

**THE DEVELOPMENTAL CHANGES IN
CONCEPTUAL UNDERSTANDING AND PROBLEM-SOLVING IN
THE DOMAIN OF ELECTRIC CIRCUIT
AMONG STUDENTS OF VARIOUS AGES AND
DIFFERENT ACADEMIC ABILITIES**



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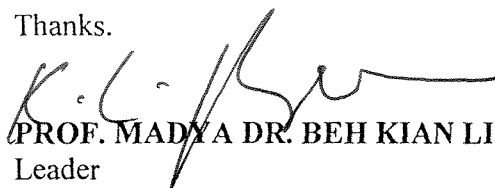
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Prof,

**A FINAL REPORT OF THE RESEARCH ENTITLED
“THE DEVELOPMENTAL CHANGES IN CONCEPTUAL UNDERSTANDING
AND PROBLEM-SOLVING IN THE DOMAIN OF ELECTRIC CIRCUIT
AMONG STUDENTS OF VARIOUS AGES AND DIFFERENT ACADEMIC
ABILITIES”**

With reference to the above matter, I am submitting to you 3 (three) copies of the final report for your reference and safe keeping.

Thanks.



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Project Leader

Prof. Madya Dr. Beh Kian Lim

ABSTRACT

The aim of this study was to offer a comprehensive description of 643 students of different academic abilities as gauged by their Physics grades obtained at SPM in their developmental understanding of simple electric circuits especially of the parallel type after an initial instruction at PMR, and a repeated instructions at SPM, and Post-SPM.

The data used in this study was based on the responses to the previous three survey questionnaire studies on three different sectors of students, namely PMR, SPM, and Post SPM levels using the same instrument. The three studies are: 1. Beh, K.L. and Tong, S. F. (2003); 2. Beh, K.L. and Abdullah, N (2002); and Beh, K. L (2000). The instrument consists of six sections examining six academic abilities, i.e., circuit identification, conceptual understanding pertaining to current, voltage, and resistance, circuit connection, and problem solving skills.

The study revealed many interesting findings. The major findings include the followings:

- a. Students of low and high academic ability categories show high in problem solving skills, circuit identification, and in circuit connections but low in conceptual understanding pertaining to current, voltage, and resistance;
- b. Students of low and high academic ability categories show that achievement at Post-SPM is relative higher than at SPM;

- c. The achievement by the high academic ability students is higher than that demonstrated by the low academic ability students in all the six sections;
- d. The improvement in student understanding for high academic ability categories is very much higher than for low academic ability categories;
- e. The changes in achievement across the 3 levels of studies (PMR, SPM, and Post-SPM) for are:
- A vast improvement in the problem solving skills;
 - Recognition of parallel circuit has been good since PMR and is improving after further treatments i.e., repeated instructions at higher levels;
 - Achievement in practical knowledge of current, voltage, and resistance has been low at every stage of learning although it shows overall improvement when it reaches the Post-SPM. However, a dip in achievement is indicated at SPM level for current and voltage. The dip for voltage is not significant;
 - For circuit connection, the achievement is moderate at each stage of learning and the achievement is improving after each treatment.; and
 - Although a few students only have displaced the appropriate construction of the scientific models for each stage of learning of the topic of parallel circuitry, the overall understanding of the parallel circuitry has shown improvement after each stage of repeated instruction.

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

Resistive parallel circuitry is considered an important content knowledge to be mastered by all Malaysian students. Resistive Parallel circuitry together with its series counterpart is first introduced formally in the section of electricity in science at year 9 (PMR level). This science subject is a mandatory one and is taken by all students. At year 11 (SPM level), students again revisit this section of resistive parallel circuitry either in the subject of general science for students in the art track or the subject of physics for students in the science track. The treatment at this level is more quantitative. At year 13, that is the precollege level (e.g. STPM level), resistive parallel circuitry is again discussed before Kirchhoff's laws are introduced in the section of electric circuitry in Physics. For the science track year 11 students, students can, after completing their study, apply to study in the various science and technology/engineering courses that are organized by various other institutions of higher learning. For these courses, normally Physics is a mandatory subject. The treatment of the subject is similar to the physics for pre-college preparation. The aim is to ensure that students have a good foundation in physics before embarking on the various science-based courses.

