

**DEVELOPMENT OF PODS BASED ACTIVITIES TO IMPROVE
STUDENTS' UNDERSTANDING OF BRIGHTNESS AND
CURRENT CONCEPTIONS IN SIMPLE DC ELECTRIC
CIRCUITS: A CASE STUDY OF FIRST YEAR MYANMAR
UNDERGRADUATE STUDENTS**

WIN THU ZAR

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OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
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entitled

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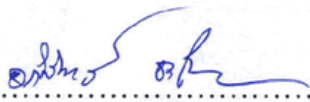
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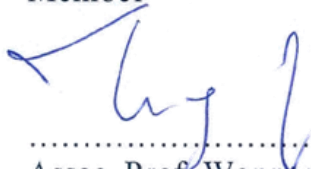

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ABSTRACT

This study presents the development of the Prediction-Observation-Discussion-Synthesis (PODS) learning cycle, the Brightness and Current Conceptual Evaluation (BCCE), and the results of the students' responses to the BCCE. The study composes of two phases; a pilot study and a case study. The participants of the pilot study were the first year 208 Thai and 50 Myanmar students in government universities in Thailand and Myanmar. The pilot study involves the exploration of the students' prior knowledge in the concepts of brightness of two light bulbs and current passing through two resistors by using BCCE. The case study involves the development of the effectiveness of the PODS based hands-on activities that proposed to develop the first year undergraduate students' conceptual understanding of the topic of simple DC electric circuits (in terms of brightness of two light bulbs and current passing through two resistors connected in both series and parallel circuits). The participants of the case study were 50 first year undergraduate Myanmar students. The study found that the average normalized gain in this study was found to be ($\langle g \rangle = 0.7$). These results indicate that PODS learning cycle can help the students understand the concepts of simple DC electric circuits.

KEY WORDS: PODS/ BCCE/ SIMPLE DC ELECTRIC CIRCUITS/ BRIGHTNESS AND CURRENT/ AVERAGE NORMALIZED GAIN

80 pages

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LIST OF ABBREVIATIONS

AAPT	American Association of Physics Teachers
AC	Alternating Current
AUTC	Australian Universities teaching Commission
BCCE	Brightness and Current Conceptual Evaluation
CAT	Conceptual understAnding Test
DC	Direct Current
DIRECT	Determining and Interpreting Resistive Circuit Concepts Test
ECCE	Electric Circuit Conceptual Evaluation
EUPEN	European Physics Education Network
FCI	Force Concept Inventory
FMCE	Force and Motion Conceptual Evaluation
ICT	Information and Communication Technology
ILD	Interactive Lecture Demonstrations
IOP	Institute of Physics
MBL	Microcomputer-Based Laboratory
MOE	Ministry of Education
MOST	Ministry of Science and Technology
PER	Physics Education Research
PODS	Predict-Observe-Discuss-Synthesize
POE	Predict-Observe-Explain
TUG-K	Test of Understanding Graphs in Kinematics
UK	United Kingdom

CHAPTER I

INTRODUCTION

Overview

This chapter provides an overview of a research study including of the significance, research questions, research objectives, definition of terms, framework of the study, scope of the study, and expected outcomes of the research.

1.1 Significance of Research Study

Students' conception about electrical circuits were previously documented that students had difficulty to distinguish electrical terms, concepts, and often lacked a conceptual model for analyzing circuit behavior (Bryan & Stuessy, 2006). In addition, some researches were conducted to define students' understanding, their alternative conceptions and their mental models on electricity ranging from the simple concepts treated in primary school science to the more complicated concepts addressed in introductory physics courses at university level. Especially, the topics "electric circuit", "electric charge flows within an electric circuit", "how the brightness of bulbs and the resistance changes in series and parallel circuits" were investigated well. The reason why students have alternative conceptions are their little academic knowledge about electric circuits, their learning difficulties, their preexisting knowledge, and the current flows through the resistors is not able to perceive, directly (Ates, 2005; Ipek & Calik, 2008).

Students' understanding of DC electric circuits is quite extensive. Engelhardt (2004) found some misconceptions from the pattern of students' responses to the *Determining and Interpreting Resistive Electric Circuit Concepts Test* (DIRECT) VERSION 1.0 and 1.1. According to his finding, students believed that current is consumed, and the battery is a source of constant current. In addition,

Kucukozer & Kocakulah (2007) reported students' misconceptions about simple electric circuits that had been found by some researchers are as follows:

- The concepts of current, energy and potential difference are not respected as different concepts and used interchangeably with each other.
- Current is consumed by circuit components.
- Current comes out from the (+) pole of the battery and enters to the bulb where it is consumed to light the bulb which is not affected by the second wire connected between the (-) pole and itself.
- Current comes out from the both poles of the battery and clashes in the bulb to light it.
- Current is divided equally in each line of the parallel circuits.
- A change before the bulb affects the brightness of the bulb in circuit connected in series but the same bulb is not affected by change in anywhere of the circuit after the bulb.
- Batteries are constant current sources.

Moreover, Bryan & Stuessy (2006) noted that students in his study had a very brief introduction to electrical circuitry and its relevant terms. At that time of the activity, students most likely did not have a strong conceptual grasp of the meaning of terms or an accurate mental model of circuit flow. Students also filtered and interpreted their observations with an incomplete and inaccurate foundational understanding. Despite facing such obstacles to the development of scientifically accepted concepts during the activity, students developed their own model of light bulb brightness that was supported by many of simple circuit arrangement they observed. Students often used the terms "brightness" during discourse in places where either the term "current" or "voltage" would be more scientifically appropriate because the standard electrical circuit terms, such as current, voltage, power, and energy, were often used interchangeably.

Furthermore, Baser (2010) found that misconceptions are preferred for referring to 1) the mistaken answers given by students, 2) their ideas about particular situations, and 3) their fundamental beliefs about how the world works. Misconceptions related to different subjects of physics were also documented in the

literature. However, changing misconceptions is not an easy task since these conceptions are very stable, well embedded in students' cognitive domain, and difficult to remove with traditional teaching methods. Thus, physics educators search for new methods to change these misconceptions. In addition, Nurmi & Jaakkola (2004) reported that many misconceptions about electricity are held by many students in the traditional teaching class. This is because textual teaching material, application tasks or hands-on laboratory (used in the traditional teaching class) can not encourage students to change their preconceptions. In addition, the concept of electricity is quite complicated and very abstract to students since they can not see and touch electricity.

As Mazzolini (2010) presented an efficacy of one active learning cycle named as PODS (Predict-Observe-Discuss-Synthesize). It has been used for over a decade to engage students in lecture environments and to improve their conceptual understanding and deep learning in many physics topics such as mechanics, optics, heat, electric circuits, etc. Therefore, the researcher would like to create PODS learning cycle based activities to help students correct their misconceptions on simple DC electric circuits. Researcher thus designed and implemented the Brightness and Current Conceptual Evaluation (BCCE) to explore students' misconceptions about simple DC electric circuits. Moreover, the concepts covered in the BCCE consists of 1) Brightness of two identical light bulbs connected in series and parallel circuit, and 2) Current passing through two resistors connected in series and parallel circuit. Students' response to this evaluation as a pre-test and post-test was used to evaluate an efficacy of the activities in terms of how much the activities could help students to improve their understanding in the concept of brightness and current for series and parallel circuit.

1.2 Research Questions

- 1) What are the Thai and Myanmar first year undergraduate science students' misconceptions about simple DC electric circuits in terms of brightness of two identical light bulbs and current passing through two resistors connected in both series and parallel circuits?

2) How to develop the simple DC electric circuit activities that could help Myanmar students improve their understanding about the brightness of two identical light bulbs and current passing through two resistors connected in both series and parallel circuits?

3) How to evaluate an efficacy of the activities in terms of an improvement of Myanmar students' understanding in the related concepts?

1.3 Research Objectives

The objectives of this research are as follows:

1) To find out the first year undergraduate science students' misconceptions about simple DC electric circuits both in Thailand and Myanmar without any comparison.

2) To develop simple DC electric circuit active learning activities to facilitate Myanmar students to get the correct understanding about simple DC electric circuits in terms of brightness and current.

3) To evaluate an efficacy of the activities in terms of an improvement of Myanmar students' understanding in the related concepts.

1.4 Definition of Terms

Simple DC Electric Circuit is the simplest form of an electrical circuit when an energy source (such as a battery) is connected to a load/ loads (connected in series or parallel). The connections must be made in such a way as to allow the energy to flow from the source, through the load and back into the source to form a loop.

A series circuit is a closed circuit in which the current flows through single path. In a series circuit, the current pass through each load is the same and the total voltage across the circuit is the sum of the voltages across each load. Ohm's law is applied where the total resistance is equal to the sum of the individual resistances: $R_T = R_1 + R_2 + \dots + R_N$. A series circuit will not function if one part is broken because the current will not flow through the rest of the circuit.

A **parallel circuit** is a closed circuit in which the current divides into two or more paths (named as “branch current”) before recombining to complete the circuit. Each load connected in a separate path receives the full circuit voltage, and the total circuit current is equal to the sum of the individual branch currents. Ohm's law applies where the total resistance is equal to the reciprocal of the sum of the reciprocals of their individual resistances: $1/R_T=1/R_1+1/R_2+\dots+1/R_N$ (note the total resistance will always be less than any individual resistance).

1.5 Framework of the Study

The framework of this study is shown in Figure 1.1. The focus of this study is to help Myanmar students improve their understanding of simple DC electric circuits in terms of brightness of two identical light bulbs and current passing through two resistors, connected in series and parallel circuit. The PODS learning cycle is used as a guideline to design the activities. To explore and evaluate students' understanding about the related concepts, the BCCE had been developed and introduced as a pre-test and post-test to Myanmar students. This is because researcher could not communicate well to Thai students but researcher believes that the information about students' prior knowledge is useful for teachers to help their students improve the understanding. Therefore, the BCCE was introduced to Thai students as only a pre-test. However, the comparison between an understanding of students from both the nations is not an objective of this research because the contexts of both nations are difference.

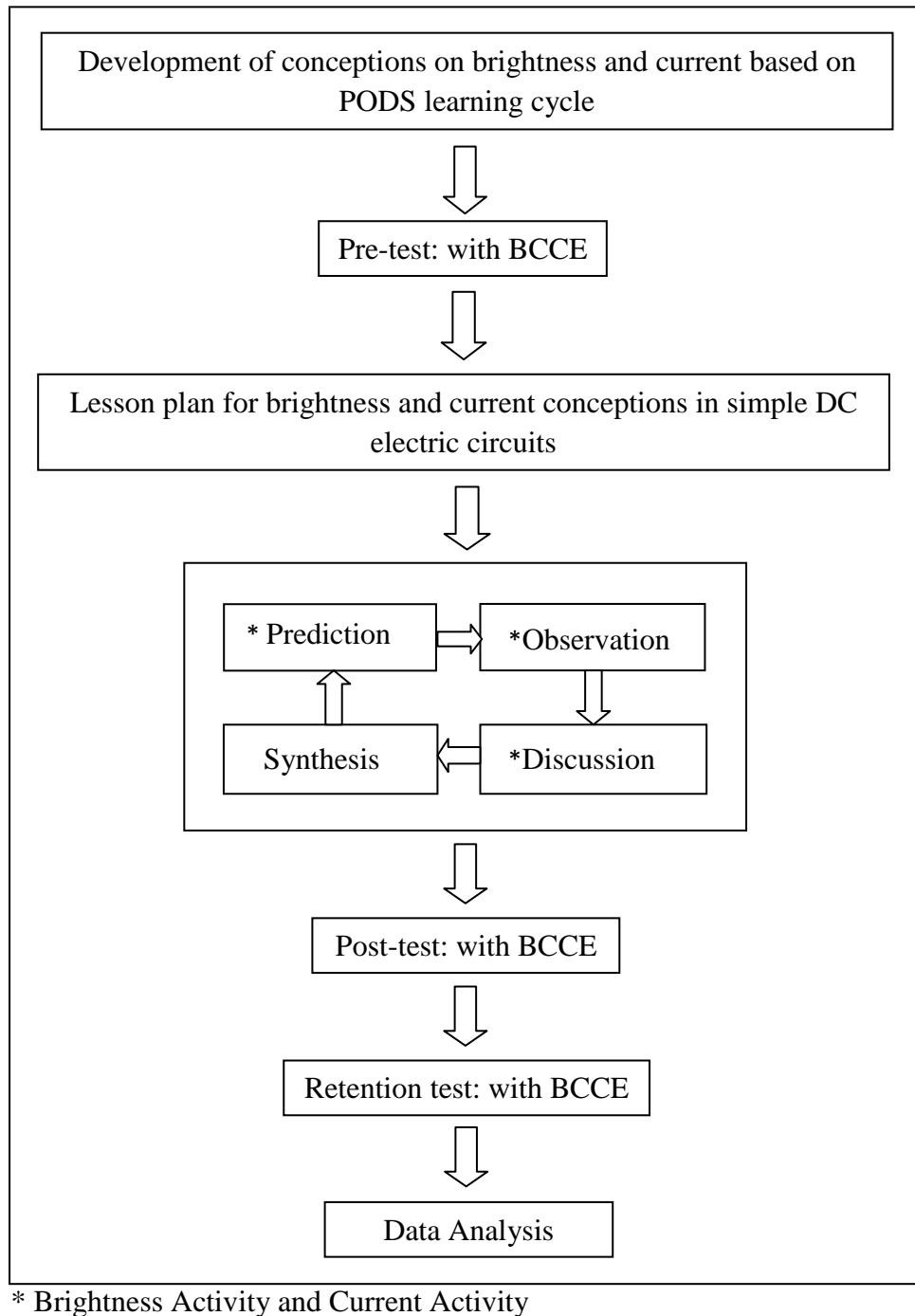


Figure 1.1 Framework of the study

1.6 Scope of the Study

This study focused on students' understanding about a brightness of two identical light bulbs and current passing through two resistors connected in series and parallel circuits. The participants were 50 Myanmar first year undergraduate science students who studied in the government university of Myanmar in an academic Year 2011. In addition, the BCCE was introduced to 208 Thai first year undergraduate science students of one government university in the same academic year as only pre-test to survey their prior knowledge. The activities were developed based on PODS learning cycle. The students' results from different countries will not be compared because of the difference of the contexts.

1.7 Expected Outcomes

The expected outcomes of this research are:

- 1) Thai and English evaluation that can explore students' understanding about simple DC electric circuit.
- 2) Some Thai and Myanmar first year undergraduate science students' misconceptions of simple DC electric circuits in terms of brightness of two identical light bulbs and current passing through two resistors, connected in both series and parallel circuits.
- 3) The activities that could help Myanmar first year undergraduate science students improve their understanding of related concepts.

CHAPTER II

LITERATURE REVIEW

Overview

There are six main sections in this chapter. The first section starts with the teaching and learning physics around the world then the teaching and learning physics in Myanmar is briefly described in the second section. The third section provides the curriculum of high school and undergraduate level of DC electric circuits in Myanmar. The fourth section explains about the concepts of DC electric circuits by covering the concept maps for “how a light bulb work”, briefly and misconceptions in these areas are provided in the fifth section. The PODS learning cycle are presented in the sixth section.

2.1 Teaching and Learning Physics around the World

McDermott (1991) reported that physics teaching in the past had motivated instructors to develop new curricula and the most significant between the 1991 situation and the post-Sputnik era was the growing body of knowledge about students’ understanding in physics. McDermott’s major work was begun at the University of Washington, Seattle resulting in the formation of the physics education group in the physics department at the University of Washington. McDermott’s early investigations arose out of an attempt to help new teachers by identifying concepts that interfered with learning. She noted that up until the late 1950s and 1960s, science in elementary and high school consisted mostly of reading and memorization. In high school as in college, the physics curriculum was generally considered to consist of a course syllabus, a text, a collection of standardized problems and a set of prescribed laboratory experiments. In addition, she explained that the learning and teaching of physics was a relatively new field that involved physicists, cognitive psychologists, and science educators who had a different approach to do their research (see Fig. 2.1).

However, the outputs were the same which were theories of cognition or instruction. Physics instructors were slightly different from the others as they were not only focus on the contents but also students' difficulties. In other word, physics instructors used students' difficulties to design specific instructional strategies/materials. This could also be done by cognitive psychologist and science educator.

