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Development, Validation and Evaluation of Home-Based Laboratory Worksheets in General Chemistry

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ABSTRACT

Home-based laboratory activities are vital for ensuring hands-on learning in remote education, yet challenges like limited resources, student engagement, and safety persist. Despite their benefits, effective instructional materials for college-level General Chemistry in remote settings are lacking. This study develops, validates, and evaluates worksheets designed to support home-based labs, ensuring safe and effective practical work. Results show that the worksheets engage students in learner-centered, experiential learning. Teachers noted their effectiveness in enhancing scientific understanding, despite challenges with material availability and procedural uncertainty. This study provides a model for home-based lab instruction, offering a structured approach to adapt General Chemistry learning for flexible, remote, and resource-limited environments.

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INTRODUCTION

Teaching science using laboratories enhances students' learning outcomes and scientific skills. Modern laboratories play a significant role in biology education by promoting experiential learning, scientific inquiry, and skill development (Ibragimova, 2023). Studies emphasize the importance of practical work in science education, highlighting the essential role of labs in improving student learning and science teaching at the secondary level (Shahzad et al., 2023). Furthermore, the effectiveness of science labs in developing critical thinking skills among students has been recognized, recommending the activation of labs for conducting experiments and scientific activities mentioned in textbooks (Alqubelat, 2022). Laboratory activities are crucial in Philippine Science Education, aligning with the Science Framework for Philippine Basic Education's emphasis on developing students' inquiry skills (Arboiz & Malayao Jr., 2024). These activities, such as experiments, project work, and scientific investigations, enable students to actively engage in the science process skills, fostering a deeper understanding of scientific concepts and principles (Rahayu & Muqtada, 2023).

Teaching laboratory-based subjects has many challenges. Issues such as lack and absence of room for a laboratory, the inadequate amount of resources such as science equipment and tools, and even lack of laboratory facilities (Chala, 2019), defective laboratory equipment, inadequate to no time allotment for practical work (Niyitanga et al., 2021), the inadequate amount of teaching and learning materials, lack of electricity and water supply are typical in the delivery and execution of both practical and laboratory works in teaching science courses or subject. The same is manifested in private and public schools in the Philippines (Abas & Marasigan, 2020).

With the recent pandemic, the education system has shifted to blended, flexible learning and distance learning modalities. CHED COVID-19 Advisories No. 6 and 7, dated April 13 and May 24, 2020, provide strategies or procedures for control, prevention, and mitigation measures for COVID-19 in higher education institutions (HEIs). It advised the suspension of face-to-face classes, but instead, there will be different alternative delivery modes of teaching. This advisory also aligns with UNESCO and OECD recommendations to continue implementing strategies that evolve education response to COVID-19. Both suggest ways to ensure continued learning, such as hybrid learning, distance learning programs (UNESCO, 2020), and flexible and blended learning (OECD, 2020).

In recent years, interactive simulations, videos, animations, and simple "Do-It- Yourself-Experiments have become the answer. Consequently, this technological approach requires the presence of gadgets that are at least internet-capable for accessing the applications and fostering communication with group members. With countries like the Philippines employing emergency types of distance education, there is clear evidence that this technological approach promotes impetus to equity in receiving quality science teaching and learning.

An informal interview with chemistry teachers in the locale was conducted to gain in-depth data or information about the current issues of delivering laboratory work in teaching. According to the teachers, the non-face-to-face delivery of the chemistry lessons makes it more difficult to explain certain concepts. Some concepts need hands-on experience or activity to visualize and understand the concept better. It was also mentioned that laboratory experiments significantly develop students' manipulative, critical thinking, and practical skills. This intensifies the need to provide practical work for hands-on chemistry lessons.

The objective of this present study is to produce a home-based laboratory worksheet with a teacher's guide in topic-specific contents in General Chemistry and provide a model for the production and delivery of home-based instructional material. Home-based experiments use simple household materials and readily available equipment, which may serve as alternatives to laboratory work or experiments. The use of locally available materials and equipment at home in teaching science has been explored before and during this pandemic. However, how they are integrated into the Philippine science curriculum to produce a model instructional material is still not established.

