Development of Laboratory Manual in Physics for Engineers

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Abstract: ***This study aimed to identify the least learned competencies, needs, and challenges of engineering physics students and teachers, and develop a laboratory manual for Engineering Physics through a mix method design and ADDIE model, but limited to analysis, design and development of Laboratory Manual only. The participants were six Engineering Physics Laboratory teachers and ten second year engineering students. The result showed that the prevailing challenges that needs to be addressed in the laboratory class were lack of updated instructional materials such as laboratory manuals and laboratory equipment, old laboratory apparatus that give inaccurate data and the least learned competencies were thermodynamics, waves and optics, and electricity and magnetism. From the least learned competencies, a laboratory manual was developed to address the needs identified by students and teachers. Results revealed that the developed laboratory manual is much acceptable (M=4.64), by experts. In particular, the laboratory manual is acceptable in terms of Content Quality (M = 4.69), Instructional Quality (M = 4.64) and Technical Quality (M = 4.58). In conclusion, the implementation of the engineering physics curriculum faces many challenges especially the lack of laboratory facilities and instructional materials. The validated developed laboratory manual was found very much acceptable and can be used to address the needs of the students and teachers of engineer physics. It is recommended that the laboratory manual will be used as a supplemental instructional material. Also, further review and evaluation of the manual maybe considered to make it more contextualized, localized and indigenized in the Philippine setting.***

Keywords: Development, Engineering Physics, Laboratory Manual, ADDIE Model

1. Introduction

Educational curriculum continues to evolve in order to fit to the students' needs and capabilities[1]. In fact, recently the Commission on Higher Education released a memorandum order mandating to change the curriculum in tertiary level; hence, topics in college courses especially experiments have changed. Science learning is practical-oriented which entails that it requires practical activities in the laboratory, at the same time, broad-based experiences to widen students' understanding in a world of opportunities to give meaning to the learning they have acquired from lectures[2]. In addition, [3]stated that science learning involves experimentation that uses hands-on and minds-on activities for better understanding. However, when there is no laboratory manual to be used, how can these practical activities be done properly? These reasons are the primary consideration on developing a laboratory manual.

Experimental methods enable students to verify theories, laws and principles surrounding science phenomena; however, hands-on activities and practical experiments need a guide in order to realize the observation and results and to better grasp the concept behind[4] this is through a laboratory manual because laboratory applications are playing a significant role in Physics education[5]. Due to the change in the curriculum in tertiary education, coverage in engineering physics has changed dramatically; hence, there are no existing manuals in the laboratory that can support the learning of the students on the practical applications.

The terms practical work, which is common in the UK and Germany context, and laboratory work, which is common in USA were activities done in order to establish students understanding through practical work. A precise definition is difficult as they embrace an array of activities in school, but generally they refer to experiences in school settings in which students interact with equipment and materials or secondary sources of data to observe and understand the natural world[6]. On the other hand, the objectives of studying science in Nigeria are contained in the Western African examination council[7]. Syllabus include-understanding basic science concepts, acquisition of laboratory skills, awareness of linkage between science and industry/environment and everyday life in terms of benefits and hazards, and acquisition of critical skills and logical thinking. These objectives require that science must be learnt through experimentation by doing practices and making thorough observations that give meaning and relevance to understanding it. Thus, the WAEC developed and assessed the manual and concluded that practical manuals are effective in teaching science concepts. This is due to the fact that students had direct access and adequate instructional materials to work with[8].

On the other hand the current state of science education in the Philippines lags behind other countries in the world. The results of the Second International Science Study (SISS) and Third International Mathematics and Science Study (TIMSS) placed the Philippines in disadvantaged position among participating[9]. In the SISS, the Philippines ranked almost at the bottom of the list of seventeen (17) nations which took part in this large-scale evaluation of educational achievement. The factors that resulted to this rank of the Philippines are the lack of instructional materials and the use of inappropriate materials[10]. Research results confirm that instructional materials improved learning, if used appropriately such as laboratory manuals[11, 12], workbook/worktext[13, 14], learning modules[15].

Locally, the HEIs in Region XII have adopted already the suggested subjects and contents for the different programs in accordance to the CMO's, although most of the schools are still trying to adjust to the new curricula. A part of this adjustment is the development of instructional materials such as a laboratory manual to be used for the offered engineering physics subject, because, since the transition phase last S.Y 2018-2019, Notre Dame of Marbel University has no existing manual in engineering physics that would match to the chapters and topics taught in the lecture, and if this will continue the science education will be impaired due to lack of appreciation. This study hopes to develop laboratory manual that can be used for the betterment of students' academic performance and to give them meaningful learning. This would serve as a tool to improve and enhance students understanding of physics in general and would strengthen more the scientific literacy of the students as well as the quality of science education in the institution.

