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Recommending and Implementing Measures to Enhance Experimental Teaching Competence in Teaching Physical Pedagogical University Students

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Abstract: *Constructing and enhancing the essential traits and competencies for learners is the current innovation teaching trend. The competency to apply experimental teaching is extremely crucial for physical pedagogical students. The Practical module of teaching High school Physics Experiments might foster the competency level of students. In this article, we created the competency framework in conducting experiments in instruction. Based on the framework, we also proposed a development procedure of employing experiments in teaching, which we will apply to educate physics pedagogy students in the Practical module of teaching High school Physics Experiments.*

Key words: *Competence, experimental teaching competence, experiments, self-experiments, experimental teaching.*

I. Introduction

The Practical module of teaching high school Physics Experiments contributes to the development of experimental teaching competence of students. The proposed and implemented measures are within the scope of this module framework. Based on this approach, we recommended and executed four measures as follows:

Measure 1: Enhancing seminar activities and seminar content associated with learners' career activities.

Measure 2: Developing designing and manufacturing activities, the use of do-it-yourself experiments.

Measure 3: Diversifying forms of assessment and evaluation, focusing on assessing process.

Measure 4: Developing websites to support teaching activities for "the Practical module of teaching High school Physics Experiments".

II. Definitions of key terms and results of the research

2.1. The competency to use experiments in teaching

Mr. Josephy assessed experimental activities in Physics, including four processes: Planning (designing experiments, developing and clarifying issues); Performance (observing, implementing, and collecting data); Explanation (processing data, giving deductions, predictions, and explanations); Communication (reporting data, obtaining information), there is no hierarchy or sequence described for this process as well as for different competency abilities [2].

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Robin Millar defined Practical work as the activity that involves observing and impacting on the participants of the study. Practical work includes both laboratory and home-based activities. Experimental activities enable students to act as scientists' styles [3].

Lin Zang stated that: teaching methods influence over students' competence in applying knowledge and skills in familiar situations when employing experiments in teaching. However, they make no difference in implementing for new situations.

According to Woolnough, the use of experiments in teaching has not received appropriate emphasis in developing countries, hence, this experimental teaching needs to be enhanced. Therefore, it is essential to take teachers' competency to use experiments into consideration. This competency plays a crucial role and has a significant impact on the quality of Physics education [4].

Nguyen Van Bien believes that experimental competency is one of the most significant capabilities of students needed to be formed and strengthened through Physics training. He presented several major components of the experimental competence but solely dealt with the issue of the students' experimental competencies [1].

Other research also discussed the significance role of the competency to use experiments in teaching. However, this competency has merely been researched and clarified which was primarily about the abilities to use experiments in research. Survey content of teachers or students consists of determining experimental objectives, designing the experimental strategies (including selecting experimental tools, planning the implementation and collecting data during the experiment), executing the experiment (assembling, arranging the experiment, obtaining results), finally processing data and assessing the outcomes.