The Home-based laboratory worksheet from this study can provide alternative options to gadget-based simulations in topic-specific content in General Chemistry. Details from the instructional material can be integrated with related course packets to achieve the requirement of quality science education amidst emergency distance learning. The instructional material will integrate two relevant theories in laboratory work, particularly Investigative Practical Work and SPS (Science Process Skills), into its specifications. The home-based laboratory worksheet and teacher’s guide developed in this study offer an alternative to traditional laboratory work, making the science education more accessible through the use of common household materials and locally available equipment. This approach is not only cost-effective but also empowers communities by providing the students and teachers with the resources to conduct meaningful science practical investigations in a home setting.

THEORETICAL REVIEW

This research study was ideated along Progressivism, Constructivism, and Experiential Learning Theory.

Progressivism

Progressive Education is described by Dewey (1938) as "a product of discontent with traditional education", which enforces standards, subject matter and methodologies. It advocates for learning through direct experiences and active participation in the learning process. Progressivism seeks to highlight and improve the skills of the learners (Florungco & Caballes, 2022). Progressivism views education as a process of continuous growth and promotes reflective thinking (Dewey, 1910).

This theory is relevant to the study of the development of home-based laboratory worksheets in general chemistry since laboratory activities involve direct experience and active engagement or participation in the learning process. The home-based experiments allow the learners to have a first-hand and hands-on experience, which also allows learners to acquire scientific knowledge and produce scientific information while actively engaging in their own learning process.

Constructivism

According to Piaget (1973), learners must use cognitive structure to construct their knowledge through experience. Constructivist learning theory is about how people learn. It happens when learners build knowledge by interpreting information in the context of their own experience. According to Efgivia et al. (2021), a constructivist learning environment must use learners' prior knowledge to create a meaningful learning experience and a conducive learning environment that will allow learners to create their own knowledge out of experiences independently.

Constructivism in home-based experiments emphasizes personalized learning, active engagement, and reflection. This encourages the learners to explore scientific concepts through hands-on activities to foster a more profound understanding. It also promotes a dynamic and learner-centred approach to teaching science. Likewise, the practical activities involve both the basic and integrated process skills in science.

Kolb's Experiential Learning Theory

Finally, Kolb's Experiential Learning Theory states that learning occurs most effectively when it involves a continuous cycle of active experimentation, reflective observation, abstract conceptualization, and direct experience (Kolb, 1984). Kolb argues that ideas are not fixed or unchangeable but rather formed and re-formed on the basis of new experiences. Hence, this defines theory as a "process in which knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (Kolb, 1984).

Relatively, considering this aspect of reinventing knowledge through experience made it relevant to this present study of developing a home-based chemistry experiment worksheet. The goal of this study is to provide learners with a direct, hands-on, authentic learning experience of chemistry concepts with the use of readily available and affordable materials that can be found at home.

The three theories, Progressivism, Constructivism, and Experiential Learning Theory, are involved and play significant roles in the present study on the development of home-based laboratory worksheets in teaching general chemistry. This highlights experiential learning through practical experiments, aligning with the emphasis of progressivism on real-world application. Constructivism contributes by fostering a learner-centred approach, building on a schema or prior knowledge, and promoting cooperating and collaborative learning among learners. The development is facilitated by experiential learning theory, which encourages practical application, reflective observation, and active experimentation. Through the integration of these three theories, a dynamic and engaging learning environment is created that links theoretical concepts with the real-world and practical application in the context of home-based chemistry experiments.

Related Literature

Delivery of Science Laboratory in Chemistry

With the unexpected onset of the global pandemic, educational institutions quickly adopted a blended and flexible learning model. This method of instruction was implemented to ensure that both theoretical and practical subjects, including laboratory-based courses, could continue. However, teaching practical chemistry in this new format presents substantial challenges (Campbell et al., 2020). This situation has led to the development of various strategies to deliver laboratory instruction. Gamage et al. (2020) highlight that delivering laboratory courses online faces obstacles such as the need for reliable resources, including computers and internet access, at home. Chemistry subjects, particularly organic chemistry, are difficult for students to grasp, making remote teaching even more challenging. This subject often requires the use of molecular models to illustrate three-dimensional structures, which cannot be achieved without specialized equipment (Crucho et al., 2020).