Statement of the Problem

The main goal of the study is to develop a Laboratory Manual for Engineering Physics 101. Specifically, it aimed to answer the following questions:

1) What is the level of learned competencies of the engineering students based on CMO?
2) What are the needs of teachers and students in teaching and learning engineering physics?
3) What are the experiences/ challenges of the students and teachers in engineering physics laboratory class?
4) What are the suggestions and possible remedy on the challenges/ needs that the students and teachers have identified.

2. Materials and methods

2.1 Research Design

The study adopted a mixed method approach which allows the researcher to explore the experiences, the level of learned and least learned competencies, challenges and needs of the teachers and students of the engineering physics laboratory class. This study used a semi-structured interview guides, CMO and the past exam questions because the researcher opted to gather information that would have salient contribution in the success of the study.

2.2 Participants of the Study

The participants of the study were the second year engineering students of Notre Dame of Marbel University as well as the teachers who have experienced teaching Physics laboratory class. They were selected because these people had direct experience both teaching and learning Engineering Physics. The participants of the study played a very important role in the conduct of the study because their responses, perceptions and suggestions determined how the laboratory manual was designed and developed.

The participants of the study were chosen purposively. There were 16 informants, 6 teachers and 10 second year engineering students who have contributed to the focus group discussion sessions, and key informant interview.

The teacher participants were selected according to the following criteria: (1) He or she is teaching engineering physics laboratory class in the new curriculum, (2) Should be teaching at least 1 year or more.

The engineering student participants were selected according to the following criteria: (1) he or she should be second year engineering students of any major. (2) have taken the engineering physics lecture and laboratory class, (3) was able to pass the subject.

2.3 Research Instruments

The research utilized the following instruments: Focus group discussion guide, key informants interview guide, previous test questions and CMO, and evaluation tool for Laboratory manual.

The researcher developed a semi-structured interview guide for focus group discussion (FGD) and for key informant interview (KII) that was validated by 3 experts on the field to assure that the guide questions stated really helped the researcher in gathering the needed information in the conduct of the study. The researcher used semi-structure interview guide because this allows and gives a flexible way in asking questions to the participants about their experiences, challenges and suggestions in the conduct of laboratory class of engineering physics that they have in their mind.

Another supplementary materials used in the study were the previous exams used by the teachers who taught laboratory class for Engineering physics and the issued new curriculum guide by the Commission on Higher Education. The exams and the curriculum guide from the teacher and CHED, respectively were used to match the competencies leaned and achieved by the students to the prescribed course outcome of the new Physics for Engineers curriculum. In order to have an accurate capture of the result of the interview, the researcher used a voice recorder to assure the reliability and the veracity of the information for transcription and analysis.

To evaluate and validate the developed laboratory manual, the researcher devise an evaluation tool rubric based from the study of Alegre, Charles C. (2012) to assess the 3 components of the developed laboratory manual, the technical quality, the content, and instructional quality. It is made up of a 5 point rating scale, where 5 means strongly agree, 4 means agree, 3 means disagree, 2 means strongly disagree and 1 if the criteria stipulated in the laboratory manual is not applicable.

2.4 Data Gathering Procedures

In conducting this study, the researcher wrote a letter addressed to the Dean of the College of Engineering and Technology and to the University President of the school. After securing the approval from the proper authorities, the researcher immediately started the conduct of the study.

During the conduct of the study, the researcher briefed the participants that their participation will be voluntary and if agreed they will be given a letter of consent that the researcher prepared. After securing the participants' consent, the mechanism and purpose of the interview were briefed to them such as the use of audio recording while the interview, or focus group discussion are on-going, and for the record of raw responses that helped the researcher to achieved the goals of the study.

After briefing the participants about the mechanism during the conduct of focus group discussion, it was then conducted. The first session of FGD was for teachers. There were 4 teachers who were assigned as informant 1, 2, 3, 4 randomly so that their responses can be recorded and transcribed accurately. The next session was intended for students so their experiences and suggestions which were properly accounted for the needs analysis as well as the remedies they have suggested to have a better learning experience in physics for engineers laboratory class.

Furthermore, gathering of data was done by the researcher, through an in-depth interview. It was done with 2 teacher participants, as well as 5 student participants which are different from the focus group. Before starting the interview briefing was made by the researcher so that the participants will be aware of their rights, role and the confidentiality of their participation in the study. They were interviewed individually by the researcher. The interview utilized an interview guide which was validated by experts to assure that the data needed to the study will be obtained.

After doing the qualitative data collection, the quantitative part of data gathering was conducted. Using the previous examination test papers used by the teachers teaching engineering physics and the CHED memorandum order on the new curriculum for physics for engineers the learned and unlearned competencies were identified. The test questions in the exams were matched in the course outcomes stated in the new curriculum for the physics for engineers. Then the researcher used a 5 point bracket to determine the level of learned competencies based on how many of them were attained with respect to the total number of competencies to be learned by the engineering students.

