RESEARCH ARTICLE

DEVELOPMENT AND EVALUATION OF PHYSICS MICROLAB (P6-μLab) KIT

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ABSTRACT

The development of Science in general and Physics in particular relies heavily on the interplay between theory and experiment. Therefore, the teaching and learning process in Physics must involve not only concepts but also experiments. To partly address the lack of available materials for experiments in the basic education level, the researchers developed and evaluated the Physics Microlab Kit (*P6-μLab Kit)* cum laboratory manual and the materials needed for the physics experiments. This project aims to help solve the perennial lack of resources, especially for Physics, at the basic education level. The developed *P6-μLab Kit* was evaluated by the experts and the students to be a good set of laboratory experiments, as indicated by an overall mean of 3.76 and 3.38, respectively. Its strength lies on its non-conventional format following the inquiry-based approach in doing an experiment.

Keywords: *Physics instructional materials, Physics experiments, Physics microlab kit (P6-μLab Kit)*

INTRODUCTION

Physics, like any other branches of science, is both theoretical and experimental; its advancement brought about by the close interplay of ideas and experiment. Due to the empirical nature of

Science, observation, measurement, and experimentation all play a vital role in its progress. In fact, the first test of whether an idea is scientific or not is the possibility of conducting any means of verifying it through observation or experiment. If the idea cannot be tested or verified, it can easily be classified as unscientific. A scientific hypothesis will remain a hypothesis unless it has undergone a series of tests through experiments and observations. Scientific laws, principles, and theories can never be formulated and accepted, if they have not survived the rigorous standards of scientific method.

Since the development of Science in general and Physics in particular heavily relies on observation and experimentation, its learning must also be accompanied by them. Torres (1994) in his book *Learning Excellence* mentioned that the best way to learn is to involve the students in actual applications of theories, principles, and concepts. The more senses involved in the teaching and learning process the better the outcome. Every inch of the learning process should be learned concretely through examples, exercises, hands-on activities and practical applications (Arevalo et. al, 2006). Harris (1993) also avers that hands-on/minds-on activities provide an opportunity for learning through participation and observation, enabling the students to be exposed to the scientific method.

For his part Gagne (2005) explained in his theory that a teacher cannot be certain if students learn unless they perform the task given them. Carpenter and Minnix (1993) claimed that teaching Physics concept using instructional materials is a very effective way to combat the *Physics-is-too-difficult* syndrome. Demonstration of a concept, using very simple materials, leaves an impression to the students that Physics, after all, is easy to understand. Based on Broomfield's work 1994), experiments are an integral part of any Physics program. Therefore, physics teaching, especially in the basic education level, must be accompanied by activities that demonstrate the concepts, and experiments that verify or even discover important principles in nature.

Because of the perennial problems of the Philippine educational system, such as the lack of laboratory materials and equipment, teachers find it difficult to teach the subject without the materials students need to perform experiments. In teaching science and technology, especially in the field of physics, the lack of laboratory materials and equipment greatly affects the students understanding of the concepts being taught (Arevalo et. al, 2006). Rojas (1990) further claimed that science instruction in the Philippines lacks much experimentation and investigation due to insufficient science materials. He suggested that *"if we must develop future scientists upon whom we can pin our hopes for scientific advancement and national prosperity, we must support science instruction with apparatus and instructional materials*."

However, setting up an adequate Physics laboratory is expensive. Many fundamental experiments require pieces of equipment that are very exorbitant commercially. Due to this challenge, Deauna (1990) suggested that the manufacture of equipment using locally available materials be encouraged and supported to address the lack of budget for the needed laboratory materials. Moreover, Simpson (1992) claimed that teaching apparatus need not be highly sophisticated to illustrate science concepts. He added that simply locally-made apparatus enable the students to understand the basic principles easily and make them aware that scientific principles applied to everyday things are not associated with special apparatus, making it less intimidating to study. The implication is that teachers should have the initiative, imagination, skill, and the know how in improvising and developing of needed science equipment to compensate for the lack of instructional materials vital in the effectiveness of teaching science subjects (Albarracin, 1994). Hence, this project-based research was proposed by the faculty of Physical Sciences.

In response to the K-12 curriculum, this Physics micro-scale laboratory kit (*P6-μLab Kit*) aims to facilitate more effective instruction in concretizing abstract concepts in Physics through simple hands-on activities. The kit includes a laboratory manual, a teacher's guide with expected experiment outcomes, and common laboratory equipment necessary for doing the activities. Each activity further enhances the understanding of the basic Physics concepts to maximize the learning experience through the performance of experiments, despite the limited resources in the public secondary school setting.