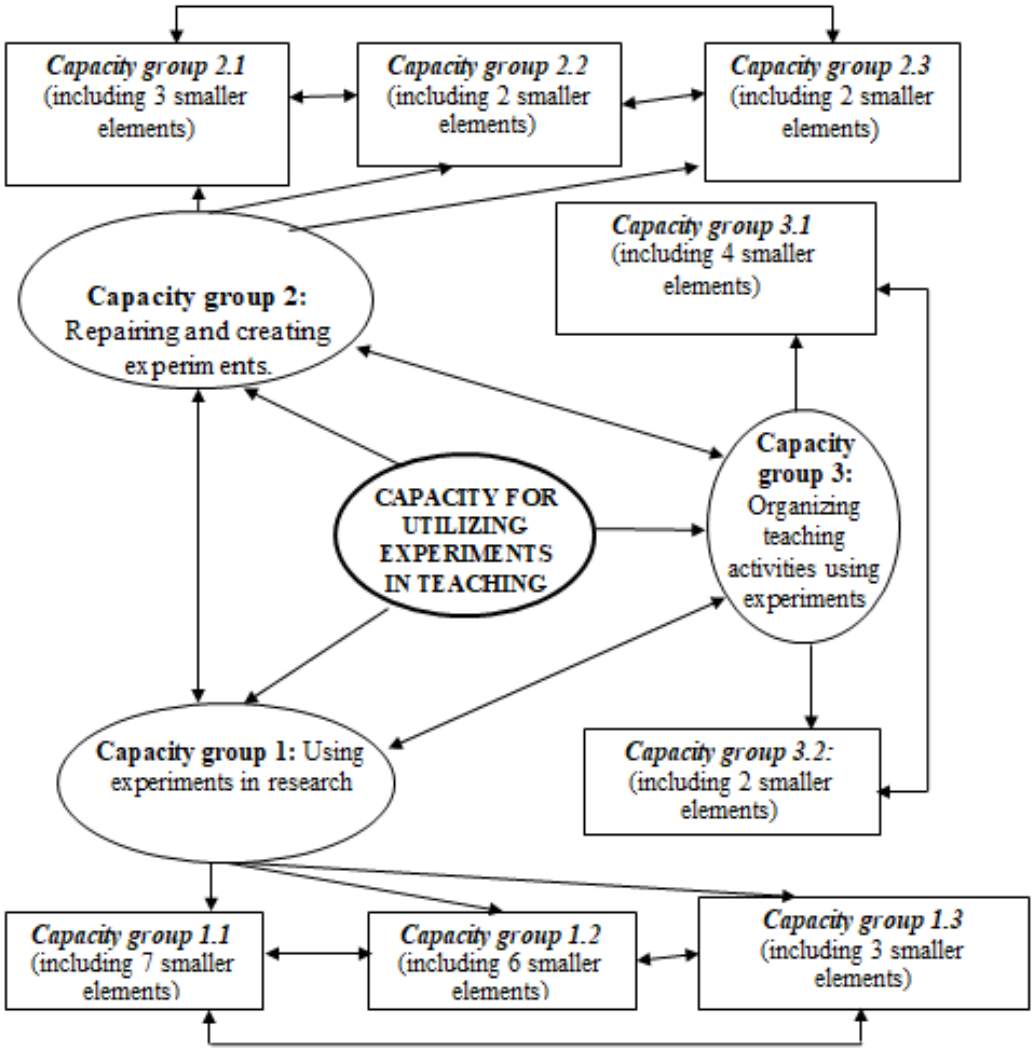


Diagram 1. Structure of the capacity for utilizing experiments in teaching

From these research, the author describes competency concept as follows: ability to use experiments in teaching is the ability to apply knowledge (understanding of experiments, knowledge of teaching and teaching methods), skills (experimental skills such as assembling, measuring, collecting data...) with interest, belief, and determination to establish (designing) as well as implement a system of teaching procedures (organizing teaching activities) in accordance with the conditions of not only experimental facilities but also objects in order to achieve teaching objectives.

In addition, we propose five levels of this competency: unsuccessful imitation, acceptable imitation, competent imitation, unsuccessful creation, successful creation. This competency structure is made up of three components: using experiments in research, resolving and creating experiments, organizing experimental teaching activities. The structure is presented through Figure 1.

2.2. Implementing measures to enhance competence in employing experiments in teaching for physical pedagogical students

a) Measure 1: Enhancing seminar activities and seminar content associated with learners' career activities.

We must emphasize on developing activities associated with practical teaching, exploiting extensively and investigating deeply various approaches of using experiments to make this measure more effective. Therefore, we need to pay attention to these three key points:

Content 1: Seminar on how to conduct experiments in research. At the end of the lesson, students will conduct experiments. After that, they will present on how they used experimental tools to survey, and established a specific knowledge unit of the conducted experiment. (Seminar 1).

Content 2: Seminar on using experiments for organizing learning activities. At the end of the lessons, students will conduct them. In class, they teach a trial lesson (Seminar 2).

Content 3: Seminar on solving and creating experiments. At the last two weeks of the module, students will conduct them. They will give a presentation of solving and manufacturing a specific set of experiments (Seminar 3).

One activity in each seminar content will construct to the development of certain components of competence; nevertheless, there are different strengths in increasing specific groups of competencies of each activity in different content. The competences are sharped and improved throughout the three seminar contents above during the teaching and learning process of the module. This is also a key aspect and a prominent benefit of this measure.

b) Measure 2: Developing designing and manufacturing activities, the use of do-it-yourself experiments.

The activities of self-made teaching aids play a crucial part in the formation and development of experimental teaching competence for physical pedagogical students, as follows:

Students' learning interest is stimulated through participating in the design and construction of teaching tools. Furthermore, they also become more conscious of the significance of experiments bringing in their respective lessons. They have experienced a large sets of modern experiments when studying at university, however, future sets of experiments in their working environment will be various. To be more specific, a great deal of teaching institutions have had out-of-date equipment which is quite different from what they had experimented at their university. Learners will be flexible towards different workplace when they have already experienced self-made teaching tools for teaching experiments.