Development of Laboratory Manual

After the conduct of needs analysis, as well as knowing the learned and least learned competencies of the students compared to the course outline of physics for engineers planning was done by the researcher. Careful planning was made in order to identify what are to be included in the manual, and how the manual will address the needs of the teachers and students, as well as enable the students to learn better the competencies stated in the course outline of physics for engineers, this part of the study is under the design phase. After the designing of what are to be included in the manual and how it should be incorporated, the development of manual began. In developing the laboratory manual many considerations were taken, from the materials available, unlearned competencies, alignment to the curriculum and the quality of the manual in terms of content, illustrations and questions to be asked were all scrutinized.

The contents of the manual were chosen from the suggested experiments by the new curriculum for physics for engineers. 12 different experiments were chosen in order to observe the course outcome as stipulated in the curriculum. The laboratory manual is composed of the following parts: Preliminaries which include, title page, foreword, safety guidelines in the laboratory, table of contents, and score sheet. Secondly, the experiments or laboratory activities which the students will be performing. Every activity is composed of introduction which will explain and elaborate the background and the concepts behind the experiment, objectives, list of materials to be used, equations, illustrations, procedures, tables & data sheet, follow-up questions and conclusions. And lastly, the references which the introductions, some of the illustrations used in developing the manual and equations were based.

2.5 Data Analysis

The data were analysed and interpreted using a thematic content analysis. This analysis method comprises steps, namely; (1) transcriptions, checking and editing, analysis and interpretation and verification[17]. The transcription was done by transferring the recorded data on to paper, and read it to get an idea of what the data was all about. (2) Checking and editing the data were divided into smaller related (meaningful) units. This was be done by reading the paragraph and recording the themes that were in every paragraph. Similar themes were grouped together to make related units. (3) Analysis and interpretation, psychological meanings were used to interpret the themes from step 2. This was achieved based on the researchers understanding of the themes presented. (4) Generalization, the data were summarized by looking into the differences and similarities between interview. Lastly, (5) validation of the data, this was done by going through the transcripts again and allowing a colleague to read it as well as to validate the findings, then the central theme can be obtained such as the challenges, the needs and the suggestions of the participants on how to improve the laboratory class in physics for engineers.

In identifying the level of learned competencies by the engineering students, a five point scale was used. Every scale has a corresponding number of competencies learned and labelled with an interpretation from poor to excellent. The numbers of learned competencies were based from pairing the exam questions used by the instructor from midterm to final exam. Below is the range which the level of learned competencies was based:

Table 1: Range for the level of learned competencies

Scale	Range of learned competencies	Verbal Description
1	1-3	Poor
2	4-7	Fair
3	8-11	Good
4	12-15	Very Good
5	16-18	Excellent

Based on the needs analysis and to the level of learned and the unlearned competencies, a Laboratory Manual was developed. It was validated and evaluated by 4 Physics experts using the 5 point Likert rating scale below and the mean was calculated to evaluate its content, instructional, and technical quality.

Table 2: Rating Scale for the Developed Laboratory Manual Validation

Range	Verbal Description
1.00 – 1.40	Not Applicable
1.50 – 2.40	Strongly Disagree
2.50 – 3.40	Disagree
3.50 – 4.40	Agree
4.50 – 5.00	Strongly Agree

3. Results & Discussion

Level of Learned Competencies

The numbers of competencies of Physics for engineers in the new prescribed curriculum by the Commission on Higher Education (CHED) were eighteen (18) and out of this number only seven (7) competencies were achieved throughout the course during the semester the subject was offered. These seven (7) competencies that have been learned were identified by matching the test items in the course outcome where the item belongs to. Please refer to Table 3.

As presented in Table 3, the seven competencies were namely; (1) *Use calculus to solve problems in force statics and kinematics*, (2) *Apply the Newton's law of motion*, (3) *Use calculus to solve work and energy problems, (4) Apply the law of conservation of energy problems, (5) Solve problems on impulse and momentum and collisions, (6) Determine the stress and strain on a body, (7) Solve basic problems in fluid statics and kinematics.* Among the competencies included in the exam, the number 1 competency which is all about statics and kinematics has the most number of items, followed by competency number 5 on impulse, momentum and collision, then by Applications of Newton's laws, followed by stress and strain and fluid mechanics, and lastly the work and energy conservation. If you can notice, all this topics and competencies achieved and included in the exams were the coverage for engineering Physics 111 under the old curriculum, and they deal more on the introductory part of Physics which is the coverage of General Physics 1 in the Science, Technology, Engineering and Mathematics (STEM) strand of the Senior High School, following the curriculum guide of K-12 program.

