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# THE EFFECTIVENESS OF HANDS-ON AND MINDS-ON ACTIVITIES IN PHYSICS LEARNING

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## Abstract

The main purpose of this study is to find out the effectiveness of hands-on and minds-on activities in physics learning of high school students. In this study, experimental research design (both qualitative and quantitative) was used. Sixty Grade Nine students from BEHS (2) Lanmadaw, Yangon were chosen as the participants of this study by using purposive sampling. The participants were divided into two groups: experimental group and control group. There were thirty students in each group. The four physics activities were constructed from Grade 9 Physics Curriculum (2017-2018 Academic Year). Before conducting intervention by using hands-on and minds-on activities, students were administered the pretest (comprised 50 multiple-choice items) in order to assess their achievement on prior knowledge in physics learning. After intervention, students took the posttest in order to determine their ideas, thinking and problem solving ability on physics learning. In this study, the observation checklist including ten items was developed for treatment verification. The results showed that the mean scores of control group (27.23) for pretest was slightly higher than experimental group (26.50). However, the results of *t*-test showed that there was no significant difference between experimental group and control group for pretest. On the other hand, the mean scores of experimental (36.77) for posttest was higher than that of control group (26.67). According to this study, the *t*-test result showed that there was a significant difference between two group for posttest. In control group, the mean scores of pretest and posttest were (26.20) and (27.70). And, the *t*-test result showed that there was a significant difference between pretest and posttest scores in control group. And then, in experimental group, the mean scores of posttest (36.77) was higher than that of pretest (26.50). Moreover, the results of *t*-test also showed that there was a significant difference between pretest and posttest of experimental group. Thus, the results can be concluded that the experimental group performed better than the control group because students in experimental group studied their physics lessons with hands-on and minds-on activities.

## Introduction

During the seventeenth century, the modern science of physics started to emerge and become a widespread tool used around the world. Many prominent people contributed to the buildup of this fascinating field and managed to generally define it as the science of matter and energy and their interactions. The study of physics is a fundamental science that helps the advancing knowledge of the natural world, technology and aids in the other sciences and in our economy.

Without the field of physics, the world today would be a complete mystery, everything would be different because of the significance physics has on our life as individuals and as a society. Physics is the natural science that involves the study of matter and its motion and behavior through space and time, along with related concepts such as energy and force. Physics is one of the fields of knowledge that underlies the physical universe and applies constantly to people's everyday lives. Physics is not a standalone field. Its tenets actually apply to a wide variety of fields.

Physics is also integral to engineering and is generally relevant for all the sciences. Many people are scared of studying physics because it has a reputation as a difficult subject. Specific

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aspects of physics that many people find daunting include the need to understand different mathematical equations and graphs and then be able to translate those concepts into real life.

Hands-on activities were perceived as an enjoyable and effective form of learning of almost all the major U.S science curriculum reforms of the late 1960s and early 1970s (Hodson, 1990). According to the U.S. National Science Education Standards (1995), students should have minds on and/or heads on experiences during hands on activities.

Minds-on activities, while taking hands-on activities, the teacher leads to discuss with students about the activities that they made. By asking questions and seeking answers, the students can develop their thinking processes and enhance their knowledge and understanding in their real life. Minds-on activities challenge students to actively develop their understanding of science concepts using logical inference and the application of concepts to the interpretation of real-world situations experimental and observational data.

So, hands-on and minds-on activities are important in physics learning. As students observe, measure, and manipulate, they are exploring content as well as the nature of science. Teaching physics with hands-on and minds-on inquiry may have more effects on student achievement. Hence, this study applied hands-on and minds-on activities and investigated their effect on students' physics learning.

**Purpose of the Study**

The main purpose of this study is to find out the effectiveness of hands-on and minds-on activities in physics learning of high school students.

**The Specific objectives**

1. To investigate the effectiveness of hands-on and minds-on activities in physics learning
2. To investigate any significant difference in the physics achievement of Grade 9 students exposed hands-on and minds-on activities and students exposed to traditional instruction by gender

**Definitions of Key Terms**

**Hands-on.** Students are actually allowed to perform science as they construct meaning and acquire understanding (David, & Peter, 1994).