Hands-on and minds-on activities are important to maximize learning abstract concepts. According to Dale's Cones of experience, people generally remember ninety percent of what they say as they do a thing, that is, active learning takes place, as the students "do the real things". The more sensory channels possible in interacting with a resource, the better the chance the students can learn from it. Experiential learning theory defines learning as the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience (Kolb 1984). A perennial challenge in teaching physics is lack of laboratory apparatus and equipment to provide firsthand experience to students and aid them grasp abstract concepts, improve critical and logical thinking, and develop manipulative skills and positive scientific attitudes through scientific investigation.

The contents of the kit together with instructional materials were pilot tested and validated at the Philippine Normal University - Institute of Teaching and Learning (PNU-ITL). This phase was followed by introducing the kit to secondary public schools with successive improvement and revision phase before mass production. The final phase of the study focused on evaluating the Physics µLab Kit's effectiveness in addressing the high schoolers' least learned concepts and skills in Physics.

The Philippine Normal University, being the National Center for Teacher Education entails pursuing programs and research to promote quality education, at the same time, leading the other teaching institutions (3NS) in coming up with instructional approaches and materials that will enhance both content and pedagogical techniques—a vision aligned to that of the present university's *"Nurturing Innovative Teachers"*. Thus this kit reflects novelty by utilizing economical and functional equipment envisioned to help students appreciate underlying Physics principles through experiments. It will also encourage teachers to deliver Physics lessons in a more interactive way—far from traditional teaching strategies. Equally, the project serves as a prototype for developing activity-based lessons in Physics.

The terminal objectives of this project seek to:

General Objective: To develop a Physics micro-scale laboratory kit (*P6-µLab Kit*) with activities aligned to the K-12 curriculum

Specific Objectives:

1. identify the least learned concepts and skills in Physics based on the K to 12 curriculum;

2. construct manipulative materials/tools/equipment useful in enhancing understanding of least learned concepts and in acquiring least learned skills in Physics;

3. design laboratory manuals for using the manipulative materials/tools/equipment for least learned concepts in Physics;

4. validate the manipulative materials/tools/equipment and their manual use by experts, teachers, student teachers and students; and

5. improve, modify and finalize the manipulative materials, tools and equipment and their manual use based on the feedback of experts, teachers, student teachers and students.

Graphical Conceptual Frame

Based on the K-12 curriculum, the researchers surveyed the least learned physics concepts and the necessary skills for the students to develop. Having identified them, the team members were given their assigned topic in order to develop the experiments for the laboratory manual for the *P6-µLab Kit*. Purposely, the kit utilizes the inquiry-based approach in doing the experiments. Hence, the team of writers agreed to depart from the conventional format of laboratory experiments where the guide questions are usually placed after the whole recipe-type procedure or activity has been performed. Instead, the whole process of the experiments to be developed must conform to an inquiry-based format wherein students are given guide questions, as they perform the experimental tasks. In other words, instead of providing students direct instructions, the majority of the procedures come in the form of questions to be answered by doing a certain task. This feature of the *P6-μLab Kit* hopes to expose the students to the more accurate process that scientists encounter in doing experiments, instead of the usual recipe-type procedure of common laboratory experiments. Moreover, such method ensures that the students play an active role not only in manipulating (hands-on) the materials and equipment but also in developing concepts (minds-on) through inquiry and discovery. The activities should also cover a segment that allows the students to generalize or synthesize the concepts learned in performing the experiment, instead of the teacher providing them.

After developing the laboratory manual, the materials needed were canvassed and bought, keeping the cost of the kit as low as possible, but not compromised in quality. The materials and the manual were then assessed by experts and tested by the Physics majors to check, if the included experiments with the given materials properly work. The assessment and revisions done, high school students at the PNU Institute of Teaching in Learning used the *P6-μLab Kit*. They performed the activities using it and assessed its overall effectiveness in learning physics concepts.

Below is the conceptual framework used in conducting the present study.