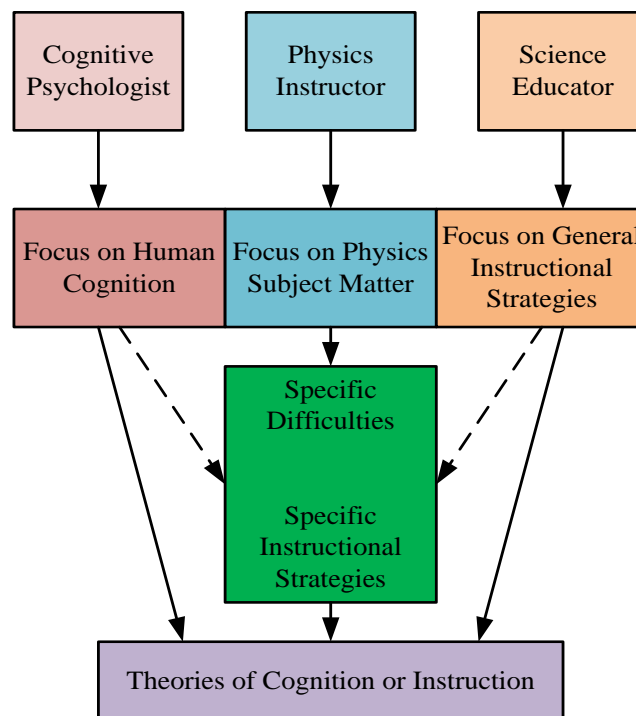


Figure.2.1 McDermott's perspective on Research in Physics Education (McDermott, 1991)

There were many projects dealing with the development of physics education research established by many organizations since 1997 (Hersh, 2005; Sharma et al., 2009). The details of these projects are as follow:

- In the year of 1997 and 1998, the European Physics Education Network (EUPEN) conducted a comparative study into undergraduate physics throughout Europe.
- In 2000/2001, the Institute of Physics (IOP) carried out the project named as "*Inquiry into Undergraduate Physics*" in the United Kingdom. The aim of this project was to survey physics departments and students about undergraduate physics education for understanding

and improving university physics learning and teaching that key international studies have been taken throughout the United Kingdom.

- In 2001/2002, the American Association of Physics Teachers (AAPT) established the National Task Force on Undergraduate Physics.
- In 2004/2005, the Australian Universities Teaching Commission (AUTC) and the Carrick Institute for Learning and Teaching in Higher Education funded the project entitled “*Learning Outcomes and Curriculum Development in Physics*”. This project included academics from 13 institutions across Australia and a panel of expert advisors to conduct undergraduate physics education in Australia.

Sharma (2009) also presented the findings of the “*Inquiry into Undergraduate Physics*” project as follow:

- Physics provides the foundation for all of engineering and many scientific disciplines including Information and Communication Technology (ICT), geosciences, biomedicine, and life sciences.
- Physics education develops strong intellectual and practical skills, well matched to the evolving needs of employers.
- The overall numbers of physics degree graduates have been maintained in the 15 years prior to 2001 but there are growing employer demands for scientists and engineers that are not being met.
- There is a critical shortage of physics teachers in secondary schools, with two thirds of physics taught by teachers without a physics degree.
- There is a drop in the number of undergraduate physics courses offered in regional universities.

Beside the above projects, there were many physics education research. The followings are a summary of selected physics education research related to teaching and learning physics.

Sokoloff and Thornton (1998) had studied Interactive Lecture Demonstrations (ILDs) teaching technique together with Microcomputer-Based Laboratory (MBL) tool to bring the significant changes in the laboratory learning environment or making the learning environment in large (and also small) lectures to establish an active learning environment in the lecture portion of the introductory

course and evaluated the effectiveness of ILDs in introductory physics lectures since 1989. The MBL was an example of the use of “interactive technology” as a tool in physics education that was introduced into physics teaching almost three decades ago. MBL tools used with the ILDs could help students to develop their scientific thinking. Students were asked to give a response to a sequence of conceptually simple physical experiments. They were actively engaged by the use of a learning cycle including a written prediction of the results of an actual physical experiment, small group discussion with their nearest neighbors, observation of the physical event in real time with the MBL tools, and comparison of observations with the predictions. Sokoloff and Thornton found a strong evidence of students’ learning and retention of fundamental concepts by comparing ILDs method and traditional lectures.

Whitelegg (1999) revealed that using context-based learning approach to teach physics contents especially the context of energy will encourage students in high quality learning in the UK and Australia. The real-life contexts were used to engage students to learn any physics contents related to the context. This learning approach can be developed independent learning skills amongst students. The independent learning skills could be introduced gradually into students’ learning programs and teachers were expected to manage their students’ learning rather than the teaching in the traditional way. Whitelegg found that the outcomes of using context-based learning approach were being investigated in terms of students’ achievement and motivation for learning physics.

Ogborn (2001) noted that science curriculum needed to focus on questions related to a good variety of scientific methods and techniques. These questions could help people understand the importance of science then they would be interested in science. In addition, he said that the laboratory work should be the backbone of the physics course. Furthermore, the experimental work should aim to bring clearly the physical meaning of laws and processes to pupils, which enable him/her to organize and apply such knowledge.

Varma (2001) proposed the self experiments and investigations based teaching technique. Once the basic principles have been taught, the applications should be in the form of investigations of some real-life problems that children are involved in. In addition, suitable equipment has to be prepared for the students. Teachers’ role

for this technique is to conduct the experiments and investigations. He also said that the teaching of physics in the 2001 situation in India was slowly becoming a theoretical activity because teachers treated physics only as a body of knowledge that had to be transmitted to their students. In conclusion, he suggested that “teachers must be provided space for personalizing the curriculum and must be supported” to develop the teaching and learning physics in India.

Emarat et.al (2002) studied the effectiveness of the Thai traditional teaching in the introductory physics course by comparing the students’ understanding with that of the United States and Australian. They had used the Force and Motion Conceptual Evaluation (FMCE) test to assess the students’ understanding of Mechanics before their traditional instruction was given. The participants in their research were the first year students majoring in medical science, engineering and pure science at Mahidol University. After three weeks implementation of the Mechanics lecture, the students were received the same test again. They found that a few students could understand force and motion from the Newtonian point of view. After a semester, the improvement in students’ performance was to be quiet poor. Moreover, they also found that Thai students’ understanding was lower than that of Australian students but higher than that of United States students.

Bernhard et.al (2007) have been developed ILDs as a platform for helping students to acquire a functional understanding of physics. In their project, ILDs has been implemented in an introductory physics course (mechanics, wave motion, optics and thermodynamics) taken by engineering students at Campus Norrkoping, Linkoping University. The results showed that ILDs is possible to do reforms and achieve active learning in the framework of a lecture setting.

Ornek et.al (2008) investigated what happened in physics education in the past, students’ difficulties on physics learning, and students’ misconceptions on some topics in physics including simple DC electric circuits. They found that students’ difficulties stem from physics concepts; the way in which a physics course is taught and physics problems which are sometimes very vague. Researchers also suggested the course instructors should use students’ views about their difficulties with physics to 1) prepare the course curriculum, 2) choose the course textbooks, and 3) employ the

curriculum in a way that lessens students' difficulties of understanding and learning of physics.

Adeyemo (2010) revealed that general science (Biology, Chemistry, and Physics) was being taught in lower forms of secondary schools before 1960. Physics has been found to be the most basic science subject and bedrock of scientific and technological development worldwide in both developed and developing countries like USA and Nigeria have some essential features are as follows:

- The teaching of physics should be guided discovery method instead of the old and routine lecture method used in teaching the subject.
- The learning efficiency and effectiveness should be take place during explanation, experimentation and discussion.
- There should be interaction between the teacher of physics and the students.
- Each topic should have a target and specific objectives to be met at the end of that lesson.
- Each topic should cut across other topic that is the knowledge guided in previously taught topic should be transferable.
- Evaluation should not only be based on the recalling of facts but also on the affective and psychomotor.
- Emphasis should be placed on the theoretical aspect as well as practical aspect of the subject.
- Each topic should be taught in a way that takes into consideration its relevance to the societal norms, values etc so that each student can appreciate the values, norms of his society in which he/she lives.

2.2 Teaching and Learning Physics in Myanmar

The Ministry of Education (MOE) is the main provider of education in Myanmar and is functioning with the vision to create an education system. It will generate a learning society capable of facing the challenges of the knowledge age (Myint, 2010). Students in Myanmar have to learn science subjects (Physics,

Chemistry, and Biology) in English language at Standard 9 and 10 which mean Grade 10 and 11. Textbooks of science subjects for Standard 9 and 10 have been introduced in English since 1991. In practice, most teachers give explanations in Burmese (Myanmar) language, but pupils are required to read and write in English language. Question papers are also in English language (Lwin, 2000).

Before 2000-2001 academic years, Grade 10 and 11 students were necessary to learn physics according to the curriculum consideration by MOE, which were:

1. Burmese;
2. English (second language);
3. Mathematics;
4. Science (Physics, Chemistry, and Biology);
5. Social (History, Geography, and Economics).

In the academic year of 2000-2001, this curriculum was changed to subject grouping (Lwin, 2000). After their Standard 8 examinations, students have to choose one of seven groupings, which are:

1. Burmese (Myanmar), English, Mathematics, Physics, Chemistry, Economics;
2. Burmese (Myanmar), English, Mathematics, Geography, History, Economics;
3. Burmese (Myanmar), English, Mathematics, Geography, History, Optional Burmese;
4. Burmese (Myanmar), English, Mathematics, History, Economics, Optional Burmese;
5. Burmese (Myanmar), English, Mathematics, Physics, Chemistry, History;
6. Burmese (Myanmar), English, Mathematics, Physics, Chemistry, Optional Burmese;
7. Burmese (Myanmar), English, Mathematics, Physics, Chemistry, Biology;

Students in Myanmar have been started to learn physics subjects from the upper secondary level Grade 9 to 10 (high school level). High school physics

textbooks are published by only education department of MOE in Myanmar (Lwin, 2002). Regarding to the curriculum of 2000-2001 academic years, the teaching and learning physics in Myanmar has been depended on the students' choice. In 2009, some researchers studied a history of science education department in Myanmar. They investigated why high school level students had to learn physics. The result was "Myanmar people think that physics effectively contribute to the development and high school students in science course are most important human resources to develop the future industrial society". Moreover, scientific talent of young power will be a key to attain to a wealth of country (Kyi & Koji, 2009).

In the curriculum of physics, simple DC electric circuits is one topic that student who take the science subjects including physics have to learn. The details of the DC electric circuits' curriculum in Myanmar for high school level and undergraduate level are presented in the next section.

2.3 DC Electric Circuits in Myanmar Curriculum

DC electric circuits are included in the main contents of physics at high school level and undergraduate level in Myanmar. These contents are imparted to students effectively with the experimental tools so students can master the high school physics as well as students of developed country. The high school physics textbook is published by only department of the Ministry of Education (MOE) and the undergraduate level of physics curriculum is provided by the Ministry of Science and Technology (MOST) in Myanmar. This section presents a detail of Myanmar curriculum in a high school and undergraduate level. The details are as follow:

2.3.1 High School Level

The contents that Myanmar Grade 11 students have to learn are printed in "Physics High School Textbook in Highest Grade 11". The names of fourteen chapters are as follows:

Chapter 1	Work done and power
Chapter 2	Pressure

Chapter 3	Transfer of Heat
Chapter 4	Vibration of Strings, Resonance and Vibration of Air Columns
Chapter 5	Introduction to Light
Chapter 6	Refraction, Diffraction and Interference of Light
Chapter 7	Optical Instruments
Chapter 8	The Electric Field
Chapter 9	Electric Potential
Chapter 10	Capacitance
Chapter 11	Current and Electric Circuits
Chapter 12	Electrical Energy and Power
Chapter 13	Electromagnetism
Chapter 14	Modern Physics

Researcher focused on a topic of simple DC electric circuit in terms of brightness of two identical light bulbs and current passing through two identical resistors connected in series and parallel circuit. It is corresponding to the “Chapter 11: Current and Electric Circuits” that covered the concepts of “Current and Effects of Current, Ohm’s Law and Electrical Resistance, Resistors in Series, Resistors in Parallel, Electromotive Force and Electric Circuits, and Batteries in Series and Parallel”.

2.3.2 Undergraduate Level

There are nine chapters presented in “EPh 1011 Engineering Physics” course syllabus for first year undergraduate Electronic Engineering Myanmar students at all Technological University in Myanmar. The topics consist of:

Chapter 1	Kinematics
Chapter 2	Kinetics
Chapter 3	Equilibrium and Elasticity
Chapter 4	Thermal Physics
Chapter 5	Fluid Mechanics
Chapter 6	Current and Electricity
Chapter 7	Magnetism

Chapter 8 Optics

Chapter 9 Quantum Physics and Nuclear Physics

In order to find out the students' misconception on simple DC electric circuit, "Chapter 6: Current and Electricity" is specific for this study. This chapter covers the main concepts as "Current and Resistance, Direct Current Circuits, Alternating Current Circuits". The sub-concepts are "Electric Current, Resistance, A Model for Electrical Conduction, Resistance and Temperature, Superconductors, Electrical Power, Electromotive Force, Resistors in Series and Parallel, Kirchhoff's Rules, *RC* Circuits, Electrical Meters, Household Wiring and Electrical Safety, AC Sources, Resistors in an AC Circuit, Inductors in an AC Circuit, Capacitors in an AC Circuit, The *RLC* Series Circuit, Power in an AC Circuit, Resonance in a Series *RLC* Circuit, The Transformer and Power Transmission, and Rectifiers and Filters".

2.4 DC Electric Circuits Concepts

The DC electric circuits are the most fundamental concepts and important for engineering students and students who take physics subjects (Baser & Durmus, 2010; Carstensen & Bernhard, 2007a). Carstensen and Bernhard argued that students who take physics subjects should not only to understand theories and models but also to apply the models and theories. Many science education researches of Carstensen and Bernhard concerned with the concepts of DC circuits, even though common objectives in physics is to develop an understanding of the relationships between the theory/model world and object/event world (see Figure 2.2). Most research of Carstensen and Bernhard focused on pre-university students' understanding of direct current in DC circuits. They found that students had confusion between concepts such as current, brightness, voltage, power and energy (Carstensen & Bernhard, 2007c). This was because students did not clearly distinguish between the concepts and were not able to relate each other concepts properly i.e., current consumption, battery as constant current supply, no current-no voltage, and voltage is a part or a property of current.

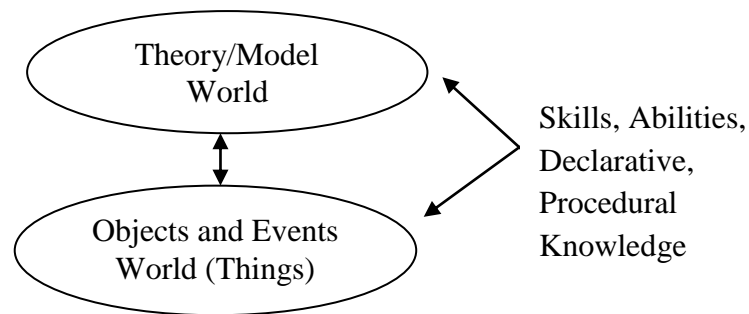


Figure 2.2 Categorization of knowledge based on a modeling activity (Carstensen & Bernhard, 2007b)

Research also showed that it was very difficult for students to perceive a circuit as a whole system and to understand that local changes in a circuit result in global changes as it affects all voltages and currents in a circuit (Carstensen & Bernhard, 2007a, 2007b, 2007c, 2009; Carstensen, Bernhard, & Holmberg, 2010).

In addition, Engelhardt & Beichner (2004) reported that electricity is a challenging science topic at all school levels and learners often have many misconceptions and difficulties in understanding and learning this topic. The concepts of the introductory direct current electricity have frequently been focused on investigation. Students tend to focus on current in 1) solving the problems and confuse terms, 2) assigning the properties of current to voltage and/or resistance. Students did not have a clear understanding of electric circuit phenomena. On the other hand, students were not able to translate easily from a “realistic” representation of a circuit to the corresponding schematic diagram (Engelhardt & Beichner, 2004).

In order to develop students’ understanding on the concepts of DC electric circuits, McDermott and Shaffer (1992) had investigated many researches related to the concepts of batteries and resistive elements to be a guideline for curriculum development. The process consisted of three part as 1) conducting systematic investigations of students’ understanding, 2) applying the results in the development of specific instructional strategies to address specific difficulties, and 3) designing, testing, modifying, and revising the materials in a continuous cycle on the basis of classroom experience with the target population. In practical, their works were divided into two parts consisting of investigation of students’ understanding on the

concepts of DC circuits by the Physics Education Group and design of instructional strategies for these concepts.

The first part described how investigation of students' understanding of electric circuit can be used to guide the development of curriculum that matches the needs and abilities of students. Some serious conceptual and reasoning difficulties of these concepts were not successful after using standard lecture and laboratory instruction. The methods of investigation used in this research range from individual demonstration, interviews conducted in a formal setting to descriptive studies carried out during instructions in the classroom. Students were asked to predict the relative brightness of bulbs in real circuits as shown in Figure 2.3. Many students had difficulty with the task thus Shaffer and McDermott decided to limit a number of elements on circuits. They then formulated written questions that were administered to the test and course examination to large groups. The students' difficulties were divided into three general categories: an inability to apply formal concepts to electric circuits, an inability to use and interpret formal representations of electric circuits, and an inability to reason qualitatively about the behavior of electric circuits.