**Minds-on.** Activities focus on core concepts, allowing students to develop thinking process and encouraging them to question and seek answers that enhance their knowledge and thereby acquire an understanding of the physical universe in which they live (David, & Peter, 1994).

**Physics Learning**. Atherton (2005) defined physics is the study of the natural world, covering the behavior of matter and energy. It explores the fundamental laws and principles that govern the universe, such as motion, energy, force, and gravity. It applies these laws and principles to explain the behavior of objects and systems.

## Review of Related Literature

Teachers need to remember that a hands-on activity is 'useless if students' hands are on, but their heads are out' (Skamp, 2007). Hands-on and minds-on teaching methods involve the students in a total learning experience which enhances students' ability to think critically. Students investigate experiment, gather data, organize results, and develop conclusions based on their own actions.

Many educators believe that the traditional measures of achievement should be replaced by use of alternative assessment and other performance-based assessment including hands-on and minds-on activities. The use of hands-on and minds-on activities for high school students was aimed more towards relating the activities to real world situations, rather than getting the students excited.

Hands-on activities are used to get students working in groups, manipulating various objects, asking questions that focus observations, and collecting data in an attempt to explain natural phenomena. To achieve significant learning, hands-on activities must become minds-on learning. Hands-on and minds-on teaching is giving rise to new ideas and techniques and is fostering creativity, intuition, and problem solving skills. The popularity of hands-on and minds-on teaching is also creating a need for more labs.

Physics is generally defined as the study of matter and motion. Physics encourages certain attitudes and carries a specific information content. Some of these attitudes and parts of the information are especially relevant to a developing society. Physics underlines all other basic sciences and is the basic for much of technology (Dayal, 2009, cited in Zitzewitz, 1999).

## Method

Sixty Grade Nine students from No (2) Basic Education High School, Lanmadaw, Yangon were chosen as the participants of this study by using purposive sampling.

### Research Method

In this study, experimental research design (both qualitative and quantitative) was used.

### Instrumentation

Five measuring tools that have been used in this study were as follows:

Physics activities were constructed from Chapter 7 (Measurement of Heat), Chapter 10 (Reflection of Light) and Chapter 11 (Electricity and Magnetism) taught in Grade 9 Physics Curriculum. There were four activities such as specific heat capacity of a metal block, specific heat capacity of a liquid (oil), reflection at two plane mirror and conductors and insulators.

Before conducting intervention by using hands-on and minds-on activities, students were administered the pretest in order to assess their achievement on prior knowledge in physics learning. The 45 minutes pretest comprised 50 multiple-choice items.

After intervention, students took the posttest in order to determine their ideas, thinking and problem solving ability on physics learning. Students were allowed for 45 minutes to take the posttest.

In this study, the observation checklist including ten items was developed for treatment verification.

## Procedure

First of all, Literature review concerning title and purposes was made from several available books, journals, reports and thesis. Grade 9 Physics Textbook prescribed by Basic Education Curriculum, Syllabus and Textbook Committee were studied thoroughly, together with the official instructional objectives and aims of teaching physics. Secondly, pretest, posttest and physics activities were constructed from Chapter 5 (Work and Energy), Chapter 7 (Measurement of Heat), Chapter 10 (Reflection of Light) and Chapter 11 (Electricity and Magnetism) in order to get the required data. Thirdly, the observation checklist was developed. And then the expert review was conducted. Based on the results of the pilot study, questions which were inappropriate and vague, and could get incomplete answers were revised and changed.

# Data Analysis and Findings

In the quantitative study, the data obtained from the pretest and posttest achievement and attitude scores of all students were analyzed descriptively. This study involves analysis of pretest and posttest for experimental and control group. In the qualitative study, observation checklist, assessment criteria, and interview questions were used to investigate their physics process skills, improvement, feeling and ideas about the study of hands-on and minds-on activities.

