EFFECTS OF PROBLEM-BASED LEARNING ON COGNITIVE PERFORMANCE, MATHEMATICAL VALUES AND MOTIVATION TO LEARN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS IN MALAYSIA

FATIMAH BINTI RAMLI

IPM 2019 6

EFFECTS OF PROBLEM-BASED LEARNING ON COGNITIVE PERFORMANCE, MATHEMATICAL VALUES AND MOTIVATION TO LEARN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS IN MALAYSIA

By

FATIMAH BINTI RAMLI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirements for the degree of Doctor of Philosophy

July 2018

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

EFFECTS OF PROBLEM-BASED LEARNING ON COGNITIVE PERFORMANCE, MATHEMATICAL VALUES AND MOTIVATION TO LEARN MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS IN MALAYSIA

By

FATIMAH BINTI RAMLI

July 2018

Chairman: **Associate Professor Ahmad Fauzi bin Mohd Ayub, PhD**
Faculty: **Institute for Mathematical Research**

This study examined the effectiveness of implementing Problem Based learning (PBL) strategy on the students' cognitive performance, mathematical values and motivation in learning mathematics for Form two secondary school students.. A quasi-experimental nonrandomized control group post-tests design was conducted consists of 62 students on two intact groups. 35 students were placed in the experimental group while 27 students in the control group participated in this study. Students in the experimental group underwent Problem Based Learning instruction strategy (PBL), while the control group learned mathematics using conventional instruction strategy (CI) in class over a period of eight weeks. Problem-based learning strategy refers to the use of problem-based learning modules in teaching and learning mathematics. Form two students from one of schools in Selangor were the sample of the study. Four instruments were used in this study namely, Achievement Test, Paas Mental Effort Rating Scale, ARCS motivation survey and mathematical values scoring rubric. Achievement test and Paas Mental Effort Rating Scale were used to measure cognitive performance. Students' mathematical values were measured using a set of rubrics consist of nine mathematics educational values while ARCS motivation survey were used to measure students' motivation toward learning mathematics. The data were analysed using one-way between-group analyses of covariance (ANCOVA) and independent t-test.

The results of this study showed that students who were exposed to the PBL strategies achieved significantly better achievement scores with less mental effort as compared to those who were taught using the CI strategy. Similar findings also showed the PBL strategies helped students achieved better scores in solving higher order questions compared to the CI strategy group. However, there were no significantly different scores in solving the lower order questions between the two

groups. The students from the PBL strategy group acquired significantly higher scores than the CI strategy group in the overall mathematical values in the subscales of accuracy, conjecturing, consistency, creativity, effective organization, efficient working/strategies, persistence, and systematic working. The result also indicated that PBL strategy also induced higher level of overall motivation towards learning in the subscale of attention, relevance and confidence as compared to CI strategy.

Therefore, the study shows that the PBL strategy enhanced students' cognitive performance, students' mathematical values and students' motivation in learning mathematics. These findings indicated that the problem based learning instruction is superior in comparison to the CI strategy, hence implying PBL strategy in teaching and learning of mathematics was more efficient than the CI strategy. The results from this study suggested the using of problem based learning strategy in the teaching and learning topics of Pythagoras theorem, Transformation, Solid Geometry II is beneficial and the utilization of this strategy should be continued. Therefore, it is recommended that by using PBL strategy would help to enhanced students' cognitive performance, mathematical values and motivation better as compared to CI strategy.

Abstrak tesis yang dikemukakan kepada Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN PEMBELAJARAN BERASASKAN MASALAH KE ATAS PENCAPAIAN KOGNITIF, NILAI MATEMATIK DAN MOTIVASI UNTUK BELAJAR MATEMATIK DI KALANGAN MURID SEKOLAH MENENGAH

Oleh

FATIMAH BINTI RAMLI

Julai 2018

Pengerusi: **Profesor Madya Ahmad Fauzi bin Mohd Ayub, PhD**
Fakulti: **Institut Penyelidikan Matematik**

Kajian ini adalah bertujuan untuk mengenalpasti keberkesanan strategi Pembelajaran berasaskan masalah (PBL) ke atas pencapaian kognitif, nilai matematik dan motivasi murid tingkatan dua sekolah menengah. Kajian kuasi eksperimen dengan reka bentuk ujian pasca kumpulan kawalan tidak setara dijalankan ke atas 62 orang murid daripada dua kumpulan sedia ada. 27 orang murid diletakkan dalam kumpulan kawalan dan 35 murid dalam kumpulan eksperimen. Murid dalam kumpulan eksperimen menggunakan stategi pembelajaran berasaskan masalah (PBL) manakala kumpulan kawalan menggunakan strategi pembelajaran konvensional (CI) di dalam kelas selama 8 minggu. Pembelajaran berasaskan masalah merujuk kepada penggunaan modul pembelajaran berasaskan masalah dalam pengajaran dan pembelajaran matematik. Sample bagi kajian ini adalah murid tingkatan dua di sebuah sekolah di Selangor. Empat instrumen telah digunakan dalam kajian ini iaitu Ujian pencapaian, Paas *Mental Effort Rating Scale*, soal selidik motivasi ARCS dan Skor rubric nilai matematik. Ujian pencapaian dan Paas *Mental Effort Rating Scale* digunakan untuk mengukur pencapaian kognitif murid. Nilai matematik murid diukur menggunakan satu set rubric yang mengandungi Sembilan nilai pendidikan matematik manakala Motivasi murid diukur dengan menggunakan soal selidik motivasi ARCS. Data di analisis menggunakan Analisis covariate antara kumpulan satu hala ANCOVA dan ujian-t antara dua kumpulan berbeza.

Kajian ini menunjukkan bahawa murid yang diajar menggunakan strategi PBL mendapatkan skor pencapaian dan *mental effort* yang lebih baik secara signifikan berbanding dengan murid yang diajar menggunakan strategi CI. Dapatan kajian juga menunjukkan bahawa strategi PBL juga membantu murid mendapat skor yang lebih baik dalam menjawab soalan aras tinggi berbanding dengan berbanding dengan kumpulan strategi CI. Walaubagaimanapun, tidak terdapat perbezaan yang signifikan dalam menjawab soalan aras rendah bagi kedua-dua kumpulan. Murid dari kumpulan

strategi PBL memperoleh skor yang lebih tinggi secara signifikan berbanding dengan kumpulan strategi CI dari segi skor keseluruhan nilai matematik bagi sub-skala ketepatan, penumpuan, konsisten, kreativiti, keberkesanan organisasi, kecekapan tugas, kegigihan dan tugasan yang sistematik. Keputusan kajian juga menunjukkan bahawa strategi PBL meningkatkan tahap motivasi murid secara keseluruhan terhadap pembelajaran matematik bagi sub-skala perhatian, releven, dan keyakinan. Oleh yang demikian, kajian ini menunjukkan bahawa strategi pembelajaran PBL dapat meningkatkan pencapaian kognitif, nilai matematik dan motivasi murid dalam pembelajaran matematik berbanding strategi CI. Oleh itu menggunakan PBL strategi adalah lebih efisen berbanding dengan strategi CI.

Keputusan kajian menyarankan penggunaan PBL strategi dalam pembelajaran matematik untuk tajuk Teorem Pythagoras, Penjelmaan dan pepejal geometri II adalah lebih baik dan penggunaan strategi PBL harus diteruskan. Oleh itu adalah dicadangkan penggunaan strategi PBL dapat meningkatkan pencapaian kognitif, nilai matematik dan motivasi murid lebih baik berbanding strategi CI.

ACKNOWLEDGEMENTS

Alhamdulillah, praise to Allah. I would like to express my deepest appreciation to my committee chair, Associate Professor Dr Ahmad Fauzi bin Mohd Ayub for his continually and convincingly conveyed a spirit of adventure in regard to research. Without his guidance and persistent help this dissertation would not have been possible.

