PHYSICS EDUCATION TECHNOLOGY: AS A STRATEGY IN THE DEVELOPMENT OF AN INSTRUCTIONAL MATERIAL IN TEACHING CHEMISTRY

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ABSTRACT

The purpose of the study is to develop a PhET-inspired instructional material that supports the use of investigative practical work in secondary school Chemistry. This study employed a Design-Based Research (DBR) design. In the preliminary data, the researcher surveyed 7 experienced public junior high school chemistry teachers. Analysis of the current practices in teaching Chemistry shows that most of the Grade-10 Science teachers in the selected schools are female and were trained in Chemistry teaching. Investigative practical work is evidently used during group experiments and least used in demonstrations and projects. The first prototype of materials designed was appraised by 2 college instructors, one master teacher in science, and a professional teacher with a specialization in Chemistry teaching. The feedback from the experts was used to redesign and refine the materials producing the second-level prototype which was tried out by two experienced teachers with their selected students. Lesson observations and teacher interviews were used to determine the practicality and effectiveness of the materials in an online classroom setup. Teacher interviews in the implementation of the instructional materials found that (i) the instructional material complies with the content standards of the DepEd Curriculum Guide for the selected topics, (ii) it is a good source of activities for lesson preparation on the selected topics in Chemistry specifically in the areas of Additional Activity, Motivation, and Investigative Practical Work, (iii) it guides the teacher to be a facilitator of the lesson and not the sole producer of information, (iv) it guides the student to produce efficient scientific explanation by guiding them to provide claim, evidence, and reasoning, (v) the PhET simulation serve as readily available alternative for laboratory equipment. The issues found from lesson observations and teacher interviews were used to redesign the materials thus developing the final model of exemplary materials. The structure of such materials was detailed and a model for the development of instructional materials for online investigative practical work was created. Chemistry teachers can use the model to develop materials that guide them using learner-centered strategies in practical work that can be administered in online distance learning.

Keywords: ***Online Laboratory, Investigative Practical Work, Instructional Materials, PhET simulationsResearch Capabilities, Teacher Education***

INTRODUCTION

The Philippines Department of Education (DepEd) recognizes the importance of science in technological development and is therefore committed to implementing strategies that will ensure the provision of quality education (SEIDOST and UP NISMED, 2011). The

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impact of these strategies will be greatly reflected in the national and international assessment which can be categorized into elementary and secondary levels. In the year 2004, Motswiri described chemistry learning as highly characterized by the lecture method. Although practical work is implemented, it only requires students to follow instructions developed by the teacher or from textbooks instead of allowing students to engage in lesson activities in a meaningful way. This was supported by the study of Orado in 2009 where the students were involved in fostering the acquisition of mainly basic scientific skills leaving out key integrated scientific skills such as experimental design and hypothesis formulation. A March 2020 needs assessment result of 34 chemistry teachers in the district of Dinalupihan reveals that teachers appear to be confident in applying content knowledge and pedagogy in the field however they lack management of classroom structure to engage learners (individually or in groups) in meaningful exploration, discovery, and hands-on activities. This weakness consequently fails to develop appropriate learning experiences to address learners' gender, needs, strengths, interests, and experiences. From the mentioned evidence, it was observed that there is a need to provide teachers with exemplary instructional materials that contain a large amount of specific and concrete guidelines for the teacher on how to plan, organize, and conduct practical lessons that can boost the expectancy-value of the students. The purpose of the study is to develop a module that would influence secondary school students' interests in Chemistry practical work. This entailed producing a model for the development of the material for practical work that engaged learners in designing and carrying out investigations in Chemistry through PhET simulations. This study will find out the current practices in teaching Chemistry using investigative practical work. Also, it will show the features provided by PhET simulations to support investigative practical work in Chemistry. Additionally, the study will produce a PhET-inspired laboratory worksheet that supports the use of investigative practical work in secondary school Chemistry. Moreover, the study will identify the challenges that Chemistry teachers experienced in the use of PhET-inspired instructional material for investigative practical work in Chemistry. The results of the study will be beneficial to the Science teachers to guide them to become more student-centered rather than purely teacher-centered in their approach to their teaching. Likewise, the model design in creating learners' worksheets and teachers' guides can be used to create more instructional materials other than Chemistry that were focused on investigative practical 36 GALLANTRY BPSU Graduate School Research Journal work. Consequently, science students now have a chance to develop science process skills, manipulative skills, develop their scientific attitudes. School administrators can also use the results of the study to conduct LAC (Learning Action Cell) sessions, so the teachers are knowledgeable enough in designing their own instructional materials in the proper way using investigative practical work.