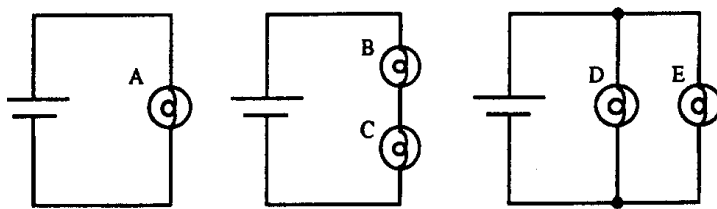
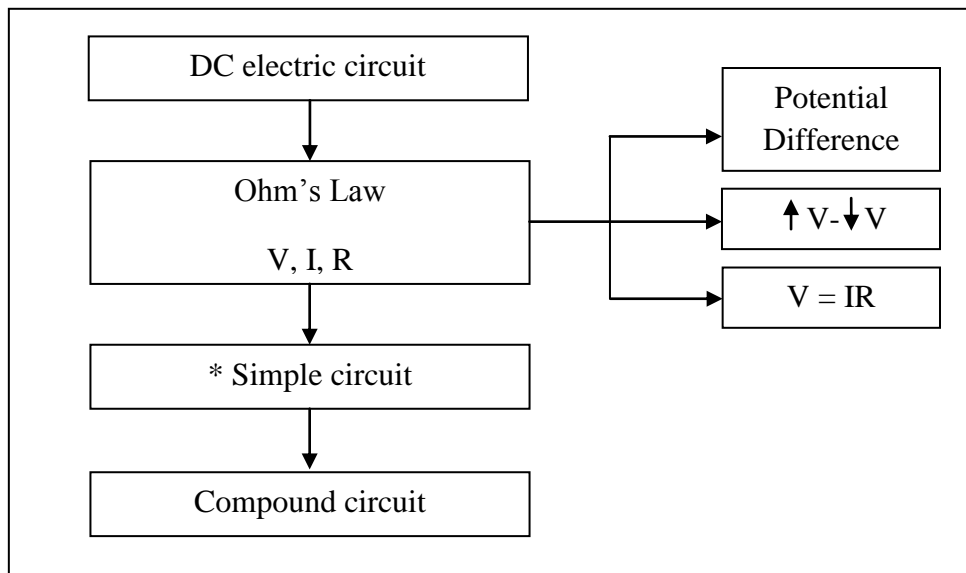


Figure 2.3 Students were asked to rank a brightness of the five identical bulbs connected in the circuits as shown above (the batteries were assumed to be ideal). Students also needed to give an explanation of their reasoning. The correct response is $A = D = E > B = C$ (McDermott, 1991; Shaffer & McDermott, 1992).

The second part described how McDermott and Shaffer used the results from prior research to fit the limitation of the traditional introductory course. They applied the specific instructional strategies to address specific difficulties and designed task, modified and re-examined the materials into classroom. The research development of a laboratory-based curriculum encouraged students to make the process of constructing a conceptual model for DC electric circuit from direct “Hands-

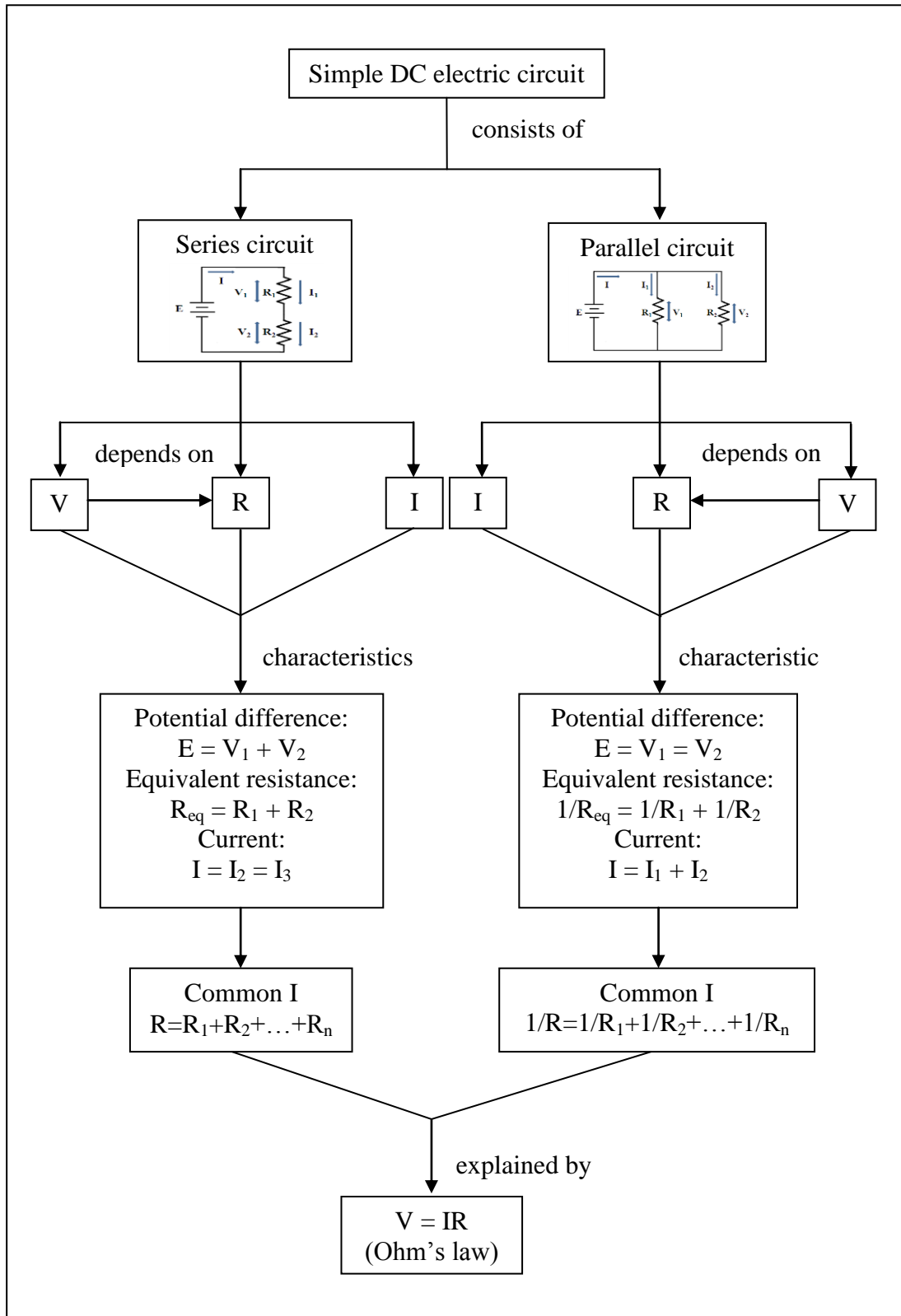
on” activities with batteries and bulbs. However, they found that the use of model building as an instructional strategy was usually not sufficient. Many students could not develop a functional understanding of material unless certain difficulties were explicitly addressed. Researchers also recognized that a laboratory-based curriculum was not feasible in courses with large enrollments. They suggested that “Hands-on” activities and open-ended investigations must be replaced by demonstrations and task to develop the students’ understanding on the concepts of DC electric circuits.

Therefore, the “Hands-on” activities were developed in this research to help Myanmar undergraduate students improve their understanding on related concepts as showed in Figure 2.4 (b). Figure 2.4 shows that the concepts map of DC electric circuit, simple DC electric circuit, and light bulb circuit in terms of brightness and current. By applying this concept map, students can learn how the light bulb works in details. In this research, a light bulb was introduced to students as an electric component used to transfer an electric to brightness which depends on an electric power ($P=IV$) consumed by itself.

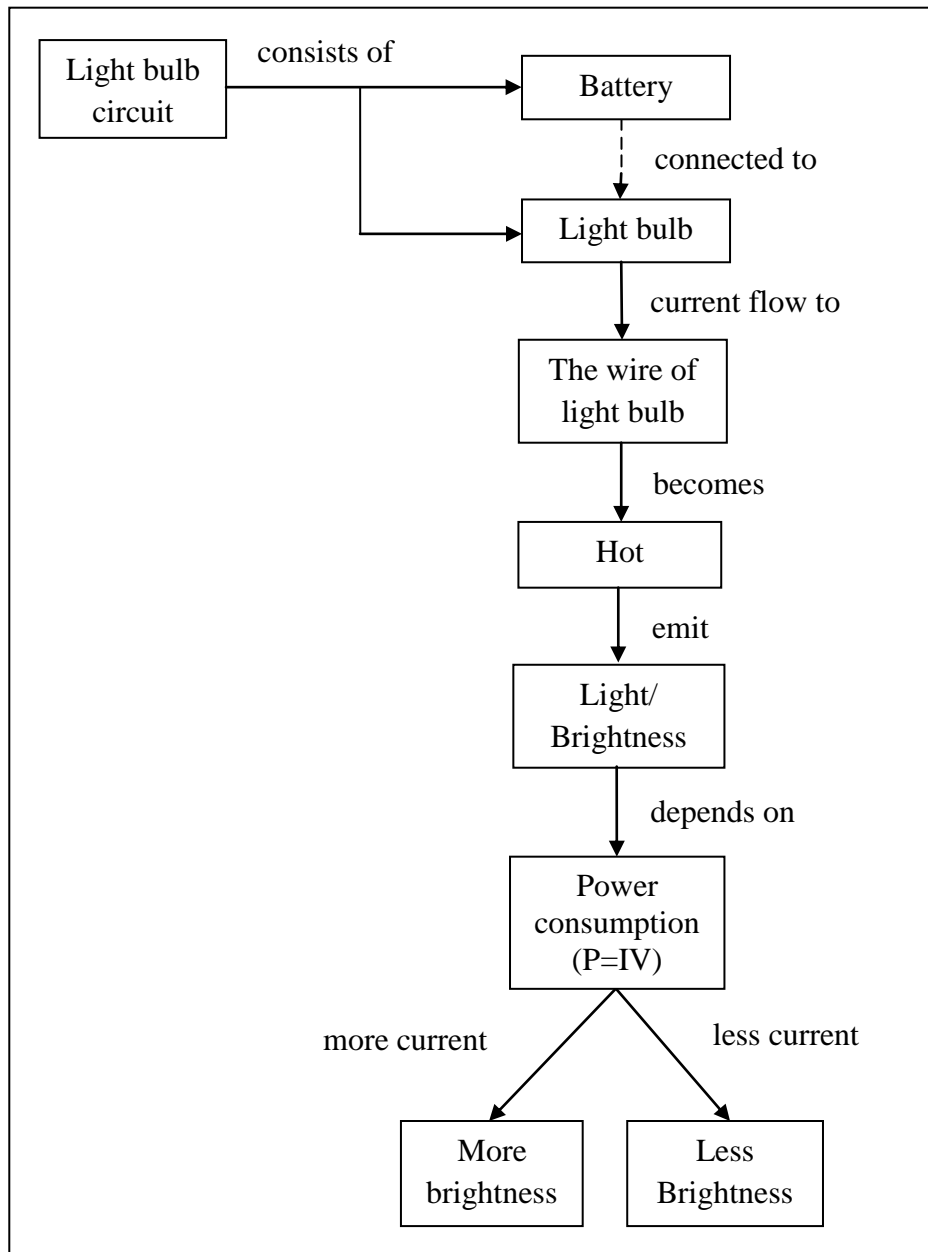


* The study focus on this topic and the detail is listed in the next map

(a) DC electric circuit concept map



(b) Simple DC electric circuit concept map



(c) Light bulb circuit concept map

Figure 2.4 Concepts map of (a) DC electric circuit, (b) Simple DC electric circuit, and (c) Light bulb circuit

2.5 Misconceptions on DC Electric Circuits

Sencar, et al. (2001) proposed that the term “misconception” refers to the students’ ideas about any phenomena that were inconsistent with scientific

conceptions. It was known that students link their preexisting conceptions named as “preconceptions”, constructed from previous experiences, to a newly presented science concepts. On the other word, students’ preconceptions could interfere what students learned of science (Sencar, et al., 2001).

Many previous researches revealed that it is difficult for students to change their preconceptions. Incorrect perceptions (alternative conceptions) were very persistent to change and present a learning difficulty for learners at all levels. Therefore, diagnosing students’ alternative conceptions and presenting a helpful treatment for them was extremely important for developing instruction and fostering meaningful learning (Ates, 2005; Taser, 2006).

The goal of effective science instruction is to encourage the student to construct an understanding that is generally consistent with accepted scientific theory. Therefore, students’ preconceptions in science have aroused science educators’ interest for 30 years. The principle idea of constructivist learning theory suggests that students come to the learning environment with their preconceptions. The preconceptions are formed during students interact with physical and social environment (Kucukozer & Kocakulah, 2007).

Kucukozer & Kocakulah (2007) also reported that there were many researchers had been conducted the main features of what students’ misconceptions are and where these come from as follow:

- Misconceptions of students who have different culture, religion and language are frequently similar to each other.
- Misconceptions may deeply penetrate into students’ minds and resist changing. Everyday language, culture and religion can cause the formation of misconceptions.
- Misconceptions can be parallel to the explanations made by earlier scientists in interpreting scientific phenomena.
- Misconceptions may develop after a formal teaching.

Physics, itself is difficult for students to acquire a functional understanding of canonical physics even after studying physics at university level. This is supported by the evidence that most students’ conceptions (usually called

misconceptions or alternative conceptions) are very different from those held by experts (Bernhard, Carstensen, & Holmberg, 2007).

In addition, students' attitude about a course has an influence to their understanding and learning. Many students believed that Physics is difficult because they have to contend with different representations such as experiments, formulas and calculations, graphs, and conceptual explanations at the same time. Moreover, they have to make transformations among them. For example, students need to be able to transfer from graphical representations to mathematical representations or vice versa (Ornek, et al., 2008).

Scientific knowledge always be abstract and relate to students' everyday life. Students so come to a class with their gray-understanding, they learn from environment and form their own understanding. The gray-understanding is named as preconception, preexisting knowledge, children's science, etc. If students' preconception was different from scientist' conception, it was named as misconception or alternative conception. The interesting question as "Why students hold alternative conceptions" can be explained by several reasons: teaching method, student preexisting knowledge, insufficient connection between concepts or preexisting knowledge and new one, text book, procedural learning and so forth. In addition, students' alternative conceptions are very common even if different cultures and countries are. Therefore, science education studies have focused on the following questions: "how to teach?", "why to teach?", and 'whom to teach?'. Many researchers have made an attempt to elicit students' alternative conceptions of some perceptive such as heat and temperature, force and motion, energy, mechanics, electricity and magnetism, mass and weight, and so on" (Ipek & Calik, 2008).

One example is the study on the topic of "A testing system for diagnosing misconceptions in DC electric circuits" by Chang, Liu, and Chen (1998). They found nine primitive misconceptions as follows:

- *Current existence*: Students believe that a single wire connection between a battery and a bulb will light up the bulb. But the students do not know that the existence of current is associated with the condition of closed circuit.
- *Voltage existence*: A large number of pupils know that current only

exists in a closed circuit, but they also believe it is the same for voltage.

- *Weakening of current*: Students believe that current flows around the circuit in one direction and becomes weakened as it goes so that the later circuit elements receive less current.
- *Division of current*: Students believe that current flows around the circuit in one direction and is shared equally by the circuit components, but is partially or completely used up in the circuit components.
- *Battery role*: Students believe that the battery is a “current reservoir” delivering a constant current whatever the circuit attached.
- *Current in series circuit*: many students believe that currents are the same in two contrasting circuits while ignoring the doubled resistance in the series circuit.
- *Voltage in series circuit*: Students regard voltage the same as the current in the series circuit and guesses that all voltages crossing components in the series circuit are the same.
- *Current in parallel circuit*: a large number of pupils believe that bulbs in parallel would shine less than a single identical bulb.
- *Voltage in parallel circuit*: Students believe that branch voltages in the parallel circuit are different.

Since concepts in DC electric circuits are abstract, students so develop a wide range of misconceptions related to brightness and current as reported in many studies in physics education (Cohen, Eylon, & Ganiel, 1983; Engelhardt & Beichner, 2004; Kucukozer & Kocakulah, 2007; Lee & Law, 2001).

