in Public Secondary Schools of Machakos and Nairobi Counties in Kenya. International Journal of Science and Research (IJSR), 7(9). https://doi.org/10.21275/ART20191080
44. Olipas, C. N. P. (2022). Students' Evaluation of the Instructional Learning Modules for Application Development and Emerging Technologies Course. Puissant – A Multidisciplinary Journal, 4, 1074–1089. https://files.eric.ed.gov/fulltext/ED622667.pdf
45. Oliveira, H., & Bonito, J. (2023). Practical work in science education: A systematic literature review. Frontiers in Education, 8. https://doi.org/10.3389/feduc.2023.1151641
46. Pacifico, E., & Prudente, M. (2021). DLSU Research Congress 2021. In Grade 12 STEM Students' Perceptions and Experiences in Home-grown Chemistry Experiments.
47. Pareek, R. B. (2019). An assessment of availability and utilization of laboratory facilities for teaching science at the Secondary Level. Science Education International, 30(1), 75–81. https://doi.org/10.33828/sei.v30.i1.9
48. Puspaningtyas, A. A., Hernani, & Suhandi, A. (2020). Analysis of the readability of Scientific

Literacy Enrichment Book on earth science concept. Journal of Physics: Conference Series, 1521(4), 042103. https://doi.org/10.1088/1742-6596/1521/4/042103

49. Rose, D.E. (2012). Context-Based Learning. In: Seel, N.M. (eds) Encyclopedia of the Sciences of Learning. Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-1428-6_1872
50. Rogayan Jr., D. V., & Dollete, L. F. (2019). Development and validation of Physical Science Workbook for senior high school. Science Education International, 30(4), 84– 290. https://doi.org/10.33828/sei.v30.i4.5
51. Royal Society of Chemistry. (2021). Chapter 1 The Role of the Laboratory in Chemistry Teaching and Learning (RSC Publishing) DOI:10.1039/9781839164712-00001. https://pubs.rsc.org/en/content/chapterhtml/2021/bk9781839162084-00001?isbn=978-1-83916-208-4
52. Rochsun, R.; Agustin, R. D.(2020) The Development Of E-Module Mathematics Based on Contextual Problems. European Journal of Education Studies, [S.l.], v. 7, n. 10, ISSN 25011111. Accesses at https://oapub.org/edu/index.php/ejes/article/view/3317/5953>. Date accessed: September 25. 2023. doi http://dx.doi.org/10.46827/ejes.v7i10.3317.
53. Santos, J. T. D., Lim, R. R., & Rogayan, D. V. Jr. (2021). Least mastered competencies in biology: Basis for instructional intervention. JPBI (Journal Pendidikan Biology Indonesia), 7(2), 208-221. https://doi.org/10.22219/jpbi.v7i3. 17106
54. Sagcal, R. (2017). Development and Evaluation of Context-Based Laboratory Activities in Chemistry Using Low-cost Kits for Junior Public High School. Kimika. https://kimika.pfcs.org.ph/index.php/kimika/article/view/243/203
55. Seda Cetin, P., Eymur, G., Southerland, S. A., Walker, J., & Whittington, K. (2018). Exploring the effectiveness of engagement in a broad range of disciplinary practices on learning of Turkish high-school chemistry students. International Journal of Science Education, 40(5), 473–497. https://doi.org/10.1080/09500693.2018.1432914
56. Sison, A. J. R. N., Bautista, J. M., Javier, J. L., Delmonte, R. J. B., & Cudera, R. B. (2023). Development and Acceptability of Virtual Laboratory in Learning Systematics. ASEAN Journal of Educational Research and Technology, 3(1), 9–26.
57. Shadreck, M. (2018). Recurrent Difficulties: Stoichiometry problem-solving. Researchgate. https://www.researchgate.net/publication/344178914_Recurrent_Difficulties_Stoichiometry_problem-solving
58. Shana, Z., & Abulibdeh, E. S. (2020). Science practical work and its impact on students' science achievement. Journal of Technology and Science Education, 10(2), 199. https://doi.org/10.3926/jotse.888
59. Spatioti, A. G., Kazanidis, I., & Pange, J. (2022). A comparative study of the addie instructional design model in distance education. Information, 13(9), 402. https://doi.org/10.3390/info13090402
60. Taber, K. S. (2018). Scaffolding learning: principles for effective teaching and the design of classroom resources. In M. Abend (Ed.), Effective Teaching and Learning: Perspectives, strategies and implementation (pp. 1-43). New York: Nova Science Publishers.
61. Tolentino, J. C., Danganan, C. G., David, A. A., & Peña, J. T. (2023). Development and validation of a booklet in educational research: A supplementary material for Filipino teacher education students. Multidisciplinary Journal for Education, Social and Technological Sciences, 10(2), 1–23. https://doi.org/10.4995/muse.2023.18678
62. Tolentino, J. C. G., & Takanawa, H. A. (2020). Towards the development of a workbook in Fitness Testing and Basic Exercise Programming. Asia Pacific Journal of Multidisciplinary Research, 8, 107–117. https://www.apjmr.com/wp-content/uploads/2020/12/APJMR-2020.08.04.12.pdf
63. Tomas, E. A., & Cabansag, M. G. S. (2019). De La Salle University Dasmariñas. Research Portal. Retrieved January 12, 2023, from https://portal.dlsud.edu.ph/research/DetailView.aspx?ContentID=4067
64. Timilsena, N. P., Maharjan, K. B., & Devkota, K. M. (2022). Teachers' And Students' Experiences in Chemistry Learning Difficulties. Journal of Positive School Psychology, 6(10). https://journalppw.com/index.php/jpsp/article/download/13764/8923/16709
65. Tirfu, M. (2016). Common difficulties experienced by grade 12 students in learning chemistry in webinar preparatory school. Issn.
66. Troop, "W White, D. Wilson, K.E., & Zeni, P. (2020). OUL user experience design for Learning (UXDL) framework: The undergraduate student perspective. The Canadian Journal for. Scholarship of Teaching and Learning, 11(3). 1-25 https://www.doi.org/10.5206/Cjsotl-rcacea.2020.3.8328