Table 3: Matched number of tests items to the course outcomes from the CMO

Course outcomes / competencies in physics for engineers	Number of Items included in the exam
1) Use calculus to solve problems in force statics and kinematics	24
2) Apply the Newton's law of motion	8
3) Use calculus to solve work and energy problems	1
4) Apply the law of conservation of energy problems	1
5) Solve problems on impulse and momentum and collisions	11
6) Determine the stress and strain on a body	6
7) Solve simple harmonic motion applications	0
8) Describe the characteristics of fluids at rest and in motion	0
9) Solve basic problems in fluid statics and kinematics	6
10) Describe three methods of heat transfer	0
11) Solve basic problems in heat transfer	0
12) Discuss the properties of waves, modes of vibration of strings and air column	0
13) Define electric current, electric resistance and voltage	0
14) Compute the electric force between electric charges	0
15) Solve problems on resistance and cells in series and parallel	0
16) State Kirchhoff's rule and apply them in a given circuit	0
17) Describe electromagnetism and apply its principles to problem on magnetic field and torque	0
18) Describe image formation by mirrors and lenses and solve basic optics problems	0

Subsequently, the data above shows that the focus of the laboratory class examination is on Newtonian classical mechanics (Kinematics and the forces that acts on a particular system). The primary reason on having this data is the instructional material being used in the engineering laboratory class which is based on the old curriculum where physics for engineers is divided into 2 subjects namely Mechanics, and Electricity and Magnetism.

On the level of learned competencies based on the new curriculum in physics for engineers, the finding revealed that it is at *Fair* range because only seven (7) course outcomes were achieved, and this is based on the scale used by the researcher to determine the level of learned competencies. This simply means that something should be done in order to increase the level of learned competencies for Engineering Physics. Furthermore, the topics being covered were already been introduced in the basic education due to the spiral progression of the K-12 program; hence, the topics which are least learned should be emphasized more to the students[18]. As shown in Table 3, there are good number of course outcomes which are not achieved and included in the examinations in Physics for Engineers specifically; Thermodynamics, Waves and Optics, and Electricity and Magnetism.[19]These topics and their course outcomes were the least learned concepts in Physics, and most students have difficulties mastering these concepts. Another study supported the results on the least learned concept. It was mentioned that Electricity, Magnetism, Optics and Thermodynamics were the most difficult topics of physics that students cannot simply grasp and struggle the most[20].

On the study conducted in 2014 instructional materials such as modules, manual, textbooks and electronic books are effective in delivering instruction and promote students' performance in content and knowledge acquisition[21]. Also,

International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

on utilization of effective resources in teaching Physics, achievement level of students increases as the innovative, updated and contextualize resources are used in delivering instruction[22]. As a matter of fact, laboratory manuals which are designed to help students master the least learned concepts in Physics play an important role in the success of instruction delivery[19]. Studies have shown that in order to address the problem on unachieved course outcomes of the curriculum, instructional material such as a laboratory manual should be developed aligned to the existing guide issued by the commission on higher education.

Experiences and Challenges of Students and Teachers

This section discusses the perceived challenges experienced by the Physics instructors and students of Engineering Physics laboratory class.

Table 4 shows distinctive responses from the participants about the challenges they have experienced. The common and prevailing problem of the school as shown in table 4 are lack of updated laboratory instructional materials and equipment. Topics on the lecture do not coincide or not related to the activities done in the laboratory. This is also supported by the findings on the level of learned competencies which is on fair level. This finding can be attributed to the lack of updated instructional materials as well as the laboratory equipment that would result to limited number of experiments to be performed in order to cover the stipulated course outcomes in the curriculum.

Obtaining in accurate data was also one of the challenges expressed by the students which will also boil down to the common prevailing challenge on the lack of updated and calibrated laboratory apparatus. Students have said that it is hard for them to gather accurate data because laboratory equipment were already rusty and crooked and is difficult to operate.

Table 4: Challenges experienced by the students and teachers in Engineering Physics Laboratory Class

Physics teachers	• Lack of laboratory equipment and updated laboratory apparatus • Different teachers in the laboratory and lecture classes • Old instructional materials and laboratory apparatus • Students' difficulty in following and understanding procedures • Topics on the lecture does not coincide with the laboratory activity • Hard to cope to the new curriculum • Congested topics and Big class size • Defective laboratory apparatus • Classrooms are not conducive for learning • Students who are not STEM strand graduates
Students	• Concepts and the procedure on how to conduct experiments were not explained • We are left by our instructor while conducting experiments • Lack of instructional materials such as manuals and laboratory apparatus • Old and uncalibrated laboratory equipment • Some activities in the laboratory are not related to the lesson in the lecture • Difficulty in operating laboratory equipment • Obtaining inaccurate data • Unable to perform experiments because of insufficient materials • We do not have access to the instructional material • Writing the laboratory report consumes most of our time

The conduct of pre-laboratory discussion and post-laboratory discussion play vital roles in the success of students experiment sessions; failure to incorporate comprehensive pre-lab and post lab discussion will mislead the students and affect the outcome of the activity[23]. It was believed that teachers have different practices and different ways on how to deal with their students, and not all teachers are doing what students have expressed. The statements of students above are partly explaining why they have encountered difficulties in understanding and following procedures of the experiment. At some point, we can also attribute the challenges on difficulties of students to understand the procedures and concepts of experiment on the instructional materials being used, the students shared their experience.