## Descriptive Analysis of Pretest and Posttest for Control Group and Experimental Group

Firstly, the data obtained from pretest and posttest were analyzed by using the independent samples *t*-test since it was assumed that there might be differences between experimental and control group in pretest as well as posttest. The results of test indicated the differences in means and standard deviations of experimental and control group with respect to pretest and posttest and showed whether these differences are significant or not (see Table 1).

**Table 1. Analysis of Pretest and Posttest for Control Group and Experimental Group**

| Test | Groups | N | Mean | SD | *t* | *df* | Sig (2- tailed) |
|---|---|---|---|---|---|---|---|
| Pretest | Control | 30 | 27.23 | 7.646 | -.362 | 58 | .719 |
| | Experimental | 30 | 26.50 | 8.042 | | | |
| Posttest | Control | 30 | 26.67 | 6.551 | 6.760*** | 58 | .000 |
| | Experimental | 30 | 36.77 | 4.904 | | | |

*******The mean difference is significant at 0.001 level.

Thus, it can be said that the scores obtained from the application of hands-on and minds-on activities were higher than those from the traditional method of teaching. This result demonstrates that hands-on and minds-on physics learning plays a role in regard to increase in academic achievement.

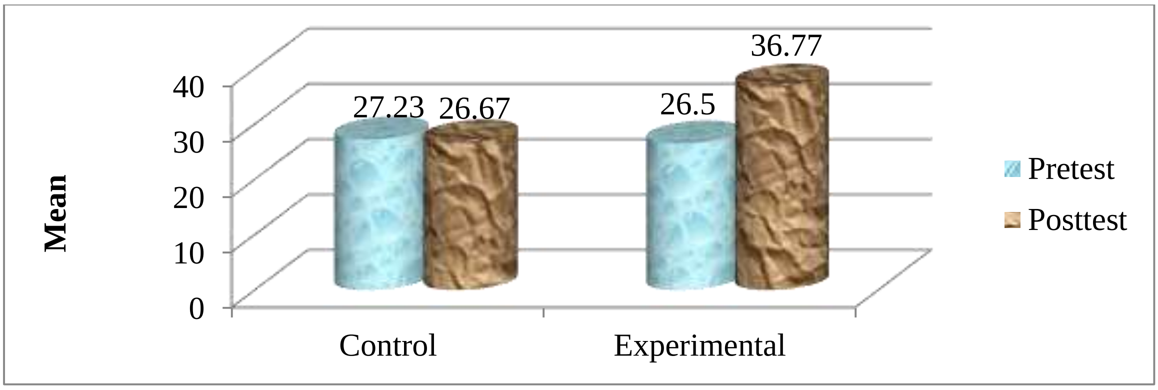



**Figure 4.1** Analysis of Pretest and Posttest for Control Group and Experimental Group

**Analysis of Control Group and Experimental Group for Pretest and Posttest**

In Table 4.2 and Figure 4.2, results showed the means comparison of control group and experimental group for pretest and posttest.

**Table 4.2 Analysis of Control Group and Experimental Group for Pretest and Posttest**

| Test | Groups | N | Mean | SD | *t* | *df* | Sig (2- tailed) |
|---|---|---|---|---|---|---|---|
| Control | Pretest | 30 | 26.20 | 6.925 | -.820 | 58 | .416 |
| | Posttest | 30 | 27.70 | 7.240 | | | |
| Experimental | Pretest | 30 | 26.50 | 8.042 | -5.970*** | 58 | .000 |
| | Posttest | 30 | 36.77 | 4.904 | | | |

***The mean difference is significant at 0.001 level.

Moreover, the results of *t*-test also showed that there was a significant difference between pretest and posttest of experimental group at 0.001 significant level. Thus, the results can be concluded that the experimental group performed better than the control group because students in experimental group studied their physics lessons with hands-on and minds-on activities. In the use of hands-on and minds-on activities, the students gained more interest and achieve higher scores than in traditional method of teaching (explanation).