Designing and creating experiment are categorized as three levels:

Level 1: Developing and creating experimental equipment according to available samples.

Level 2: Creating experiments based on available samples, but improving certain ineffective points.

Level 3: Creating an entirely new set of experiment.

Process of forming and developing the competency to utilize experiments in teaching through self-made creation and production of experiments, as follows:
Step 1: Proposing the experimental set needed to be designed and constructed.
Step 2: Planning strategies for implementation.
Step 3: Conducting the creation according to the planned strategies.
Step 4: Completing and operating the set of experiment, then assessing the feasibility of it.
Step 5: Presenting the product to the whole class.
Step 6: Synthesizing feedback from lecturers and other groups of students, exchanging and adjusting the products to improve the product.
We would like to provide some self-made sets of experiments:

Experiment set No.1: An investigation into the relativity of motion – the formula for calculating velocity.
Three experiments can be carried out using the above set of experiment:
Experiment No.1: The relative velocity of two objects moving in the same direction.
Experiment No.2: The relative and drag velocity in opposite directions.
Experiment No.3: The relative velocity and drag velocity are perpendicular.
Experiment No.4: The angle between the relative velocity and drag velocity is α.

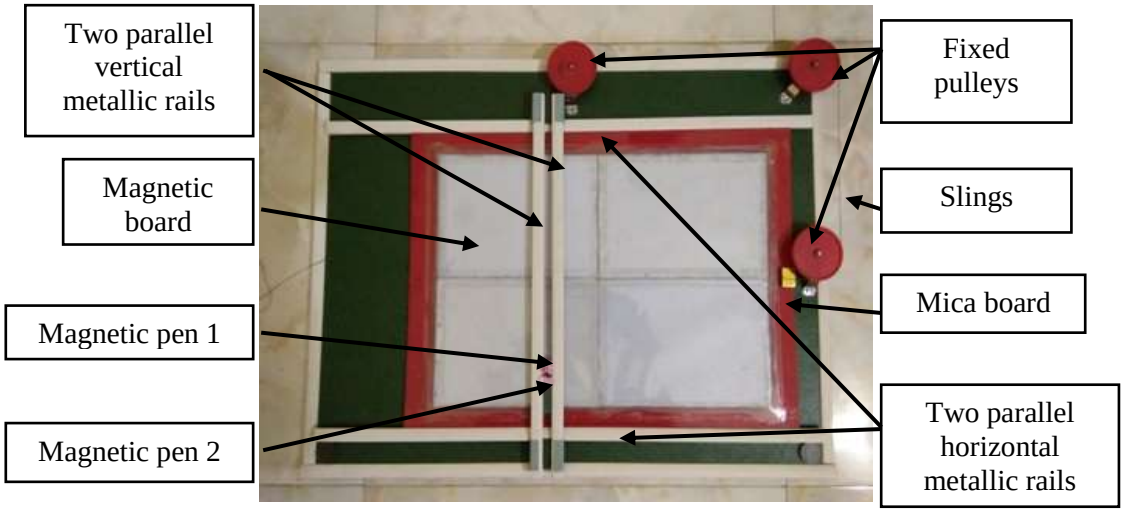


Figure 1: Main parts of the experimental set into the relativity of motion – the formula for calculating velocity.

Here are advantages of this set of experiment: Procedure of making the experimental set is easy. The experiment's durability and aesthetics are both assured. The experimental kit is inexpensive ($5) and could be used several times. Tools are easy to find and replace when damaged. The experimental set is highly intuitive, the velocity is calculated through the distance outlined on the magnetic board (the same motion time), and the distance represents the direction of the velocity. The experiment's error is minimal (less than 5%).

Experiment set No.2: *Set of experiments to investigate the motion of a thrown object.*