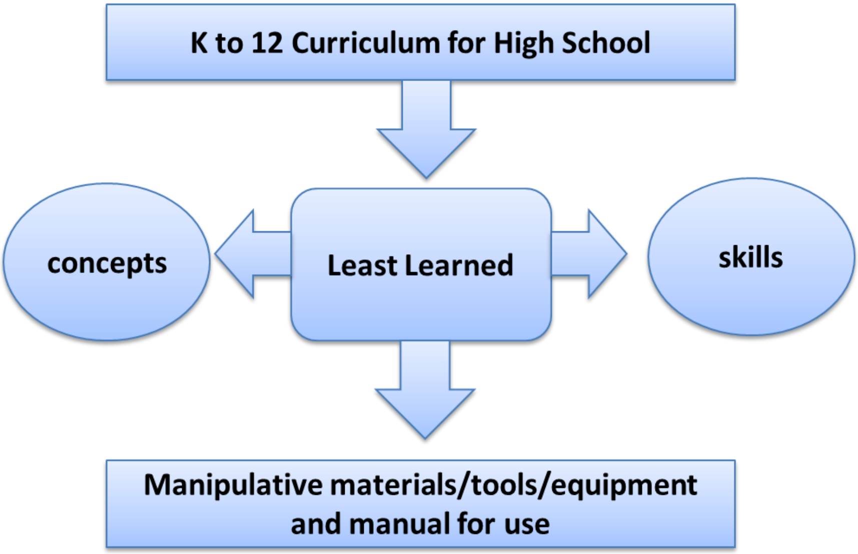

Figure 1. Conceptual Framework

METHODOLOGY

METHODOLOGY

A. Research Design
   - This educational research focuses on the development of an instructional material in a form of an alternative laboratory kit to facilitate learning of the least learned concepts and skills of students in the secondary level despite limited resources.

B. Target Users and Participants
   - This *P6-μLab Kit* is designed for Physics experiments conducted by students at the secondary level.
   - Student teachers trained prior to pilot testing for executing the experiments and evaluating the kit.

C. Instrument and Data Gathering Procedure

- A rubric was devised, evaluated and used to assess the kit in terms of face and content validity. The students who performed the experiments commented and provided more insight into assessing the kit.
- The effectiveness of the *P6-μLab Kit* was evaluated by administering rubrics to students, student teachers, teachers and field experts.

D. Phases of the Study

- PHASE I–Needs assessment and designing the kit
- PHASE II–Producing the prototype kit with face and content validation
- PHASE III–Initial testing of the kit at PNU-ITL with evaluation/ assessment of the pilot testing results and revision of the *P6-μLabKit*
- PHASE IV–Finalizing the *P6-μLab Kit* for Pilot Testing at selected public secondary schools
- PHASE V–Final evaluation with statistical analysis of the effectiveness in using *P6-μLab Kit* in Teaching – Learning of Physics
- PHASE VI–Writing the *P6-μLab Kit* research output

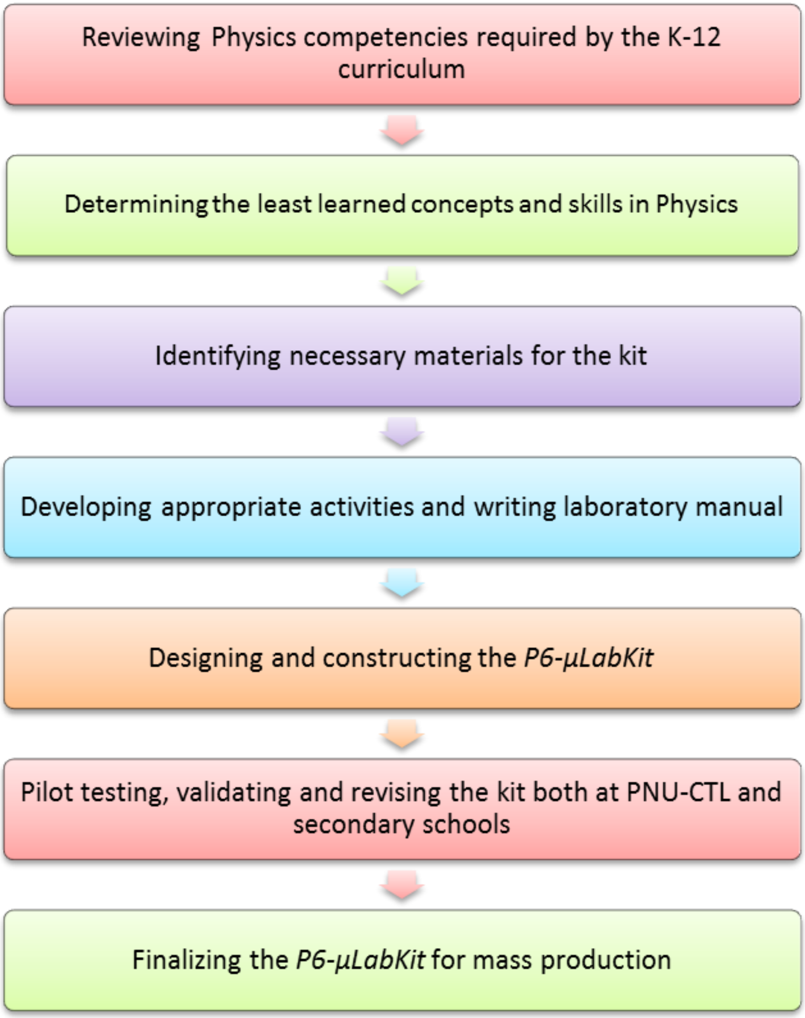

Figure 2. Product development flow chart.

