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EFFECTS OF VARIATION THEORY-BASED STRATEGY ON FORM TWO STUDENTS' ALGEBRAIC ACHIEVEMENT AND MOTIVATION

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EFFECTS OF VARIATION THEORY-BASED STRATEGY ON FORM TWO STUDENTS' ALGEBRAIC ACHIEVEMENT AND MOTIVATION

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October 2016

Chair: Associate Professor Rohani Ahmad Tarmizi, PhD
Faculty: Institute for Mathematical Research

This study investigated the effects of utilizing Variation Theory-Based Strategy (VTBS) on students' algebraic achievement and their motivation in learning algebra. Examination on difficulties in learning Form Two algebra faced by both experimental and control groups in urban and rural were also conducted.

The study used quasi-experimental non-equivalent control group research design. It involved 120 Form Two students in four intact classes (two classes were from an urban school, another two classes from a rural school) in Sarawak, Malaysia. The first group of students from each school learnt algebra through VTBS while the second group of students in each school learnt algebra through Conventional Teaching Strategy (CTS). A 24-item Algebra Test (Chow, 2011) and a 36-item Instructional Material Motivation Survey (Keller, 2010) questionnaire were administered to measure students' algebraic achievement and motivation of learning and its four subscales; attention, relevance, confidence, and satisfaction.

ANCOVA analysis showed that that VTBS had significant effect on students' algebraic achievement from both locations with urban students had significant better performance than their counterparts in rural school ($p<0.05$). Two-way ANOVA showed there were significant interaction effects in terms of instructional strategy and school location on students' overall motivation of learning and its four subscales: attention, relevance, confidence, and satisfaction ($p<0.05$). There were evidences that VTBS had significant effect on rural VTBS students' overall motivation of learning in all the four subscales but it was not so for urban VTBS students' motivation. The rural students in experimental group were more motivated in the environment of VTBS which had captured the interest of students (attention), met their personal needs (relevance), assisted them to have believe and control success (confidence), and allowed them to have good experiences (satisfaction).

The result of the study showed that the primary predicament in learning algebra faced by VTBS and CTS groups was use of appropriate algebraic expression in making relationship. Both groups of students also encountered problem in use of appropriate rules to solve problems. The result of the study also showed that rural students did not perform well in understanding of variables in algebra. Inadequate understanding of algebraic symbols and the used of its properties when it was used in an equation was also a major problem that hindered the students solving equations correctly.

The result of the study confirmed the effectiveness of VTBS in learning algebra. The developed learning modules had incorporated variation theory into algebra learning activities and tasks. The result also demonstrated the potential of VTBS as useful learning strategy particularly among students in rural Malaysian schools.

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

KEBERKESANAN STRATEGI PENGAJARAN BERASASKAN TEORI VARIASI TERHADAP PENCAPAIAN ALGEBRA DAN MOTIVASI MURID TINGKATAN DUA

Oleh

TING JING JING

Oktober 2016

Pengerusi: Profesor Madya Rohani Ahmad Tarmizi, PhD
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Kajian ini dijalankan bagi menentukan keberkesanan penggunaan Strategi Berasaskan Teori Variasi (VTBS) ke atas pencapaian algebra murid dan motivasi mereka terhadap pembelajaran. Pemeriksaan ke atas kesukaran pembelajaran algebra Tingkatan Dua yang dihadapi oleh kumpulan eksperimental dan kawalan di bandar dan luar bandar juga dilaksanakan.

Kajian ini menggunakan reka bentuk kuasi-experimental kumpulan kawalan tak serupa. Ia melibatkan 120 murid Tingkatan Dua dalam empat intak kelas (dua kelas dari sekolah bandar, dua kelas lagi dari sekolah luar bandar) di Sarawak, Malaysia. Pelajar kumpulan pertama belajar algebra melalui VTBS manakala kumpulan kedua belajar algebra melalui Strategi Pengajaran Konvensyenal (CTS). Ujian Algebra (24 item) dan Soal Selidik Motivasi Bahan Instruksional (36 item) telah ditadbir untuk mengukur pencapaian algebra murid dan motivasi terhadap pembelajaran serta keempat-empat subskalanya: perhatian, relevan, keyakinan, dan kepuasan.