I would like to thank my committee members, Associate Professor Dr Mat Rofa bin Ismail and Associate Professor Dr Rohani binti Ahmad Tarmizi for their guidance and help. A special thanks from my heart to INSPEM members, my family and friends for helping me during this long project.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Ahmad Fauzi bin Mohd Ayub, PhD
Associate Professor
Faculty of Educational *Studies*
Universiti Putra Malaysia
(Chairman)

Rohani Ahmad Tarmizi, PhD
Associate Professor
Institute for Mathematical Research
Universiti Putra Malaysia
(Member)

Mat Rofa Ismail, PhD
Associate Professor
Institute for Mathematical Research
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: ________________________ Date: __________________

Name and Matric No.: ____

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: ___________________________

Name of Chairman of Supervisory Committee: ___________________________

Signature: ___________________________

Name of Member of Supervisory Committee: ___________________________

Signature: ___________________________

Name of Member of Supervisory Committee: ___________________________

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The education system in Malaysia plays a significant role in supporting the development of a knowledgeable society and producing a first-class world talent base. Hence, highly skilled and qualified human capital is much needed to spur the nation's drive to achieve a productive economic growth by the year 2020. However, compared to the developed Asia-Pacific countries like Singapore, the Republic of Korea, Hong Kong and Japan, the Malaysian work force has yet to match these countries' high scores on competent labour force with high tertiary qualification, productive and knowledgeable workers (Ministry of Education, 2013). Although there are many areas of concern, however, crucially important are the values and contextual thinking in mathematics of students who are going to make up the nation's workforce. Hence students' performances in Mathematics and Science are of concern, especially with the decline in the minimum benchmarks in both these subjects based on the Trends in Mathematics and Science Survey (TIMSS) for year 2015, 2011, 2007 when compared to the performance in 2003.

Malaysian education system was revised and revamped through Malaysian education blueprint 2013-2025 in order to improve and sustain students' outcomes (Ministry of Education, 2013). The mathematics curriculum specifically, was designed to inculcate 'mathematical values' among Malaysian students. Values in Mathematics were defined as the ability to do mathematics, understand mathematical ideas and apply mathematical knowledge and skills responsibly in daily life based on attitudes and values in mathematics (Ministry of Education, 2013). The ability to think mathematically and to use mathematical thinking to solve problems is an important goal in schooling. In this respect, mathematics attainment among students will support science, technology, economic life and development in a nation's economy.

Mathematics can never be context and values free (Bishop, 1988). Choosing suitable activities allows us to address these issues but also within the wider dimension to see the relevance of mathematics both as a tool for everyday life and as a creative discipline in its own right. Our teaching brings with it a set of theories on how children learn mathematics and with our theories come the potential for influencing students' beliefs about mathematics itself (Jones, 1999).

1.2 Problem-based learning (PBL)

Problem-based learning (PBL) is a strategy in teaching where learning activities are developed around a real-life problem (Barrows, 1986). PBL was formulated to overcome the issue of students' inability to apply knowledge learned and solve problems in real-life situations. Students are challenged to explore and develop potential solutions or decisions over the problem (Goodman, 2010). The strategy provides students with a rich context of learning, leading to the anchoring of a new mathematical knowledge to real problems and experiences (Hung, 2016). More importantly, they develop a better understanding of concepts and able to apply knowledge learned to solve problems in real-world situations which lead to positive effects on their motivation towards learning (Hung, 2016).

PBL also features opportunities for students to work cooperatively in groups and challenges them to understand how to apply knowledge in the real-life situations. (Hung, 2011). Students must develop self-regulated learning skills where they are motivationally, meta-cognitively and behaviourally active in their own learning process. The role of a teacher as a facilitator is to structure activities to stimulate students' motivation, to encourage reflection and facilitate their learning processes through guidance, scaffolding feedbacks and prompting independent thinking (English & Kitsantas, 2013).

The PBL real-life problems serve a number of functions. The problems will trigger students' motivation to study the necessary content knowledge (Hung, 2016). The problems will also stimulate the students' effort to master the content knowledge. The problems contextualize the content knowledge and provide an opportunity for students to apply the content knowledge (Hung, 2016). When encountering a problem that makes the students realize what knowledge they are lacking, it will motivate them to study the content knowledge. Problems not only trigger learning, but also furnish the entire learning process of PBL.

1.3 Mathematics Curriculum and Students' Performance in Malaysia

The mathematics curriculum for secondary schools in Malaysia aims to develop individuals who are able to think mathematically, and apply mathematical knowledge effectively and responsibly in solving problems and making decisions; and face the challenges in everyday life brought about by the advancement of science and technology (Curriculum Development Division, 2011). This mathematics curriculum was based on The National Education Philosophy written in 1988 and revised in 1996, which enshrined the vision of the government and the ministry of education as a means of comprehensive development for all children: intellectually, spiritually, emotionally, and physically as stated below.

> *"Education in Malaysia is an ongoing effort towards further developing the potential of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally, and physically balanced and harmonious, based on a firm belief in and devotion to God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards, and who are responsible and capable of achieving high levels of personal well-*

being as well as being able to contribute to the harmony and betterment of the family, the society, and the nation at large." (Curriculum Development Division, 2011)

The Malaysian government allocated huge budgets in education over the last 59 years since independence. The Malaysian federal government allocated the highest percentage of Gross Domestic Product (GDP) for primary and secondary education compared to other East Asia countries (Ministry of Education, 2013). In 2011, the amount allocated was 3.8% of GDP or 16% of total government spending. This amount was also at par with or more than top-performing systems like Singapore, Japan, and South Korea. By the year 2016, with an education budget of RM41.3 billion, the government continued to devote the largest share of the national budget to education. However, the return on investment was not as high as desired (Ministry of Education, 2013).

For example, result from the previous international student assessments, such as the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) showed students' performance had slipped to below the international average in Mathematics with a corresponding drop in ranking (Refer Table 1.1 and Table 1.2). Critically, 18% and 20% of Malaysia's students failed to meet the minimum proficiency levels in Mathematics. These students were identified as possessing only limited mastery of basic mathematical concepts and in need of deeper understanding of mathematical concepts and procedures (Mullis et al., 2016).

Table 1.1: Mean Scores of Selected Countries In The Trends In International And Mathematics And Science Study (TIMSS) – Mathematics For Grade 8

Country / Year	1999	2003	2007	2011	2015
Chinese Taipei	585	585	598	609	599
Republic of Korea	587	589	597	613	606
Singapore	604	605	593	611	621
Japan	579	570	570	570	586
England	496	498	513	507	518
United States	502	504	508	509	518
Australia	509	505	496	505	505
Malaysia	**519**	**508**	**474**	**440**	**465**
Thailand	467	NA	441	427	431

Table 1.2: Comparison of Malaysia's PISA ranking against other countries

Country	Mean score		
	2009+	2012	2015
Shanghai-China	600	613	531
Singapore	562	573	564
Hong Kong	555	561	548
Vietnam		511	495
International Average			**490**
Thailand	419	427	415
Malaysia	404	421	446
Indonesia	371	375	386

The results of TIMSS and PISA showed the aspiration of the Ministry of education to educate the students holistically along intellectual, spiritual, emotional, and physical dimensions, as reflected in the National Education Philosophy was far from the target. These results showed the full potential of KBSR and KBSM was not fully implemented in the classroom. There were two reasons for this. Firstly, skills and content that were often tested in the National exams were given emphasis in teaching and learning while the untested were taken out of the lesson plans. Secondly, teaching of the higher order thinking skills was ineffective in the classroom (Ministry of Education, 2013).

1.4 Problem Statement

A report by the Trends in International and Mathematics and Science Study 2015 found the Malaysian students' average score for mathematics was 465 which was categorised as a low benchmark country (Mullis, Martin, Foy & Hooper, 2016). It indicated the students possessed only basic mathematical knowledge in straight forward situations such as addition and multiplication and solving one-step word problems. These clearly indicated the students did not reach in-depth understanding of mathematics concepts. Jenkins (2010) defined in-depth learning as mathematical thinking in terms of methods and strategies to be applied to solve problems, expressing conceptual representations made, and understanding the arguments in demonstrating the concepts.