RESULTS AND DISCUSSION

The first phase of the study involved the use of a survey result from the regional office of the Department of Education during one of the conducted summer in-service trainings which revealed a list of least mastered concepts in Physics based on the participants' teaching experience. The researchers then identified from the least mastered concepts in physics the topics included in the new K-12 curriculum. After clustering the topics into different branches of Physics, the group of writers were then assigned the identified topics for the development of the laboratory manual. For uniformity, the writers devised a standard format of the experiments to be developed. The various compiled experiments underwent the necessary formatting and revisions before subjecting them to the different stages of validation discussed in the foregoing paragraphs.

The completed *P6-μLab Kit* with the laboratory manual and the material for the experiments was first subjected to initial pilot testing. Students taking up Physics specialization performed the experiments first to assess the kit initially. After performing the experiments, the Physics majors were asked to evaluate the kit and write down their comments. Later the revised initial version of the laboratory manual was subjected to the validation process by Physics experts within and outside the university. The following is the final list of experiments included in the *P6-μLab Kit* that has undergone the experts' validation process.

P6-μLAB KIT **LIST OF EXPERIMENTS**

MOTION & ENERGY:

1. INERT-SIYA… Inertia
2. Speeding UP…
3. What is your WORK?
4. Do you need more ENERGY?

HEAT & THERMODYNAMICS:

5. HOT Bodies
6. MELTS in my brain

Electricity & Magnetism:

7. May the CHARGE be with you!
8. LIGHT me up
9. Electromagnetically INDUCED 4 u!
10. Step No: UP or DOWN?

Waves & Optics:

11. Diffraction: You Look Odd!
12. Through Thick and Thin
13. MIRROR, MIRROR on the floor
14. The Limbo rack of LIGHT

Each experiment has these parts; a) Introduction, b) Materials, c) Safety Reminders, d) Procedure, e) Conclusion, and f) Application. The introduction part discusses some common daily experience related to the experiment and some discussion of the theoretical aspects and important definitions that will be helpful in performing the activity. The materials needed for the given activity were already provided in the *P6-μLab Kit* and listed after introducing each experiment. Safety reminders were also included, especially the experiments for Electricity and Magnetism to avoid untoward incidents in doing the activities. One very unique feature of the *P6-μLab Kit* is that it follows the inquiry-based approach in sequencing the procedure wherein the students have to answer probing questions before proceeding to do a certain step. Hence, the students were easily exposed to the more accurate process that scientists encounter in doing experiments, instead of the usual recipe-type procedure of common laboratory experiments. This ensures that the students play an active role not only in manipulating (hands-on) materials and equipment but also in developing concepts (minds-on) about a certain topic. After answering the probing questions and completing the tasks, the students were guided to generalize and synthesize what they learned. Lastly, they answered two to three at the end of each activity that applied the concepts and principles learned in doing the experiment.

Four physics validators evaluated the kit's face and content validity based on the format, language, reproducibility and equipment. Judged on the mean obtained per category in every criteria of the checklist, most of the Physics Validators strongly agreed that these criteria were visible in the *P6-μLab Kit*. Table 1 shows the *P6-μLab Kit* Physics Validators' Evaluation Checklist by Physics Validators.

Table 1. *P6-μLab Kit* Physics Validators' Evaluation Checklist

CRITERIA		MEAN	SD	REMARK
FORMAT				
1	Title gives enough detail to get main ideas across.	4.00	0.00	SA
2	Establishes the scientific concept of the experiment.	4.00	0.00	SA
3	Presents the objectives and purpose of the experiment.	4.00	0.00	SA
4	Logically sequenced.	3.75	0.50	SA
5	Sections clearly distinct from each other.	3.75	0.50	SA
	COMPOSITE	***3.90***	***0.31***	***SA***
LANGUAGE				
1	Appropriate.	3.75	0.50	SA
2	Consistent.	3.75	0.50	SA
3	Free from grammatical errors.	3.50	0.58	SA
4	Sentences are properly constructed and punctuated.	4.00	0.00	SA
5	Simple and easy to understand.	3.75	0.50	SA
	COMPOSITE	***3.75***	***0.44***	***SA***
REPRODUCIBILITY				
1	Identifies all materials used in the experiment.	4.00	0.00	SA
2	Provides concise, step-by-step description of procedure.	3.75	0.50	SA
3	Diagrams clear and accurate.	3.75	0.50	SA
4	Appropriate tables for data are provided.	4.00	0.00	SA
5	Calculations and formulae for analysis are clearly laid out.	3.25	0.50	A
	COMPOSITE	***3.75***	***0.44***	***SA***