The Malaysian science curriculum is structured in the 'spiral' mode. Students visit a particular concept several times in their years of studying science. At each

subsequent visit, the concept is dealt with in a greater depth. It is a 'content driven' curriculum.

1.2 Objectives

Three studies have been carried out by the project leader on various groups of Malaysian students pertaining to their understanding of electricity using the instrument developed by the project leader. The studies are as follows:

1. **Beh, K.L. and Tong, S. F. (2003).** The Development Of Conceptual Understanding And Problem-Solving In The Domain Of Electric Circuit Among PMR High-Achievers. Unpublished research report, Biro Penyelidikan dan Perundingan, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia
2. **Beh, K.L. and Abdullah, N (2002).** The Effect Of Physics Instruction On Conceptual Change And Problem Solving In The Domain Of Electric Circuits Among High Achiever College Students. Unpublished research report, Biro Penyelidikan dan Perundingan, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia..
3. **Beh, K. L (2000).** An Investigation Of The Effect Of Instruction In Physics On The Formation Of Mental Models For Problem Solving In The Context Of Simple Electric Circuit. Unpublished Ph.D. Thesis, The University of Iowa, USA.

The studies explored the effect of various specific programs, such as, PMR science, SPM physics, A-level physics, and College Physics at diploma level of Electrical Engineering only.

The proposed study is an extension of these three studies. It examines the developmental changes in conceptual understanding and problem-solving in the domain of electricity circuit among students from the following perspectives:

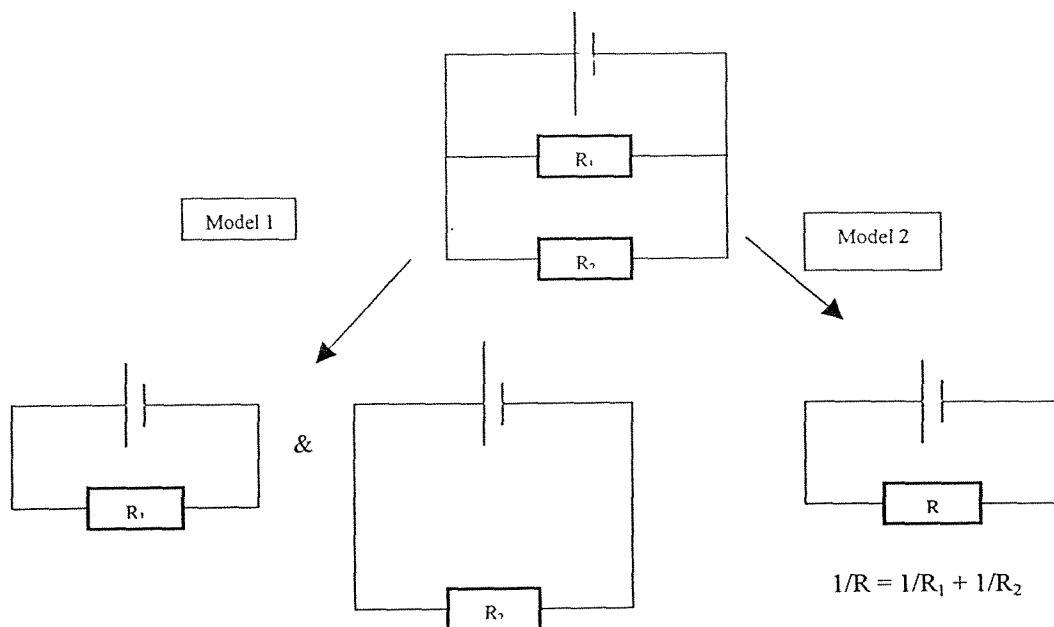
1. Across the programs i.e., PMR, SPM, and Post-SPM (A-level/ College); and
2. Academic ability as indicated by student grade in Physics at SPM.

The result from the study would offer a comprehensive view regarding the developmental change in student ideas about electricity in general and parallel circuit in particular. In the paradigm of constructivism that focuses on students' conceptions or beliefs regarding physical phenomena, the results of the study will contribute to a more global and comprehensive view regarding student problems in understanding of the physics of electric circuits. More importantly knowing the status of student mastery of the various concepts pertaining to parallel circuitry with reference to the grades obtained at PMR Science and SPM Physics should be deemed an important piece of local relevant information for Malaysian Public and science educators in general and physics educators in particular as well as science textbook writers, and science curriculum developers. This information provides good guidelines for curriculum planning and for devising more efficient teaching strategies and assessment for the teaching of electricity in general and in the Malaysian context in particular.