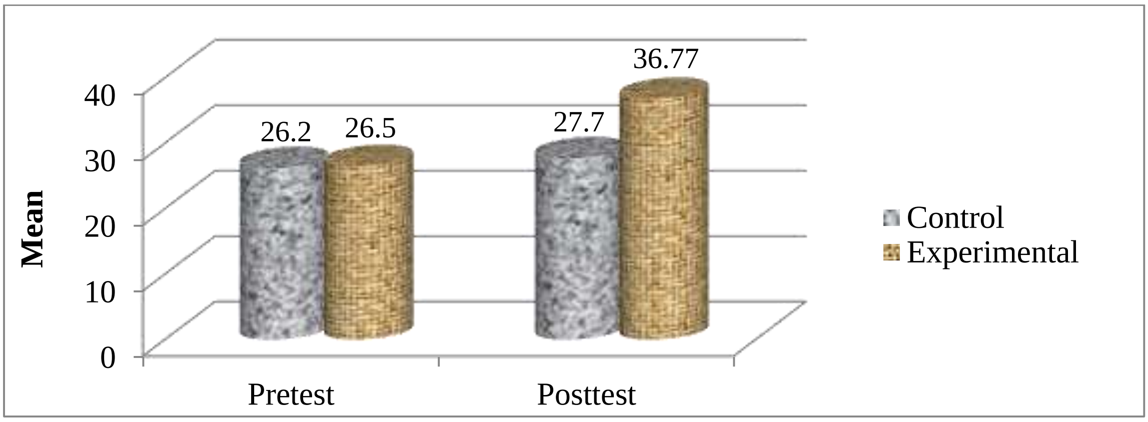



**Figure 4.2** Mean Comparison of Pretest and Posttest for Control Group and Experimental Group

**Interpretation of Science Process Skills**

While doing physics activities, students' physics process skills (criteria) for each activity were assessed according to scoring rubric and observation checklists.

**Activity 1 (Specific Heat Capacity of a metal block)**

In this activity, there were six criteria. In observing, all groups achieved score 3 as they could use appropriate objects such as calorimeter, stirrer, insulating support and outer jacket, metal block, stove, beam balance and weight box, thread, thermometer (-10˚-110˚C) and hot water bath.

**Table 3 Scores Attained for Science Process by Groups on Activity 1 (Specific Heat Capacity of a Metal Block)**

| Group / Process (Criteria) | Score | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| Observing | 3 | 3 | 3 | 3 | 3 | 3 |
| Manipulating (Handle the equipment) | 3 | 3 | 3 | 3 | 3 | 3 |
| Measuring | 3 | 3 | 2 | 3 | 2 | 2 |
| Data Recording | 2 | 2 | 2 | 2 | 2 | 2 |
| Inferring & Classifying | 3 | 3 | 3 | 2 | 3 | 2 |
| Communicating | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 16 | 16 | 15 | 15 | 15 | 14 |

**Activity 2 (Specific Heat Capacity of a Liquid (Oil))**

In this activity, there were six criteria. In observing, all groups achieved score 3 as they could use appropriate objects such as calorimeter, stirrer, insulating support and outer jacket, liquid (oil), stove, beam balance and weight box, thread and thermometer (-10˚-110˚C).

**Table 4.4 Scores Attained for Science Process by Groups on Activity 2 (Specific Heat Capacity of a Liquid (Oil))**

| Group / Process(Criteria) | Score | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| Observing | 3 | 3 | 3 | 3 | 3 | 3 |
| Manipulating (Handle the equipment) | 3 | 3 | 3 | 3 | 3 | 3 |
| Measuring | 3 | 3 | 2 | 2 | 2 | 2 |
| Data Recording | 2 | 2 | 2 | 2 | 2 | 2 |
| Inferring & Classifying | 3 | 3 | 3 | 2 | 3 | 2 |
| Communicating | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 16 | 16 | 15 | 14 | 15 | 14 |

**Activity 3 (Reflection at Two Plane Mirrors)**

In this activity, there were six criteria. In observing, all groups achieved score 3 as they could use appropriate objects such as drawing board, drawing paper, two plane mirrors, protractor, pins and cello tape.