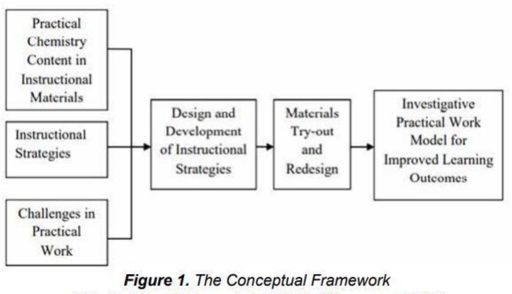

Figure 1. *The Conceptual Framework*
(Adapted from Reiser et al, 2003 & Ottevanger, 2013)

The study considered the content of teachers' reference materials for practical work with the aim of finding out the characteristics in these materials that support the investigative type of practical work. It also considered teaching strategies currently used by teachers and challenges that teachers faced in teaching using a practical work approach. These variables will determine the Design and Development of Instructional Strategies for the creation of the 1st prototype of laboratory worksheets which will undergo appraisal and classroom try out to produce the Model Materials for online Investigative practical work.

RESEARCH METHODOLOGY

This study employed a Design-Based Research (DBR) design. DBR design was appropriate because it helped create and extend knowledge about developing, enacting, and sustaining innovative learning environments (DBRC, 2003). The guidelines for the design and development of the instructional materials were based on the instructional design model (IDM) which provides a procedural framework for the systematic production of instructional materials. The five basic phases of IDM (shown in Figure 2) made up this study. These stages were (i) assessment of the practices and needs of Chemistry practical work in schools, (ii) design and development of prototype Chemistry practical work instructional materials, (iii) try out of the prototypes, (iv) evaluation of the instructional materials and (v) refinement and redesign of the materials.

The figures are as follow:

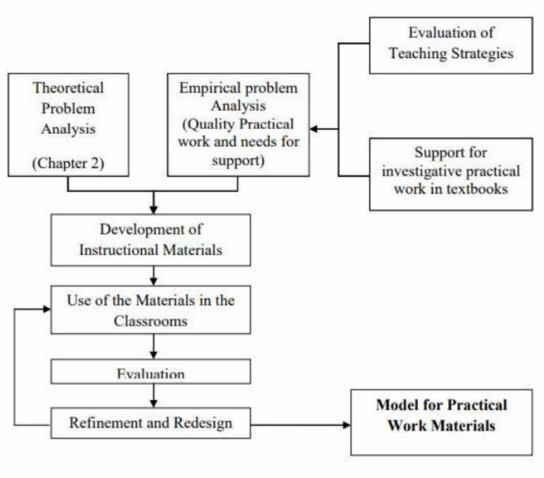

Figure 2. *Research Design and Process of the Study*

Table 1. Sample of Learners Used in Classroom-try-out of the Study

Teacher Code	Type of Delivery	Number of Students
Teacher A	Virtual Online	5
Teacher B	Virtual Online	5
Total		10

Table 2. Sample Size of Teachers Used in the Study

Nature of Study	Sample Size
Survey	7 Chemistry Teachers
Appraisal of Materials	1 Master Teacher
	1 BS Chemistry
	2 College Instructors
Classroom Try-out	2 Chemistry Teachers

Table 1 shows the sample of learners used in the classroom try-out of the study. Participating teachers both test the instructional materials in a virtual class of 5 students. Only teachers and their students who volunteered are chosen to proceed to the classroom tryout. Table 2 shows the sample size and types of teachers who participated in the study.