Hence, the implementation of KSSR (*Kurikulum Standard Sekolah Rendah*) focussed more on higher order thinking skills in students and SBA (School based Assessment) offered less exam-orientated tasks that emphasized mainly on continuous assessments. These would be the right direction for curriculum reform. A revamp of the national examinations and school-based assessments called for a gradually increasing percentage of questions testing higher-order thinking. By 2016, higher-order thinking questions made up 80% of the questions for UPSR, 80% for Form 3 central assessment, 75% of the questions for SPM core subjects and 50% of the questions for SPM elective subjects.

This change in examination design means teachers will focus less on predicting what topics and questions will come out and drilling for content recall (Abdul Halim & Effandi, 2013; Noraini, 2005). Instead, students will be trained to think critically and to apply their knowledge in different settings. Similarly, school-based assessments will also shift focus to testing higher-order thinking skills.

However, are the teachers ready for the change? In a report review by UNESCO (2013), it was reported teachers lacked the understanding and application of the philosophy and objectives of the curriculum with regard to classroom practice such as the integration of learning to the real life, holistic education, instilling creativity in students and practise innovation, for the classroom teaching was still very traditional (UNESCO, 2013). In Malaysia, mathematical teaching and learning are reported using teacher-centered methods and the students are not given the opportunity to develop their own critical and creative thinking (Abdul Halim & Effandi, 2013; Noraini, 2005).

Mathematics can never be context and values free. Choosing suitable activities allows us to address these issues but also within the wider dimension to see the relevance of mathematics both as a tool for everyday life and as a creative discipline in its own right. Our teaching brings with it a set of theories about how children learn mathematics and with our theories come the potential for influencing students' beliefs about mathematics itself (Jones, 1999). Study done by Nymas & Uzi (2014) to teachers in secondary school in Indonesia showed that only a small value of teaching design by teachers. The mathematics educational values were not shown in teacher's lesson plan. This would certainly affect the mathematics learning process in class. Finding from many other studies indicated that there is a need to tailor dynamically instructional techniques and procedures of inculcate values to current level of learning task (Bishop, 1998; Dede, 2006; Patry, Weyringer, & Weinberger, 2007; Falkenberg & Noyes, 2010; Hodara, 2011; Borhan & Yassin, 2013) as aspired by The National Education Philosophy of Malaysia.

Problem based learning is a strategy for teaching in which learning activities are developed around a problem which is rich in values. Students are challenged to explore and develop potential solutions or decisions about the problem. When done well, the strategy will provide students with a rich context of learning, leading to the anchoring of a new knowledge to real problems and experiences Students learn in a PBL class are equal or more expert knowledge than in a traditional class. Moreover they develop a better understanding of values, which also positively affects their social environment. PBL also features opportunities for students to work cooperatively in groups and challenges them to "learn to learn" (Duch, Groh, & Allen, 2001).

Constructivism is a theory of learning concentrates on the individual learner as an active person in the process of knowledge acquisition. The fundamental tenets of the constructivist paradigm are not only based on the logical principles of epistemology, but also on the theoretical findings of Piaget & Barbel (2000) and Vygotsky (1978).

Constructivist moral development is based on the two principles which include Moral development occurs through interaction with the environment and children can reorganize their thinking if they have chance to actively involved with moral conflict (Kohlberg,1976).

The views mentioned and discussed above, suggest teachers highly influence students' learning. Mediocre teaching techniques may result in poor understanding of mathematics concepts. Introducing dynamically instructional techniques and instilling higher order thinking skills in the students are always challenging for both the teachers and students because the investment in terms of time, efforts, cognitive engagement are needed. In this context, it is the important role of the teachers to plan more effective pedagogical approaches to the mathematics classroom which could improve students' mathematics conceptual knowledge.

Many findings such as by Hodara (2011), Hung (2009) and Dolmans et al. (2005) suggested one of the mathematical pedagogical techniques suitable for the 21th century students is Problem Based Learning (PBL). Studies done in Malaysia showed learning mathematics through PBL allowed students to work in groups (Abdullah, Tarmizi, & Abu, 2010; Botty, Shahrill, Jaidin, Li, & Chong, 2016; Hatisaru & Küçükturan, 2009; Hatısaru & Küçükturan, 2009a), and increased their confidence level and motivation (Fatade, Arigbabu, Mogari, & Awofala, 2014).

The application of PBL is important in mathematics education for it offers active learning situations, instigating cognitive valuing and conflicts in student thinking. Encountering a different learning mode (the PBL module) that is different from the conventional teaching enable students to try to formulate better contextual learning and accommodate the new information efficiently and acquire higher order thinking skills (Napitupulu, Suryadi, & Kusumah, 2016). These have a positive impact on students' achievement scores in mathematics (Fatade, Mogari, & Arigbabu, 2013; Kalaivani & Tarmizi, 2014; Padmavathy & Mareesh, 2013; Zakariya, Ibrahim, & Adisa, L. O, 2016), their thinking skills through PBL (Happy, Listyani, & Si, 2011; Kalaivani & Tarmizi, 2014).

Most of the past findings emphasized on the effectiveness of the usage of computers and focus was on the set knowledge domain. Studies should be extended to other knowledge domain. In this study, learning mathematics was by problem-based learning. The aims were to identify students' cognitive performance, higher order thinking skills, mathematical values and motivation. It was also to find out the new way of instilling values into students' mathematics learning and hence this research would provide the baseline strategy in mathematics learning. To elevate the interest in learning mathematics among Malaysian students, research in this area is very much needed. In line with the Malaysian National Education Philosophy, the problem-based learning approach in teaching of mathematics was utilised.

The National Examination results at ages 12, 15 and 17 in 1996-2000 showed girls performed better than boys in mathematics (Zalizan & Hazadiah, 2010) and the report from TIMMS 2015, showed Malaysia was among seven countries where girls had higher achievement than boys (Mullis et al., 2016).

As a conclusion, the application of PBL is important in education to offer situation that cause cognitive conflicts in student thinking. Encountering a different view that does not fit into students' actual worldwide view lead them to try to formulate better arguments and accommodates the new information. Recent research only examined the integration of values in the textbook and teachers' perception about values in mathematics education. New concept of tailoring values to students' in mathematics learning has been sought out and much needed to be research.

1.5 Objectives and Hypotheses of the Study

This study consists of three objectives as stated below. There were eights hypotheses for the first objective, nine hypotheses for objectives two and five hyphoteses for objectives three.

1. To examine the effects of the Problem-based learning (PBL) strategy and the Conventional instruction (CI) strategy on students' cognitive performance.

   H_{o1} There is no significant difference in the mean overall performance in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

   H_{o2} There is no significant difference in the mean score in solving higher order thinking questions in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

   H_{o3} There is no significant difference in the mean score in solving lower order thinking questions in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

   H_{o4} There is no significant difference in the mean of the problem-solving time between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

   H_{o5} There is no significant difference in the mean of performance efficiency in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o6} There is no significant difference in the mean of the mental effort in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o7} There is no significant difference in the mean of instructional efficiency between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o8} There is no significant difference in the number of errors obtained in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

2. To examine the effects of the PBL strategy and the CI strategy on students' mathematical value.

H_{o9} There is no significant difference in the mean of the overall students' mathematical values in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o10} There is no significant difference in the mean of accuracy in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o11} There is no significant difference in the mean of conjecturing in the learning of mathematics during the problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o12} There is no significant difference in the mean of consistency in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and Conventional Instruction (CI) strategy group.

H_{o13} There is no significant difference in the mean of creativity in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o14} There is no significant difference in the mean of effective organisation in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o15} There is no significant difference in the mean of efficient working in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group

H_{o16} There is no significant difference in the mean of flexibility in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o17} There is no significant difference in the mean of systematic working in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

3. To examine the effects of the PBL strategy and the CI strategy on students' motivation in learning the mathematics subscales (attention, relevance, confidence and satisfaction)

H_{o18} There is no significant difference in the overall mean of students' motivational level in the learning of mathematics during problem solving sessions between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o19} There is no significant difference in the mean of students' motivation attention subscale in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o20} There is no significant difference in the mean of students' motivation relevance subscale in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o21} There is no significant difference in the mean of students' motivation confidence subscale in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

H_{o22} There is no significant difference in the mean of students' motivation satisfaction subscale in the learning of mathematics between the Problem-based learning (PBL) strategy group and the Conventional Instruction (CI) strategy group.