**Table 5 Scores Attained for Science Process by Groups on Activity 3 (Reflection at Two Plane Mirrors)**

| Group / Process (Criteria) | Score | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| Observing | 3 | 3 | 3 | 3 | 3 | 3 |
| Manipulating (Handle the equipment) | 3 | 3 | 3 | 3 | 3 | 3 |
| Measuring | 3 | 3 | 2 | 3 | 2 | 2 |
| Data Recording | 2 | 2 | 2 | 2 | 2 | 2 |
| Inferring & Classifying | 3 | 3 | 3 | 2 | 3 | 2 |
| Communicating | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 16 | 16 | 15 | 15 | 15 | 14 |

**Activity 4 (Conductors and Insulators)**

In this activity, there were six criteria. In observing, all groups achieved score 3 as they could use appropriate objects such as drawing board, drawing paper, two plane mirrors, protractor, pins and cello tape.

**Table 6 Scores Attained for Science Process by Groups on Activity 4 (Conductors and Insulators)**

| Group / Process (Criteria) | Score | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** |
| Observing | 3 | 3 | 3 | 3 | 3 | 3 |
| Manipulating (Handle the equipment) | 3 | 3 | 3 | 3 | 3 | 3 |
| Measuring | 2 | 3 | 3 | 3 | 2 | 2 |
| Data Recording | 2 | 2 | 2 | 2 | 2 | 2 |
| Inferring & Classifying | 3 | 3 | 3 | 2 | 3 | 2 |
| Communicating | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 15 | 16 | 16 | 15 | 15 | 14 |

**The Observation Checklist for Experimental Group**

This observation checklist was used for experimental group to study the students' behavior while doing activities. There are 10 items in the observation checklist. Students' performance behavior was observed while doing activities by using observation checklist.

For item 1, 95% of students paid attention to the teacher's attention. For item 2, 93% of students could choose appropriate materials concerned with activities and also use them correctly while doing activities. For item 3, 98% of students obeyed the procedures that have to perform in doing activities. For item 4, 98% of students were interested in the activities because they can study with authentic materials about the activities. For item 5, 92% of students can follow the activities easily.

For item 6, 100% of students seem to enjoy the activities. They do the activities happily and learn the lessons very well. For item 7, 18% of students asked for help from the teacher when they needed. Most students didn't ask for help to perform every activity. For item 8, 94% of students got the science concepts and information while doing the activities. For item 9, all of students share materials with each other. For item 10, 99% of students could do the activities from the beginning to the end successfully until they get the correct results.