EQUIPMENT				
1	Attractive.	3.50	0.58	SA
2	Durable.	3.75	0.50	SA
3	Non hazardous, nontoxic, safe.	3.75	0.50	SA
4	Locally available.	3.50	0.58	SA
5	Easy to set up.	3.75	0.50	SA
	COMPOSITE	***3.65***	***0.49***	***SA***

The criteria used in evaluating *P6-μLab Kit* by four Physics Validators are shown in Table 2. Mean, standard deviation and percent agreement were indicated with the corresponding remarks. The validators strongly agreed that the *P6-μLab Kit* followed appropriate format, language, reproducibility and equipment. Using linear weighted analysis, they had marked substantial agreement in format and reproducibility and moderately agreed in language and equipment criteria. Table 3 was used in interpreting percent agreement with remarks.

Table 2. *P6-μLab Kit* Physics Validators' Evaluation Checklist

CRITERIA	MEAN	SD	REMARK*	% AGREEMENT^	REMARK*
Format	3.90	0.308	SA	80.0	MSA
Language	3.75	0.444	SA	56.7	MA
Reproducibility	3.75	0.444	SA	70.0	MSA
Equipment	3.65	0.489	SA	43.3	MA
OVERALL	3.76	0.428	SA	62.5	MSA

*based on mean ^using linear weighted analysis

Table 3. Interpretation of Percent Agreement

RANGE	REMARK
0	No agreement
$0.0 < P \leq 20.0$	Negligible agreement
$20.0 < P \leq 40.0$	Low agreement
$40.0 < P \leq 60.0$	Moderate agreement
$60.0 < P \leq 80.0$	Marked substantial agreement
$80.0 < P \leq 90.0$	High agreement
$90.0 < P < 100.0$	Very high agreement
100	Perfect agreement

Data gathering was conducted at the PNU Institute of Teaching and Learning (ITL) to enable the secondary school students to use and evaluate the *P6-μLab Kit*. The experiments were all performed as a group with five to six members each, with five sets of the *Kit* for each class. Each experiment was conducted for about thirty minutes (30 mins) each session. After each experiment, the students were asked to assess the acceptability of the kit based on the given evaluation sheet below.

Table 4. Evaluation Checklist Used by the Students

ITEM	SA	A	D	SD
1. Language used is easy to understand.				
2. Identifies all materials used in the experiment.				
3. Provides step-by-step description of procedure.				
4. Diagrams are clear and accurate.				
5. The experiment is easy to set-up.				
6. Tables for data are provided.				
7. Formulae for calculation are given.				
8. The experiment enhanced my understanding of the topic.				
9. I enjoyed performing the experiment.				
10. The experiment increased my interest in Biology/Chemistry/Physics.				

SA – Strongly Agree; A – Agree; D – Disagree; SD – Strongly Disagree

The following tables present the students' detailed evaluation for each activity performed.

The first activity falls under the topic about Motion and Energy—specifically about inertia. As shown in Table 5, the students agree that all the aspects of the activity, as stated from the evaluation checklist. Its strength lies on item number 9 which means that the students find the activity enjoyable; by contrast, its weakness are items 2 (about the listing of materials) and 10, that asked the students whether the activity increased their interest or not.

Table 5. Student's Evaluation of Activity 1

Item No.	Mean	SD	Remarks
1	3.29	0.79	Agree
2	3.24	0.86	Agree
3	3.29	0.67	Agree
4	3.35	0.61	Agree
5	3.35	0.78	Agree
6	3.41	0.78	Agree
7	3.35	1.10	Agree
8	3.41	1.24	Agree
9	3.47	1.56	Agree
10	3.24	1.79	Agree
Overall	**3.34**	**0.56**	

Activity 2 still falls under Motion and Energy, which specifically involves acceleration. Evidently, it received one of the highest evaluations given by the students who strongly agreed that the experiment satisfied all the items from the table above. It also showed that the students really enjoyed the aforesaid activity, as indicated by an almost perfect mean rating of item number 9 which asked how they felt doing the experiment.