1.6 Significance of the Study

Education is a major contributor to the development of the social and economic capital. The educational aspiration in Malaysia is to produce innovative and creative students who can compete in the rapid changes of the modern world. The students must be imbued with values, ethics and a sense of nationhood to be successful in life. Therefore there is a need for the transformation of the education system in Malaysia to implement new strategies and approaches to provide students with the necessary skills required in the 21st century.

In line with the Malaysian educational aspiration, the teaching of mathematics no longer emphasised on the development of strong content knowledge, but the development of higher-order thinking skills. The importance of the study is to introduce teaching methods that can provide the opportunity for the student to develop higher order thinking skills, mathematical values and motivation in the learning of mathematics. The use of PBL strategies applying real life problems can develop problem solving skills and also enhance the level of motivation and engagement in the learning process (Hung, et al., 2013). PBL gives the opportunity to the students to use the knowledge domain in solving real-world problems and to work collaboratively, the skills desired by the society now and the near future (Hung, 2016).

The curriculum developers at the Curriculum Development Division, teaching colleges, and universities can use the results of this study to plan appropriate teaching and learning mathematics curricula based on real life problems in the areas relevant to curriculum. The results of the study may also help the curriculum planners to integrate the PBL strategies in mathematics teaching development programme to stimulate teachers to apply them in the classroom. This may enhance the confidence of the teachers to use this 21st century pedagogy. This study can also contribute in making some recommendations in integrating PBL strategies to mathematics textbook authors.

The use of PBL strategies in mathematics teaching and learning have positive impact on students' cognitive performance, students' mathematical values and students' motivation which provide a theoretical and conceptual framework that encompass the skills of individuals, students' social interactions and real life application. Therefore, this study is useful in expanding the knowledge base for the theories.

1.7 Limitations of the Study

Although all aspects have been taken into account to reduce errors in terms of design and analysis, there are several limitations in this study. Firstly, this study only focus on the effects of problem based learning on students' cognitive performance, mathematical values and motivation toward learning mathematics. Secondly, there are only three topics of geometry (Pythagoras theorem, transformation and solid geometry) in the Form Two Mathematics syllabus was studied. Therefore, the findings of the study may not necessary apply to other mathematics area or other levels of Geometry. Thirdly, the sample chosen was limited to the average Form Two students from schools in Selangor only. Thus, the findings of this study can only be generalised to the similar samples of secondary school students in Malaysia. Finally, the duration of the study is only eight weeks. A different duration may provide defferent results.

Furthermore, this study was only limited to test the applicability and usefulness of those theories in generating more effective instructional methods as compared to the other current educational practice. In short, this study was useful in expanding the knowledge base for existing theories.

1.8 Operational Definition of Terms

The following are the definition of terms used in this study.

1.8.1 Cognitive Performace

Cognitive performance consists of overall performance, higher order thinking skills, lower order thinking skills, problem soving time, performance efficiency, mental effort, number of error obtained leads which leads to instructional efficiency in learning mathematics using PBL instruction strategies.

Higher Order Thinking Skills

Higher order thinking skills are the ability to think critically, logically, reflectively, meta-cognitively and creatively at the higher-levels of the cognitive processing hierarchy such as application, analysis, evaluation and creativity as in Bloom's Taxonomy (Collin, 2014). In this study, higher order thinking refers to how the students could use the information to interpret or solve unfamiliar problems. The students' cognitive performance was tested based on the problems set in the PBL module. The performance in solving higher order thinking questions was measured by the students' total scores on higher-order thinking questions in the post-test. The test scores would show the ability of the students to demonstrate their skills in answering higher order thinking questions.

Lower Order Thinking Skills

Lower order thinking skills are the ability to recall facts and basic concepts such as defining, listing, memorising and stating. The skills also include the explaining of ideas or concepts such as classifying, describing and recognising problems in mathematics. Lower order thinking does not involve application to real life situations (Collin, 2014). In this study the cognitive performance in solving lower order thinking questions refers to the students' total scores on lower-order thinking questions in the post-test. The test scores would show the ability of the students to demonstrate their skills in answering lower order thinking questions.

Performance efficiency

Performance Efficiency refers to the ratio of performance and time used to determine individual efficiency. Performance efficiency refers to the regulation of effort during problem solving (van Gog & Paas, 2008). In this study, performance efficiency is measured by the ratio of overall performance and problem solving time.

Mental effort

Paas, et al. (2003) defined mental effort as 'the aspect of cognitive load that refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task: thus, it can be considered to reflect the actual cognitive load. In this study, mental effort was measured using Paas (1992) self-rating scale to measure the amount of mental attempt the students spent during problem solving in the achievement test.

Instructional efficiency

Instuctional efficiency measured as a combined mental effort (Paas, 1992) and task performance indicators developed by Paas and van Merriënboer (1993). Instructional efficiency is a diagnostic instrument to identify and differentiate the efficiency of instructional modes. The instructional efficiency is measured on mean score in the achievement test and mean mental load invested in the achievement test. The two scores were substitute in the Instructional Efficiency (E) formula below:

$$E = (Z_{Ptest} - Z_{Etest}) / 2$$

Z_{Ptest} represents the standardised (Z scores) achivement test scores, and
Z_{Etest} the standardized mental effort scores collected during the testing period.

The difference between performance and effort is represented as instructional efficiency score (E) employing a two dimensional Cartesian coordinate system using performance as ordinate and effort as the abscissa (See figure 1.1). Score above the line were posititive and described as more efficient and score below the line were negative and described as less efficient (Paas and van Merriënboer 1993).

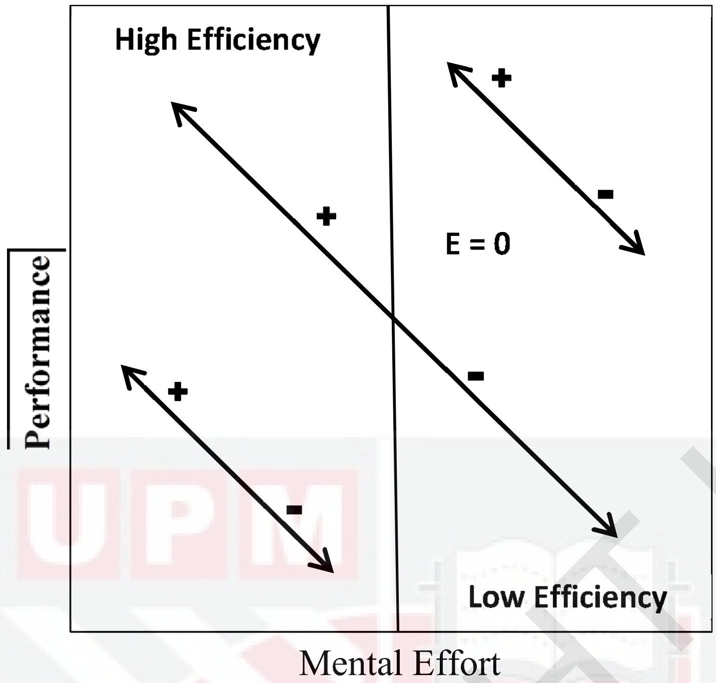

Figure 1.1: Graphic presentation used to visualize instructional efficiency
(Paas and van Merriënboer (1993)

Each efficiency score was determined based on the degree to which the observed. In this study the instructional efficiency was the comparison between the PBL instruction strategy and the Conventional instruction strategy.

Number of errors obtained per problem

Error performed in the problem solving activity due to carelessness, misunderstanding of symbols or text, unable to connect mathematical concept insolving problems, and the results a misconception (Hansen, Drews, Dudgeon, Lawton & Surtees, 2005). In this study, the number of errors obtained per problem in this study refers to the total number of errors obtained made in answering the achievement test divided by the total number of problems attempted in the achievement test.

Problem-solving time

Problem solving time was the total time used by the respondents to complete the achievement test. Reduced problem solving time with less number of errors obtained implying more efficient cognition (Hoffman, 2012).

1.8.2 Afective domain

Affective domain consists of mathematical values and motivation towards learning mathematics using PBL instruction strategies.