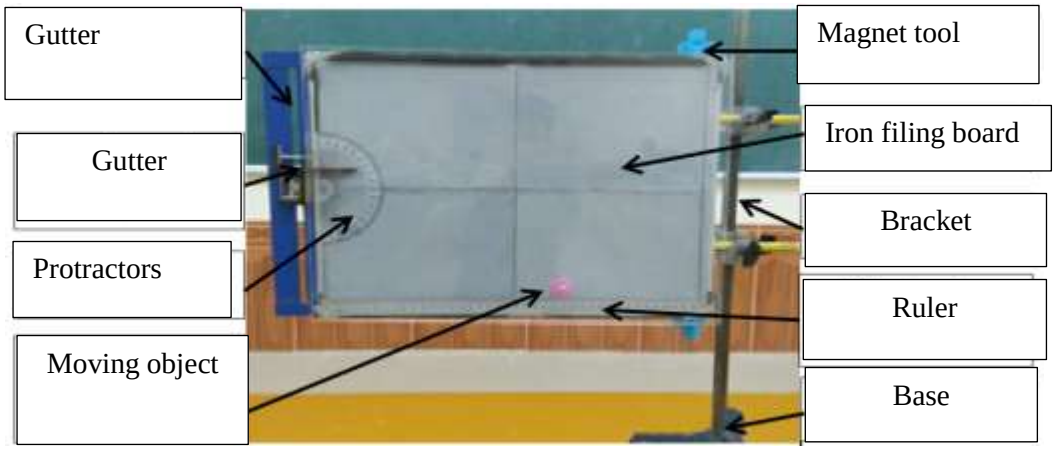


Figure 2: Main parts of the experimental set to investigate the motion of a thrown object.

Five experiments can be carried out using the above set of experiment:
Experiment No.1: Horizontal throwing motion with different heights.
Experiment No.2: Horizontal throwing motion with different velocities.
Experiment No.3: Oblique throwing motion with different heights.
Experiment No.4: Oblique throwing motion with different velocities.
Experiment No.5: Oblique throwing motion with different angles of inclination.
Here are advantages of this set of experiment: Procedure of making the experimental set is easy. The experiment's durability and aesthetics are both assured. The experimental kit is inexpensive ($7) and could be used several times. Tools are easy to find and replace when damaged. The experiment set is highly intuitive, the object's motion trajectory is easily recorded through the iron filing on the magnetic board. The experiment's error is minimal (less than 5%).

Experimental set No.3: *Set of experiment to investigate types of oscillations*

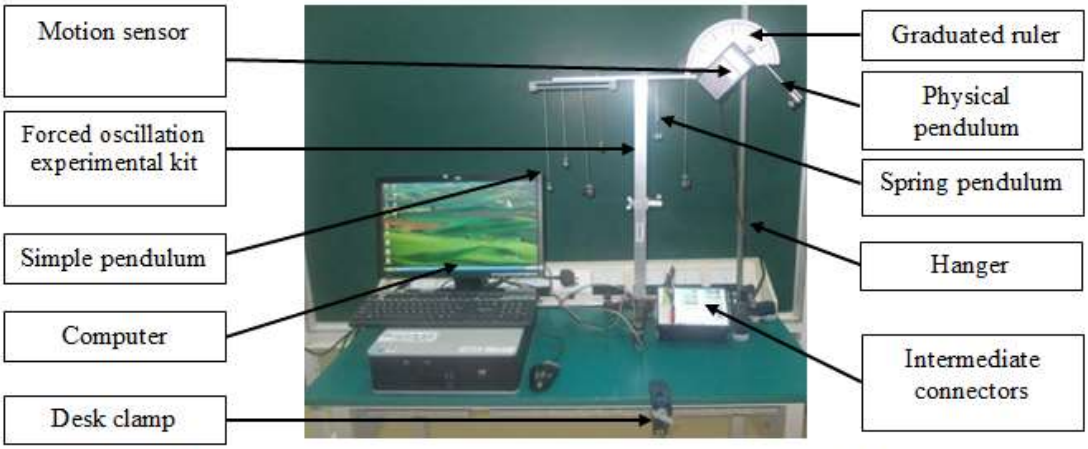


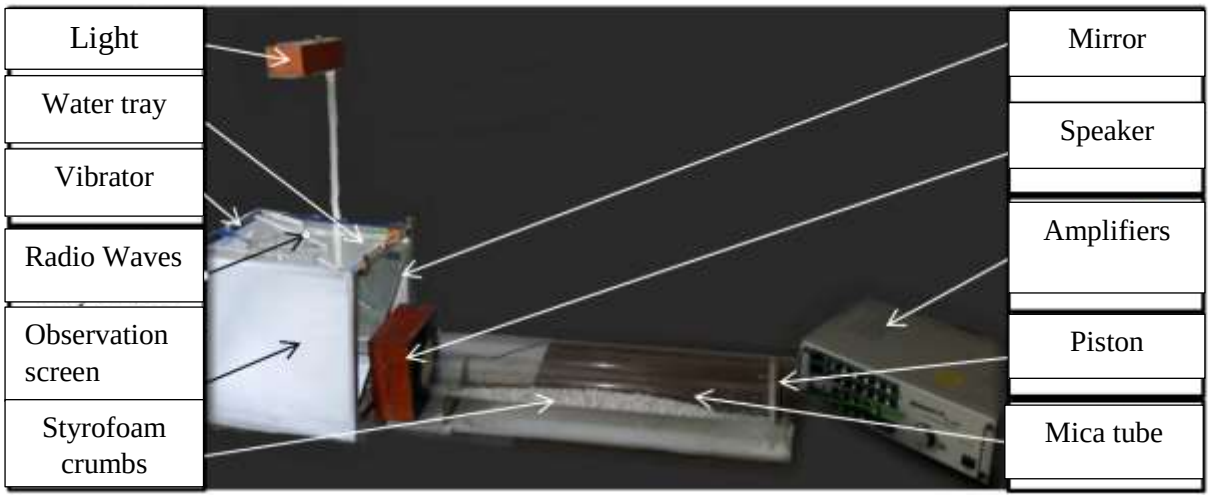
Figure 3: The main equipment of the experiment set to investigate the types of oscillations