In the study of Roberts (1988), it was found out that limited purchase of instruments, lack of maintenance and unavailability of the laboratory facilities were also common challenges experienced by schools[24]. Subsequently, the challenges experienced by teachers and students revealed in table 4 were unconducive classrooms for learning, students which are not graduates of STEM strands in Senior High School, congested topics, inaccurate data and etc. It was emphasized that students who were none product of STEM strand encounter much difficulties and have tendencies to shift or change course; hence, it will affect how the teacher delivers instruction[25].

A major problem of the institution is the lack of updated instructional materials, facilities and equipment. The participants express their struggle on their need for adequate Science materials and equipment especially the Physics laboratory as shown in table 4. This was supported by by study of Ramdari, et al. (2019) that Physics learning is rarely done thoroughly due to many things such as lack of inventory practical tools, practice rooms, modules, manuals and incomprehension to poor teaching materials into practical materials.

This finding was affirmed by Jalmasco (2014) that approximately 20% of the typical laboratories are present among Philippine schools, which was also supported by the study of Ongowo and Indoshi (2013), and Roberts (1988). This is the reason why the students have less opportunity to engage in laboratory activities and develop their scientific inquiry. Another challenge that the students and teachers faced was the lack of laboratory equipment. This was based on the responses of the students and teachers and Orleans (2007) affirmed this finding.

Class size can also have a versatile effect in other factors of the teaching and learning process experience and can affect in different ways. An example of this is it can have negative effects on laboratory class interactions. This will lead to noise, disruptive behaviour, laziness of students to participate, and greater demand for instructional materials and facilities which in turn affect the teaching-learning process. Lesser class size is more advantageous and less burdensome for teacher, and will enable the teacher to aid the students need better. Class size can also affect the materials needed for activities and also for allocated time (Ehrenberg et al., 2001).

Need of Students and teacher in Engineering Physics 101 class

This section discusses the needs of the students and teachers of Engineering Physics laboratory class.

Table 5 shows commonality between the responses from the teacher and student participants about the urgent needs of teachers and students in Engineering Physics laboratory class that are to be addressed as soon as possible. The common and prevailing needs as shown in table 5 is the updating of instructional materials and facilities. It was found out during the conduct of the in-depth interview (Appendix J) with the teachers and students, as well as in the focus group discussion to another of teachers and students (Appendix I), and this is supported also by the findings in the level of learned competencies which is in Fair level. It is perceived that due to outdated instructional materials and facilities limited number of activities can be done in order to satisfy the course outcome stipulated in the curriculum.

Table 5: Needs of Students and teacher in Engineering Physics laboratory class

Physics teachers	• Updated laboratory manual based on the new curriculum • Enough laboratory equipment and facilities in the stock room • Calibrated laboratory apparatus
Students	• We need new sets of laboratory materials and apparatus • We need laboratory workbook where we can write observations and data gathered • I want Specific laboratory activities incorporated to our courses

These needs expressed by the teachers and students are clear manifestation that there is an existing inadequacy of laboratory instructional materials and facilities. Roberts (1988), on her study about the assessment of laboratory needs, found out that purchase of instruments, installation and maintenance of the laboratory facilities are the most common need of the schools in communities. This way of expressing their needs is also a way of expressing their desire to have a complete, updated, and sufficient laboratory facilities as shown in table 5. This is related to the encountered challenges of the teachers and students which are lack of instructional materials and laboratory apparatus which were mentioned in the previous discussion and in table 4. It was pointed out during the interview and focus group discussion that this needs would affect the attitudes of the participants in the teaching-learning process.

As perceived by the students when the needs will be addressed this will help them become more advanced in terms of skills, learning and facilities. This would also help them learn in a different way and would trigger curiosity, stimulate interest and critical thinking that would enable them to apply their learnings in the real life scenario. Based on the results of study done by Ongowo and Indoshi (2013) on the analysis of undergraduate laboratory manuals, high percentage of basic science process skills is incorporated rather than to integrate complex science process skills which are highly needed in tertiary education.

On the other hand, teachers have also enumerated some effects on the way they teach Engineering Physics when this needs will be provided. It would be easier for them to conduct classes and this will make them more efficient and organized.