Students' mathematical value

Values in mathematics education generally are expressed in terms of affect and attitudes (Bishop, 2014). Values in mathematics education are the deep affective qualities which education aims to foster through the school subject of mathematics (Bishop, et al.,1999). In this study, students' mathematical values were mainly focussed on students' mathematics educational values through student problem solving. These values were measured using the researcher-constructed instrument which employed the rubric scale on nine values expressed explicitly during problem solving. The values were; Accuracy, Conjecturing, Consistency, Creativity, Effective organization, efficient working / Strategies, Flexibility, Persistence and Systematic working.

Students' motivation towards learning through PBL

Motivation is defined as the direction and magnitude of behavior to explain the goals people choose to pursue (Keller, 2010). In this study, motivation refers to the dimensions of students' motivation in the context of learning mathematics using CI strategy and PBl strategy. Motivation was measured using ARCS model developed by Keller (1983). It was a motivational design questionnaires consisting of a synthesis of motivational concepts and theories clustered into four categories: attention (A), relevance (R), confidence (C), and satisfaction (S).

Attention

Attention refers to the capability of the PBL instructional strategies to capture students' interest and stimulate inquiry attitude in learning mathematics (Keller, 2010). In this study, attention means using PBL instructional strategies in learning to capture the students' interest and stimulating the curiosity to learn mathematics.

Relevance

Relevance refers to the students' feeling or perception of attraction towards learning mathematic is useful for real life application (Keller, 2010). Relevance refers to the capability of PBL instructional strategies to meet students' personal needs or goals to produce positive attitude towards mathematics.

Confidence

Confidence defined as the ability to enhance the students' beliefs in their competent in mathematics (Keller, 2010). Confidence in this study refers to the use of PBL instructional strategies in helping the students believe or feel they will succeed and manage their success in mathematics.

Satisfaction

Satisfaction defined as the positive feeling of the students as they achieved a desirable level of success while studying the topics in mathematics (Keller, 2010). Satisfaction in this study refers to the capability of PBL instructional strategies in helping students feel good about their experiences and desire to continue learning mathematics.

1.9 Summary

This chapter described the background of the research problem, objectives, hypotheses and the problem statement of the study. This chapter also described the scope and limitations of the study and clarified the operational definitions.

REFERENCES

Abdullah, N., Tarmizi, R. A., & Abu, R. (2010). The effects of problem based learning on mathematics performance and affective attributes in learning statistics at form four secondary level. *Procedia social and behavioral sciences*. *8*(2010)*,* 370-376.

Adnan, N. H., & Shahrill, M. (2015). *Investigating the efficiency of problem-based learning intervention (PBL) among lower secondary school students*. Paper presented at the 7th ICMI-East Asia Regional Conference on Mathematics (EARCOME 7) , Cebu City, Philiphines

Ajai, J. T., Imoko, B. I., & I.O'kwu, E. (2013). Comparison of the learning effectiveness of problem-based learning (PBL) and conventional method of teaching algebra. *Journal of Education and Practice*, *4*(1), 131–136.

Ali, R., Hukamdad, Akhter, A., & Khan, A. (2010). Effect of using problem solving method in teaching mathematics on the achievement of mathematics students. *Asian Social Science*, *6*(2), 67–72.

Allison, P. D. (2012). *Logistic regression using SAS: Theory and application, (2nd. Ed).* Cary, NC : SAS Institute.

Alrababah, F. E. A (2017). The effectiveness of problem – based learning strategy in the acquisition of scientific concepts in physics and the development of science operations among the 9th grade female students. *British Journal of Education*. *5*(2), 1-9.

Aras, G., & Sungur, G. (2007). Effectiveness of problem-based learning on academic performance in genetics. *Biochemistry and Molecular Biology Education, 35*(6), 448-451.

Ary, D., Jacobs. L. C., & Sorensen, C. (2010). *Introduction to research in education* (8th ed). California: Wadsworth.

Bandura, A. (1969). Social learning of moral judgments. *Journal of Personality and Social Psychology, 11*(3), 275-279.

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20* (6), 481–486.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond: A brief overview. *New Direction for Teaching and Learning, 1996*(68), 3–12.

Barrows, H. S., & Tamblyn, R. (1980). *Problem-based learning*. New York: Springer.

Berlyne, D. E. (1963). Motivational problems raised by exploratory and epistemic behaviour. In S. Koch (Ed.), *Psychology: A study of a science*. New York:

McGraw-Hill.

Bishop, A. J. (1988). *Mathematical enculturation: A Cultural perspective on mathematics education*. Dordrecht : Kluwer Academic Publishers.

Bishop, A. J. (1996). How should mathematics teaching in modern societies relate to cultural values? Some preliminary questions. In D. T. Nguyen, T. L. Pham, C. Comiti, D. R. Green, E. Southwell, & J. Izard (Eds.). Proceedings of the 7th South East Asian Conference on Mathematics Education (SEACME 7). 19-24.

Bishop, A. J. L., FitzSimons, G. E., Seah, W-T. T. & Clarkson, P. (1999). Values in mathematics education: making values teaching explicit in the mathematics classroom. Paper presented at the combined Annual Meeting of the Australian Association for Research in Education and the New Zealand Association for Research in Education (Melbourne, Australia, November 29-December 2, 1999.

Bishop, A. J. (2008) Values in Mathematics and Science Education: Similarities and differences, *The Mathematics Enthusiast*. *5*(1). 47-57.

Bishop A. (2014) Values in Mathematics Education. In: Lerman S. (eds) *Encyclopedia of Mathematics Education*. Dordrecht : Springer.

Blumenfeld, P. C., Marx, R. W., Soloway, E. & Krajcik, J. (1996). Learning With Peers: From Small Group Cooperation to Collaborative Communities. *Educational Researcher*, 25(8), 37-40.

Borhan, M. T. B., & Yassin, S. M. (2013). Implementation of problem based learning (PBL) - in a Malaysian teacher education course: Issues and benefits from students perspective. In K. Mohd-Yusof, M. Arsat, M. T. Borhan, E. de Graaff, A. Kolmos, & F. A. Phang (Eds.), *PBL Across Cultures* (pp. 181-190). Aalborg: Aalborg Universitetsforlag.

Borko, H. & Putnam, RR.T. (2000).*The role of context in teacher learning and teacher education, In Contextual teaching and learning: Preparing teachers to enhance student success in the workplace and beyond* (pp. 34-67). Columbus, OH: ERIC Clearinghouse on Adult, Career and Vocational Education.

Botty, H. M. Shahrill, R. H., M., Jaidin, J. H., Li, H. C., & Chong, M. H. F., (2016). The implementation of Problem-based learning (PBL) in a year 9 mathematics classroom: A study in Brunei Darussalam. *International Research in Education*. *4*(2), 34-47.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*, 32–42.

Brown, R. (2001). Educational Values and Summative Assessment A View Across Three Educational Systems. Paper presented at the Annual Conference of the Australian Association for Research in Education, Fremantle, Australia.

Chan, S.K. (2014). The impacts of problem-based learning on students' academic achievement, motivation and self-regulated learning strategies: a perspective from a law subject. (Ph.D. dissertation). The Chinese University of Hong Kong. Retrieved from ProQuest, (UMI No. 3647760).

Chen, C. (2011). E-book instruction and its effects on teaching and learning. In S. Barton, J. Hedberg, & K. Suzuki (Eds.), *Proceedings of Global Learn Asia Pacific 2011* (pp. 1282–1291). Melbourne, Australia.

Chin C., Leu Y.C., Lin F.L. (2001) Pedagogical Values, Mathematics Teaching, and Teacher Education: Case Studies of Two Experienced Teachers. In: Lin, F.L. & Cooney T.J. (eds) *Making Sense of Mathematics Teacher Education*. Dordrecht : Springer.

Collins, A. (2006). Cognitive apprenticeship. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 47–60). New York: Cambridge University Press.