The shift away from in-person laboratory sessions and practical experiences in science education has forced instructors to rethink lesson plans and assessments while dealing with limited technological resources (Landicho, 2021). O'Neill (2021) states that one of the main challenges for lab-based courses is redesigning them for remote delivery, maintaining a hands-on experimental approach.

The pandemic-driven shift to online learning has posed difficulties, especially for courses that require laboratory-based data collection (Sun et al., 2020). To address this, scientific calculations and simulations can be conducted using home computers or supercomputers. Similarly, Pinar (2021) notes that the absence of laboratory activities in general chemistry is a significant drawback of synchronous online learning. In these cases, students were unable to perform hands-on laboratory work, with virtual simulations being used as supplementary tools. As Balmaña and Ligsanan (2023) emphasize, science education should focus on hands-on activities to enhance learning.

In addition to distance learning, flexible learning has also become a prevalent modality in both secondary and tertiary education in the Philippines. According to the Department of Education (2020), flexible learning options offer a variety of interventions and pathways that quickly adapt to the circumstances, needs, and diversity of learners. The Commission on Higher Education defines flexible learning as an approach that allows flexibility in time, location, and audience, incorporating technology in the process. Anderton et al. (2021) suggest that delivering laboratory and practical work through flexible learning remains a challenge. To address this, simulated and interactive tutorials have been developed as supplements to traditional laboratory work.

Delivery of Home-based Laboratory

Home-based experiments are practical activities that allow students to perform an experiment using materials easily found at home (Robledo et al., 2023). Robledo (2021) identifies six key attributes of home-based experiments (HBEs) that should be considered before implementing hands-on activities. These attributes include: (1) being ethical and safe to perform, (2) capable of producing a tangible product or output, (3) encouraging student reflection, (4) fostering collaboration, (5) using easily accessible and affordable materials, and (6) being adaptable. Home-based experiments support independent learning and provide an authentic hands-on experience, even in remote or distance learning environments.

The delivery of home-based laboratory instruction has gained a significant attention in the recent years, particularly in the context of enhancing learning outcomes and accessibility. One of the primary advantage of a home-based laboratory is its ability to facilitate science practical work outside the traditional classroom settings. Kelley (2021) that at-home organic chemistry laboratory activities can easily be incorporated in the curricula which enhances student engagement and learning outcomes. In the same context, Permana (2022) stated that science laboratory kits can significantly improve the students' attitude and achievement during distance learning modality which makes complex concept in science more accessible and meaningful. Furthermore, interactive remote demonstrations can encourage active participants which enriches learning experiences in chemistry instruction (Zuidema & Zuidema, 2021). Zulirfan and Yennita (2022) proposed that providing affordable and easily accessible STEM project materials can effectively support science learning at home. This also aligns with the findings of Funnell et.al (2022) which highlighted the benefits of take-home kits in providing practical activities to cater diverse learning styles.

Development and Validation of Home-based Laboratory Worksheet

The development and validation of home-based laboratory worksheet has gained attention, particularly in the context of remote and distance learning modality. In such context, an online and home-based delivery modes became the alternative mode for delivering remote and distance laboratory works (Ligsanan et.al, 2024). Home-based laboratory exercises provide hands-on experience that can effectively supplement traditional laboratory activities. Youssef et.al (2021) emphasized that home-based labs can reduce the need for face-to-face interaction which is beneficial for students in a resource-limited setting. In the study of Allauigan et.al (2023), it is observed that while student face challenges in accessing alternative laboratory materials at home, students develop essential skills such as resourcefulness and communication skill. Furthermore, Sanchez et.al (2021) describe home-based experiments as carefully designed activities that allow students to engage in practical work that is accessible and educational.

The development and validation of home-based laboratory worksheet is essential for enhancing the educational experience to ensure effectiveness and accessibility of materials. In this study, the six attributes of home-based experiments (HBEs) identified by Robledo (2021) was incorporated as element in the development of the material as well as the characteristic of a science practical work as stated by Moeed (2013). The first prototype of the home-based laboratory worksheet will be evaluated by experts using the validation tool adapted from the study of Rogayan and Dollete (2019), where attributes of HBEs were included as well as the characteristic of science practical work. Further evaluation of the worksheet commenced through pilot testing and actual class tryout of the worksheet. This iterative process of evaluation followed the design-based research to ensure the quality of the model material produced in the process.