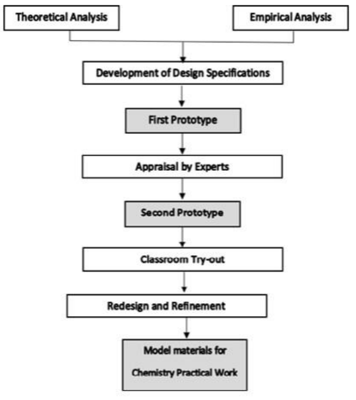

Figure 3. *Research Design and Process of the Study*

Figure 3 Shows the Development framework of Instructional materials that guided the researcher. It started with Phase 1, Theoretical Analysis and Empirical Analysis. It was followed by Phase 2, Development of Design Specifications leading to the 1st Prototype of laboratory worksheets. In Phase 3 the 1st prototype will undergo Appraisal by Experts leading to 2nd Prototype of laboratory worksheets. Finally, the instructional material will go through Phase 4, Classroom Try-out and Evaluation of the Materials leading to the Model Materials for Chemistry Practical Work. Categorization of questions and calculations of frequency distributions means and percentages for various responses were done as guided by the research questions. Data was presented in appropriate tables, charts, or graphs. The questionnaire items structured by observing Likert–scale guidelines, were tallied and their frequencies were calculated according to Likert Scale to show strengths of agreement or disagreement. In connection with this, Denscombe (2001) emphasized that the answers to interview questions were analyzed by inductive content analysis. Classroom observations were analyzed through the categorization of responses.

RESEARCH FINDINGS

Current Practices in the Teaching of Chemistry Practical Work (Phase 1)

The goal of this stage of the study was to categorize the existing methods of Chemistry teachers in practical work. Data was gathered by means of a questionnaire for teachers as well as a document analysis schedule. Results and discussion from this phase show the *(i)* demographic data of teachers, *(ii)* types of chemistry practical work used by teachers, *(iii)* reasons for using practical work in Chemistry, (iv) current classroom practice in Chemistry practical lessons, *(v)* opportunities provided by curriculum materials for support of investigative practical work in Chemistry, and *(vi)* support provided by the curriculum materials for Chemistry practical work.

Demographic Data of Teachers

Table 3. Distribution of Teachers According to Sex (N=7)

Classification	No. of Teachers	%
Female	6	85.71%
Male	1	14.29%
Total	7	100%

Table 4. Professional Qualification of Teachers (N=7)

Professional Qualification	No. of Teachers	%
Ph.D.		
MA/MS Science	1	14.29%
BSEd in Science	6	85.71%
Other Qualification		
Total	**7**	**100%**

Table 5. Teaching Experience (N=7)

Teaching Experience (Years)	No. of Teachers	%
0-4	1	14.29%
5-9	2	28.57%
10-14	3	42.8%
15-20		
Above 20	1	14.29%
Total	7	100%

Data from Table 3 shows that most of the Grade-10 Science teachers in the selected schools are female. Meanwhile, data from Table 4 and Table 5 reflects that chemistry teachers that responded to the study questionnaire were highly qualified and experienced in Chemistry teaching. This implies that they have a good understanding of the strategies of practical work used in teaching Chemistry and would therefore provide appropriate information regarding Chemistry practical work.

Types of Chemistry Practical Work Used by Teachers

Table 6. Practical Activities Used by Teachers in Chemistry (N =7)

Method	No. of Teachers	%
Demonstration	2	28.6%
Group Experiments	6	85.7%
Project	2	28.6%
Individual Student Activities	3	42.9%

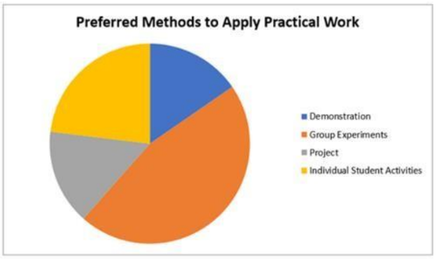

***Figure 4.** Methods of Teaching Practical Work Preferred by Chemistry Teachers (N=7)*

The data from Table 6 shows that the most used method in practical work is through group experiments and the least used methods are demonstration and project. Likewise, it could be obtained also from the pie chart (See Figure 4) that the use of group experiments is the preferred approach to achieve their practical way of teaching.