Three experiments can be carried out using the above set of experiment:
Experiment No.1: Investigation of harmonic oscillation.
Experiment No.2: Investigation of damping oscillations.
Experiment No.3: Investigation of forced oscillation.

The experimental kit is assembled from modern equipment available in the laboratory. This is a hybrid of two experimental sets: Types of Oscillators and a computer-connected physical pendulum inquiry set. Therefore, the experimental set provides great aesthetics and durability.

The experimental set is highly intuitive, data is automatically collected after 50 seconds and shown in graphs and tables, ensuring that the results obtained are accurate.
With the given equipment, we can perform a wide range of qualitative and quantitative experiments to examine various types of oscillations.

Experimental set No.3: *An experimental set to describe and investigate mechanical waves*



Four experiments can be carried out using the above set of experiment
Experiment No.1: Experiment on describing and investigating mechanical waves.
Experiment No.2: Experiment on interference phenomenon.
Experiment No.3: Experiment on standing wave phenomenon.
Experiment No.4: Experiment of water wave diffraction.

Procedure of making the experimental set is easy. The experiment's durability and aesthetics are also assured. The experimental kit is inexpensive ($20) and could be used several times. Tools are easy to find and replace when damaged. The experimental set is extremely user-friendly, with interference and standing wave pictures visible in all three forms solid, liquid, and gaseous. The experimental kit is capable of carrying out both qualitative and quantitative research with low error rates (less than 6%). The experimental kit can be utilized to conduct a wide variety of mechanical wave investigations.
The presentation of the above experimental sets has also been published in specialized journals to ensure the scientific and feasible aspects of the implemented options.

c) Measure 3: Diversifying forms of assessment and evaluation, focusing on assessing process.
Assessing ability to use experiments in research, ability to use experiments in organizing teaching activities, and ability to repair and create experiments.
Form of assessment and evaluation:

We evaluated based on the capacity structure using the experiments with the corresponding behavioral expression levels through test reports; through the process of studying documents and using students' experiments on research and teach; through seminars and oral test for final test. Instructors would evaluate on designed rubrics, and students would also evaluate themselves and their peers when watching videos from their groups and also other groups. The assessment focuses on the ability to use experiments in research, in organizing teaching activities, and in making experiments. Assessment also take the development progress of

each individual through each specific capacity through each lesson into account, supporting the learning process through both assessment and self-assessment.

d) Measure 4: Developing websites to support teaching activities for "the Practical module of teaching High school Physics Experiments".

From teaching experience of this module, students would have difficulties of accessing the experimental sets, especially in the first lecture. Most students took a period of time to access the experiment sets. Monitoring students' input (reading documents at home) not only costs a large amount of time but also gets hardly feasible for lecturers with traditional teaching methods. Seminar activities of students have not achieved the desired effectiveness, learners will have difficulties of saving information to monitor, evaluate and learn from experience. The teaching time allocates quite short, therefore, it is necessary to strengthen the students' learning activities at home to increase teaching efficiency. Hence, we need to design and use the website to teach this module.

Building a website requires these following steps: **Step 1:** Pointing out limitations needed to be solved from teaching practice. **Step 2:** Building data. **Step 3:** Designing the website. **Step 4:** Establishing a procedure to apply in teaching. **Step 5:** Preparing instruction manual for students. **Step 6:** Applying the website into practice then completing it.