METHODOLOGY

This present study utilized a qualitative research within Design-based research design (DBR) to develop and refine educational material, specifically a home-based laboratory worksheet in general chemistry, focusing on iterative cycles of design, implementation, and feedback from participant in real-world educational setting. Wang and Hannapin (2005) describe Design-Based Research (DBR) as an organized yet flexible methodology aimed at improving educational practices. It follows an iterative cycle of analysis, design, development, and implementation, which is based on collaboration between researchers and practitioners in real-world settings, and seeks to derive principles and theories that are contextually relevant. Anderson and Shattuck (2012) characterize this approach as a practical research methodology that effectively bridges the gap between research and practice in formal education. Similarly, Easterday et al. (2014) explain that DBR is a process that combines design and the scientific method to produce valuable outcomes and operational theories designed to address both individual and collective educational challenges.

In this study, the process outlined by Gakii (2012) was adopted, which is based on the five key phases of instructional systems design from Dick and Carey (2005). These phases include analysis, design, development, implementation, and evaluation. The research procedure, which follows these five stages, is summarized in Figure 3.

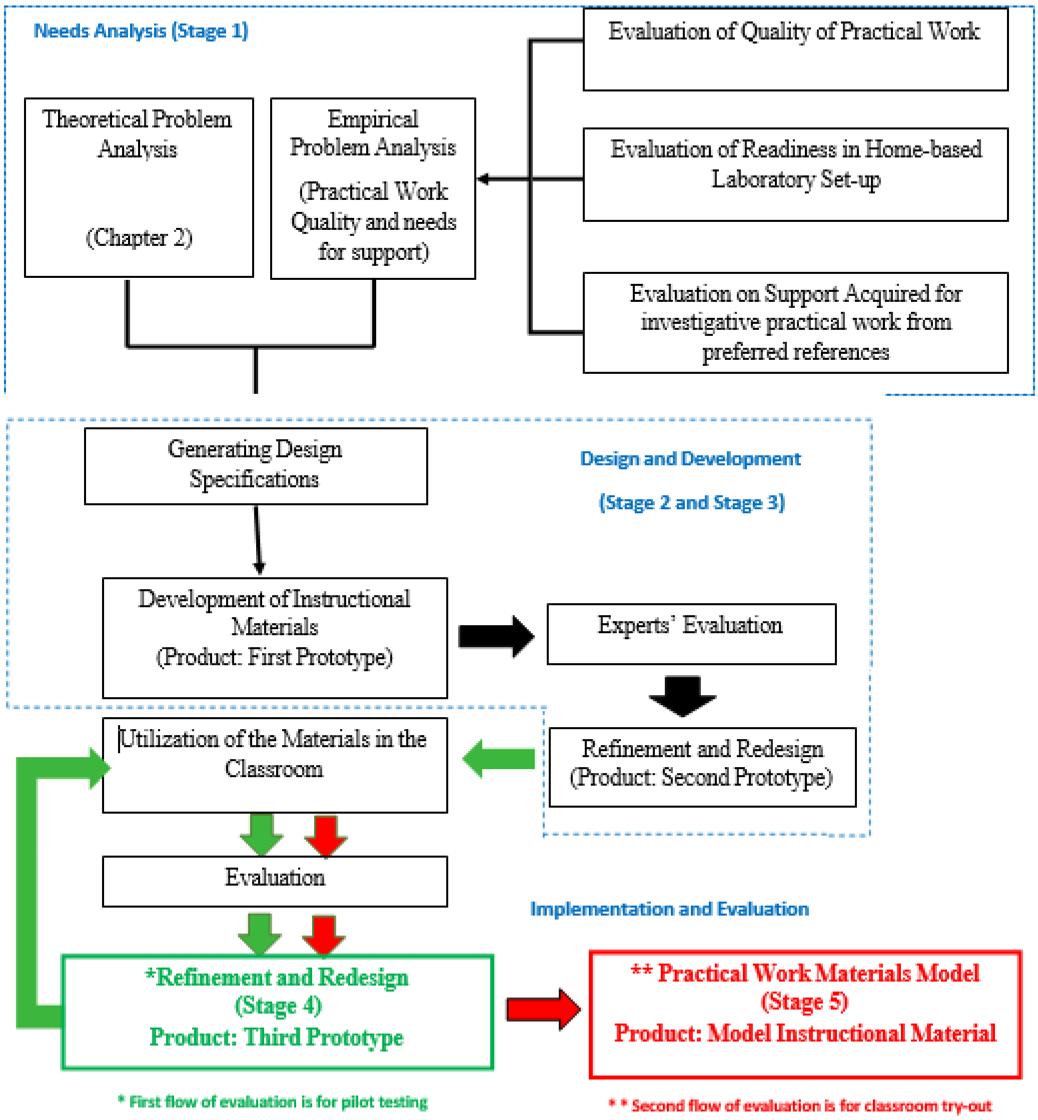

Figure 1. The process of study and research design

Samples and Sampling

The study employed purposive sampling to select Chemistry teachers who met specific criteria: at least five years of teaching experience, a Science Teaching degree, and a valid teaching license. This approach, as highlighted by Ames et al. (2019) and Campbell et al. (2020), ensures a sample closely aligned with the study's objectives, enhancing data accuracy and trustworthiness. Teachers who were willing to engage, try new ideas, and provide critical feedback were included, with participation also contingent on their availability to host online classes due to ongoing face-to-face class restrictions. Student participants were also included as part of the focus group discussion in identifying concerns and adjustment necessary to produce the final prototype of the worksheet.

RESULTS AND DISCUSSION

This part presents the findings, the analysis and the interpretation of the data gathered from the different phases of the study. These are the (i) theoretical and empirical considerations to produce the first prototype, (ii) The result of Experts' evaluation, (iii) The result of Pilot testing, and (iv) The result of actual classroom tryouts.

Result of Needs Analysis