Lee and Law (2001) investigated students’ alternative conceptions of electric circuits and developed a teaching strategy for promoting conceptual change in the learning of basic electric circuitry concepts. They used *the pencil and paper test* and *the semi-structured interview* to the six secondary 6 science stream students (17 yrs. old) from a secondary school in Hong Kong. The pencil and paper test was designed to elicit students’ alternative conceptions of electric circuits consisting of nine questions that required students to (a) compare the size of current at different points in a circuit, (b) compare the brightness of the bulbs in the same circuit, (c) compare the brightness of bulbs in different circuits, and (d) predict what would

happen to the brightness of a bulb if a change was made to the circuit (by adding or removing a bulb in the circuit). The semi-structured interview was taken about 20 to 30 minutes after the test was completed. From the interview, they found some common students' alternative conceptions as follows:

- A battery is a source of current.
- A battery releases a fixed amount of current.
- Bulbs use up or consume current.
- Current is used up by the components in the circuit.
- The further away the bulb is from the battery, the dimmer it will be.
- In a parallel circuit, current is divided into equal parts.

Engelhardt and Beichner (2004) provided the list of students' misconceptions related to the DC electric circuits and created the development test of *The Determining and Interpreting Resistive Electric Circuit Concepts Test (DIRECT) VERSION 1.0 and 1.1*. One objective of their resource was to provide instructors with a way of evaluating the progress and conceptual difficulties of their students on the topic of direct current resistive electrical circuits. VERSION 1.0 of DIRECT consisting of 29 multiple-choice items was administered to 1,135 students from high school (N=454) and universities (N=681) across the United States and it took approximately half an hour to complete. DIRECT VERSION 1.1 consisting of 29 items, but each with five alternatives, was administered to 692 students from high schools (N=251) and universities (N=441) in Canada (one high school and one university test site), Germany (one high school test site), and the United States. They found some misconceptions as follow:

- *Battery as a constant current source*: Battery supplies same amount of current to each circuit regardless of the circuit's arrangement.
- *Current consumed*: Current value decreases as you move through circuit elements until you return to the battery where there is no more current left.
- R_{eq} : Students equated the equivalent resistance of a circuit with an individual resistor.
- A resistor resists the current so a current must flow for there to be any resistance.

- Current is the cause of the voltage. Voltage and current always occur together.

Kucukozer & Kocakulah (2007) reported in their research that the students' misconceptions came from 1) the use of everyday language, 2) students' acquisition of new misconceptions during teaching, and 3) the extent to which teachers hold the same misconceptions. Throughout the learning progress, students may not perform as expected due to many reasons so some deficiencies in knowledge are formed. Once misconceptions in a certain knowledge domain are formed, students are not able to understand the topic. Therefore, methods to diagnose and to correct the misconceptions are very important to students' learning. In addition, they used the Conceptual understanding Test named as (CAT) consisting of eight open-ended questions, to reveal secondary school students' misconceptions about simple electric circuits and to define whether specific misconceptions from Turkish students. The participants in their research were 76 students in three Grade 9 classes in Balikesir. Kucukozer and Kocakulah noted that some students' misconceptions about simple electric circuits in their research are as follow:

- None of the bulbs are lit when the switch is closed.
- Bulbs in parallel give more light than bulbs in series.

These two misconceptions were emerged from Turkish students based on Turkish language and teaching. The following misconceptions were common with the findings of the other researchers.

- Concept of potential difference, current and energy were used interchangeably as if they all are the same.
- Bulb gives more light when the number of batteries increases and bulb becomes brighter when batteries are connected in parallel compared to batteries connected in series.
- Batteries are constant current sources.
- Current is consumed by circuit component.
- Bulbs in series always give more brightness.

There are many difficulties for students to analyze the electric circuits, to understand the circuit diagrams and to interpret a short circuit. For example, if a circuit

is modified, they tend to analyze only the modified part of the circuit rather than the whole circuit (Cohen, et al., 1983).

Students' misconceptions cause such serious learning problem; we so can not only address the diagnosis while ignoring follow-up corrective work. Once a students' misconception in a certain knowledge domain has been identified, he or she should immediately be provided with an appropriate correcting procedure (K. Chang, et al., 1998). One possible explanation might be student's preconceptions are different from the perspective found in the textbook delivered by their instructor in the classroom; students so misread the textbook and mishear the words of their instructor (Nahum, Hofstein, Maml-Naaman, & Bar-Dov, 2004).

To help students correct their misconception, only traditional method might not alter students' misconceptions as reported by Jaakkola & Numri (2004). Some researchers also developed some active learning approaches and investigated the use of active learning cycle promotes students' conceptual understanding of electric circuit rather than the traditional teaching method (Kearney, Treagust, Yeo, & Zadnik, 2001; Mazzolini, Edwards, Rachinger, & Nopparatjamjomras, 2011; Prince & Felder, 2006; White & Gunstone, 1992). Therefore, the PODS based activities was developed in this research to help Myanmar undergraduate students improve their understanding of the related concepts.

2.6 PODS Learning Cycle

Many studies reported that students' misconceptions are deeply rooted and be able to develop as a lifetime of incorrectly interpreted personal experiences and observations (Hestenes, Wells, & Swackhamer, 1992). Physics Education Research (PER) found that these deeply-held misconceptions made students' understanding and hence appreciation of very basic physics concepts not greatly improve, especially when students were taught based on traditional instruction. Therefore, the quantification and interpretation of students' misconceptions have been given insights for the development of more effective instructional methods in introductory physics courses (Cambaliza, Mazzolin, & Alarcon, 2004).

The fact that an active learning method could help students improve their conceptual understanding was reported in many PER (Laws, 1991; Thornton & Sokoloff, 1990). This is because an active learning method reproduces the scientific process in the classroom and aids in the development of good physical reasoning skills. Moreover, Hake (1998) reported that active learning methods are far superior to traditional teaching method for improving students' understanding of physics concept at both secondary and tertiary education levels. Furthermore, Bernhard and his team suggested that traditional lectures commonly did not help students acquire sufficient functional understanding of physics so the researchers had sufficiently to design different active learning techniques (Bernhard, Lindwall, et al., 2007). Table 2.1 compares the characteristics of active learning environments to traditional (passive) environments (Tanahoung, 2008).

Table 2.1 Passive versus Active Learning Environments (Tanahoung, 2008)

Passive Learning Environment	Active Learning Environment
Instructor (and textbook) is the authority-source of all knowledge.	Students construct their knowledge from hands-on observations. Real observations of the physical world are the authority.
Students' beliefs are never overtly challenged.	Uses a learning cycle in which students are challenged to compare predictions (based on their beliefs) with observations of real experiments.
Students may never even recognize difference between their beliefs and what they are told in class.	Changes students' beliefs when students are confronted by differences between their observations and their beliefs.
Instructor's role is as the authority.	Instructor's role is as guide in the learning process.
Collaboration with peers is often discouraged.	Collaboration and shared learning with peers is encouraged.
Experimental results are presented as facts in a lecture.	Results from real experiments are observed in understandable ways – often

	in real-time with the support of microcomputer-based tools.
Laboratory work, if any, is used to confirm theories “learned” in lecture - often in a recipe – type approach.	Laboratory work is used to learn basic concepts – discovery - approach.

Active learning techniques (where are encouraged to engage in the learning experience) have been used for many years to improve students’ conceptual understanding of introductory physics at the university and high school levels. The efficacy of using active learning is now well established. Many PER have been demonstrated that student held deeply-rooted misconceptions in the areas of physics and these misconceptions often are not corrected by traditional passive learning techniques. Therefore, some researchers proposed the active learning cycle in educational field which are Prediction-Observation-Explanation (POE), Inquiry-Based Learning (IBL), Predict-Observe-Discuss-Synthesize (PODS), and so on (Cambaliza, et al., 2004; Mazzolini, et al., 2011). However, a common factor of active learning or active engagement in innovative teaching techniques is an actively engage students in the learning process (Cambaliza, et al., 2004). A brief explanation of these active learning cycle is described in the following paragraphs.

White & Gunstone (1992) proposed the POE (Prediction-Observation-Explanation) procedure as an efficient teaching strategy. The POE strategy involves students’ predicting the result of a demonstration and discussing the reasons for their prediction, observing the demonstration, and finally explaining the discrepancies between their predictions and observations. In order to expose the learners’ prior knowledge, instructors allow students to interpret their new observation of the demonstration and then offer more opportunities to share and negotiate their own personal interpretations with the class. The use of POE strategy is consistent with the theory of constructivism, which highlights the importance of prior knowledge and the construction of interpretations. In addition, the POE strategy is regarded as a constructivist-oriented learning strategy to promote learners’ conceptual learning (Kearney, et al., 2001; White & Gunstone, 1992).

The other teaching approach is learning through inquiry known as “Inquiry-Based Learning (IBL)”. Prince (2006) proposed the inquiry-based learning approach beginning with an interpretation of a set of observations or data or a complex real-world problem. When students study the data or problem, they generate a need of facts, procedures, and guiding principles. IBL is a one of active learning techniques which best enables students to experience the processes of knowledge creation. The key attributes are learning stimulated by inquiry, a student-centered approach, a move to self-directed learning, and an active approach to learning (Justice, Rice, Roy, Hudspith, & Jenkins, 2009).

Active learning in physics has been demonstrated in the United States and other developed countries to enhance students’ understanding of basic physics concepts. In this learning strategy, students are guided to construct their knowledge by direct observations of the physical world. PODS is one of learning cycle used for design active learning teaching module. PODS is a short form of Predict, Observe, Discuss and Synthesize. In the PODS learning cycle, students are encouraged to make a prediction about the result of a particular physics experiment before any treatment. The experiment is then performed and the students are encouraged to make a quantitative (or qualitative) observation of the experimental results. And then, students can discuss and share their predictions and observations with the group or class; whether the same or not from any conflict between their predictions and observations can be resolved during the discussion phase. After discussion, students come to be a better understanding about the physics principle underlying the observations amongst themselves and or with the facilitator. Finally, students are encouraged to synthesize their newly learned ideas and conclusions into the more general framework of their physics knowledge (Laws, 1991; Thornton & Sokoloff, 1990).

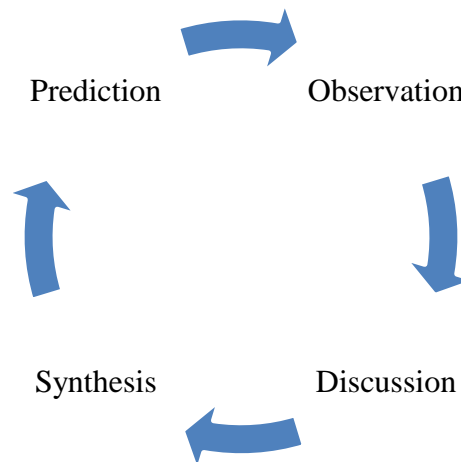


Figure 2.5 Diagram of PODS learning cycle

Figure 2.5 shows the diagram of PODS learning cycle that always start with the Prediction. In the case of developing students' conceptions on simple DC electric circuits, the researcher developed and used the PODS learning cycle based hands-on activities. This is because it is suitable for the topic and students who learn in the science program. Students have a chance to discuss, share their ideas and experience between their predictions and observations in this study. Moreover, it is important that students are encouraged to synthesize what they have learned. This can reflect how their understanding of a particular topic has been evolved to try to identify the critical issues that need to be addressed for meaningful learning to occur. As they progress in their investigation of electric circuits, the researcher can be given many opportunities to express their ideas.

CHAPTER III

METHODOLOGY

Overview

This research is divided into two phases; pilot study and case study. Details of research methodology including of research design, participants, instrument, data collection and data analysis are described in this chapter.

3.1 Phase I: Pilot Study

3.1.1 Research Design

The aim of this pilot study is to find out the misconceptions about DC electric circuits (series and parallel) in terms of brightness and current that holds by first year undergraduate science students both in Thailand and Myanmar without any comparison between both groups. This is because they are in different contexts. Therefore, 208 Thai and 50 Myanmar students' responses to the Brightness and Current Conceptual Evaluation (BCCE) are categorized.

This BCCE was developed from *The Key Testing Problems of Basic Electricity* (K. E. Chang, Liu, & Chen, 1998) and *The Electric Circuit Conceptual Evaluation (ECCE)* (D. Sokoloff, 2002). The BCCE was used to identify students' misconceptions about DC electric circuits in series and parallel circuit. The BCCE consists of 8 multiple-choice questions related to the concept of brightness of two light bulbs and current passing through two resistors connected in both series and parallel circuits. The evaluation test was introduced to participants before they were taught in a topic of DC electric circuit and they had 15 minutes to respond.

3.1.2 Participants

The participants in this pilot study were 208 first year undergraduate Thai students and 50 first year undergraduate Myanmar students. All of them studied in a science program in the government universities of Thailand and Myanmar, respectively.

3.1.3 Instrument: Brightness and Current Conceptual Evaluation (BCCE)

There were many research about a developing of conceptual evaluation to identify students' misconceptions in many physics topics. For example: 1) Hestenes, Wells and Swackhamer (1992) used the *Force Concept Inventory (FCI)* to evaluate the students' conceptual understanding on force and motion. 2) Beichner (1994) developed the *Test of Understanding Graphs in Kinematics (TUG-K)* to evaluate the students' conceptual understanding of kinematics. 3) Sokoloff (2002) created the *Electric Circuits Conceptual Evaluation (ECCE)* to develop the students' understanding on the topic of electric circuits. 4) Engelhardt (2004) used the *Determining and Interpreting Resistive Electric circuits Concepts Test (DIRECT) VERSION 1.0 and 1.1* to evaluate the students' understanding of a variety of direct current (DC) resistive electric circuits concepts.

The BCCE was adapted from some existed conceptual tests (K. E. Chang, Liu, S. H., and Chen, S. W., 1998; D Sokoloff, 2002). The first version of the BCCE was created in English and consisted of 12 items. The test covered concepts in simple DC electric circuit: Brightness and Current in Series and Parallel Circuits, Series and Parallel Resistor Circuits, and Series and Parallel DC batteries. The BCCE was validated by three Thai expert physics lecturers who had more than 5 years of experience in teaching physics for undergraduate students. The evaluation was then translated to Thai and again verified by three Thai expert physics lecturers who had more than 10 years of experience in teaching physics for undergraduate students. One of experts also responded for the validity of the evaluation. After verification and validation from Thai experts, the number of question was reduced to 8 questions. The four eliminated questions related to the comparison between single component circuit and two components circuit connected in series and parallel. Each item had five

alternatives (A, B, C, D, and E) but the experts suggested to decrease a number of alternative to be three (A, B, and C). Therefore, the concepts covered by the evaluation were Brightness of two light bulbs and Current passing through two resistors connected in both series and parallel circuits. The Thai version of BCCE was introduced to Thai students while the English version was used with Myanmar students.

The categories of conceptual areas, types, and condition of circuits are listed in Table 3.1.

Table 3.1 Categories of conceptual areas, types, and condition of BCCE

Question Number	Conceptual Areas	Types	Condition
1	Brightness*	Series	$L_1 = L_2$
2	Brightness*	Parallel	$L_1 = L_2$
3	Current**	Series	$R_1 = R_2$
4	Current**	Series	$R_1 > R_2$
5	Current**	Series	$R_1 < R_2$
6	Current**	Parallel	$R_1 = R_2$
7	Current**	Parallel	$R_1 > R_2$
8	Current**	Parallel	$R_1 < R_2$

* Brightness (B) of two light bulbs

** Current (I) passing through two resistors

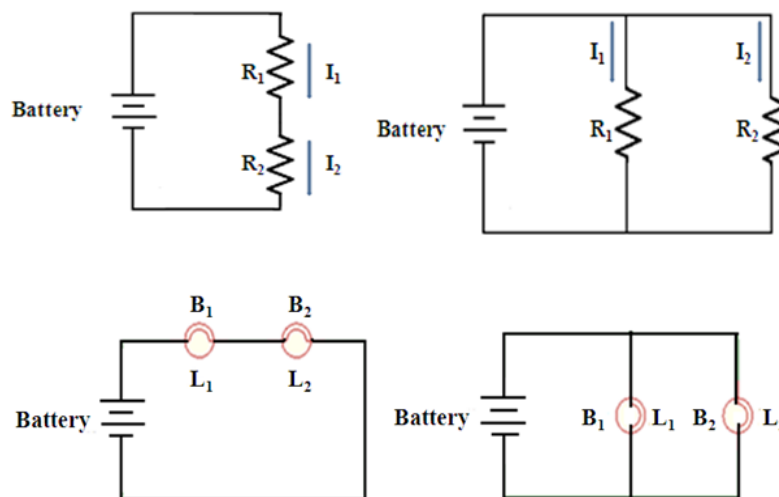


Figure 3.1 Circuits used in BCCE

To evaluate the quality of the BCCE, item difficulty index and item discrimination index were used.