Collins, R. (2014). Skills for the 21st Century: teaching higher-order thinking. *Curriculum and leadership journal, 12*(14). Retrieved from http://www.curriculum.edu.au/leader/teaching_higher_order_thinking,37431.html?issueID=12910

Cotic, M. & Zuljan, M. V. (2009). Problem-based instruction in mathematics and its impact on the cognitive results of the students and on affective-motivational aspects. *Educational Studies*, *35*(3). 297-310.

Cook, D. A., Beckman, T. J, Thomas, K. G., & Thompson, W. G. (2009). Measuring motivational characteristics of courses: Applying Keller's instructional materials motivation survey to a web-based course. *Academic Medicine, 84*(11), 1505–1509.

Cook, T.D. & Campbell, D.T. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Chicago: Rand McNally.

Coulson, R. L. & Osborne, C. E. (1984). Insuring curricular content in a student-directed problem-based learning program. In H. G. Schmidt & M. L. de Volder. *Tutorial in Problem-Based Learning Program*, (pp. 225–229). Assen : Van Gorcum.

Curriculum Development Division. (2011). *Integrated Curriculum for Secondary Schools: Curriculum Specifications, Mathematics Form 2*. Kuala Lumpur: Ministry of Education.

Curriculum Development Division. (2016). *Secondary school standard-based curriculum: Curriculum Specifications, Mathematics Form 1*. Kuala Lumpur: Ministry of Education.

Creswell, J. W. (2012). *Qualitative inquiry & research design: Choosing among* *five approaches* (4th. ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2014). *A Concise Introduction to Mixed Methods Research*. Thousand Oaks, CA: Sage.

Dede, Y. (2006). Mathematics educational values of college students' towards function concept. *Eurasia Journal of Mathematics, Science and Technology Education*. *2*(1), 82-102.

de Jong, T.(2010). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science*. *38*(2), 105-134.

Dolmans, D. H. J. M., De Grave, W., Wolfhagen, I. H. A. P., & Van Der Vleuten, C. P. M. (2005). Problem-based learning: future challenges for educational practice and research. *Medical Education, 39*(7), 732-741.

Duch, B. (2001). Writing problems for deeper understanding. In B. Duch, S. E. Groh, & D. E. Allen (Eds.), *The power of problem-based learning: A practical "how to" for teaching undergraduate courses in any discipline* (pp. 47–53). Sterling, VA: Stylus Publishing.

Dunkin, M.J., & Biddle, B. J. (1974). *The study of teaching*. New York: Holt, Rinchart & Winston.

Dunlap, J. C., & Grabinger, R. S. (1996). Rich environments for active learning in the higher education classroom. In B. G.Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design,* (pp. 65-82). Englewood Cliffs, N J: Educational Technology Publications.

Dunn, R., Rockinson-Szapkiw, A., Holder, D., & Hodgson, D. (2010). Of student teachers and avatars: Working towards an effective model for geographically distributed learning communities of pre-service educators using virtual worlds. In D. Gibson & B. Dodge (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 423–427). Chesapeake, VA: AACE.

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, *14*(1), 1-55.

Echeverri, J. F., Sadler, T. D. (2011). Gaming as a Platform for the Development of Innovative Problem-Based Learning Opportunities. *Science Educator*, *20*(1), 44-48.

English, M. C. & Kitsantas, A. (2013). Supporting Student Self-Regulated Learning in Problem- and Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning,7*(2), 128– 150.

Fatade, A. O., Arigbabu, A. A., Mogari, D., & Awofala, A. O. A. (2014). Investigating senior secondary school students' beliefs about further mathematics in a problem-based learning context. *Bulgarian Journal of Science and Education Policy* (BJSEP), *8*(1), 5–47.

Fatade, A. O., Mogari, D., & Arigbabu, A. A. (2013). Effect of problem-based learning on senior secondary school students' achievements in further mathematics. *Acta Didactica Napocensia*, *6*(3), 27–44.

Falkenberg, T., & Noyes, A. (2010). Conditions for linking school mathematics and moral education: A case study. *Teaching and Teacher Education*, *26*(4), 949–956.

Fleming, D. S. (2000). *A Teacher's guide to project-based learning*. West Virgina : AEL Inc.

Fraenkel, J. R. & Wallen, N. E. (2003). *How to design and evaluate research in education* (6th ed.). New York : McGraw-Hill.

Goodman, R. J. B. (2010). Problem-Based Learning: Merging of economics and mathematics. *Journal of Economic Finance*, *34*(4), 477-483.

Gijbels, D., Dochy, F., Van Den Bossche, P. and Segers, M., (2005). Effects of problem-based learning: A Meta-analysis from the angle of assessment. *Review of Educational Research*, *75*(1), 27-61.

Gijselaers, W. H., & Schmidt, H. G. (1990). Development and evaluation of a causal model of problem-based learning. In Z. H. Nooman, H. G. Schmidt, & E. S. Ezzat (Eds.), *Innovation in medical education: An evaluation of its present status*. New York: Springer.

Hair, J. F., Balck, W. C., Babin, B. J. & Andeson, R. E.(2010). *Multivariate Data Analysis: A Global Perspective*. Upper Saddle River, NJ: Pearson Education.

Happy, N., Listyani, E., & Si, M. (2011). Improving The mathematic critical and creative thinking skills in grade 10th. sma negeri 1 kasihan bantul on mathematics learning through problem-based learning. Paper presented at International Seminar and the 4th. National Conference on Mathematics Education 2011 (pp. 978–979).

Hatisaru, V., & Küçükturan, A. G. (2009). Vocational and technical education problem-based learning exercise: sample scenario. *Procedia - Social and Behavioral Sciences*, *1*(1), 2151–2155.

Hatısaru, V., and Küçükturan, A. G. (2009a). Student views on problem-based learning of 9th. grade industrial vocational high school. *Procedia - Social and Behavioral Sciences*, *1*(1), 718–722.

Hmelo, C. E. (1998). Problem-based learning: Effects on the early acquisition of cognitive skill in medicine. *Journal of the Learning Sciences*, *7*(2), 173–208.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*(3), 235-266.

Hmelo-Silver, C. E., Duncan, R. G., Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist*, *42*(2), 99-107.

Hodara, M. (2011). Reforming mathematics classroom pedagogy: evidence-based findings and recommendations for the developmental math classroom. *CCRC Working Paper, 27. Assessment of evidence series.* Community College Research Center, Columbia University.

Hoffman, B. (2012). Cognitive Efficiency: A conceptual and methodological comparison. *learning and instruction*, *22*(2), 133-144.
Hoffman, B., & Schraw, G. (2010). Conceptions of efficiency: Applications in Learning and Problem Solving. *Educational psychologist, 45*(1), 1 - 14.

Horak, A. K., & Galluzzo, G. R. (2017). Gifted middle school students' achievement and perceptions of science classroom quality during problem-based learning. *Journal of Advanced Academics*, *28*(1), 28–50.

Hung, W. (2006). The 3C3R model: A conceptual framework for designing problems in PBL. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 55–77.

Hung, W. (2009) The 9-step problem design process for problem-based learning: Application of the 3C3R. *Educational Research Review, 4*(2), 118–141.

Hung, W. (2011). Theory to reality: A few issues in implementing problem-based learning. *Educational Technology Research & Development*, *59*(4), 529-552.

Hung, W. (2016). All PBL starts here: The Problem. *Interdisciplinary Journal of Problem-Based Learning, 10*(2). Retrieve from : https://doi.org/10.7771/1541-5015.1604.

Hung, W., Bailey, J. H., &Jonassen, D. H. (2003). Exploring the Tensions of Problem-Based Learning: Insights from Research. In D.S. Knowlton, and D.C. Sharp, (eds.), *Problem Based Learning in the Information Age*. San Francisco: Jossey Bass.

Hung, W., Jonassen, D. H., & Liu, R. (2008).Problem-based learning. In J. M. Spector, M. D. Merrill, J. van Merriënboer, & M. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd. ed.), Vol. 1. (pp. 485–506). New York: Erlbaum.

Hung, W., Mehl, K., & Holen, J. B. (2013). The relationships between problem design and learning process in problem-based learning environments: Two cases. *The AsiaPacific Education Researcher, 22*(4), 635–645.