The target of the needs analysis is to evaluate the challenges teachers face in conducting investigative practical work and their readiness for home-based laboratory activities. This involves using interview protocols to explore difficulties encountered in practical investigations and assess teachers' preparedness for facilitating lab work outside traditional settings. Additionally, document analysis of textbooks, laboratory manuals, and other instructional materials is conducted to gauge their effectiveness as references for laboratory experiments. The goal is to understand the current state of resources and teacher readiness comprehensively. This analysis informs the development of strategies to enhance investigative and home-based laboratory practices.

Theoretical Considerations

The study developed a home-based laboratory worksheet based on three key theoretical frameworks: progressivism, constructivism, and experiential learning theory. These theories emphasize learning through direct experience, active participation, and reflection, aligning with the design of the worksheet to facilitate hands-on chemistry learning. Additionally, related studies highlight the importance of adapting teaching strategies to remote learning, suggesting that home-based experiments are effective alternatives to traditional labs. The worksheet design incorporates these insights to ensure students engage in practical, meaningful experiments using easily accessible materials.

Table 1. Theoretical Considerations

Theories	**Proponent**	**Application to the Worksheet**
Progressivism	Dewey (1938)	Emphasizes learning through direct experiences and active participation, aligning with hands-on activities in home-based labs.
Constructivism	Piaget (1973)	Focuses on knowledge construction from experience, promoting active engagement and reflection in the design of the home-based worksheet.
Experiential Learning Theory	Kolb (1984)	Stresses active experimentation and reflective observation, guiding the development of hands-on, practical chemistry learning.

The worksheet was designed to address challenges in remote learning by providing accessible, engaging, and safe home-based experiments that foster active student participation and scientific inquiry.

Empirical Considerations

The study gathered empirical insights from interviews with chemistry teachers about the development of home-based laboratory worksheets. These insights revealed that practical hands-on activities using household materials are crucial in general chemistry teaching, especially in remote settings. The study also explored how teachers address challenges such as limited resources, safety, and the use of virtual labs. Teachers emphasized their roles as guides, ensuring students' safety while encouraging active participation. These considerations have been integrated into the worksheet design to support effective, remote chemistry learning.