Table 6. Student's Evaluation of Activity 2

Item. No.	Mean	SD	Remarks
1	3.50	0.90	Strongly Agree
2	3.60	0.69	Strongly Agree
3	3.60	0.52	Strongly Agree
4	3.60	0.50	Strongly Agree
5	3.70	0.60	Strongly Agree
6	3.70	0.83	Strongly Agree
7	3.60	1.14	Strongly Agree
8	3.60	1.41	Strongly Agree
9	3.90	1.57	Strongly Agree
10	3.60	1.99	Strongly Agree
Overall	**3.64**	**0.30**	

The third activity is an experiment to develop the scientific concept of work which still falls in the category of Motion and Energy.

Although the students agreed that the activity satisfied most items in the evaluation checklist, their rating is generally low. Items 8, 9, and 10 obtained means lower than 3.00 which pertain to student's understanding, enjoyment, and interest; respectively. This was attributed to the difficulty encountered by the students in accomplishing the parts that require calculations which made them disinterested, as reflected by their comments after doing the experiment. Its only strength lies on the organization of data as described in item number 6.

Table 7. Student's Evaluation of Activity 3

Item No.	Mean	SD	Remarks
1	3.33	0.97	Agree
2	3.29	0.60	Agree
3	3.38	0.57	Agree
4	3.13	0.62	Agree
5	3.17	0.83	Agree
6	3.42	0.82	Agree
7	3.08	1.05	Agree
8	2.96	1.21	Agree
9	2.67	1.55	Agree
10	2.88	1.60	Agree
Overall	**3.13**	**0.45**	

The last activity under Motion and Energy deals with conservation of mechanical energy. As revealed in Table 8, the students rated the activity poorly in all items, as indicated by means lower than 3.00. In some items the students disagreed that the conditions stated in the checklist were satisfied, as in 4 to 5 which got evaluations lower than 2.50 interpreted to a lack of diagrams and illustrations for the experimental set-up as well as tables for the data. The means of the students' rating for item 8 and 10 also indicate a negative effect to the students' understanding of the topic and their interest in physics. These results were attributed to the highly mathematical nature of the activity in demonstrating how mechanical energy is conserved based on the students' comments after the experiment. They experienced a lot of difficulties in following the procedure due mostly to its highly computational nature, as mentioned by the students after the experiment.

Table 8. Student's Evaluation of Activity 4

Item No.	Mean	SD	Remarks
1	2.71	1.18	Agree
2	2.86	1.26	Agree
3	2.79	1.08	Agree
4	2.36	1.19	Disagree
5	2.36	1.30	Disagree
6	2.43	1.45	Disagree
7	2.57	1.60	Agree
8	2.43	1.66	Disagree
9	2.64	1.91	Agree
10	2.36	2.26	Disagree
Overall	**2.55**	**0.88**	

The first experiment about Heat and Thermodynamics gained one of the highest ratings given by the students who strongly agreed that all items stated in the evaluation checklist are highly satisfied by the experiment. It can be gleaned from Table 9 that its greatest strength lies in the use of easily understood language given a perfect rating.

Table 9. Student's Evaluation of Activity 5

Item No.	Mean	SD	Remarks*
1	4.00	0.90	Strongly Agree
2	3.80	0.67	Strongly Agree
3	3.90	0.40	Strongly Agree
4	3.60	0.50	Strongly Agree
5	3.60	0.65	Strongly Agree
6	3.80	0.77	Strongly Agree
7	3.70	1.10	Strongly Agree
8	3.80	1.33	Strongly Agree
9	3.80	1.62	Strongly Agree
10	3.70	1.95	Strongly Agree
Overall	**3.77**	**0.28**	

Activity 6 covers the other experiment involving Heat and Thermodynamics, specifically about phase change of water from solid to liquid. The students agreed that the experiment satisfied all the descriptions in the evaluation sheet. Table 10 suggests that items 1, 2, and 9 gained the highest approval from the students in this particular experiment as to language used, materials provided, and the extent of enjoyment respectively.

Table 10. Student's Evaluation of Activity 6

Item No.	Average	SD	Remarks
1	3.53	0.82	Strongly Agree
2	3.74	0.59	Strongly Agree
3	3.47	0.51	Agree
4	3.32	0.49	Agree
5	3.37	0.60	Agree
6	3.37	0.83	Agree
7	3.21	0.99	Agree
8	3.42	1.14	Agree
9	3.53	1.40	Strongly Agree
10	3.42	1.55	Agree
Overall	**3.44**	**0.29**	

The first activity in Electricity and Magnetism deals with the nature of charge. Based on the student's evaluation, there is a general agreement whether the experiment satisfied the descriptions, its strength found in properly identifying the materials used for the activity. Only items 5, 7, and 10 received a little lower evaluation than the other descriptions that involve the experimental set-up, the availability of formulae for calculations, and the student's interest in physics; respectively.