3.1.3.1 Item Difficulty Index

The *item difficulty index* (P) is normally determined to the percentage of the total number of correct responses to the test item. It is calculated by the formula:

$$P = R/T$$

(or)

$$\text{Facility} = \text{No. of correct response} / \text{Total no. of students}$$

where R is the number of correct responses and T is the total number of respondents.

Hence, the higher this index value, the lower is the difficulty, and the greater the difficulty of an item, the lower is its index (Sim & Rasiah, 2006).

A value of $P = 100\%$ for a particular item indicates that all the students selected the correct answer and that item is considered very “easy”.

A value of $P = 0$ for a particular item indicates that none of the students selected the correct answer and that item is considered very “difficult”.

Hence, this ratio is one measure of how difficult the question was to answer (Hotiu, 2006). The facility should preferably be around 0.6 that is the expected mean for the class on the test is about 60% (Wong, 2006).

3.1.3.2 Item Discrimination Index

The *item discrimination index* (D) is a useful measure of item quality whenever the purpose of a test is to produce a spread of scores, reflecting differences in students' achievement, so that distinctions may be made among the performances of respondents (Hotiu, 2006).

It measures the difference between the percentage of students in the higher 27% group (PU) and the lower 27% group (PL) who obtained the correct response. Therefore the discrimination index is calculated by using the formula $D = PU - PL$.

The higher the discrimination index, the better the item can determine the difference, i.e., discriminate, between those students with high test scores and those with low ones.

Note that $-1 \leq D \leq +1$.

When $D = 0$, i.e., $PU = PL$, there is no discrimination.

When $D = +1$, i.e., $PU = 1$ and $PL = 0$, there is perfect discrimination, and when $D = -1$, there is inverse discrimination, which is most likely caused by a mis-keyed item (Sim & Rasiah, 2006).

Thus, discrimination indices ≈ 0 are found on difficult items such that almost everyone gets them wrong and on items so easy that almost everyone gets them right. For instructional purposes it is important to know the content areas and type of items that most students get right or wrong (Hotiu, 2006).

The value of discrimination index (D) is between +1 and -1 and the interpretation of the index is listed in Table 3.2 (Wong, 2006).

Table 3.2 The interpretations of item discrimination value

Index Value	Meaning
+1	Perfectly! There is a perfect relationship between students' test score and their scores on that item. (only high students get a correct answer)
(0,1)	Good! It refers that students in a higher group tend to perform better on that item than the one in a lower group. A detail of an interpretation as follow: <ul style="list-style-type: none"> • 0.4 or over : very good item • 0.30 to 0.39 : Reasonably good item but can be improved • 0.20 to 0.29 : Marginal item that should be improved • Below 0.2 : Poor item which should be discarded unless it can be restructured or it either too difficult or too easy that is fails to discriminate high performers with low performers.

0	Fair! All students perform the item correctly.
(-1,0)	Not good! It refers that students in a lower group tend to perform better on that item than students in a higher group.
-1	Poor! Only low score students answer the item correctly.

3.1.4 Data Collection

The researcher used the BCCE to collect students' conception about simple DC electric circuit in terms of brightness of two light bulbs and current passing through two resistors connected in series and parallel circuit. Students had 15 minutes, before the lesson started, to respond BCCE, individually. Thai version was used to collect from 208 Thai students and English version was used for 50 Myanmar students.

3.1.5 Data Analysis

The students' responses were grouped to identify students' conceptions on simple DC electric circuits (series and parallel circuit) in terms of brightness and current. There is no comparison between both groups of students. This is because Thai and Myanmar students have a different background and context. Results and discussion are described in the next chapter.

3.2 Phase II: A Case Study Research

3.2.1 Research Design

In the case study, the researcher evaluated the efficacy of PODS based activity in terms of students' improvement in simple DC electric circuit's concepts. The participants were 50 first year undergraduate Myanmar students. Almost all of them were participated in the pilot study.

BCCE was introduced to students as a pre-test, a post-test, and retention test. They had 15 minutes to do the evaluation, individually. In addition, they were allowed to do some hands-on activities with a designed activity sheet based on PODS

learning cycle for three periods (one period = 50 minutes). In detail, every student had 1) to conduct their group experiments during the lecture, 2) to perform their experiments by using physical materials which consisted of copper wire, light bulbs, resistors, battery, digital multi-meter, and 3) to give their response to the BCCE before and after the lecture for pre-test and post-test. After one month, all the students received the BCCE for retention test to check their retention. During the implementation process of PODS, the researcher started the class by introducing the DC circuit activity sheet (see Appendix A and B). Researcher then engaged them to make prediction for the questions related to the concepts of brightness and current in the activity sheet, individually. After the students finished their prediction, the researcher introduced the basic electric components as shown in Figure 3.2 and explained to the students about “How to construct the light bulbs according to the figure in the brightness activity sheet?” and “How to measure the current passing through the resistors connected in the circuit according to the figure in the current activity sheet?” After that, the researcher allowed the students to do the hands-on activities with a group of 5 members. They observed and compared between their prediction and observation. In the discussion phase, students had to share and explain the difference between what they predicted and what they observed. Finally, students were challenged to learn and synthesize their observation to everyday life. All students had to do the BCCE after the activities as a post-test and again after one month of intervention as a retention test.



Figure 3.2 Basic electric components used in the activities: light bulbs with holder and crocodile clip, resistors, battery and holder, and digital multi-meter

3.2.2 Participants

The participants in this study were 50 first year undergraduate Myanmar students who studied Electronics Engineering course in science program in one government university in Myanmar.

3.2.3 Instrument and Lesson Plan

3.2.3.1 Brightness and Current Conceptual Evaluation (BCCE)

The details of BCCE, used to collect the data for identifying the students' misconception and evaluating the efficacy of PODS based activity in this case study, are described in the section 3.1.3.

3.2.3.2 Lesson Plan

Structure and details of PODS based lesson plan used in this case study are shown in Table 3.3.

Table 3.3 A structure of the lesson plan based on PODS learning cycle

Topic	Brightness and current conceptions in simple DC electric circuits
Objective	To get the correct understanding about simple DC electric circuits in terms of brightness and current.
Main Concepts	<p>Brightness</p> <ul style="list-style-type: none"> • The brightness of light bulb is directly proportional to the power it dissipates. • Brightness depends on power consumption ($P=IV$). If the voltage across the bulb was constant, the brightness will be directly proportional to the current. <p>Current</p> <ul style="list-style-type: none"> • Current passing through each resistors connected in series circuit are the same even both resistors are same or differences. • Current passing through each resistors connected in parallel circuit are inversely proportional to the

Main Concepts	resistance.
Duration	150 minutes
Students' Level	50 Myanmar first year undergraduate students who studied in science program
Teaching and Learning Activity: PODS	<ol style="list-style-type: none"> 1. Introduction (5 minutes) <ul style="list-style-type: none"> • Lecturer introduces the topic, objective and activities. 2. Taking Pre-test (15 minutes) <ul style="list-style-type: none"> • Lecturer explores the students' prior knowledge on DC electric circuits in terms of brightness and current by BCCE. 3. Teaching and Activities (115 minutes) <ul style="list-style-type: none"> • Prediction <ul style="list-style-type: none"> ▪ Students are encouraged to predict the brightness of the light bulb and current passing through the resistors connected in series and parallel circuit. (Use activity sheet) • Observation <ul style="list-style-type: none"> ▪ Students are allowed to do the hands-on activities for observing brightness of the light bulb and current passing through the resistors connected in series and parallel circuit with real electronics components. ▪ Students work in group of 5 to observe the brightness and current. (Use activity sheet) • Discussion <ul style="list-style-type: none"> ▪ Students are asked to discuss whether the same or difference between their prediction and observation. In addition,

<p>Teaching and Learning Activity: PODS</p>	<p>they also discuss about the theoretical results and practical results in terms of brightness and current.</p> <ul style="list-style-type: none">• Synthesis<ul style="list-style-type: none">▪ Students are challenged to apply their newly learned ideas to explain from any conflict between their prediction and observation to the situation related to their everyday life. For example: [Brightness]<ol style="list-style-type: none">1) How do series and parallel circuits affect the brightness of a light bulb?2) What is an advantage of the brightness of the light bulbs in a parallel circuit compared with a series circuit?3) Why are two light bulbs in a parallel circuit brighter than two light bulbs in a series circuit?4) How do you think that lights in a house are connected? Give some reasons why you think that is the case.5) How does the brightness of the light bulbs change, when you add more battery?[Current]<ol style="list-style-type: none">1) Why is the current in a parallel circuit larger than that in a series circuit?2) Why is the equivalence resistance in a series circuit higher than that in a parallel circuit?3) How does a current passing through the resistor change, when you add
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Teaching and Learning Activity: PODS	<p>more battery?</p> <p>4. Taking Post-test (15 minutes)</p> <ul style="list-style-type: none"> • Students have to take the BCCE after intervention. (Use BCCE for post-test).
Learning Materials	<ol style="list-style-type: none"> 1. Blackboard and chalk 2. Documents (BCCE conceptual evaluation sheet, Brightness activity sheet, Current activity sheet, Handout for lecture) 3. Circuit-board 4. Battery with holder 5. Digital multi-meter 6. Wires 7. Resistors 8. Light bulbs with holders
Assessment	Summative: (BCCE) Brightness and Current Conceptual Evaluation (8 Marks)

3.2.4 Data Collection

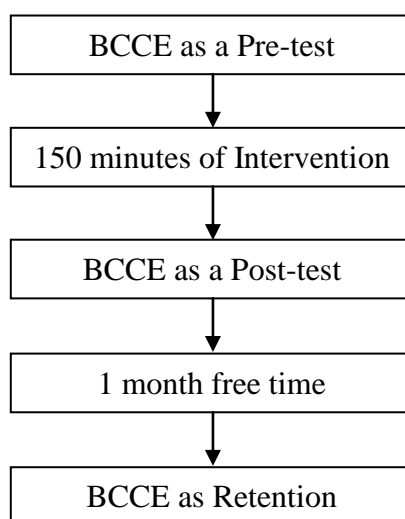


Figure 3.3 Procedure for data collection for case study

The procedure for data collection for case study is shown in Figure 3.3. The BCCE conceptual evaluation was used to collect the data for pre-test and post-test. Students had 15 minutes, before and after participating 150 minutes of intervention of PODS based hands-on activities, to respond the evaluation. After one month of the implementation, all students in this study received the conceptual evaluation again as a retention test.

3.2.5 Data Analysis

The researcher used the average normalized gain $\langle g \rangle$ to evaluate the efficacy of the activities in terms of students' improvement in the related concepts. The average normalized gain, $\langle g \rangle$, is the ratio of the actual average gain to the maximum possible average gain (Hake, 1998).

$$\langle g \rangle = \frac{(\langle \text{postscore} - \text{prescore} \rangle)}{(100 - \langle \text{prescore} \rangle)}$$

Three distinct of the average normalized gain was defined as follows:

- **High** when the value is greater than 0.7,
- **Medium** when it is between 0.7 and 0.3, and
- **Low** for value is below 0.3.

Moreover, details of students' understanding are presented in terms of the description and number of students who got the same conception.

CHAPTER IV

RESULTS

Overview

This chapter presents results and discussion of students' responses to the Brightness and Current Conceptual Evaluation (BCCE). The data was collected from 208 Thai and 50 Myanmar first year undergraduate students who studied in the government universities in Thailand and Myanmar in the Year 2011. The results were analyzed and separated into two parts as a pilot and a case study. The PODS based activities were introduced to only 50 Myanmar students in their normal physics class for three periods (one period = 50 minutes) and the class was conducted by the researcher. This is because of difficulty in communicating between Thai students and the researcher. The details of the discussion are: students' responses to the BCCE (students' prior knowledge and misconception), an analysis of the evaluation in terms of item difficulty and item discrimination index, an efficacy of the activity determined by an average normalized gain and students' responses to the activity.

4.1 Phase I: Pilot Study

4.1.1 Students' responses to the BCCE

The numbers of Thai and Myanmar students' responses to each item of BCCE are shown in Table 4.1 and 4.2, respectively. The results show no significant difference between these two groups of students. The data were grouped by students' misconceptions on the concepts of simple DC electric circuit and the discussions are presented in this section.

Table 4.1 208 Thai Students' Response

Question No.	A	B	C
1	156	40	12
2	143	31	34
3	146	60	2
4	32	89	87
5	32	132	44
6	182	12	14
7	30	42	136
8	37	134	37

* The bold letter indicates the correct answer

Table 4.2 50 Myanmar Students' Response

Question No.	A	B	C
1	35	12	3
2	29	8	13
3	45	5	0
4	21	14	15
5	21	18	11
6	32	16	2
7	4	13	33
8	2	33	15

* The bold letter indicates the correct answer

The BCCE is created by researcher and covers the concepts of brightness of two light bulbs and current passing through two resistors connected in both series and parallel circuits. It consists of 8 multiple-choice questions and each question has three alternatives (A, B, and C). Only one alternative is correct as indicated with the bold letter as shown in Table 4.1 and Table 4.2. Almost the correct answers are alternatives A because researcher want to maintain the consistency of the alternative pattern as ($B_1 = B_2$, $B_1 > B_2$, and $B_1 < B_2$) for the concepts of brightness and ($I_1 = I_2$, $I_1 > I_2$, and $I_1 < I_2$) for the concepts of current.

Question 1 and Question 2 are related to the brightness of two light bulbs connected in series and parallel circuit, respectively. Some students do not know that the brightness of the light bulbs, connected in the same circuit, is the same. They think that the brightness of the light bulbs connected in parallel circuit is not the same even they know that those is the same for a series circuit.

Question 3 is about the current passing through two **identical** resistors

($R_1 = R_2$) connected in series circuit. Results reveal that some students do not know that the currents passing through each resistor (I_1 and I_2) are the same. They may believe that current is reduced when it pass through the resistor as discussed in (Chang, Liu, & Chen, 1998; Engelhardt & Beichner, 2004).

Question 4 and Question 5 are similar to Question 3 except the resistance of the two resistors is not the same ($R_1 \neq R_2$). Most of the students do not know that the currents in these cases are the same (Currents in a series circuit are the same). They may think that the nearer the battery, the larger the current that flows in the circuit (Chang, et al., 1998; Engelhardt & Beichner, 2004) or they might misuse the concepts of Ohm's law. Some students have ideas that the current passing through resistors is directly proportional to the resistance which means if the resistor R_1 is greater than the resistor R_2 , the current I_1 is greater than the current I_2 .

Question 6 is about the current passing through two **identical** resistors ($R_1 = R_2$) connected in parallel circuit. Results indicate that some students do not know that the currents in this case are the same.

Question 7 and Question 8 are about the current passing through two resistors ($R_1 \neq R_2$) connected in parallel circuit. Some students believe that the currents in a parallel circuit do not depend on the resistors. Hence, their response is $I_1 = I_2$, while other students may have the idea that the currents are directly proportional to the resistors.

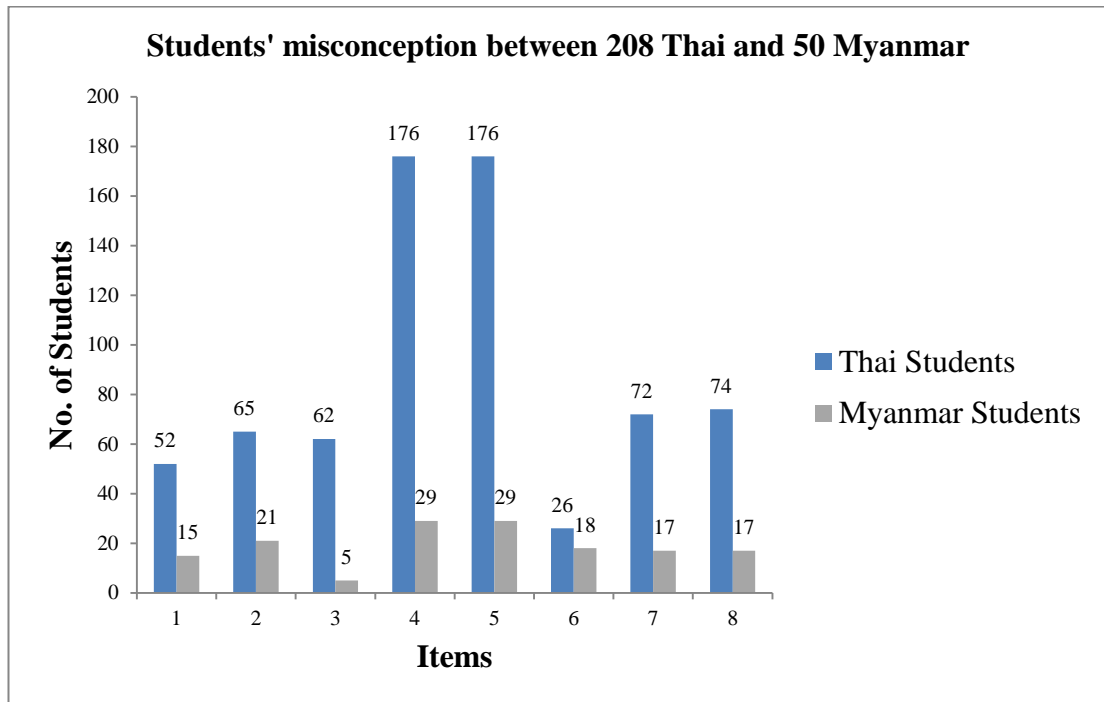


Figure 4.1 Number of students' incorrect response to the BCCE in the Pilot Study

Figure 4.1 shows the number of students who gave an incorrect response to the BCCE in the pilot study. In other word, these students had some misconceptions as presented in the previous paragraphs. Results also indicate that students from two countries have almost the same misconceptions even they had learned these concepts more than one time (high school and then first year undergraduate level). This is a strong motivation for the researcher to develop an active learning based teaching module that could help students correct their understanding in these concepts.