Table 2. Summary of Empirical Considerations from the Interview of Chemistry Teachers

Emerging Themes	Application to the Worksheet
Lensing Hands-on Activities as a Viable Method for General Chemistry	Includes practical activities using household materials, with step-by-step instructions to achieve learning objectives and skills.
Mediating Hindrances of Practical Work through Modification	Modifies activities and materials based on availability, with a focus on safety and effective learning using accessible resources.
Virtual Laboratory as a Modern Platform for Laboratory Works	Incorporates home-based experiments as a modern alternative, offering hands-on, authentic learning experiences remotely.
Roles of the Teachers and Students during Laboratory Experiments	Provides clear guidance for teachers in supervising experiments remotely, emphasizing safety, and encouraging student participation.

Theme 1: Lensing Hands-on Activities as a Viable Method for General Chemistry

In the study, teachers consistently emphasized the importance of hands-on activities in teaching General Chemistry. One teacher explained that practical work helps *students "gain a better understanding of danger, risk and safe work,"* highlighting how physical engagement allows students to grasp complex scientific concepts. Another teacher pointed out that these activities are integral for "*developing hands-on skills*" and understanding the practical aspects of chemistry. Teachers also noted that students tend to enjoy these activities, with one teacher saying, "*Students are always looking forward to our next practical work.*" This enjoyment is essential for student engagement and reinforces the value of hands-on methods, making practical work an indispensable part of the learning experience, especially when it involves real-world applications in chemistry.

Theme 2: Mediating Hindrances of Practical Work through Modification

Despite the evident benefits of hands-on activities, teachers face several obstacles, particularly related to resource availability. One teacher noted, "*The* *availability of the materials*" is often a challenge, which was echoed by another who mentioned, "*Lack of important/necessary equipment and chemicals.*" These limitations can hinder the ability to conduct practical experiments, making it difficult for students to engage fully. However, teachers found ways to overcome these challenges by modifying activities. "*I look for materials found at home or alternative materials that are safe for the learners,*" shared one teacher, emphasizing the adaptability required to ensure that learning can still take place, even with limited resources.

Theme 3: Virtual Laboratory as a Modern Platform for Laboratory Works

The shift to virtual learning, especially during the COVID-19 pandemic, led teachers to explore digital solutions, including virtual laboratories. One teacher explained, "*We use virtual lab and simple hands-on activity and demonstration,*" to bridge the gap between remote learning and laboratory-based teaching. Virtual labs became a tool for ensuring that students still experienced lab activities, even in the absence of physical equipment. Another teacher shared, "*During the pandemic, I used [virtual labs] to partially understand the topic and in some ways must know the use of some equipment and tools inside the laboratory.*" This approach allowed students to interact with lab tools and equipment virtually, filling the gaps caused by inadequate physical resources and reinforcing the importance of technology in modern education.

Theme 4: Roles of the Teachers and Students during Laboratory Experiments

The roles of both teachers and students during laboratory experiments are crucial in ensuring safe and effective learning. Teachers are seen as guides who provide essential instruction and supervision. One teacher emphasized, "*I monitor the work of school students while they are carrying out open-ended experiments,*" indicating that their role is to oversee and ensure safety during practical work. Teachers also take responsibility for educating students about safety procedures, with one teacher noting, "*Explain in detail to students the consequences of violating safety rules and procedures.*" As for students, they are expected to take an active role in their learning, with one teacher stating, "*The school students are reading the laboratory description, interacting with peers, getting messages from the teacher, interacting with the equipment and doing the experiment*." This collaborative effort ensures that both parties are engaged in the scientific process, promoting a structured yet interactive learning environment.

Result of Experts' Evaluation

The target of the experts' evaluation is to ensure the scientific accuracy and effectiveness of the developed home-based laboratory work materials (the first prototype). Science discipline and science education experts review these materials, leading to the creation of a second, improved prototype. The expert validation instrument is primarily adapted from Rogayan and Dollete (2019), with additional criteria from Moeed (2013) and Robledo (2021) to evaluate open-ended scientific investigations and the attributes of efficient home-based experiments. The overall goal is to create a comprehensive validation tool that assesses both the investigative and practical aspects of the home-based laboratory materials.