The data sources have many implications when the needs of the students and teachers will not be addressed. For the students, writing the laboratory reports will be a burden because their teacher focuses more on neatness than accuracy because of the lack and defective facilities. They can't also enjoy and feel the impact of learning laboratory activities, and they will become lazy and dependent on their group mates in doing the experiments. On teachers end, they will be more creative and wise in strategizing on how to regroup and devise a plan in order for the students to conduct the activity; also they are just going with the flow, letting things be whatever they are just to avoid stress while teaching the subject. According to Nyanda (2011), learning Science subjects in absence of well-equipped Science laboratory, students cannot master Science concept, knowledge and nature of the Science. In addition, encountered difficulties in facilitating Inquiry to their Science students will lead to failure of the specific goals of practical work to be attained. On the other hand, students also account difficulties to interact with phenomena as well as materials in order to enhance meaningful learning process. Lastly, the absence of a well-equipped laboratory would possibly hinder the leaning to occur as well as teaching process to failure.

Suggestions and possible remedies to the perceived challenges experienced by the students and teachers

This section presents the possible ways to overcome the challenges that were enumerated in the previous discussions and this part answer's the fourth statement of the problem.

Table 6 shows the suggestions given by the students and teachers on how to provide the needs and address the challenges they have experienced while taking and teaching Engineering Physics laboratory class, respectively.

Suggestions were taken during the conduct of focus group discussion and in-depth interview. There are common and prevailing suggestions from both teacher and students such as *updating of laboratory manual which is aligned to the new curriculum, purchase new laboratory equipment and apparatus based on the instructional material, and make the classroom conducive for learning by decongesting the number of members per group* which will make the teaching-learning process in Physics for Engineers better.

It was stated that lack of instructional materials and facilities, and its alignment to the curriculum were the primary challenge faced by the participants, and their needs are updated laboratory materials and facilities, which give light to the prevailing suggestion of updating the laboratory manual and that is aligned to the curriculum and purchasing of new and enough laboratory apparatus and equipment. Gobaw (2016) recommended in his study that developing a harmonized and standard laboratory manual with all the necessary scientific skills would promote the students' use of much integrated scientific skills. Also, it was mentioned by the participants that they have big number of members per group because of the fact that the class is oversized, and it pave the way for the participants to suggest the reducing of the number of group members into 2-4 persons per group which was also suggested in the study of Pascal and Schultz (2002) because it greatly affects the educational production function of a student.. Looking into the data source there is really need to aid and act on the prevailing challenges based on the suggestions enumerated by the participants.

Table 6: Suggestions and Possible Remedies to the challenges experienced by the students and teachers

Physics teachers	• Buy new laboratory apparatus based on the instructional materials • Update the laboratory manual aligned to the new curriculum • Reduce class size • Teacher should have a demonstration table • Video clip on how to conduct every activity • To have a projector inside the laboratory classrooms • There should be enough or more number of laboratory apparatus • Regular checking and calibration of laboratory equipment • Make classrooms more conducive • The teacher in the laboratory should be the same with the lecture
Students	• Reduced the number of group members to 2-4 persons. • There should be a guide that will enables us, students to be aware of the succeeding activities. • The instructor should do pre-lab and post lab discussion • Align the activities in the laboratory to the topics in lecture • Update the laboratory materials and facilities based on the number of students and instructional material • Teachers guidance during the conduct of experiment • There should be an updated laboratory manual • Teachers should be prepared well for the class, and answer students questions • Classroom rules and regulations should be established well • Physics major teacher should handle the subject.

Part of the suggestions is the conduct of pre-laboratory and post-laboratory discussions which was suggested by the students and was also suggested by the participants in the study of Gobaw (2016), in order to address the problem on understanding the concept behind the laboratory activity and follow the steps on how to conduct the activity properly so that they can gather an accurate data. On the other hand, teachers suggested to have demonstration table, additional projector on laboratory rooms and video clip of the procedure for every activity in order for them to do the pre-lab and post lab discussion and also to provide students a clear grasp on how the activity will be done and will help them overcome the difficulty in doing the experiment and will enable teachers to come to class prepared.

Other suggestions shown in table 6 were regular checking and calibration of laboratory equipment, establishing well the classroom regulations, conducting learning assessment, physics teacher should be handling the class, and etc. All of the suggestions above were perceived by the participants for the betterment of the delivery of instruction as well as to mitigate and gradually to eliminate the challenges that they have experienced.

Development of Laboratory Manual

From the aforementioned analysis, discussions and suggestions, the researcher was able to develop a laboratory manual in Physics for Engineers in order to address the needs and challenges, and to materialize the prevailing suggestion of the participant which is to develop an updated curriculum-based instructional material in a form of laboratory manual.