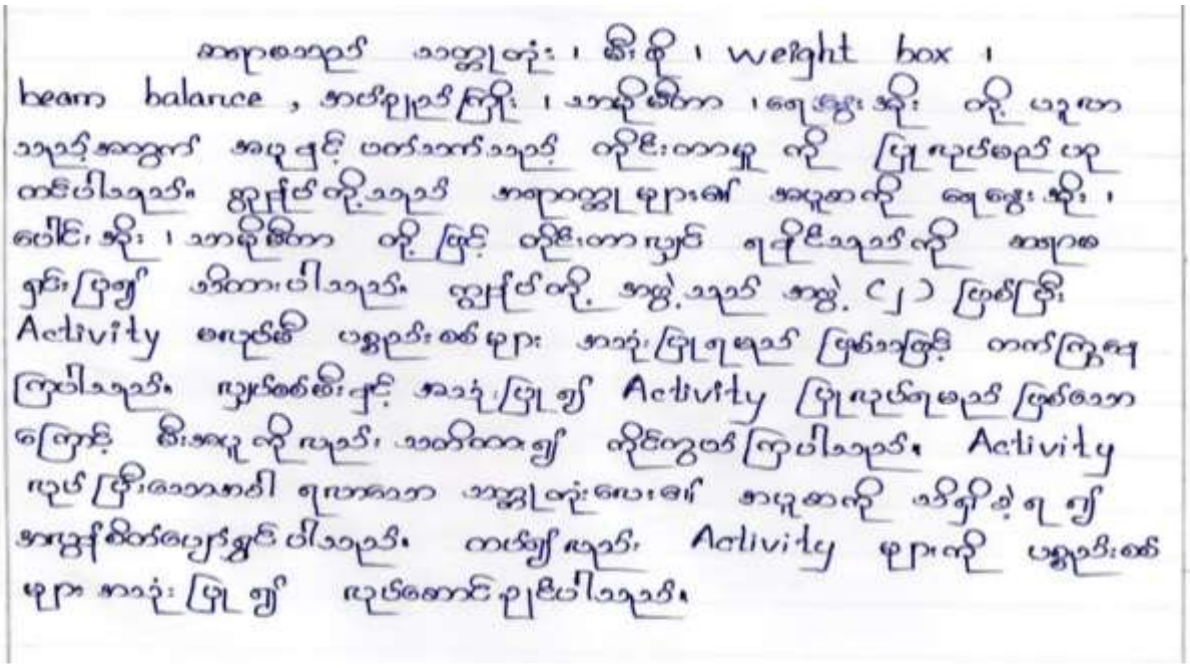
### Students' Logs from Experimental Group

Students' log from experimental group was investigated in order to know their opinion, improvement, feelings and ideas about the hands-on and minds on activities in physics learning. Four samples were mentioned as follows:

Date – 9.1.2018 (Tuesday)

Activity 1 Specific Heat Capacity of a Metal Block

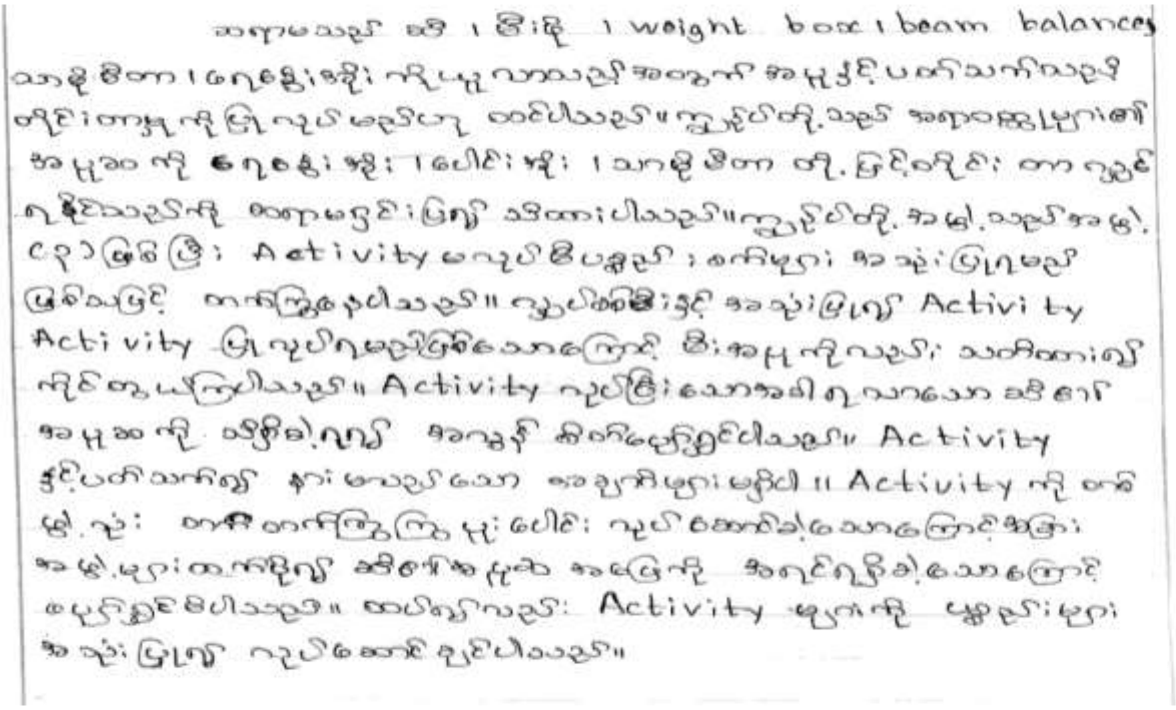
Content



Date – 10.1.2018 (Wednesday)