67. Ulfa, Z., & Trisno, E. (2022). Evaluation of Learning Material in the Textbook for Senior High School Grade XI. Advances in Social Science, Education and Humanities Research, 624. https://files.eric.ed.gov/fulltext/EJ963326.pdf
68. Vinko, L., Delaney, S., & Devetak, I. (2020). Teachers' opinions about the effect of chemistry demonstrations on students' interest and Chemistry Knowledge. Center for Educational Policy Studies Journal, 10(2), 9–25. https://doi.org/10.26529/cepsj.893
69. Widyastuti, E., & Susiana. (2019). Using the Addie model to develop learning material for actuarial mathematics. Journal of Physics: Conference Series, 1188, 012052. https://doi.org/10.1088/1742-6596/1188/1/012052
70. Yadao, Jennifer T. (2022). Development of Localized Worktext for Grade 7 Chemistry. University of Northern Philippines.
71. Yetti, D. (2021). An Analysis Of Readability Level Of Reading Material In English Textbook For First Grade Of Senior High School. Journal of Education and Teaching, 2. http://ejournal.uin-suska.ac.id/index.php/JETE
72. I am applying constructivism to the laboratory experience. Science Teaching. (n.d.). Retrieved November 16, 2022, from https://sites.miamioh.edu/edt431-531/2019/10/applying-constructivism-to-the-laboratory-experience/
73. Accredited Degree Programmes. (n.d.). Royal Society of Chemistry. https://www.rsc.org/membership-and-community/degree-accreditation/?404;http://www.rsc.org:80/images/Fach+paper+final_tcm18-76278.pdf
74. DepEd Order 31 (2012). Policy guidelines on the implementation of Grades 1 to 10 of the K to 12 Basic Education Curriculum (BEC) effective school year 2012-2013. https://www.deped.gov.ph/
75. Importance of Hands-on Laboratory Science. (n.d.). American Chemical Society. https://www.acs.org/content/acs/en/policy/publicpolicies/education/computersimulations.html
76. Just a moment (n.d.). https://www.sciencedirect.com/science/article/pii/S0187893X17301581
77. Grin, A. (2022). The importance of practical work in science education. Study Bay. https://studybay.com/blog/what-is-practical-work/
78. K to 12 updates and initiatives of Teacher Education Council (2013). https://www.ceap.org.ph
79. NCBI - WWW Error Blocked Diagnostic. (n.d.). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4669365/
80. Parikh, A. (2023). What Is the ADDIE Model of Instructional Design? D2L. December 20, 2023, https://www.d2l.com/blog/what-is-the-addie-model-of-instructional-design/
81. Solon, P. (2006). The public school system was hit worst by a need for more budget. Manila Bulletin.
82. The Importance of Science Lab Equipment in Schools. (n.d.). USA Lab. https://www.usalab.com/blog/the-importance-of-science-lab-equipment-in-schools/
83. Tuerah, R. M. S. (2019). Constructivism Approach in Science Learning. International Journal of Innovation, Creativity and Change, 5(5). https://www.ijicc.net/images/vol5iss5/Part_2/55202_Tuerah_2020_E_R.pdf
84. United Nations Development Programme. (2018). Sustainable development goals: United Nations Development Programme - Goal 4: Quality education. UNDP. Retrieved from https://www.undp.org/sustainable-development-goals