The laboratory manual contains 12 different activities. The activities were selected and included based on the least learned competencies as indicated in the levelling and matching of test items to the CMO based on the new curriculum for engineering courses specifically on physics for engineers. The completed laboratory manual was first subjected to expert validation and evaluation. Design, development, or even selection of instructional materials can be quite challenging depending on the subject, goal, target audience, context and so on (Sebdurur et al., 2016).

The developed laboratory manual is titled *"Ɛpsilon: Laboratory Manual in Physics for Engineers 1."* It contains laboratory experiments and activities that will allow the student perform practical applications that can expand the knowledge and understanding of the engineering students on the concepts of Physics that are taught in the lecture subjects. The experiments included in the manual were aligned with the competencies and course outcomes prescribed and required by the new engineering physics curriculum from the Commission on Higher Education (CHED). Every activity in the manual contained several parts, which include the introduction, objectives or learning outcomes, materials of the experiment, procedures on how to conduct the activity, tables and data sheets, follow-up questions, and summary and conclusions.

Each worksheet of the manual has an introductory paragraph to give the students the concepts and the ideas of what topic they are working on and this will serve as a review on what they have discussed in the lecture. The objectives or the learning outcomes provide the specific target that should be attained after performing the experiment. Next is the procedure which is the step-by-step process on how to do the experiment and obtain correctly the accurate data needed for the data sheets and tables. The data sheets will serve as the basis on how to discuss the results of the experiment. It will be part of the follow-up questions, and this will help to verify whether the activity was done correctly. Lastly, the summary and conclusions where the data and its implications are included and will fulfil the stated learning outcomes in the experiment. When the task in the manual will be done accordingly, it will help the students support their scientific inquiry and develop understanding about scientific ideas through experience (Yang &Lui, 2016).

Content and Face Validity of the Laboratory Manual

To secure the validity, appropriateness and usefulness of the developed laboratory manual, expert-validators were asked to validate it. The criteria for evaluation include content Quality (Table 7), technical quality (Table 8), and instructional quality (Table 9).

As shown from Table 7, the validators strongly agreed that the developed laboratory manual has content validity (M = 4.69, SD = 0.36). Each indicator received a strongly agree remarks and showed that the manual is scientifically adequate and accurate and emphasizes active learning. Also, its activities were relevant to the objectives, aligned to the curriculum, well organized and free from stereotypes, except with the indicator on allowing the development of multiple intelligences (M = 4.00, SD = 0.00) which the validators just agreed on it. Gardner (1982), pointed that the intelligence of a person cannot be summed up into a single number. It is more than scholastic ability, and the student learning will increase with differentiated instructions. Shearer (2018) said that experiments and practical activities are not the sole source of multiple intelligence development but also personalized learning strategies. Content knowledge is very important and is related to student learning (Magnusson et al., 1992). Teachers with strong content knowledge are more likely to teach in ways that help students construct knowledge, pose appropriate questions, suggest alternative explanations, and propose additional inquiries (Alonzo, 2002; Gess-Newsome& Lederman, 1995; Roehrig & Luft, 2004), and is more efficient when appropriate manual is used for teaching.

Table 7: Validators' evaluation on the Content quality of Developed manual

Content Criteria	Weighted Mean	SD	Remarks
1) The content is scientifically adequate and accurate.	4.75	0.50	SA
2) Emphasize active learning.	4.50	0.58	SA
3) Contents of each activity is relevant to the objectives.	4.75	0.50	SA
4) It is well organized.	4.75	0.50	SA
5) It evaluates student learning as stated in objectives.	5.00	0.00	SA
6) It allows the development of multiple intelligences.	4.00	0.00	A
7) Topics are supported by illustrations and tasks suited to students.	4.75	0.50	SA
8) It is aligned to curriculum.	5.00	0.00	SA
9) The contents are free to ethnic, gender, and other stereotypes.	4.75	0.50	SA
Composite	**4.69**	0.36	SA

1.0-1.40=Not applicable 2.41-3.40=Disagree
4.41-5.00=Strongly Agree
1.41-2.40=Strongly Disagree 3.41-4.40=Agree

In terms of technical quality, the developed laboratory manual got a very favourable rating as shown in Table 8 (M = 4.58, SD = 0.45) which means that validators strongly agreed to most of the indicators. Although 2 indicators namely, layout and design are attractive (M = 4.25, SD = 0.50); and the manual is aesthetically pleasing (M = 4.25, SD = 0.50) which received an "agree" rating from the validators. It was suggested that artistic layout and the over-all look of the manual should be improved. Research literature suggests that the quality of learning material is enhanced if the material is designed to take into account the learners individual preference and learning style (Ramussen, 1998; Riding & Grimley 1999; and Rogayan & Dollete, 2019).