Table 7. Frequency of using Practical activity in Chemistry classrooms (N =6)

Practical Activity	Frequency					
	Never	**Once a term**	**Twice a term**	**Once a week**	**Thrice a week**	**More often**
Group/Class Experiments		2	1	1	1	1
Teacher Demonstration		3		1	2	
Project	1	5				
Individual Student Activities		1	1	1	2	1

Note. The grouping term **"Frequent"** was considered for answers of "Once a week", "Thrice a week" and "More Often". Grouping term **"Not Frequent"** was considered for answers of "Never", "Once a term" and "Twice a term".

The data from Table 7 shows that the project is the least used method, and "Individual Student Activities" is considered the most used method for the application of chemistry investigative practical work. Although, "Group Experiment" was the initially reported preferred method by the teachers in the application of practical work it was revealed that during practice they may also deviate to "Individual Student Activities" because the location is not a critical feature in characterizing practical work.

<u>Reasons for Using Practical Work in Chemistry</u>

Table 8. Reasons for Using Practical Work in Teaching Chemistry (N=7)

Reason for using practical work	No. of teachers	%
To arouse interest in learners and motivate them.	6	85.71%
To verify facts/ theories or principles discussed in class.	5	71.43%
To make learners understand a concept more readily.	6	85.71%
To make them relate Chemistry with life outside the classroom.	6	85.71%
To keep learners engaged/busy.	4	57.14%
To develop their investigative skills for everyday life	1	14.29%
Because it is a requirement by the school/ department/ ministry	3	42.89%

It can be deemed from the responses of the teachers in Table 8 that the application of practical work was inherent in their teaching practice. They are not forced to apply for practical work just to comply with the mandates or policies of their institution.

<u>Current Classroom Practice in Chemistry Practical Lessons</u>

Table 9. Involvement of Learners in Practical work (N =7)

Learners are Involved in Practical Work Through:	Agree (Combined Agree and Strongly Agree)	Neutral	Disagree (Combined and Disagree) Disagree Strongly
Being placed in groups	7	0	0
Being provided with detailed procedures to follow.	7	0	0
Designing experiments that relate to their lives experiences.	7	0	0
Being allowed to design their practical experimental procedures.	7	0	0
Stimulating them to reflect on their prior knowledge.	7	0	0

As gleaned from the data of Table 9, 100% of the respondents provide opportunities for the learners to engage in practical work. It only shows that teachers are aware that the involvement of learners in practical work is more meaningful than just following a determined set of procedures.

Table 10. Practices in Chemistry Practical Lessons

Practice	Frequency			
	Never	**Sometimes**	**Most times**	**Always**
Working in groups		2	3	1
Use provided procedures		2	2	3
***Designing experimental procedures**		5	2	
***Design and carry out procedures that interest learners**		4	3	
*** Question-developed procedures**		4	3	
Carry out peer review of the experiment		2	3	2

Note. Items that are emphasized (*) show the practice that is **"Not Frequent"**.

The data from Table 10 revealed that the most important practices in practical work are not frequently applied. These are "Designing experimental procedures", "Design and Carry out Procedures that Interest Learners" and "Questions Developed Procedures". This result shows the lack of the important aspect of practical work, which is the free manipulation of the procedure of the experiment.

Opportunities Provided by Curriculum Materials for Support of Investigative Practical Work in Chemistry

Table 11. Instructional Materials used for Chemistry Practical Lessons in the topic on Matter (N=7)

Instructional material	Frequency of Use				
	Always	Very Often	Often	Rarely	Never
Science – 10 DepEd	6	1			
The World of Chemistry			3		3
You and the Natural World Chemistry			2	1	3

The data from Table 11 shows teachers only used the mainstream Chemistry textbooks that are approved by DepEd. They did not have laboratory manuals that they could use for practical work. This indicates the need for special instructional material support for practical work in Chemistry teaching and learning.