Table 11. Student's Evaluation of Activity 7

Item No.	Average	SD	Remarks*
1	3.43	0.67	Agree
2	3.68	0.62	Strongly Agree
3	3.43	0.63	Agree
4	3.29	0.66	Agree
5	3.14	0.68	Agree
6	3.43	0.87	Agree
7	3.14	1.03	Agree
8	3.39	1.06	Agree
9	3.39	1.21	Agree
10	3.14	1.42	Agree
Overall	**3.35**	**0.24**	

The majority of the items in the student's evaluation of activity 8 gained a relatively higher rating to mean that the students thought that the experiment about electric circuit satisfied the descriptions in the checklist. Its only weakness lies in item 4 which corresponds to the lack of diagrams and item 10 that relates to the student's interest. In contrast, its greatest strength is traceable to properly identifying the materials used for the experiment which obtained a perfect rating for item 4.

Table 12. Student's Evaluation of Activity 8

Item No.	Average	SD	Remarks*
1	3.50	0.82	Strongly Agree
2	4.00	0.52	Strongly Agree
3	3.50	0.83	Strongly Agree
4	2.93	1.00	Agree
5	3.36	0.74	Agree
6	3.86	0.76	Strongly Agree
7	3.29	1.19	Agree
8	3.57	1.25	Strongly Agree
9	3.50	1.51	Strongly Agree
10	3.07	1.96	Agree
Overall	**3.46**	**0.31**	

The students strongly agreed that most of the items were satisfied by the third activity in Electricity and Magnetism. Specifically, this activity focuses on electromagnetic induction which cannot easily be demonstrated in the classroom. Only the items about the experiment set-up (item 5), the necessary formulae for calculation (item 7), the student's understanding (item 8), and their interest (item 10) gained a lower than 3.50 rating.

An almost similar students' assessment given to Activity 10 serves as a sequel to the previous experiment. This last activity deals primarily with the same principle of electromagnetic induction covered by activity 9, but with a more specific application in transformer. Also common materials were utilized in the previous activity that could explain why the students' evaluation revealed a somewhat similar result. The lack of formulae for calculation (item 5) remains its weakest aspect.

Table 13. Student's Evaluation of Activity 9

Item No.	Average	SD	Remarks*
1	3.50	0.97	Strongly Agree
2	3.75	0.73	Strongly Agree
3	3.75	0.50	Strongly Agree
4	3.50	0.53	Strongly Agree
5	3.38	0.73	Agree
6	3.50	1.09	Strongly Agree
7	3.25	1.41	Agree
8	3.13	1.73	Agree
9	3.75	1.80	Strongly Agree
10	3.13	2.37	Agree
Overall	**3.46**	**0.26**	

Table 14. Student's Evaluation of Activity 10

Item No.	Average	SD	Remarks*
1	3.53	0.81	Strongly Agree
2	3.67	0.73	Strongly Agree
3	3.67	0.62	Strongly Agree
4	3.47	0.73	Agree
5	3.00	0.81	Agree
6	3.60	0.77	Strongly Agree
7	3.33	1.31	Agree
8	3.33	1.36	Agree
9	3.27	1.59	Agree
10	3.33	1.81	Agree
Overall	**3.42**	**0.40**	

The first activity under Waves and Optics involves diffraction. Its greatest strength relates to the students' understanding (item 8) of the concepts included in the activity which obtained an almost perfect rating. They strongly agreed that the majority of the descriptions in the evaluation form are well satisfied by the experiment. Items 4 and 7 related to diagrams and formulae are the only ones to be polished, but do not require major revision.

It can be seen from Table 16 that for activity 12, students only agreed that the majority of the criteria from the checklist were satisfied. However, most of the ratings lower than 3.50 imply that the students' evaluation was not that high. Some items require attention due to their mean rating of 3.0. The students did not experience enough enjoyment (item 9) in performing the activity, the formulae (item 5) appeared somewhat incomplete, much less the student's interest (item 10) in physics was not highly improved.

Table 15. Student's Evaluation of Activity 11

Item No.	Average	SD	Remarks*
1	3.73	0.90	Strongly Agree
2	3.55	0.67	Strongly Agree
3	3.45	0.51	Agree
4	3.36	0.51	Agree
5	3.55	0.65	Strongly Agree
6	3.55	0.87	Strongly Agree
7	3.36	1.15	Agree
8	3.91	1.22	Strongly Agree
9	3.64	1.62	Strongly Agree
10	3.73	1.86	Strongly Agree
Overall	**3.58**	**0.35**	

Table 16. Student's Evaluation of Activity 12

Item No.	Average	SD	Remarks
1	3.50	0.79	Strongly Agree
2	3.44	0.61	Agree
3	3.25	0.66	Agree
4	3.25	0.59	Agree
5	3.06	0.73	Agree
6	3.50	0.79	Strongly Agree
7	3.25	1.01	Agree
8	3.25	1.28	Agree
9	3.00	1.66	Agree
10	3.06	1.77	Agree
Overall	**3.26**	**0.45**	

The activity regarding reflection gained a satisfactory rating from the students, as shown in Table 17. Its strength lies in the availability of data tables (item 6) and its ability to enhance student's understanding of the topic (item 8). By contrast, its weakness relates to the student's enjoyment (item 9) of the given experiment. Nevertheless, the activity generally satisfied the conditions in the evaluation checklist.