Summary of Changes Based on Evaluator Feedback

The evaluators provided constructive feedback on the instructional materials for the home-based chemistry experiments, leading to several revisions that improved clarity, usability, and appropriateness for the target audience. The following table summarizes the key comments and the corresponding changes made:

Table 3. Summary of Changes Based on Evaluator Feedback

Comment Detail	Changes Applied in the Instructional Materials
E1C1: Incorporate schematic diagrams, concept maps, or flow charts.	A pictorial/illustration was added to the worksheet in place of a schematic diagram.
E2C1: Provide an introduction specifying the target level for the experiment.	The worksheet now includes a time allotment and specifies that it is intended for senior high school to college-level general chemistry students.
E3C1: Include illustrations for each activity.	Illustrations were added to the worksheet.
E4C1: Rewrite long, complex sentences for clarity and provide more specific instructions.	Sentences were rewritten to be shorter and clearer, with specific units and measurements provided.
E4C2: Provide detailed instructions (e.g., how to sandpaper the copper wire).	Specific instructions, such as how to use sandpaper, were added to the procedures.
E4C3: Clarify confusing instructions based on feedback from pilot testing.	Some sentences were rephrased to ensure clarity, and further specific instructions were included.
E4C4: Add graphical representations of the experimental setup.	Illustrations of the experimental setup were added for each activity.
E4C5: Modify the "Reflections/Application to Daily Lives" section, clarify time allocation, and improve readability.	Time allotment was stated, the module was subjected to readability tests, and it was revised to match the appropriate grade level. The readability score was 55.39 (reading level 8.06) for worksheet #1, and 52.39 (reading level 9.24) for worksheet #2. The overall reading score was 50.73, suitable for 10th-12th grade students.

The feedback provided by the evaluators was instrumental in refining the worksheet, addressing issues like sentence clarity, instructional specificity, visual aids, and readability. These changes contributed to producing a more effective and user-friendly version of the instructional materials for home-based chemistry experiments.

Result of Pilot Testing

Pilot testing of the worksheet is the fourth stage of the DBR design of this study. The teacher was asked to use the second prototype of the material in class and provide feedbacks and assessment on various aspects of their effectiveness and practicality. Feedbacks will be utilized to review and redesign the teaching material producing the 3rd prototype.

Summary of Observations and Adjustments

Observation 1 (Chemical Reaction):

The pilot test for the chemical reactions worksheet went smoothly. The teacher ensured all materials were available, reviewed key concepts, and gave students 30 minutes for the home-based experiment. Post-lab, all groups successfully presented their results.

Observation 2 (Factors Affecting Chemical Reactions & Chemical Equilibrium):

The teacher reviewed reaction rates and chemical equilibrium. One group faced difficulty measuring liquid volumes due to the lack of proper equipment, so the teacher allowed approximation. Despite this, all groups achieved the desired results in the 45-minute experiment.

Table 4. Issues and Adjustments

Issue	Adjustment
Difficulty measuring liquid volume without proper tools	- Provide alternative methods (e.g., household items). - Include instructions for approximating measurements.

These adjustments ensure the worksheet accommodates common challenges and enhances its usability.

Result of Actual Classroom Try-out

In this stage, the third prototype of the instructional material will undergo actual classroom-try out. This stage will involve effectiveness and practicality formative evaluation of the instructional and/or teaching strategies in the materials in actual teaching of chemistry in classroom settings. The feedback and data gathered from this stage will help further refine the instructional material model that can be used in home-based laboratory work in Chemistry.

Table 5. Summary of Issues and Adjustments Made

Issue Observed	Adjustment Made in the Worksheet
Working students with varying schedules	Allow more time for students to complete experiments. Introduce flexible submission deadlines and offer additional support sessions to accommodate work schedules.
Confusion regarding experiment instructions	Provide links to relevant instructional videos. Include regular check-ins during the experiment for better guidance.
Students unable to attend class	Allow for flexible submission of proof, like photos or videos, for those who miss the online class.

Need for live demonstration to clarify results	Regularly include the option for students to submit photos/videos of their experiments. Use live demonstrations to address confusion or discrepancies.