Hwang, S. Y. & Kim, M. J. (2006). A comparison of problem-based learning and lecture-based learning in an adult health nursing course. *Nurse Education Today*, *26*(4). 315-321.

Ismail, N.A. (2009). Understanding the Gap in Mathematics Achievement of Malaysian Students.*The Journal of Educational Research*, *102*(5), 389-394.

Inpinit, J. & Inprasit, U. (2016).The effect of using PBL with the STEM education concept on mathematical conceptual understanding development. AIP Conference Proceedings. 775, 030037 (2016).

Jenkins, O, F. (2010).Developing teachers' knowledge of students as learners of mathematics through structured interviews. *Journal for Research in Mathematics Education*, *13*(2), 141-154.

Jones, M. (1999) *Spiritual, moral, social and cultural education. Exploring values in the curriculum*. London : David Fulton Publishers.

Jukes, I., McCain, T., & Crockett, L. (2011). Education and the role of the educator in the future. *Kappan*, *92*(4), 15-21.

Jumawan, F. V. (2011). Healthy plate: Consuming balanced meals as a nutritional strategy to Type II diabetes prevention. Retrieved from http://etec.hawaii.edu/proceedings/masters/2011/etec_jumawan.pdf

Kalaivani, K. (2011). Effectiveness of Problem-based learning – Teaching Algebra among form four students. (M. Sc. Dissertation). Universiti Putra Malaysia.

Kalaivani, K., & Tarmizi, R. A. (2014). Assessing thinking skills: a case of problem-based learning in learning of algebra among Malaysian form four students. *Journal Of International Academic Research For Multidisciplinary, 2*(3), 166-173.

Keller, J.M. (1979). Motivation and instructional design: A theoretical perspective. *Journal of Instructional Development*. *2*(4), 26-34.

Keller, J. M. (1983). Development and use of the ARCS model of motivational design. Paper presented at the annual meeting of the Association for Education and Training Technology, Exeter, England.

Keller, J. M. (1999). Motivation in cyber learning environments. *International Journal of Educational Technology*, *1*(1), 7 – 30.

Keller, J. M. (2003). Motivation by design: A practical, theory-based process for motivational design and research. Invited address at the Department of Nursing and Midwifery, University of Ulster. Belfast, North Ireland.

Keller, J. M. (1987). The systematic process of motivational design. *Performance & Instruction*, *26* (November/December), 1–8.

Keller, J. M. (2012). Motivational challenges in the transition from a knowledge-transition to a knowledge-based system. Paper presented at the 2nd. International Exhibition and Forum for Education, Riyadh, Saudi Arabia.

Keller, J.M. (2010). Motivational Design for Learning and Performance: The ARCS Model Approach. New York: Springer.

Kelley, T. &Kellam, N. (2009).A Theoretical Framework to Guide the Re-Engineering of Technology Education. *Journal of Technology Education*, *20*(2), 37-49.

Kozulin, A. (1998). *Psychological tools*. Cambridge, MA: Harvard University Press.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86.

Kuhn, D. (2007). How to Produce a High-Achieving Child. *SAGE Journals*, *88*(10), 757-763.

Kuşdemir, M. , Yusuf, A.Y. & Tüysüz, C. (2013). An analysis of the effect of problem based learning model on the 10th grade students' achievement, attitude and motivation in the unit of "mixtures". *Education Electronic Journal of Science & Mathematics Education, 7*(2), 195-224.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lee, J. (1999). Problem-based learning: a decision model for problem selection. In proceedings of selected research and development. Papers Presented at the National Convention of the Association for Educational Communications and Technology (AECT). February 10–14, Houston, TX.

LeJeune, N. F. (2002). Problem based learning instruction versus Traditional instruction on self directed learning, motivation and grades of undergraduate computer science students. (PhD Dissertation). University of Colorado.

Li, H. C., & Tsai, T. L. (2017). The implementation of problem-based learning in a Taiwanese primary mathematics classroom: lessons learned from the students' side of the story. *Journal Educational Studies, 43*(3), 354-369.

Lim, C. S., & Ernest, P. (1997). Values in mathematics education: What is planned and what is espoused? Paper presented at the Conference of the British Society for Research into Learning Mathematics, Nottingham, U.K.

Lockhart, P. (2002). *A mathematician's lament*. London: Rutledge & Falmer Press.

Malone, T. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science*, *5*(4), 333- 369.

Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice*, *41*(4), 226–232.

McKinley, K. (2012). Using problem based learning and guided inquiry in a high school acid-base chemistry unit. (Msc. Thesis). Michigan State University.

Merritt, J., Lee, M. Y., Rillero, P., & Kinach, B. M. (2017). Problem-based learning in K–8 mathematics and science education: A Literature review. *Interdisciplinary Journal of Problem-Based Learning*, 11(2). Retrieve from https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1674&context=ijpbl.

Mailloux, C. G. (2006). The extent to which students' perceptions of faculties' teaching strategies, students' context, and perceptions of learner empowerment predict perceptions of autonomy in BSN students. *Nurse Education Today*, *26*(7), 578-585.

Ministry of Education (2013). *Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education).* Putrajaya : Kementerian Pendidikan Malaysia.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International Results in Mathematics.* Retrieved from Boston College, TIMSS & PIRLS International Study Center website. Retrieved from http://timssandpirls.bc.edu/timss2015/international-results/.

Mustaffa, N., Ismail, Z., Tasir, Z., & Said, M. N. H. M. (2016). The impacts of implementing problem-based learning (PBL) in Mathematics: A Review of Literature. International *Journal of Academic Research in Business and Social Sciences*, *6*(12), 490-503.

Mohd Yusof, K., Jamaludin, M. Z., &. Harun, N. F. (2012). Cooperative Problem-based Learning (CPBL): Framework for Integrating Cooperative Learning and Problem-based Learning. *Procedia - Social and Behavioral Sciences, 56*, 223-232.

Nachmias, C. & Nachmias, D. (1981). *Research Methods in Social Sciences*. New York : St. Martin's Press.

Napitupulu, E. E., Suryadi, D., & Kusumah, Y. S. (2016). Cultivating upper secondary students ' mathematical reasoning-ability and attitude towards mathematics through problem- based learning. *Journal on Mathematics Education*, *7*(2), 117–128.

Nargundkar, S., Samaddar, & Mukhopadhyay, S. (2014). A guided problem-based learning (pbl) approach: impact on critical thinking. *Decision Sciences Journal of Innovative Education*, *12*(2), 91–108.

O'Donnell, A.M., & King, A. (Eds) (1999). *Cognitive Perspectives on Peer Learning*. New Jersey: Lawrence Erlbaum.

Orhan, A. & Ruhan, T. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology Education*, 2007, *3*(1), 71-81.

Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive-load approach. *Journal of Educational Psychology*, *84* (4), 429.

Paas, F. & van Merrienboer, J.J.G. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performance measures. *Human Factors*. *35*(4) 737-747.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*, *38*(1), 1–4.

Padmavathy, R. D. & Mareesh, K. (2013). Effectiveness of problem based learning in mathematics. *International Multidisciplinary e-Journal*, *2*(1), 45-51.

Pallant, J. (2010). *SPSS survival manual: a step by step guide to data analysis using SPSS.* Maidenhead : Open University Press/McGraw-Hill.

Patry, J. L,. Weyringer, S. & Weinberger, A. (2007). Combining Values and Knowledge Education. In Aspin, D. N & Judith D. Chapman, J.D. (Eds). *Values Education and Lifelong Learning Principles, Policies, Programmes*. Dordrecht : Springer.

Pedersen, S. (2003). Motivation orientation in a problem-based learning environment. *Journal of Interactive Learning Research*, *14*(1), 51-78.

Perrenet, J. C., Bouhuijs, P. A. J., & Smits, J. G. M. M. (2000). The suitability of problem-based learning for engineering education: Theory and practice. *Teaching in Higher Education*, *5*(3), 345–358.

Polanco, R., Calderon, P. & Delgado, F. (2004). Effects of a problem-based learning program on engineering students' academic achievements in a Mexican university. *Innovations in Education and Teaching International*, *41*(2), 145-155.

Piaget, J., & Cook, M. T. (1952). *The origins of intelligence in children*. New

York, NY: International University Press.