Support provided by the curriculum materials for Chemistry practical work

Table 12. Teachers' Views on Support for Investigations provided in IM they are using (N=7)

Characteristics of Chemistry practical work instructional materials	Frequency		
	Agree	Neutral	Disagree
They provide clear objectives for the practical activity.	7		
The practical activities are related to learners' needs/ interests	7		
Practical activities are based on learners' real-life settings to make them relate chemistry with life outside the classroom.	6	1	
They provide the expected results of the practical.	7		
They give sufficient background knowledge related to the practical activity.	7		
They provide detailed step-by-step experimental procedures.	7		
They give a list of apparatus required for practicals.	7		
They provide grouping suggestions.	5	2	
Safety precautions are clearly indicated.	7		
They give the opportunity for predictive guiding questions.	7		
They give learners the opportunity to develop their own practical procedures.	5	1	1
They guide the teacher on probable questions from learners.	7		
They guide learners on writing a report.	4	3	
They have sufficient Assessment options.	4	3	
Allowance to look for alternatives to procedures given.	4	3	
Encourage thoughtful reflection on experience.	6	1	

The data from Table 12 shows that most of the teachers agreed that the instructional materials they are currently using possessed the required characteristics of investigative practical work. The teachers were also requested to give their opinion on how instructional materials can be improved to make them more fit to support the teacher in organizing practical work. They are all asked to answer the question, *what do you think could be improved or included in these materials to make them betterable to facilitate/support the teacher in organizing practical work?* After grouping their answers categorically, the following four (4) consensus was obtained, *(i)* the laboratory apparatus required must be readily available in the laboratory, *(ii)* let the students share their findings in class, *(iii)* alternate materials or substances must be included, *(iv)* they should add or increase the options for practical works in the learning materials.

The lessons developed for this study were based on the frequently occurring least learned competencies in Grade-10 Chemistry topics that have an equivalent PhET (Physics, Education and Technology) simulation application. The six lessons were Charles' Law, Boyle's Law, Types of Chemical Reactions, the Law of Conservation of Mass, Balancing Chemical Equations, and Reaction Rates.

Table 13. Aspects Emphasized by Practical Work in Curriculum Materials

Aspect	S10D	TWC	YNW
Knowledge of facts	6	5	3
Understanding	6	5	3
Hypothesizing /predicting	5	5	3
Application of scientific facts	6	5	3
Creativity and imagination	5	5	3
Analysis, Synthesis and Evaluation	6	5	3
Observational skills	6	5	3
Manipulative skills	6	5	3
Data recording	6	5	3
Data interpretation	6	5	3
Mean	**5.8**	**5.0**	**3.0**
Min = 0 / Max = 6			

Code Key:
S10 –Science 10 DepEd by Herma D. Acosta et.al
TWC – The World of Chemistry by Araneta et. al
YNW – You and Natural World Chemistry

Although not at full efficiency, Table 13 shows that 2 out of 3 textbooks currently used by the Chemistry teachers possessed all the aspects required to deliver at least 5 lessons nominated for this study. Since to achieve full efficiency, a book needs to have practical work features for all 6 nominated topics.

Table 14. Opportunities for Investigation on Selected Topics of "Matter" in the Chemistry Books

Opportunities for carrying out investigation	S10D	TWC	YNW	Mean
The clear objective of the practical activity	4	1	0	1.7
Background information related to the practical activity	3	1	0	1.3
List of apparatus required	5	0	0	1.7
Grouping suggestions	3	0	1	1.3
Safety precautions	5	0	0	1.7
Provide a guiding question	5	0	0	1.7
Gives step-by-step practical procedures	5	0	0	1.7
Reference to prior knowledge	4	1	0	1.7
Teacher guide on probable questions from learners	4	0	0	1.3
Guide on pooling results and support arguments	4	0	1	1.7
Providing a relevant phenomenon	5	0	0	1.7
Opportunity to develop procedures or look for alternatives to given procedures	2	1	0	1
Assessment opportunities	5	0	0	1.7
Min = 0 / Max = 6				

Code Key:
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The overall analysis of Table 14 shows that the current instructional materials used by chemistry teachers revealed a low rating in terms of providing opportunities for investigation on the six nominated topics for the study. Individually only 1 out of 3 textbooks (S10D) can satisfy the opportunities for investigation of the six topics but still not at full extent. The data from Table 15 shows that some of the opportunities for investigation are not applicable to PhET simulation since it is designed to support self-created experiments.