4.1.2 Reliability of the BCCE

The reliability of the BCCE was analyzed in terms of item difficulty and item discrimination. The details are as follows:

4.1.2.1 Item Difficulty Index

The item difficulty of the BCCE is shown in Figure 4.2. Most questions reach to a preferred value which is 0.6 and over. This means that 60 % of students or more are able to give a correct response. In other words, it indicates that these questions are suitable for probing students' understanding of brightness and

current conceptions. However, the fourth and the fifth questions are quite difficult for students to answer. There is a need to develop these items.

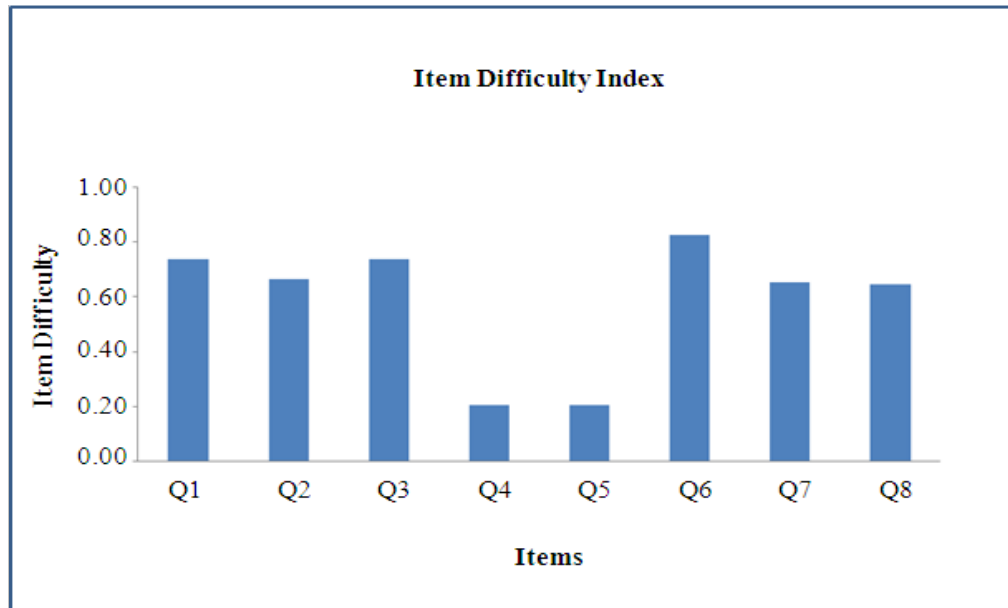


Figure 4.2 Item difficulty of BCCE

4.1.2.2 Item Discrimination Index

The item discrimination of the BCCE is shown in Figure 4.3. Most questions are classified to be very good questions because their item discrimination index are over 0.4. However, the discrimination index for the second, third, and sixth questions are found to be between 0.30 and 0.39. It means that the questions are reasonably good but can be improved.

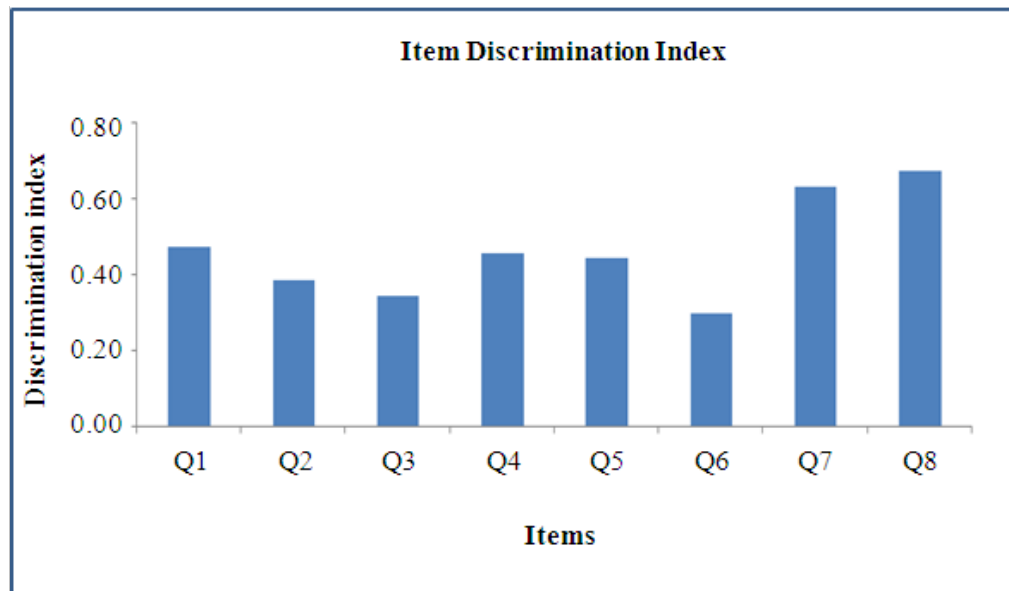


Figure 4.3 Item discrimination of BCCE

4.2 Phase II: A Case Study Research

4.2.1 Student's responses to the BCCE

The summaries of 50 Myanmar students' responses to the BCCE for a pre-test, post-test, and retention test are shown in Table 4.3. Researcher found that some students who participated in this study had the misconceptions on the topic of simple DC electric circuit (brightness of light bulbs and current passing through the resistors) even they had learned these concepts since Grade 10 in high school level.

Table 4.3 Summaries of students’ response for Pre-test (Pre-), Post-test (Post-), and Retention test (Re-)

Question No.	A			B			C		
	Pre-	Post-	Re-	Pre-	Post-	Re-	Pre-	Post-	Re-
1	22	42	45	27	8	3	1	0	2
2	31	49	48	18	1	2	1	0	0
3	48	48	49	2	2	0	0	0	1
4	25	42	44	5	4	1	20	4	5
5	26	42	43	19	4	7	5	4	0
6	43	50	47	7	0	3	0	0	0
7	1	1	0	16	8	6	33	41	44
8	1	1	0	36	41	44	13	8	6

* The bold letter indicates the correct answer

Students’ response for each item of the BCCE, presented in terms of pre-test and post-test results, are shown in the following figures.

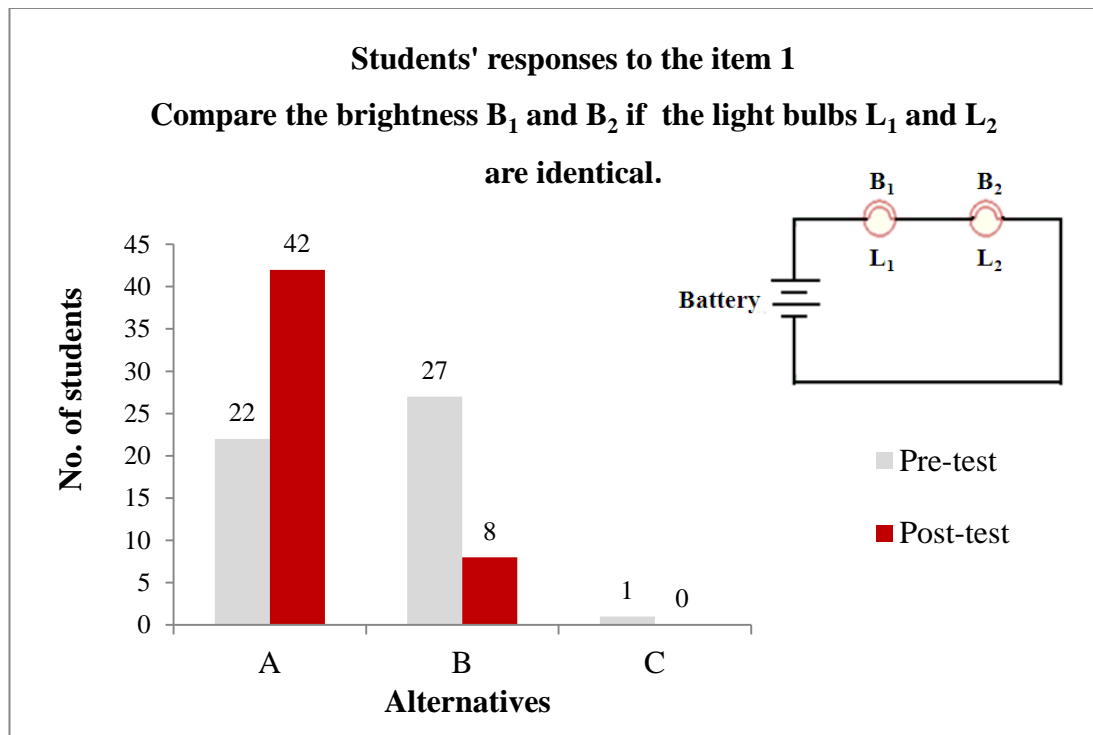


Figure 4.4 Comparison of students’ responses to the item 1 in pre-test and post-test

The comparison of students' responses to the item 1: "Comparison of the brightness B_1 and B_2 if the light bulbs L_1 and L_2 are **identical**" (series circuit) is shown in Figure 4.4. In the case of pre-test, 44% of the students gave a correct response (A) and had a correct understanding about the brightness of the light bulbs in series circuit; same brightness. The other students chose the incorrect response; (54%) for (B) and 2% for (C). They might think that the current is consumed by a light bulb. In addition, the students who gave a response as (C) might also think that the current flows from the negative terminal to the positive terminal so the light bulb L_2 consumes more current than L_1 .

After the implementation with PODS, most of the students (84%) gave a correct response (A) while some students (16%) still had misconceptions and needed to develop their understanding.

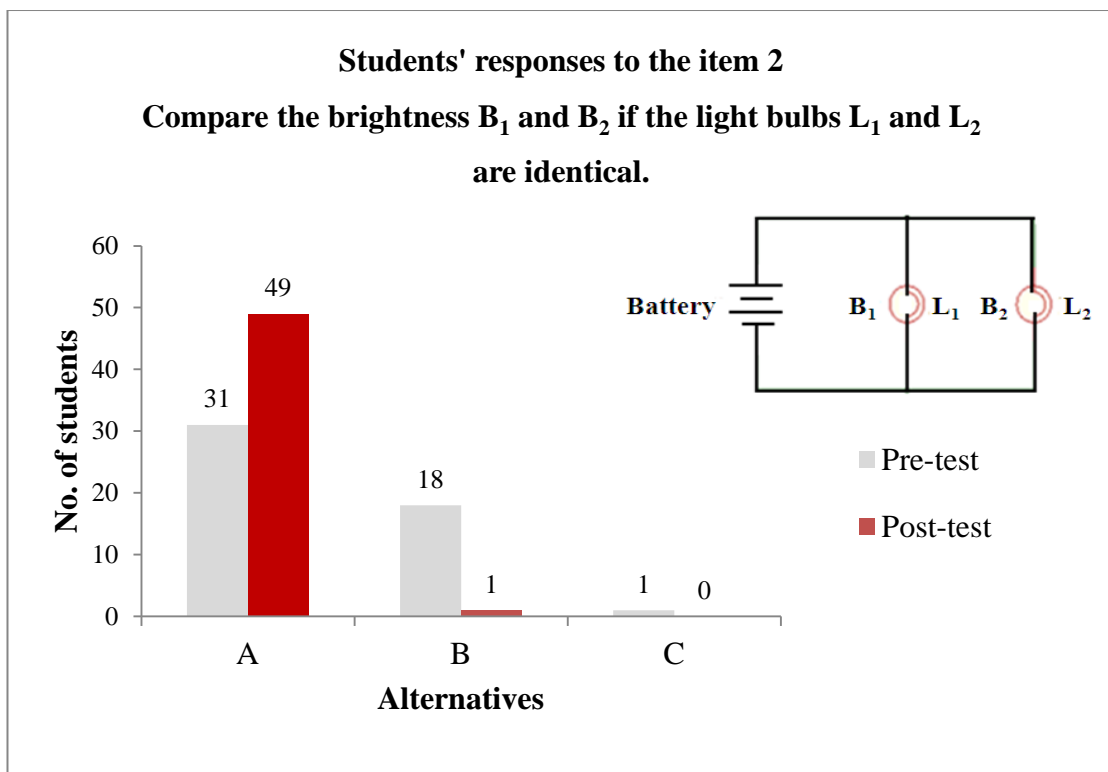


Figure 4.5 Comparison of students' responses to the item 2 in pre-test and post-test

Figure 4.5 shows the comparison of students' responses to the item 2: "Compare the brightness B_1 and B_2 if the light bulbs L_1 and L_2 are **identical**" (parallel circuit). In this figure, most of the students (62%) gave a correct response (A) in pre-test and had a correct understanding of the brightness of the light bulbs in parallel

circuit are the same. Some students (36%) who chose the response (B) and (2%) who gave an incorrect response (C) had the misconception concerned with the brightness of two light bulbs in parallel circuit. After the implementation of the learning cycle PODS based hands-on activities, (98%) of students gave a correct response (A) for the post-test.

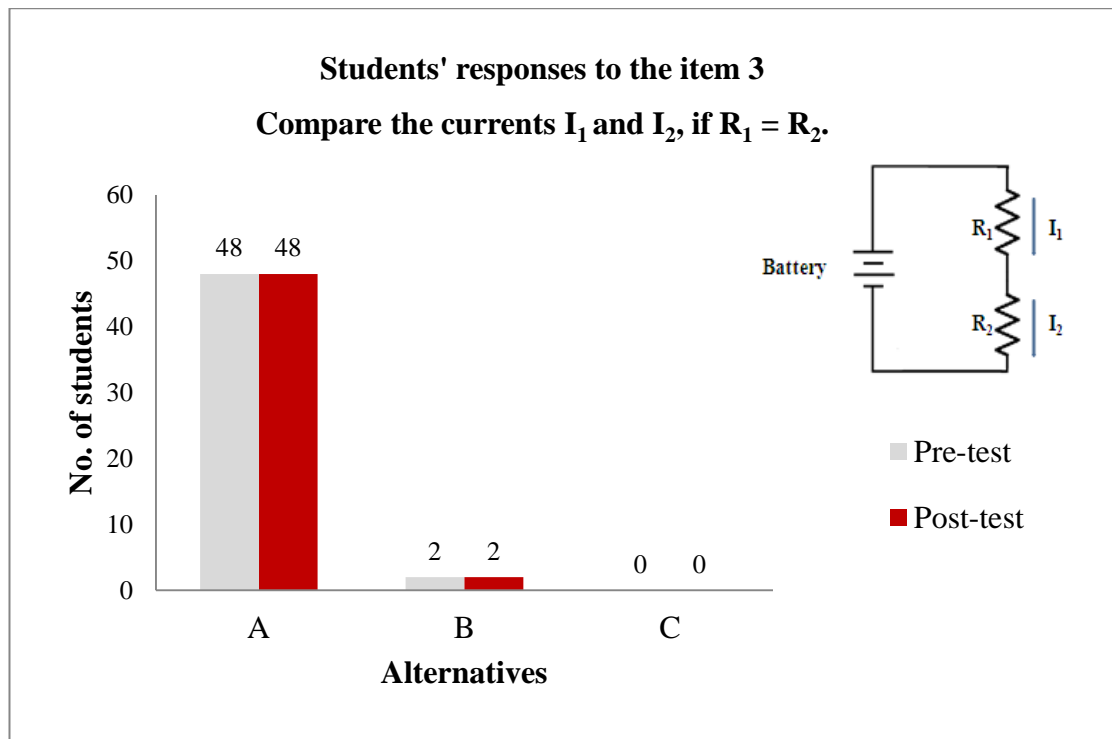


Figure 4.6 Comparison of students’ responses to the item 3 in pre-test and post-test

Item 3 is “Compare the currents I_1 and I_2 if $R_1 = R_2$ in series circuit”. As shown in Figure 4.6, most students (96%) gave a correct response (A) in both pre-test and post-test, so they had correct understanding that the current in series circuit is the same. The remaining 4% of students who chose the incorrect response (B) had the misconception that the current I_1 of the resistor R_1 is larger than the current I_2 of the resistor R_2 . They might have thought that I_1 is nearer to the battery than I_2 , so R_1 consumes more current than R_2 . No one chose an incorrect response (C) in this item.