The adjustments made in response to the issues observed aim to improve flexibility, clarity, and support for students. By allowing more time for completion, providing instructional videos, and incorporating photo/video submissions and live demonstrations, the worksheet becomes more accessible for students with varying schedules and needs. These changes help ensure all students can successfully engage with the experiments and meet learning objectives.

Table 6. Summary of Themes, Concerns, and Adjustments from Analysis of Student Responses in FGD

Theme	Concerns	Adjustment in the Worksheet
Challenges	*Time Management*	*Included a note in the teacher's guide to provide more flexible deadlines and timeframes for completing the experiment in a distance and remote learning modality.*
Challenges	*Material Availability* - *Some materials are not common in some household*	*Provide the list of required materials in advance*
Challenges	*Procedure uncertainty* - *Uncertainty about following the procedures correctly leads to repeated attempts.*	*Provide links to relevant videos*
Challenges	*Safety Concerns* - *Safety issues relevant to the conduct of experiments at home*	*Provided safety guidelines for home-based experiment setups*
Suggestion	*Need for visuals and video demonstration*	*Provide links to relevant videos*
Suggestion	*Need for Advance Preparation*	*Included a note in the teacher's guide to provide the worksheet in advance to prepare adequately especially the materials, and reading and understanding the procedure.*
Suggestion	*Need for more writing space*	*Provided more space for the students' answers/ observations*

Table 6 summarizes the concerns and adjustments made to the home-based chemistry worksheets better to suit the final prototype of the model material. To address time management, the teacher's guide now includes recommendations for flexible deadlines for the distance learning modality. Material availability concerns are tackled by providing a list of required materials in advance. Uncertainty in following the procedures and safety concerns are addressed by adding links to instructional videos and providing safety guidelines for home-based experiments. Additional adjustments include providing more writing space and ensuring the worksheet is provided in advance to improve preparation and engagement.

CONCLUSION

Based on the aforementioned findings of the study, the following were concluded to answer the statement of the problem of this study:

1. Teachers highlighted the lack of materials and equipment, inadequate resources, and challenges ensuring student safety and engagement during laboratory work in a normal classroom setup. Practical modification, alternative materials, and virtual laboratories were common strategies for overcoming these challenges.
2. The worksheets are rooted in the educational theories of Dewey, Piaget, and Kolb. They emphasize hands-on, learner-centered, and experiential learning. These features promote active participation, direct experience, and the creation of knowledge from prior understanding.
3. Students faced issues such as difficulty in following instructions, material availability, and time management. Regular check-ins, flexible deadlines, and inclusion of instructional videos and pictorial illustrations were effective strategies to address these limitations.
4. The model material includes detailed instructions and safety guidelines and uses easily accessible household materials. It provides clear, simple, and relevant hands-on practical activities that enhance engagement and ensure effective learning in a distance learning modality.

RECOMMENDATION

Based on the above-mentioned conclusions of the study, the following were therefore recommended:

1. Enhance teacher and learner support in conducting and supervising a home-based experiment. Training must include and focus on modifying science activities to ensure hands-on practical applications and strategies to overcome challenges in home-based laboratory instruction.
2. Continuous improvement of the model material is recommended, including clear instructions, more illustrations, and flexible deadlines to provide ample time for the students to complete the practical activities.
3. Learner engagement and participation must be improved in a home-based or distance and remote learning situation to ensure learning.

Regular check-ins to monitor student progress and provide guidance are encouraged.

4. For future researchers and advocates of home-based practical activities, collect and analyze feedback from teachers and students regularly to refine and enhance the worksheet. This ensures iterative feedback and adaptability to various learning environments or situations.

ADVANCED RESEARCH

While the current study provided valuable insights into enhancing home-based experiments, there are limitations that warrant further investigation. For example, the study focused on a specific group of students and may not fully represent the broader student population across different disciplines or educational contexts. Future research could explore the effectiveness of the modified worksheets in diverse settings, including varying academic levels and subject areas. Additionally, investigating the impact of different types of learner support and feedback mechanisms, such as personalized guidance or peer collaboration, could further refine the home-based experiment model. Continuous feedback from both students and teachers remains crucial to improving and adapting these materials for a wider range of learning environments.

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