Table 15. Opportunities for Investigation on Selected Topics of "Matter" in the Chemistry Books

Opportunities for carrying out investigation	PhET
Clear objective of the practical activity	X
Background information related to the practical activity	X
List of apparatus required	6
Grouping suggestions	X
Safety precautions	X
Provide a guiding question	X
Gives step-by-step practical procedures	X
Reference to prior knowledge	X
Teacher guide on probable questions from learners	X
Guide on pooling results and support arguments	6
Providing a relevant phenomenon	X
Opportunity to develop procedures or look for alternatives to given procedures	6
Assessment opportunities	X
Min = 0 / Max = 6 / x = Not applicable	

Design and development of materials for practical work in Chemistry (Phase 2)

As Motswiri (2004) pointed out, the development of instructional materials must be guided by design specifications. The design of the laboratory worksheets included content support features, support for scientific practices, and support for scientific explanation. Each one of these aspects is discussed in detail in the instructional materials design specification (See Table 16)

According to Davis et al. (2014), in relation to science-related subject matter, content support is relevant in educational curriculum materials. As a result, the material includes background information and lesson notes, providing the actual content for each developed lesson.

Reiser et al. (2003) claimed that methodology in science is attained by means of localizing as well as stimulating the investigation. Similarly, Davis et.al., (2014) impart that this involves inquiring scientific questions, formulating predictions, planning investigations, gathering data, constructing judgment, keeping information, examining data and judgment, demonstrating, and inferring data, creating evidence-based justifications, making conclusions, allocation of concepts and creating a systematic argument. All mentioned scientific processes were applied in the development of the practical work materials.

The scientific explanation framework, as per McNeill and Krajick (2008), consists of three components: a claim, evidence, and reasoning. To begin, a claim is a statement or conclusion that focuses on the original question or problem concerning a phenomenon. The actual evidence, on the other hand, supports the student's claim by presenting scientific data. As a result, the data obtained can originate from a student-led investigation or an alternative source, such as observations, reading material, or historical information, and it must be both suitable and adequate to support the claim. Furthermore, the reasoning creates a link between the claim and the evidence, indicating why the data can support the claim which can lead to the application of appropriate scientific principles to create this relationship.

Table 16. Design Specifications for the Practical Work Materials

Design specification features	Specific Content of Each Design Feature
Content support	• Background information—describes how the lesson will be presented and what will be expected. • Purpose of the Lesson (as specified by the DepEd Curriculum Guide for Grade 10 Chemistry) and the content's structure around learning goals.
Scientific Practices	• Exploring the simulation (PhET Simulation) • Determining the dependent and independent variables. • Creating questions for investigation. • Making Predictions. • Designing procedures and setting up investigations using the features of PhET simulation. • Organizing, representing, interpreting, and analyzing data and observations. • Constructing and sharing evidence-based explanations. • Reviewing predictions once more.
Scientific explanation	• Providing a claim to prove their prediction. • Supporting the claim with a summary of evidence. • Explaining results using scientific relevant concepts.

Appraisal of Instructional Materials (Phase 3)

Experts in the science discipline conducted content reviews on the developed practical work materials (first- level prototype) to ensure scientific accuracy. One Master Teacher, a teacher with Chemistry Degree, and 2 College Instructors in Science were asked to study the materials in the light of appropriate methods of teaching Chemistry and provide feedback on important characteristics for investigative practical work.

A major improvement is revealed by the evaluations in all the areas of the design of practical activities. The researcher seeks comments and suggestions from the evaluators that can be applied to improve the design of the first prototype of the ins r the d prc