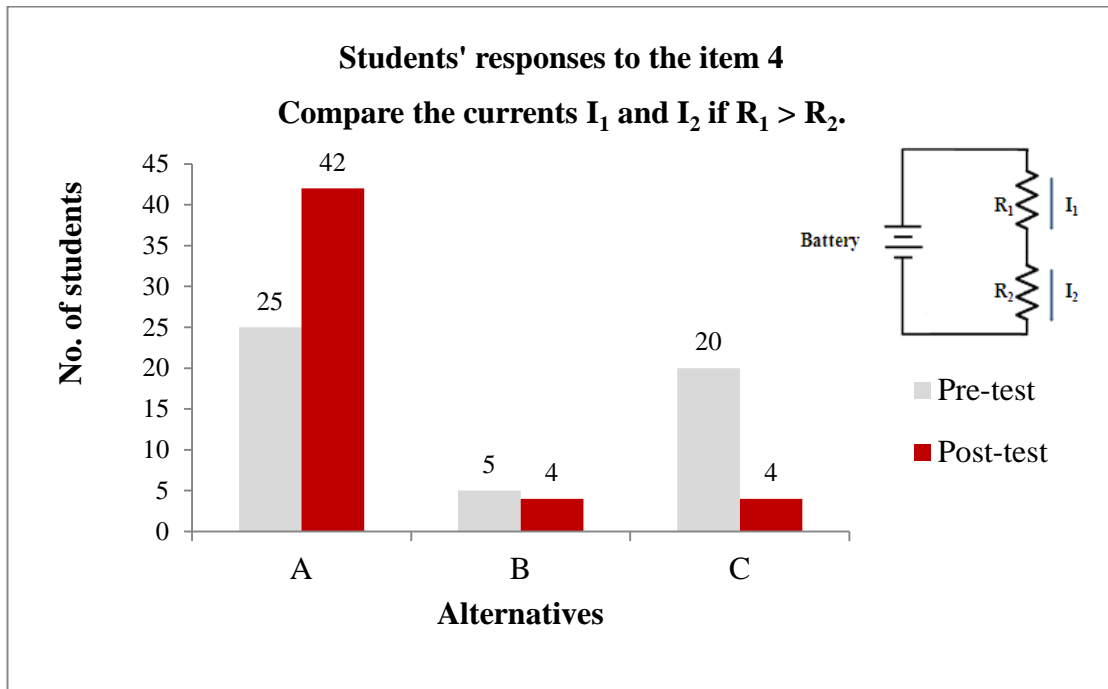


Figure 4.7 Comparison of students' responses to the item 4 in pre-test and post-test

Figure 4.7 demonstrates the comparison of students' responses between pre-test and post-test for item 4: "Compare the currents I_1 and I_2 if $R_1 > R_2$ in series circuit". In pre-test, half of the students (50%) gave a correct response (A) and had a correct understanding that all the currents in series circuit are the same. Some students (10%) who chose the response (B) and the other 40% of the students gave an incorrect response (C) had the misconceptions about the current in series. The researcher noticed that they might misused the Ohm's law and they might believe that the current is inversely proportional to the resistor, so they chose an incorrect response (C) for that item. In post-test, 84% of the students gave a correct response (A) and the remaining 16% of students still needed to get correct conceptions that the current in series circuit are the same.

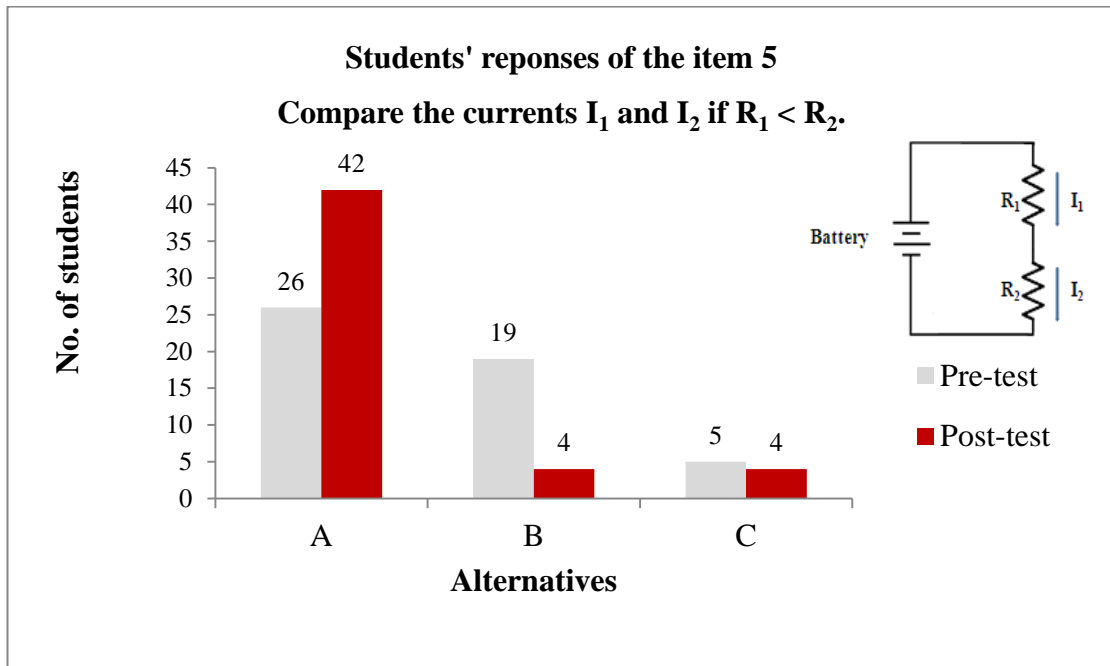


Figure 4.8 Comparison of students’ responses to the item 5 in pre-test and post-test

Item 5 is “Compare the currents I_1 and I_2 if $R_1 < R_2$ in series circuit”. As shown in Figure 4.8, 52% of students in pre-test chose the response (A). The remaining students chose (B) and (C) with 38% and 10%, respectively. These students’ misconceptions are similar to those presented in the discussion of the item 4. The students’ responses to the BCCE in post-test of item 5 are the same with the item 4.

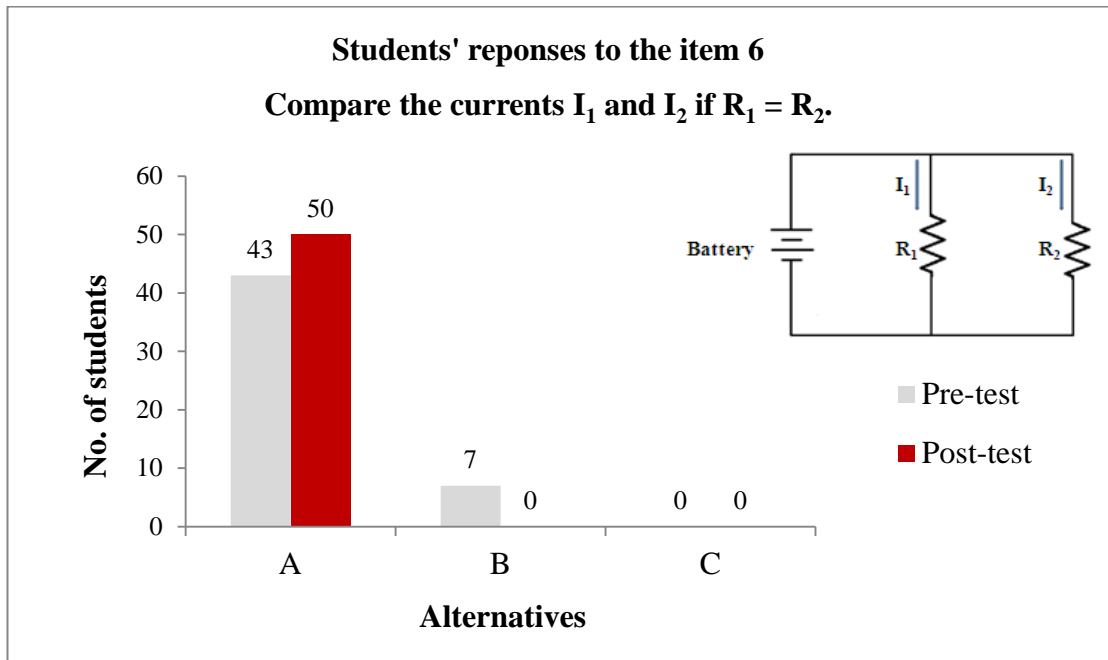


Figure 4.9 Comparison of students' responses to the item 6 in pre-test and post-test

Figure 4.9 shows that the results of item 6: “Compare the currents I_1 and I_2 if $R_1 = R_2$ in parallel circuit”. In pre-test, 86% of the students gave a correct response (A); they had a correct understanding that the currents passing through two **identical** resistors connected in parallel circuit are the same. Some students (14%) who chose the response (B) had misconception; the nearer the battery the larger the current flows. In post-test, 100% of the students gave a correct response (A). No one chose the response (C) in the item 6 for both pre-test and post-test.

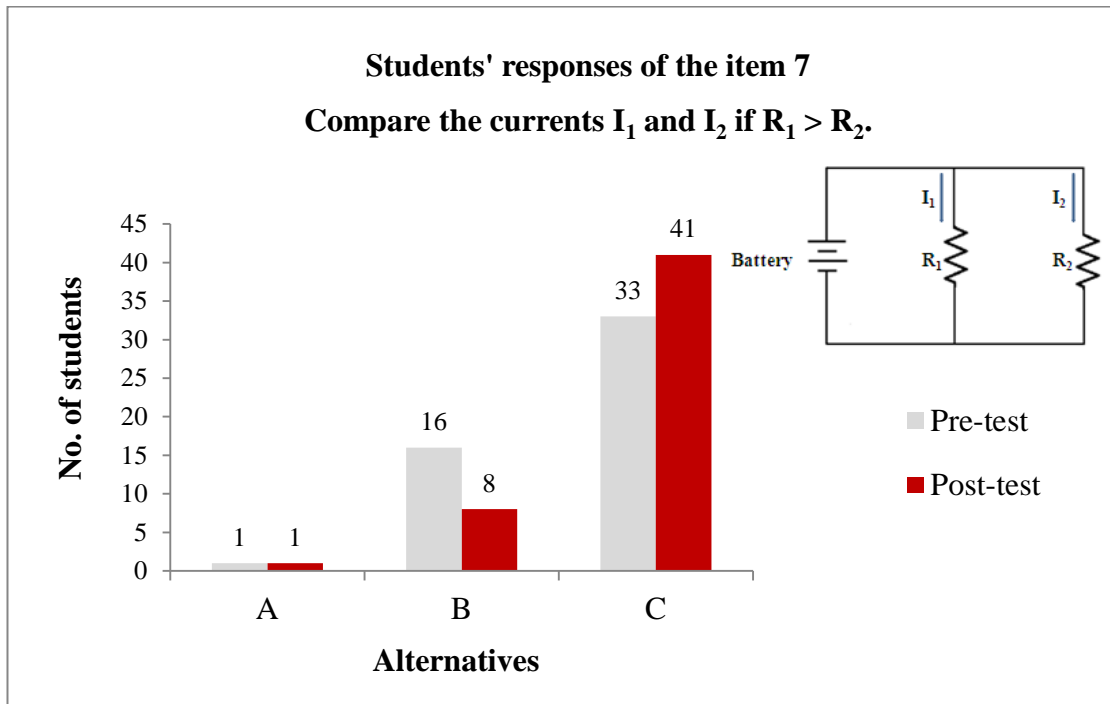


Figure 4.10 Comparison of students' responses to the item 7 in pre-test and post-test

Item 7 is “Compare the currents I_1 and I_2 if $R_1 > R_2$ in parallel circuit”. As Figure 4.10, only 2% of the students chose an incorrect response (A) for both pre-test and post-test. They might believe that the currents in parallel circuit are the same even if the resistors are different. 32% and 16% of students chose the response (B) for a pre-test and post-test, respectively. They thought that the currents passing through two different resistors in parallel circuit are directly proportional to the resistors. Most of the students (66%) in pre-test and (82%) in post-test gave a correct response (C); the current in parallel circuit is inversely proportional to the resistors.

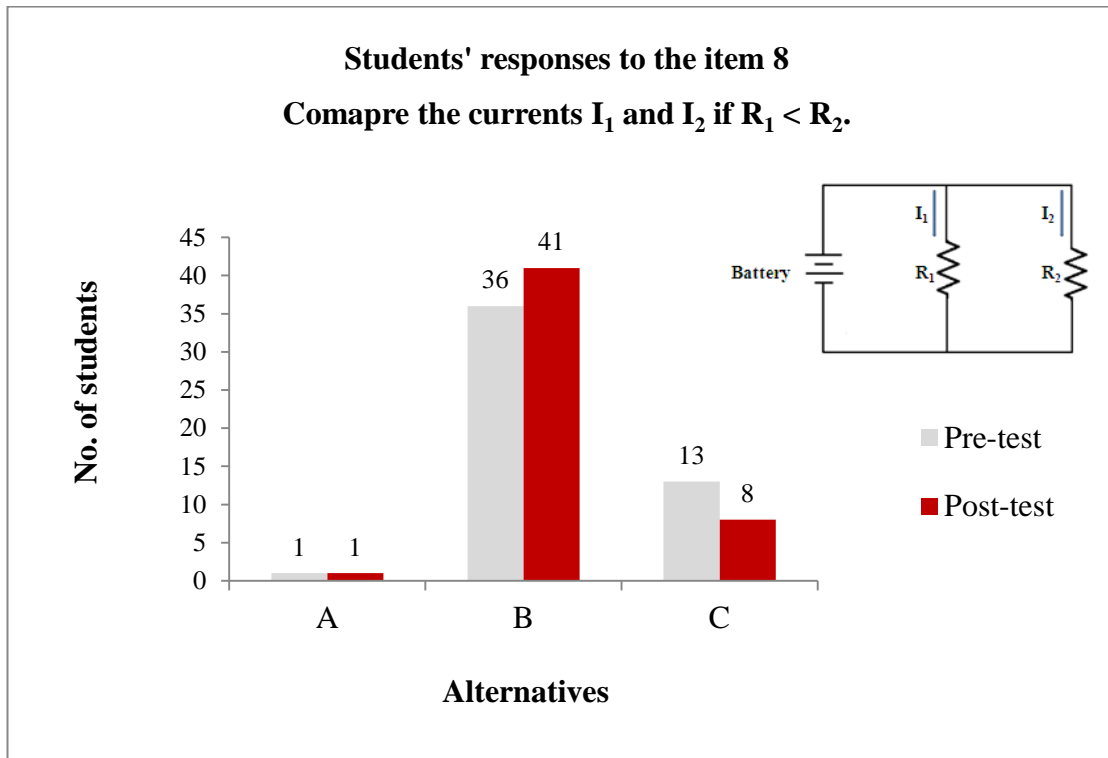


Figure 4.11 Comparison of students' responses to the item 8 in pre-test and post-test

Item 8 is “Compare the currents I_1 and I_2 if $R_1 < R_2$ in parallel circuit”. As shown in Figure 4.11, only 2% of the students in pre-test and post-test gave an incorrect response (A). Some students (26%) in pre-test and (16%) in post-test chose (C) having the misconception; the currents passing through two different resistors in parallel circuit are the same and they might have the idea that the currents in parallel circuit are directly proportional to the resistors. However, many students (72%) in pre-test and (82%) in post-test, understood that the currents passing through the resistors connected in parallel circuit are inversely proportional to the resistances. Thus, they chose a correct response (C) for this item.

4.2.2 Average Normalized Gain

The average normalized gain was used to evaluate the overall efficacy of the activities, the average score for the pre-test and post-test as shown in Figure 4.12 is 5.3 and 7.16, respectively. The gain value is found to be 0.7 and this can refer that the PODS learning cycle based hands-on activity has a good efficacy and can help

students improve their understanding on simple DC electric circuits (brightness and current in series and parallel circuit) in medium range (Hake, 1998).