Activity 2 Specific Heat Capacity of a Liquid (Oil)

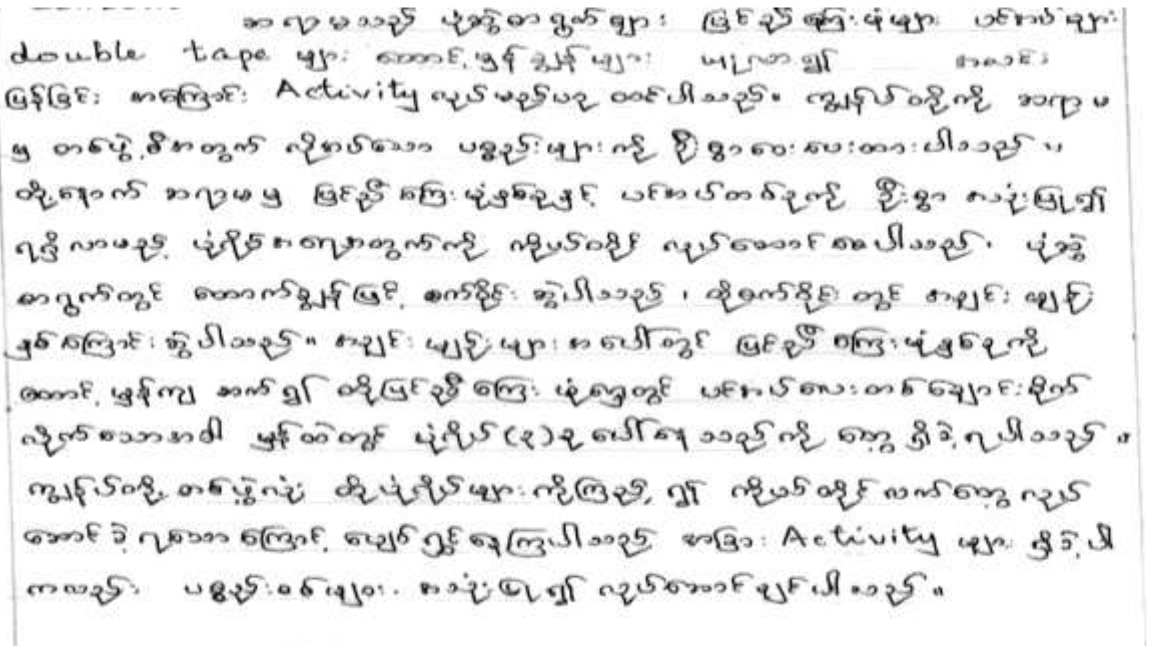
Content



Date – 16.1.2018 (Tuesday)