Piaget, J., Barbel, I. (2000) *The Psychology of the Child.* Basic Books. USA.

Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E.Duncan, R.G. (2004). A scaffolding design framework for software to support science inquiry. *Journal of the Learning Sciences*, *13*(3), 337–386.

Rattanatumma, T., Puncreobutr, V. (2016). Assessing the Effectiveness of STAD model and problem based learning in mathematics learning achievement and problem solving ability. *Journal of Education and Practice*, 7(12), 194-199.

Rockinson-Szapkiw, A. J., Holder, D. E., & Dunn, R. (2011). Motivating students to learn: Is there a difference between traditional books and e-Books? P*roceedings of Global Learn Asia Pacific 2011 (p.p* 235-239).

Rodgers, L. (2011). Examining the implementation of a problem-based learning and traditional hybrid model of instruction in remedial mathematics classes designed for state testing preparation of eleventh grade students. (Ph.D. dissertation). Robert Morris University. ProQuest, (UMI Dissertations Publishing 3532763).

Rotgans, J. I., & Schmidt, H. G. (2010). The role of teachers in facilitating situational interest in an active learning classroom. *Teaching and Teacher Education.* 27(1). 37 - 42

Rotgans, J. I., & Schmidt, H. G. (2011). Cognitive engagement in the problem-based learning classroom. *Adv Health Sci Educ Theory Pract*. *16*(4), 465–479.

Sadish, W. R., Cook, T. D., & Campbel, D. T. (2002). *Experimental and quasi experimental design for generalized causal inference*. New York : Houghton Mifflin Company.

Schmidt, H. G., Van der Molen, H. T., Te Winkel, W. W. R., & Wijnen, W. H. F. W. (2009). Constructivist, problem-based learning does work: A meta-analysis of curricular comparisons involving a single medical school. *Educational Psychologist, 44*(2), 227-249.

Schneider, R. M., Krajcik, J., Marx, R. W., & Soloway, E. (2002). Performance of students in project-based science classrooms on a national measure of science achievement. *Journal of Research in Science Teaching, 36*(5): 410-422.

Seah, W. T. (2002). Exploring teacher clarification of values relating to mathematics education. In C. Vale, J. Roumeliotis & J. Horwood (Eds.), *Valuing mathematics in society* (pp. 93-104). Brunswick, Australia: Mathematical Association of Victoria.

Seah, W. T. & Bishop, A.J. (2002). Values, Mathematics and Society: Making The Connections. In C. Vale & J. Roumeliotis & J. Horwood (Eds.), *Valuing mathematics in society* (pp. 105-113). Brunswick, Australia: Mathematical Association of Victoria.

Seah, W. T., Bishop, A. J., FitzSimons, G. E., & Clarkson, P. C. (2001). Exploring issues of control over values teaching in the mathematics classroom. Paper presented at Australian Association for Research in Education, Fremantle, Australia.

Seah, W.T. (2013) Values in mathematics classroom: Supporting cognitive and affective pedagogical ideas, *Gazi Journal of Education*, *1*(1), 45-65.

Sears, S. J. (2003). *Introduction to Contextual Teaching and Learning*. Bloomington, IN : Phi Delta Kappa Educational Foundation

Shulman, L. S. (1986). *Paradigms and research programs in the study of teaching: A contemporary perspective*. In M.C. Wittrock (Eds). Handbook of research on teaching. New York : Macmillan.

Small, R. V., & Gluck, M. (1994). The relationship of motivational conditions to effective instructional attributes: A magnitude scaling approach. *Educational Technology, 34*(8), 33–40.

Small, R. V. (1998). *Designing motivation into library and information skills instruction*. *School Library Media Research. 1*(1998). 1-15.

Small, R. V. (2006). Designing motivation into library and information skills instruction. American Library Association. Retrieved from http://www.ala.org/ala/mgrps/divs/aasl/aaslpubsandjournals/slmrb/slmrcontents/v olume11998slmqo/small.cfm.

Salomon, G. (1993). No distribution without individual cognition: A dynamic interactional view. In G. Salomon (Ed.), *Distributed cognitions* (pp. 111–138). New York: Cambridge.

Sungur, S. & Tekkaya, C. (2006). Effects of Problem-Based Learning and Traditional Instruction on Self-Regulated Learning. *The Journal of Educational Research, 99*(5), 307-320.

Swadener M., Soedjadi R. (1988). Values, Mathematics Education, and the Task of Developing Pupils' Personalities: An Indonesian Perspective. In: Bishop A.J. (eds) Mathematics Education and Culture. Dordrecht : Springer,

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science,12*, 257–285.

Sweller, J. (1999). *Instructional design in technical areas*. Camberwell: ACER Press.

Sweller, J., Ayres, P., & Kalyuga S. (2011). *Cognitive load theory*. New York: Springer.

Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251–296.

Sweller, J. (2013). Why understanding instructional design requires an understanding of human cognitive evolution. In O'Neil, H.F. & Perez, R.S (Eds). *Web-Based Learning: Theory, Research, and Practice*, (pp. 279 – 294)

Tarhan, L., & Acar-sesen, B. (2013). Problem Based Learning in Acids and Bases: Learning Achievements and Students' Beliefs. *Journal of Baltic Science Education*. *12*(5), 565–579.

Tandogan, R. O., & Akinoglu, O. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology Education*, *3*(1), 71-81.

Tosun, C. & Taşkesenligil, Y. (2011). The effect of problem based learning on student motivation towards chemistry classes and on learning strategies. *Journal of Turkish Science Education*. *9*(1). 126-131

Trafton, P. R., & Midgett, C. (2001). Learning through problems: A powerful approach to teaching mathematics. *Teaching Children Mathematics, 7*(9), 532–536.

UNESCO. (2013). Malaysia education policy review abridged report. Retrieved from. http://unesdoc.unesco.org/images/0022/002211/221132e.pdf.

Van Berkel, J. M., & Schmidt, G. (2000). Motivation to commit oneself as a determinant of achievement in problem-based learning, *Higher Education*, *40*(2), 231-242.

Van Gessel, E., Nendaz, M. R., Vermeulen, B., Junod, A., & V Vu, N. (2003). Development of clinical reasoning from the basic sciences to the clerkships: A longitudinal assessment of medical students' needs and self-perception after a transitional learning unit. *Medical Education, 37*(11), 966-974.

Van Gog, T., & Paas, F. (2008). Instructional efficiency: Revisiting the original construct in educational research. *Educational Psychologist, 43*(1), 16-26.

Von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. P. Steffe& J. Gale (Eds.), *Constructivism in education* (pp. 3–16). Hillsdale, NJ: Erlbaum.

Vye, N. J., Goldman, S. R., Voss, J. F., Hmelo, C. & Williams, S. (1997). Complex Mathematical Problem Solving by Individuals and Dyads. *Cognition and Instruction*, *15*(4), 435-484.

Vygotsky, L. S. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Widyatiningtyas, R., Kusumah, Y. S., Sumarmo, U., & Sabandar, J. (2015). The impact of problem-based learning approach to senior high school students' mathematics critical thinking ability. *Journal of Mathemathics Education*, *6*(2), 30–38.

Willis, J. (2008). Building a bridge from neuroscience to the classroom. *Phi Delta Kappan*, *89*(6). 424-427.

Witte, K. D. & Rogge, N. (2012). Problem-based learning in secondary education: Evaluation by a randomized experiment. *Education Economics*. *24*(1), 1-23

Woory, V. A. (2011). A Comparison of high school geometry student performance and motivation between traditional and project-based instruction techniques. (PhD Dissertation). Walden University.

Zakariya, Y. F., Ibrahim, M. O., & Adisa, L. O. (2016). Impacts of Problem-Based Learning on Performance and Retention in Mathematics among Junior Secondary School Students in Sabon-Gari Area of Kaduna State. *International Journal for Innovative Research in Multidisciplinary Field*, *2*(9), 42–47.

Zalizan, M. J., & Hazadiah, M. D. (2010). Gender and educational performance: The Malaysian perspective. *Procedia-Social and Behavirol Sciences, 7,* 720-727.