The study focuses mainly on answering the following questions:

1. Modeling is the essence of scientific thinking. There are two possible ways to perceive or model a resistive parallel circuit (as shown in Diagram 1). To what extent do students differ in terms of program and academic ability (after learning about resistive parallel circuitry as a part of the study of electricity) in acquiring any of the two models or any other models in particular to help them in understanding parallel circuits?

Diagram 1: The Two Models



2. In most basic physics textbooks, parallel circuits are schematically drawn in one or other of the two common standard layouts as shown in Diagram 2.

Diagram 2: Two Standard Layouts



Caillot (1984) has indicated that students interpret circuit diagrams based on their surface features. It would also be interesting for a study to reveal whether student responses to these two standard formats of parallel circuit diagrams as well as other non-conventional formats differ. Hence, a question of interest is

To what extent do students differ from the perspectives of program and academic ability have been affected by these various formats in evoking the use of different models?

3. In the previous three studies, it was found that a majority of the students have the conception that voltage from the energy source is being shared in a certain way by the two resistors in parallel. **To what extent do students differ from the perspectives of program, and academic ability in their development of this ‘shared voltage’ conception in parallel circuits?**

4. Literature reveals that students have various misconceptions about parallel circuits. Blueprints (AAAS, 1988) suggests the importance of knowing students' conceptions for effective instruction. Hence it is also the interest of this study to determine the following:

To what extent do students differ from the perspectives of program and academic ability regarding resistive parallel electric circuits in the following contexts:

- (a) the meaning of parallel,
 - (b) the practical knowledge of current,
 - (c) the practical knowledge of voltage,
 - (d) the practical knowledge of resistance, and
 - (e) circuit connection in comparison to the series types?
5. Batteries of same voltage can be connected in parallel without affecting the voltage output. **To what extent do students differ from the perspectives of program and academic ability in their understanding regarding this concept?** The answer to this question will be a focus for this study as student conceptions about batteries connected in parallel has not been investigated before even though it has been included as a part of the content knowledge in the section of electric parallel circuitry.

1.3 Significance of Study

Literature review has revealed the followings:

- a comprehensive information specifically on the developmental change in the paradigm of constructivism regarding students' conceptions or beliefs in parallel circuitry is lacking; and
- information related to student mastering of the various concepts and problem solving in physics especially pertaining to electric circuits in terms of the grading offered by the public examination syndicates for the subject such as SPM Physics has not been reported.

The results of the study not only have educational significance in the national (Malaysian) context but will surely contribute to a more global and comprehensive developmental view regarding student problems in understanding electric circuitry. In the context of constructivistic learning paradigm, such information is deemed a valuable consideration in designing effective science curriculums and instructions. The information will offer greater insights regarding grades obtained for example Physics subjects at SPM.

The design of the study will provide information regarding the impact of the Malaysian science/physics instruction has on the students in mastering the topic on basic electric circuitry while in school. Hopefully such information will enable the Malaysian science educators to make informed decisions in the national science education reform

especially pertaining to the school science/physics and college physics instruction in the topic of electricity. The local evidences gathered in the study will provide a basis for changing the instructional style needed to ensure learning, such as, introducing the two models (as illustrated earlier) explicitly during the teaching and learning of parallel circuitry. Currently no physics textbook has used the two models explicitly in its discussion of parallel circuitry. According to Bullock (1979), models can be used to explain, represent, predict, and interpret phenomena, and to enhance student understanding and their conception of the phenomena in question.

1.4 Scope of Project

This study attempts to identify the status of the developmental change in understanding, both conceptual and procedural, among students at different levels of studies (i.e., PMR, SPM, Post-SPM (e.g., A-level, and College) in terms of their PMR Science grade and SPM Physics grade. It seeks to reveal the cognitive change brought about by the science/physics instruction at these different levels pertaining to simple electric circuits with respect to student academic ability. The study is also designed to provide information regarding how different the various science/physics instructions have affected the students in mastering the topic on basic electric circuitry while in school and college. The facts revealed by the study will enable the Malaysian science educators especially the physics educators to make informed decisions when dealing with national science education reform policy.