Activity 3 Reflection at Two Plane Mirror

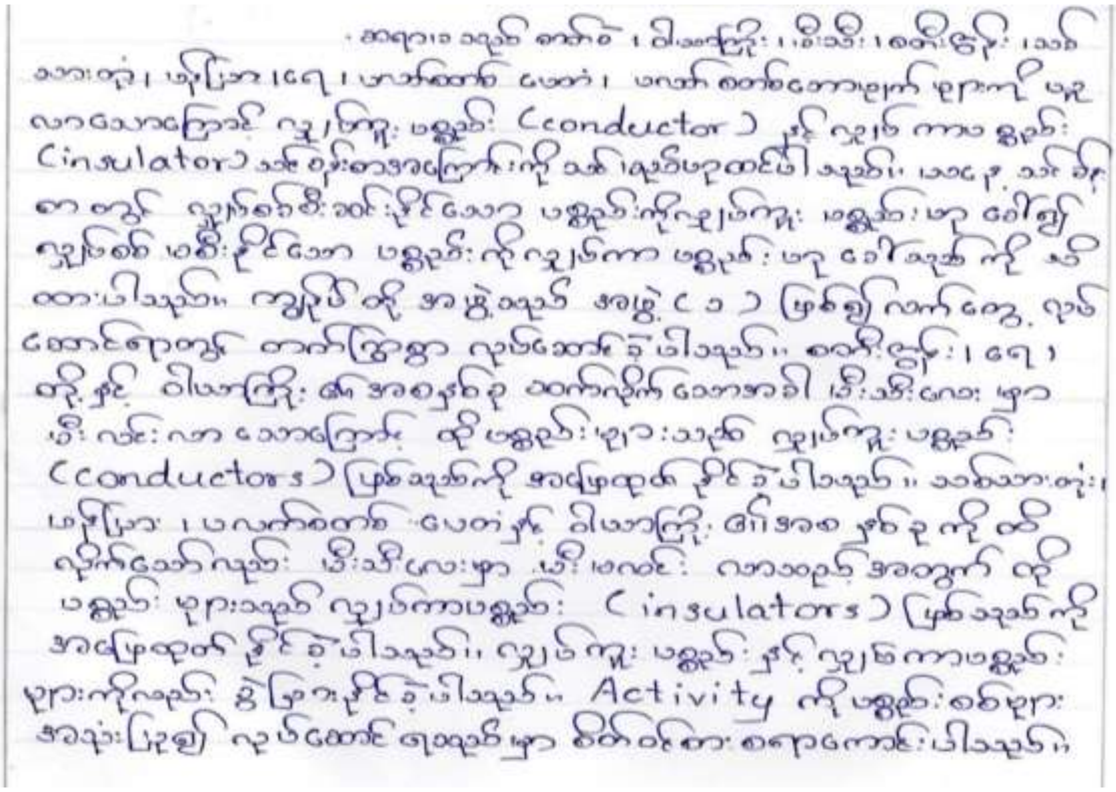
Content



Date –23.1.2018 (Tuesday)

Activity 4 Conductors and Insulators

Content



## Conclusion

The main purpose of this study is to develop hands-on and minds-on activities and to investigate the effectiveness of instruction with those activities and traditional method on Grade 9 students. Both quantitative and qualitative methods were utilized to find out the effects of hands-on and minds-on activities. According to quantitative data, the present study indicated that hands-on and minds-on activities were effective means of increasing students' physics achievement. Results showed that there was a significant difference in the physics performance of high school students exposed to hands-on and minds-on physics instruction and those exposed to traditional instruction. Students instructed by physics activities gained high achievement scores in physics.

In this study, the experimental group studied all the lessons with hands-on activities including minds-on experiences four periods a week and students in the experimental group achieved significantly higher scores compared to students in the control group. During observations, it has been noticed in this study that students were not used to perform hands-on and minds-on activities, so they had some difficulties to follow the instructions while doing activities. The reason might be the fact that in their regular lessons, they were used to listening to their teachers and taking notes during lectures without performing experiments on their own.

According to qualitative data (observation checklist), the results showed the students' positive effects of activities. The students in the experimental group were actively involved in physics learning activities. So, the results in this study indicated that there was a significant difference in physics achievement between the experimental group and the control group.

## Discussion

According to Slavin (2003), teachers teach specific skills that will help them work well together, such as active learning, giving good explanations and including other people. Teacher provides a rich variety of activities that permit students to act directly on the physical world. Teachers can easily incorporate these hands-on and minds-on activities in implementing existing curricula. Every physics teacher had provided training courses or workshops or projects concerning with hands-on and minds-on activities to gain practical experience and proficiency. When providing instruction about the activities, teachers supplies complete instructions and materials included in the activities. So, the students instructed by hands-on and minds-on activities involve in learning as active participants and they become independent learners.

## Acknowledgement

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