We followed the above outlined processes and developed database included materials relevant to teaching theory and the use of experiments in teaching. We also compiled question banks for entry tests at multiple levels. Additionally, we not only provided instructional documents for experiments but also created evaluation forms. The team recorded 29 videos of students using experiments in classes from seminar activities. We also made 30 video clips of students' seminars on repairing and creating experiments. The website is designed for teaching and learning the Practical module of teaching High school Physics Experiments. (http://45.119.81.32:63/cms).

Using the designed website for teaching is carried out according to the following steps:

Step 1: Guiding students to access to instruction manual of the website.

Step 2: Creating a personal account for students.

Step 3: Students log in, read the instructional document and take the entrance test: students who have score that is higher than 5 points are eligible to conduct with the real experimental sets, students can retake the exam if they failed the test. When the answer keys are displayed, students will know where they made mistakes and re-read the learning materials.

Step 4: The lecturer approves students who pass the entrance test.

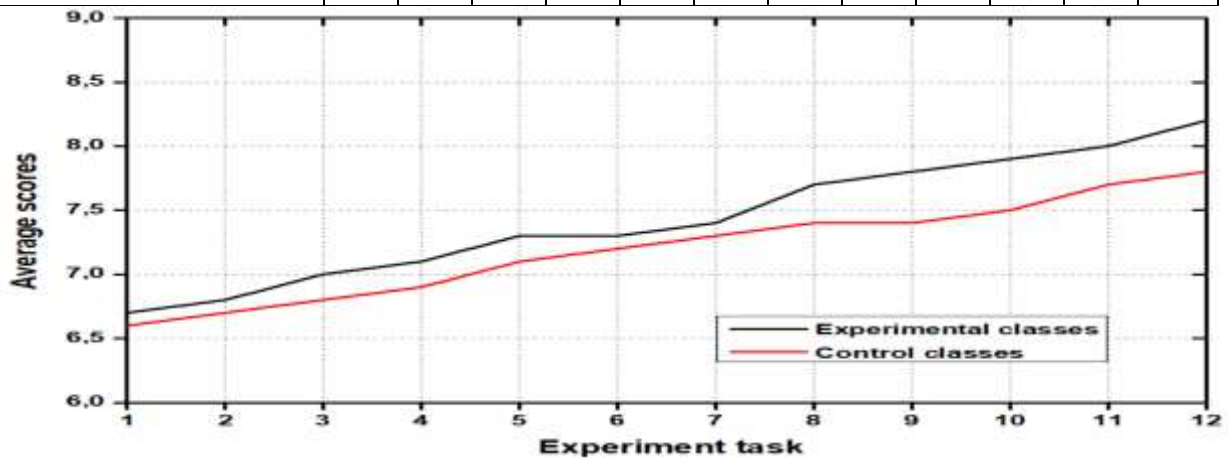
Step 5: When students conduct the seminar, the lecturer records it and uploads it to the website.

Step 6: Students at home can review the experimental videos from both of themselves and their classmates to learn from experience.

We have implemented the above 4 methods in teaching physics pedagogy students with 2 rounds. First round: There are three experimental classes (60 students) and three control classes (62 students).Second round: There are two experimental classes (38 students) and two control classes (40 students). It could be observed that the ability to use experiments of students in the experimental class developed faster than those in the control classes, and the mean scores of the experimental class were also higher. In the framework of the article, we would like to present the table of data and the graph of the average scores of the experimental classes and the control classes:

Table 1. *The average scores of experimental classes and control classes*

Experiment No.	1	2	3	4	5	6	7	8	9	10	11	12
The average scores of experimental classes	6.7	6.8	7.0	7.1	7.3	7.3	7.4	7.7	7.8	7.9	8.0	8.2
The average scores of the control classes	6.6	6.7	6.8	6.9	7.1	7.2	7.3	7.4	7.4	7.5	7.7	7.8



Graph 1. The average scores curve of the experimental classes and the control classes

In the first lesson, the abilities of students in the experimental classes accessing to the experiments were higher than those from the control classes, which indicated the effectiveness of taking entrance tests, investigating the learning materials from the support websites for learners in advance. This is a favorable premise for developing abilities to use experiments in the learning process of the Practical module of teaching High school Physics Experiments. The ability development lines of a random student from those classes showed that each student has improved themselves after each lesson by increasing their scores for each competence group.

III. Conclusion

In summary, the article suggests the recommendations for improving teaching quality for the practical module of teaching High school Physics Experiments which specifically focus on formation and advancement for experimental teaching competency in applying experiments in teaching for physics pedagogical students. These measures can be investigated and modified to broadly implement over other modules from the study curriculum.

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