Table 17. Summary of Comments from the Evaluators

Comment Detail	Changes applied in the instructional materials
E1C1 Background must include the general information in paragraph form.	Information about the lesson was added in the background such as what to expect in the lesson and possible application of the knowledge gained in the lesson.
E1C2 The purpose must change into objectives and apply knowledge, affective, and skill values.	The purpose was replaced by objectives. Objectives were categorized as cognitive, affective, and skills.
E1C3 Independent/dependent variables must be applicable to heterogeneous students. *E3C5* Consider also the independent and dependent variables in the background part.	Hints on how to determine the dependent and independent variables were defined in the background.
E1C4 The Questions for investigation must be more than one.	It was emphasized that the students can provide more than one question for investigation.
E1C5 Give a set of activities in the Balancing of Chemical equations.	The set of activities is already determined in the PhET simulation.
E1C6 Write an introduction for each simulation. *E3C1* Consider enriching the discussion part. Present as a coherent whole without compromising the skills to be developed through the activity (investigating the relationship between variables). *E3C3* Introduce the simulation.	Details about the purpose and function of the simulation are presented in the Activity Proper part of each IMs.
E2C1 Suggestions in every instruction should be prepared so that the student can finish their goal and objective.	Hints on how to proceed on each part of the module are presented.
E4C2 Designate pagination	Table of contents and page numbers are added.
E3C6 These parts must be in the Roman numeral format: I. Background II. Purpose III. Activity Proper, etc.	The topics and the corresponding number of the IMs are formatted in Roman Numeral Font.
E4C5 Scale for the Rubrics maybe: 4,3 2,1 *E4C6* May construct a stronger statement to describe the number of criteria to magnify a clearer statement.	Rubrics for grading were revised to a number scale of 1 to 4 (where the latter is the highest)
E4C7 Use related pictures on the front page of instructional material and must be related to the activities.	Front Page was added to the compilation of instructional materials. It shows pictures and Chemistry equations related to the 6 topics covered by the instructional materials.
E4C8 Use boxes instead line for the students' answers.	Lines on the spaces allotted for students' answers are replaced by fillable boxes.

Note. Codes must be interpreted as E1C1 – First comment of the first evaluator; E1C2 – Second comment of the first evaluator; E1C3 – Third comment of the first evaluator; E1C4 – Fourth comment of the first evaluator; E1C5 – Fifth comment of the first evaluator; E1C6 – Sixth comment of the first evaluator; E2C1 – First comment of the second evaluator; E3C1 - First Comment of the Third Evaluator; E3C3 -Third Comment of the Third Evaluator; E3C5 - Fifth Comment of the Third Evaluator; E4C5 -Fifth Comment of the Fourth Evaluator; E4C6 -Sixth Comment of the Fourth Evaluator; E4C7 -Seventh Comment of the Fourth Evaluator; E4C8 -Eight Comment of the Fourth Evaluator.

Evaluation of the Instructional Materials (Phase 4)

The second prototype of Chemistry practical work learning materials developed in phase three was used by an experienced teacher in class and provided feedback and assessment on different aspects of their practicality and effectiveness through an interview. Data from the interviews acted as support to the field notes gathered from the lesson observation. Interviews also helped the researcher clarify answers that were not clear from the lesson observation.

From the teacher's interview it was gathered that *(i)* the instructional material complies with the content standards of DepEd, *(ii)* the instructional material is a good source of activities for lesson preparation on the selected topics in Chemistry specifically in the areas of additional activity, motivation, and investigative practical work, *(iii)* the instructional material guides the teacher to be a facilitator of the lesson and not the sole producer of information, *(iv)* the instructional material guides the student to produce efficient scientific explanation by guiding them to provide claim, evidence, and reasoning, *(v)* the PhET simulation serve as readily available alternative for laboratory equipment, *(vi)* the instructional material (2nd prototype) is limited in terms of gadget dependency, absence of a strategy for investigation-challenged students and investigation of the simulation and lack of grouping instructions.

The focus of lesson observation was on finding out if the teacher was able to follow the essential aspects of investigative practical work during the try- out of the laboratory worksheets. During classroom try-out additional discrepancies were observed and documented by the researcher. During lesson introduction (1) the teachers failed to clarify the question to be answered by the activity, (2) the teacher forgot to inform learners how participation will be carried out, (3) problem sheets and/or lists apparatus were not completely distributed and (4) the stages of investigation (Planning, Experimenting, and Reporting) were not discussed.

During lesson development (5) the teachers did not encourage group collaboration, (6) failed to monitor experimental set-ups, (7) the collection of PhET application is not orderly, (8) failed to attune instruction to learners' ideas, (9) forgot to stop learners at appropriate times to review various lesson activities, (10) Did not encourage peer assessments, (11) failed to review the experiment plan, (12) did not encourage students to ask clarifications of their work, (13) forgot to assure if the materials are used correctly to execute the activity and (14) failed to ask the students to reflect on the result of their activities.