Table 17. Student's Evaluation of Activity 13

Item No.	Average	SD	Remarks
1	3.52	0.74	Strongly Agree
2	3.37	0.67	Agree
3	3.41	0.57	Agree
4	3.26	0.53	Agree
5	3.30	0.62	Agree
6	3.59	0.72	Strongly Agree
7	3.52	0.87	Strongly Agree
8	3.59	1.00	Strongly Agree
9	3.15	1.34	Agree
10	3.33	1.37	Agree
Overall	**3.40**	**0.40**	

Lastly, the experiment about refraction highly satisfied half of the descriptions and satisfactorily gained the students' approval. Table 18 indicates that five of the items (1-3, 6, and 7) obtained ratings higher than 3.50 while the other five items had mean ratings close to 3.50. These results revealed that activity 14 is among the activities given the most favorable evaluation.

Table 18. Student's Evaluation of Activity 14

Item No.	Average	SD	Remarks*
1	3.63	0.83	Strongly Agree
2	3.53	0.60	Strongly Agree
3	3.58	0.51	Strongly Agree
4	3.32	0.49	Agree
5	3.37	0.60	Agree
6	3.53	0.75	Strongly Agree
7	3.42	0.94	Agree
8	3.53	1.12	Strongly Agree
9	3.42	1.38	Agree
10	3.47	1.54	Agree
Overall	**3.48**	**0.30**	

The overall mean of the students' assessment of the *P6-μLab Kit* was calculated for each activity to identify its degree of acceptability. The table below presents the mean and the standard deviation (SD) for each activity included in the *P6-μLab Kit*.

Table 19. Student's Evaluation of the Laboratory Activities

Activity	Mean	SD	Remark
1	3.34	0.077	Good
2	3.64	0.107	Very Satisfactory
3	3.13	0.229	Good
4	2.55	0.191	Good
5	3.77	0.125	Very Satisfactory
6	3.44	0.143	Good
7	3.35	0.171	Good
8	3.46	0.323	Good
9	3.46	0.243	Good
10	3.42	0.209	Good
11	3.58	0.172	Very Satisfactory
12	3.26	0.180	Good
13	3.40	0.110	Good
14	3.58	0.093	Very Satisfactory
Overall	**3.38**	**0.327**	**Good**

1 – Poor; 2 – Fair; 3 – Good; 4 – Very Satisfactory

Based on Table 19; activity 2, 5, 11, and 14 obtained the most acceptable rating from the students. Activity 2 falls under the topic of Motion & Energy particularly about acceleration—"Speeding UP..." The second activity that gained a very satisfactory evaluation involves Heat & Thermodynamics in an experiment titled "HOT Bodies" about heat and temperature. The other two activities with a very satisfactory rating given by the students fall both under Waves & Optics that cover the topics of Diffraction ("Diffraction: You Look Odd") and Refraction ("The Limbo rack of LIGHT"). The rest of the experiments in the *P6-μLab Kit* were evaluated to be acceptable, based on the students' rated mean. As a result, the over-all mean of the *P6-μLab Kit* shown in the table above is good, interpreted as acceptable.

CONCLUSION

In sum, the *P6-μLab Kit* developed in this study has been evaluated to be a good set of laboratory activities in Physics based on the experts' as well as students' assessment. The included activities followed a non-conventional format that involved the inquiry-based approach in performing experiments—the main strength of the *P6-μLab Kit*, as reflected by the experts' evaluation. Experiments in the *P6-μLab Kit* can also be performed easily due to the accessibility of the provided materials together with the compiled experiments.

RECOMMENDATION

These recommendations are meant to enhance the present study:

1. The *P6-μLab Kit* be utilized and evaluated by greater number of student population in public secondary school setting to further assess its acceptability.

2. The period of study in using the kit must be incorporated throughout the whole school year to complement the actual topics being covered in the secondary school Physics.

3. Also detailed analysis of the different aspects of the laboratory manual and the included materials in the *P6-μLab Kit* be conducted by the end user to further improve its content.

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