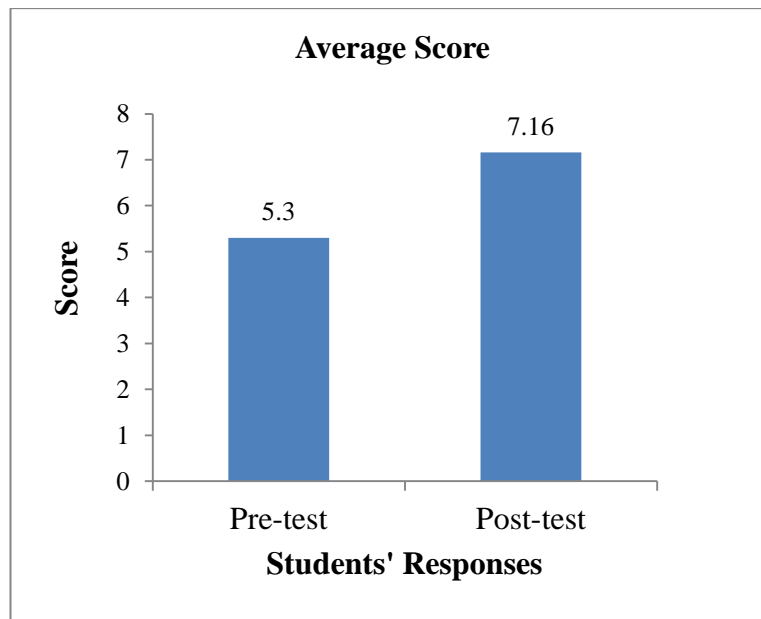


Figure 4.12 Average score of the pre-test and post-test

4.2.3 Students' responses to the Retention test

The researcher used the BCCE as a retention test to investigate students' remaining understanding of the brightness of two light bulbs and current passing through two resistors connected in series and parallel after one month of implementation. Table 4.4 shows the summaries of Myanmar students' response to BCCE for post-test and retention test. The bold letter indicates the correct answer.

Table 4.4 Summaries of students' response for Post-test (Post-) and Retention test (Re-)

Question No.	A		B		C	
	Post-	Re-	Post-	Re-	Post-	Re-
1	42	45	8	3	0	2
2	49	48	1	2	0	0
3	48	49	2	0	0	1
4	42	44	4	1	4	5
5	42	43	4	7	4	0
6	50	47	0	3	0	0
7	1	0	8	6	41	44
8	1	0	41	44	8	6

* The bold letter indicates the correct answer

According to the Table 4.4, there was no significant difference between post-test and retention test. In the question 1, there were some students (10%) who still did not know the concept of brightness of two light bulbs in series circuit is the same. In the question 2, the percentage of the students who gave the correct response to the retention test was decreased. In the question 3, only 2% of students in retention test did not recognize the concepts of current passing through two resistors in series circuit even though they did the activities by themselves in the classroom. In the question 4, the remaining 6% of students did not get the correct conceptions on the current of series circuit. In the question 5, 14% of students still did not know these concepts. However, the percentage of students who gave the correct answer to the retention test was increased. In the question 6, some students (6%) in retention test did not give the correct answer to the BCCE although 100% of the students gave in post-test. In order to develop their understanding on the concepts of current passing through two **identical** resistors in parallel circuit, they need to do more activities. In the question 7, students understood the concept that the current passing through two resistors in parallel circuit is not the same. They understood that the current passing through parallel circuit is inversely proportional to the resistor which is higher than the

students in post-test. In the question 8, students gave the correct response to the retention test was higher than the post-test.

In summary, the researcher compared the students' responses between post-test and retention test. Most of their responses to the retention test were higher than the responses in post-test except for the responses to the item 2 and item 6. In conclusion, few students could not give the correct response to the retention test and recognize the concepts. These concepts are the brightness of two **identical** light bulbs in parallel circuit and the currents passing through two **identical** resistors in parallel circuit. This is because they might not have a clear understanding on these concepts of brightness and current in parallel circuit.

CHAPTER V

CONCLUSIONS AND DISCUSSION

Overview

This chapter concludes and discusses the summary of the whole research, answering research questions, limitations of the study, and recommendations for further study.

5.1 Summary of the whole research

There are three main purposes of the research, described in the Chapter 1, consisting of 1) finding out the students' misconceptions about simple DC electric circuits both 208 Thai and 50 Myanmar first year undergraduate students who studied in science program without any comparison, 2) developing of simple DC electric circuit activities to facilitate students to get the correct understanding of brightness of two identical light bulbs and current passing through two resistors connected in both series and parallel circuits concepts, and 3) evaluating an efficacy of the activities in terms of an improvement of students' understanding in the related concepts.

Educational researches on teaching and learning physics ranging from around the world to Myanmar, the simple DC electric circuit concepts, context of simple DC electric circuit (brightness and current) in Myanmar, and introduction of PODS learning cycle are described in the Chapter 2.

Chapter 3 and 4 present the details of the BCCE as an instrument and the research design, results of the pilot and case study, respectively.

The BCCE consisted of 8 multiple-choice questions covering the concepts of 1) Brightness of two light bulbs 2) Current passing through two resistors connected in both series and parallel circuits. The BCCE was initiated in English version and validated by three Thai experts who had more than 5 years experience in teaching physics for undergraduate students. This was because the BCCE had to be

used with Thai students, so it was translated in Thai version and verified with the direction of views of three Thai experts. These groups of experts had more than 10 years experience in teaching physics for undergraduate students. One of them was in both validate and verify groups. The item difficulties were 0.6 and over except the fourth and the fifth questions which are about the current passing through two resistors in series circuit. The item discriminations were found to be 0.3 and over.

In the pilot study, the researcher used the BCCE to explore Thai and Myanmar students' prior knowledge. While in the case study, BCCE was only used with Myanmar students as pre-test, post-test, and retention test (after one month implementation).

The activities were designed based on PODS learning cycle covering the same concepts as in the BCCE. Therefore, students were encouraged to learn from any conflict between their prediction and observation during the discussion phase. They were also challenged to synthesize their newly learned ideas and conclusions into the more general framework of their physics knowledge. Only the case study, the activities conducted by the researcher was integrated to students' normal physics classes for 3 periods (one period = 50 minutes).

Students' responses to the BCCE were analyzed in terms of students' misconceptions (group according to their responses to the BCCE) and overall of their improvement indicated by the average normalized gain.

Researcher found that students from two countries had the same misconceptions and difficulties (see Figure 4.1) about simple DC electric circuit in terms of brightness and current even they had learned these concepts more than one time during their high school and university classes.

5.2 Answering Research Questions

There are three research questions of this study. Each of research questions will be considered in order.

5.2.1 Research Question 1

What are the Thai and Myanmar first year undergraduate science students' misconceptions about simple DC electric circuits in terms of brightness of two identical light bulbs and current passing through two resistors connected in both series and parallel circuits?

Answer

Generally, both Thai and Myanmar students have similar misconceptions even they might have no similar background. For example; the brightness of the light bulbs connected in parallel circuit is not the same even they know that the brightness in series circuit is the same, current is reduced when it pass through the resistor, the current passing through resistor is directly proportional to the resistance, and the nearer the battery, the larger the current that flows in the circuit. The details are discussed in the Chapter 4.

5.2.2 Research Question 2

How to develop the simple DC electric circuit activities that could help Myanmar students improve their understanding about the brightness of two identical light bulbs and current passing through two resistors connected in both series and parallel circuits?

Answer

The simple DC electric circuit activities were developed base on the PODS learning cycle. Students are engaged to do hands-on activities with some basic electrical components; light bulbs, resistors, battery, ammeter, and voltmeter. They also have to follow, step by step questions designed to facilitate them to learn from a conflict between their predictions and observations. After complete the observation, students are encouraged to discuss whether the difference between their predictions and observations in the discussion phase. At this point, students come to a better understanding about the physics principle underlying the observation via discussions amongst themselves and with the facilitator. Finally, students synthesized their newly learned ideas and conclusions into the more general framework of the related physics knowledge.

It is important to point out the strengths of the use of the PODS learning cycle in this study as follow:

Firstly, PODS learning cycle can help students improve their understanding about brightness and current concepts. The percentage of students' correct responses for each item of post-test, and retention test in BCCE were better than those in the pre-test that are described in the Chapter 4.

Secondly, PODS based hands-on activities with the real experiment can be used to engage students to learn and improve their understanding about brightness and current concepts. In this study, the students can immediately see “how the brightness of light bulbs light up in the series and parallel circuit”, “how the current passing through resistors connected in the series and parallel circuit”, and also “how to use the digital multi-meter” from their experiments. These encouraged the students to change their incorrect concept to the correct one as reflect in post-test score.

Finally, PODS directly promote investigation and communication in classroom because students have to discuss and share their ideas to the class.

5.2.3 Research Question 3

How to evaluate an efficacy of the activities in terms of an improvement of Myanmar students' understanding in the related concepts?

Answer

The post-test and retention test results indicated that students who participated in this study had better understanding as evident in terms of the average normalized gain. The average scores for the pre-test was 5.3, and 7.16 was for post-test, respectively. So the gain value was 0.7 and this could refer that the PODS learning cycle based activities had a quite good efficacy and could help students to improve their understanding on simple DC electric circuits (brightness and current in series and parallel circuit) in medium range (Hake, 1998).

5.3 Limitations of the Study

This study has some limitations which need to be considered as follows:

- The samples in the case study were only one university students in Myanmar. If the researcher was able to collect the data from the other university, the results may be difference.
- The validation of BCCE used in this study has been validated and verified by three Thai experts at the Department of Physics, Faculty of Science, Mahidol University. Therefore the others may have different points of views regarding the questions in BCCE.

5.4 Recommendations for Further Study

The recommendations for further study are as follows:

- The duration of teaching and learning activity should be increased.
- The activities of brightness and current should be related to each other.
- A number of students should be increased in many different universities in Myanmar.
- Not only summative assessment but also formative assessment should be used.
- Not only the evaluation but also the interview should be used.

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APPENDICES

APPENDIX A

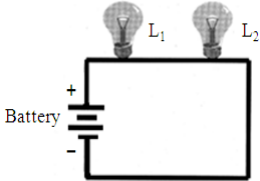
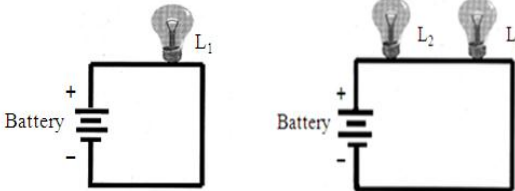
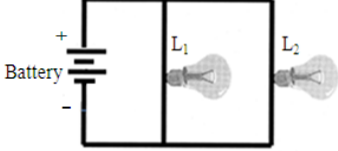
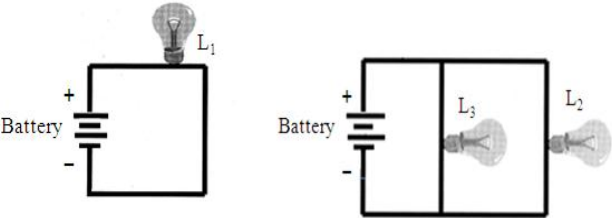
WORKSHEETS FOR THE DC CIRCUIT ACTIVITY FOR BRIGHTNESS

Name

ID

DC circuit activity sheet for brightness

Compare the brightness of the light bulbs in the following questions.

No.	Case	Prediction	Observation
1			
2			
3			
4			

APPENDIX B

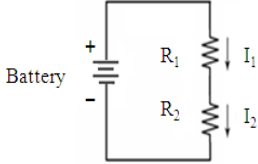
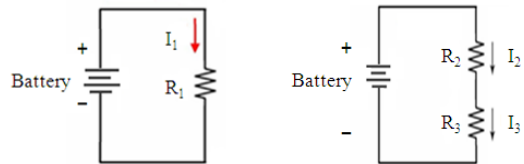
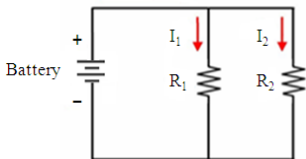
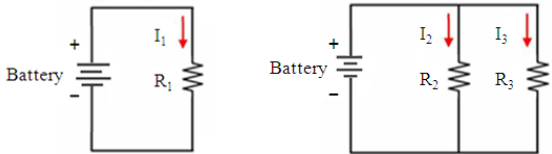
WORKSHEETS FOR THE DC CIRCUIT ACTIVITY FOR CURRENT

Name

ID

DC circuit activity sheet for current

Compare the current passing through the resistor in the following questions.

No.	Case	Prediction	Observation
1			
2			
3			
4			

APPENDIX C

CONCEPTS SUMMARY SHEET

Brightness and current conceptions in simple DC electric circuits

1.1 Simple DC electric circuits: Series and Parallel

1.1.1 Series Connection

The basic idea of a "series" connection is that components are connected end-to-end in a line to form a single path for electrons to flow:

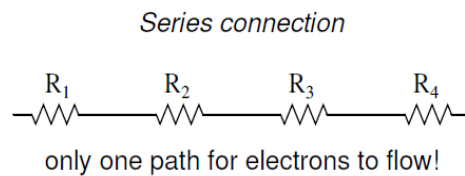


Figure 1.1 Series connection

1.1.2 Parallel Connection

The basic idea of a "parallel" connection, on the other hand, is that all components are connected across each other's leads. In a purely parallel circuit, there are never more than two sets of electrically common points, no matter how many components are connected. There are many paths for electrons to flow, but only one voltage across all components:

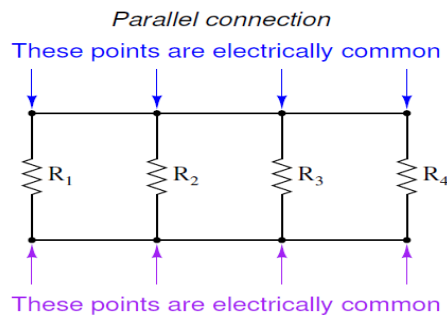


Figure 1.2 Parallel connection

1.2 Relationship between current, voltage, and resistance

Quantity	Symbol	Unit of Measurement	Abbreviation
Current	I	Ampere	A
Voltage	V or E	Volt	V
Resistance	R	Ohm	Ω

The relationship between current, voltage and resistance is called Ohm's law. It states that the amount of electric current through a mental conductor in a circuit is directly proportional to the voltage impressed across it. It can be expressed in the form of a simple equation, describing how voltage, current, and resistance interrelate:

$$V=IR \quad (1.1)$$

Let's see how these equations might work to help us analyze simple circuits:

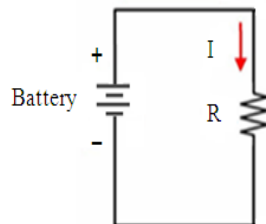


Figure 1.3 Current flows through the resistor in simple circuit with one resistor

In the above circuit, there is only one source of voltage (the battery, on the left) and only one resistor. By Ohm's Law, we found that the value of the current (I) will be increased if we add more battery to the circuit.

1.3 Characteristics of current

Electric current has a single pathway through the circuit. This means that the **current passing through each resistor in series circuit is equal in both the same and different values of resistors.** This current is resisted by the first resistor, the second resistor, and the third resistor also. The total resistance to current in the circuit is the sum of the individual resistance along the circuit path. The current in the

circuit is equal to the voltage supplied by the source divided by the total resistance of the circuit ($I=V/R_{\text{total}}$).

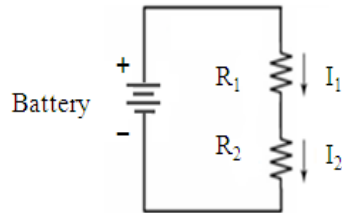


Figure 1.4 Current passing through in series circuit with two resistors

The total current in the circuit divides among the parallel branches. Current passes more readily into devices of low resistance, so the amount of current in each branch is inversely proportional to the resistance of the branch. The total current in the circuit equals the sum of the currents in its parallel branches. **Current passing through each resistor in parallel circuit depend on the values of the resistors.**

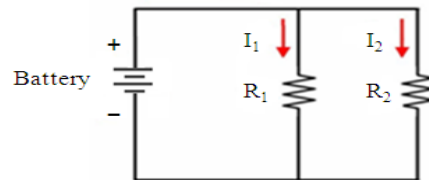


Figure 1.5 Current passing through in Parallel circuit with two resistors

1.4 Characteristics of brightness

The brightness of each bulb in a circuit is proportional to the power it dissipates.

1.5 Power in electric circuits

In addition to voltage and current, there is another measure of free electron activity in a circuit: *Power*. In electric circuits, power is a function of both voltage and current:

$$\mathbf{P=IV} \quad \mathbf{(1.2)}$$

So power (P) is exactly equal to current (I) multiplied by voltage (V) and there is no extra constant of proportionality. The unit of measurement for power is

the Watt (abbreviated W). It is important to realize that only the combination of a voltage drop and the flow of current correspond to power. So, a circuit with high voltage and low current may be dissipating the same amount of power as a circuit with low voltage and high current. In an open circuit, where voltage is present between the terminals of the source and there is zero current, there is zero power dissipated, no matter how great that voltage may be. Since $P = IV$ and $I = 0$, the power dissipated in any open circuit must be zero.

BIOGRAPHY

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