During lesson conclusion the teacher (15) did not provide feedback, (16) forgot to summarize and highlight major points of the investigation, (17) did not ask for students' opinions when responding to class questions, (18) failed to remind students to draw conclusions that relate to their specified assumptions made earlier, (19) did not ensures clear up before next lesson is done in an orderly manner and (20) failed to give students homework to prepare for the next lesson.

The actions for improvement from the observed limitations during interview and lesson observations were used by the researcher to refine and redesign the second prototype of instructional materials (See Table 18).

Table 18. Summary of limitations of the IM observed by the researcher during the classroom try-out and actions for improvement

Limitations of the IM Observed by the Researcher in the Classroom Try-out	Actions for Improvement
Actions for Lesson Introduction (The following criteria were not observed during the lesson introduction) • Teachers help simplify the question to be answered by the activity. • Teacher notifies students on how involvement will be carried out. • Distributes problem sheets and/or lists apparatus.	• In this part, the teacher will provide possible questions for investigation but must emphasize that they can create one beyond the suggested questions. • Provide a grouping strategy with predetermined roles for every member in the group. • A hint will be provided to the guide that the teacher must prepare the upload of simulations and worksheets earlier or before the schedule of the required activity.
• Discusses stages of the investigation. a. Planning b. Experimenting c. Reporting	• Teacher's guide will be provided with suggestions on what the teachers must consider during the execution of the parts of the instructional material especially on the mentioned criteria that are not observed.
Actions for Lesson Development (During the development of the lesson, the following criteria were not observed:) • Learners are divided into small groups of 2-4. • Encourages teamwork amongst members of a group. • Monitors experimental set-ups. • Ensures collection of apparatus is orderly. • Attunes instruction to learners' ideas. • Stop learners at suitable times to analyze numerous lesson activities. • Encourages peer assessment (Allow students to ask questions to one another.). • Allows peer plan reviewers to suggest alternatives or provide explanations for why the plan is indeed not practical or safe.	• Provide a grouping strategy with predetermined roles for every member in the group. • Teacher's guide will be provided with suggestions on what the teachers must consider during the execution of the parts of the instructional material especially on the mentioned criteria that are not observed. • Provide a special part in the IMs where students are encouraged to check their work. Better if this part was presented after the time for creating procedures and set-up for the experiment.
• Encourage students to ask questions to get a better understanding of their work. • Facilitator rest assured that learners use materials/equipment properly to perform the activity. • Encourages and guides learners to talk over possible experimental inconsistencies in the outcomes by asking the learners to reflect on the activities.	• Provide a special part in the IMs where students are encouraged to meet with the teacher and present the draft of their work. This will give time for the teacher to provide suggestions and make sure the investigation is on track. Better if this part is presented after the allotted time for experimentation.
Actions for Lesson Conclusion (The following criteria were not observed during the lesson conclusion) • Facilitators give comments, summarizing by emphasizing major ideas of the investigation. • When responding to class questions, seek feedback from students. • Reminds students to come to conclusions based on their previously stated expectations. • Make sure to clear up in a timely manner before moving on to the next lesson. • Assign homework to learners to make them prepare for the next lesson.	• Emphasize in the IMs that the results of the experiment will be reported by the member in charge of reporting the results. • Indicate in the IMs the maximum amount of time allotted for reporting. • State clearly in the teacher's guide that teachers are required to provide feedback by highlighting key points from the investigation.

DISCUSSIONS

The current methods of teaching practical work in Chemistry are challenged to support learner-centered practical work. Teachers needed support for the implementation of investigative practical work through appropriately designed curriculum materials, especially in online learning. PhET simulations can be an alternative to laboratory set-ups but require laboratory guides and instructions to be used in practical work. Teachers faced challenges in the implementation of PhET-inspired investigative practical work. By engaging in design research, it was possible to get insights on how to develop instructional materials that address challenges facing teachers in the implementation of online investigative practical work in secondary school Chemistry.

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