Table 8: Validators' evaluation on the Technical Quality of the Developed laboratory Manual

Technical Quality Criteria	Weighted Mean	SD	Remarks
1) The manual is easy to understand.	4.75	0.50	SA
2) The manual allows learner to control pace of learning	4.75	0.50	SA
3) The graphics are excellent	4.50	0.58	SA
4) The layout and design are attractive	4.25	0.50	A
5) Intend users can easily and independently use the manual.	4.75	0.50	SA
6) The language used is clear, concise, and motivating.	4.50	0.58	SA
7) The manual is aesthetically pleasing	4.25	0.50	A
8) The symbols used are well-define	4.75	0.50	SA
9) Topics are presented in a logical and sequential order.	4.75	0.50	SA
Composite	4.58	0.45	SA

1.0-1.40=Not applicable
2.41-3.40=Disagree
4.41-5.00=Strongly Agree
1.41-2.40=Strongly Disagree
3.41-4.40=Agree

Furthermore, the validators strongly agreed on the instructional quality (*M* = 4.64, *SD* = 0.42) of the laboratory manual which is shown in Table 9. Almost all of the indicators received a strongly agree remark except for the indicator about the current trends in Physics instruction and experiments (*M* = 4.25, *SD* = 0.50). Nevertheless, two of the indicators under the instructional quality got a perfect rating (*M* = 5.00, *SD* = 0.00) from the validators which indicates that the manual is of high educational value, and addresses the needs and concern of the students which is the primary purpose of developing this laboratory manual.

Table 9: Validators' evaluation on the instructional quality of the laboratory manual

Instructional Quality Criteria	Weighted Mean	**SD**	Remarks
1) It provides feedback on accuracy of the student's answer.	4.75	0.50	SA
2) It is of high educational value.	5.00	0.00	SA
3) It is a good supplement of the curriculum.	4.50	0.58	SA
4) It addresses the needs and concern of the students	5.00	0.00	SA
5) The manual facilitates collaborative and interactive learning.	4.50	0.58	SA
6) It integrates student's previous experience.	4.50	0.58	SA
7) The manual introduction helps answering follow-up questions.	4.75	0.50	SA
8) It reflects current trends in physics instruction and experiments.	4.25	0.50	A
9) The graphics, and colours used are appropriate for instructional objectives.	4.50	0.58	SA
Composite	**4.64**	**0.42**	**SA**

1.0-1.40=Not applicable *2.41-3.40=Disagree*
4.41-5.00=Strongly Agree
1.41-2.40=Strongly Disagree *3.41-4.40=Agree*

Table 10 shows the summary of evaluations done by the experts on the laboratory manual. As reflected in Table 10, the developed laboratory manual received a favourable rating from the experts (*M* = 4.64, *SD* = 0.26) which implied that the validators strongly agree with all the aspect of the developed laboratory manual. Content Quality (*M* = 4.69, *SD* = 0.30) rank first, followed by the instructional Quality (*M* = 4.64, *SD* = 0.25), and Technical Quality (*M* = 4.58, *SD* = 0.22).

Table 10: *Summary of experts' validation of the Developed Laboratory Manual*

Criteria	Mean & SD	Remarks	Rank
Content Quality	4.69 ± 0.30	SA	1
Technical Quality	4.58 ± 0.22	SA	3
Instructional Quality	4.64 ± 0.25	SA	2
Composite	4.64 ± 0.26	SA	

1.0-1.40=Not applicable *2.41-3.40=Disagre*
4.41-5.00=Strongly Agree
1.41-2.40=Strongly Disagree *3.41-4.40=Agree*

The expert validators provided positive feedback in the developed laboratory manual and were looking forward for the benefits it would provide to the teachers and students in the teaching-learning process once it will be used for instruction. This research finding agrees with several research studies (Rogayan & Dollete, 2019; Evangelista, et al., 2014; Ocampo, 2015; Pastor, et al., 2015). Tomlinson (1998) commented that the impact of instructional materials and facilities were achieved when the materials have noticeable effect on learners when they are stimulating curiosity, interest and attention are attracted. Likewise, when teachers use instructional materials in teaching it improves the performance of the students and enables teachers to clarify their lessons (Leonen, 2016).

4. Conclusion

Based from the findings, the following conclusions were formulated:

1) In the implementation of the new curriculum for Engineering Physics, the level of learned competencies is fair and there lots of challenges that should be addressed such as inadequate updated laboratory instructional materials and facilities, big class size, and lots of course outcomes were not achieved which has serious impact in teaching and learning process.
2) The needs that should be addressed urgently to make the teaching learning process better were updated instructional materials and facilities, and reduce the class size which were also strongly suggested by the participants to be materialized to cope with the challenges.
3) The developed laboratory manual was found to be very much acceptable as validated by experts. The expert-validators strongly agree that the "Ɛpsilon: Laboratory Manual in Physics for Engineers" possesses excellent content, technical, and instructional quality.

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