Analisis ANCOVA menunjukkan VTBS mempunyai kesan signifikan terhadap pencapaian algebra pelajar dari kedua-dua lokasi dengan pelajar bandar berpencapaian lebih baik daripada rakan mereka dalam sekolah luar bandar ($p<0.05$). ANOVA Dua Hala menunjukkan terdapatnya kesan interaksi secara signifikan strategi instruksional dan lokasi sekolah terhadap motivasi pelajar termasuk keempat-empat subskalanya; perhatian, relevan, keyakinan, dan kepuasan ($p<0.05$). VTBS terbukti mempunyai kesan secara signifikan terhadap motivasi dan keempat-empat subskala pelajar luar bandar tetapi tidak kepada pelajar bandar. Keputusan kajian ini juga menunjukkan pelajar luar bandar lebih bermotivasi dalam suasana VTBS yang telah menarik minat murid (perhatian), memenuhi keperluan peribadi mereka (relevan), memupuk kepercayaan diri dan membawa kejayaan (keyakinan), dan membolehkan mereka merasai pengalaman yang baik (kepuasan).

Keputusan kajian ini menunjukkan kesukaran utama yang dihadapi oleh kumpulan VTBS dan CTS adalah menggunakan ungkapan algebra yang sesuai untuk membuat kaitan. Kedua-dua kumpulan ini bermasalah menggunakan hukum algebra dengan tepat untuk menyelesaikan masalah. Hasil kajian ini menunjukkan pelajar luar bandar tidak berpencapaian baik dalam pemahaman terhadap pemboleh ubah dalam algebra. Ketidakmantapan pemahaman pelajar ini terhadap simbol algebra dan ciri-cirinya merupakan punca utama mereka tidak dapat menyelesaikan masalah dengan tepat.

Hasil kajian ini mengesahkan keberkesanan VTBS dalam pembelajaran algebra. Modul pembelajaran yang dibina telah mengintegrasikan Teori Variasi dalam aktiviti pembelajaran dan tugasan. Hasil kajian juga menunjukkan potensi VTBS sebagai strategi pembalajaran yang berguna khasnya bagi pelajar sekolah luar bandar di Malaysia.

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I certify that a Thesis Examination Committee has met on 5 October 2016 to conduct the final examination of Ting Jing Jing her thesis entitled "Effects of Variation Theory-Based Strategy on Form Two Students' Algebraic Achievement and Motivation" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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- 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.

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LIST OF ABBREVIATIONS

IMMS	Instructional Materials Motivation Survey
VTBS	Variation Theory-Based Strategy
CTS	Conventional Teaching Strategy
ARCS	Attention, Relevance, Confidence, Satisfaction
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
SMK	*Sekolah Menengah Kebangsaan*
EPRD	Educational Planning and Research Division
MOE	Ministry of Education
SPSS	Statistical Package for Social Science
%	Percentage
Df	Degree of Freedom
P	Significant Level
F	Comparison for value ANOVA Test
N	Number of Sample

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Mathematics is one of the most influential mental tools to be used for a man's life over centuries (Skemp, 1985). Mathematics is also a language for everyday life (Leshem & Markovits, 2013), a central part of human communication. It is used to analysis patterns, establish relationships, making logical connections, and form visual representations (Skemp, 1985). Therefore, students need to acquire mathematical knowledge and skills to compete and survive in life.

Algebra is one of the fundamental components in mathematics. It provides the symbols and techniques to represent and solve problems, a scheme of to express relationship of variables, to analyse and represent patterns, and to explore mathematical properties in various situations (Star et al., 2015). Algebra is an important prerequisite for advanced mathematics and many other branches of science. Many students do not do well in algebra are therefore unable to enrol in advanced mathematics which is a gateway to many prestigious professions as well as academic careers (Chung & Delacruz, 2014). The fundamental of algebra is abstract which has unique structure in representation of numerical relations and mathematical problems (Bush & Karp, 2013). This aspect of algebra that makes it a qualitatively different form of mathematical thinking compared to arithmetic which students encountered in their prior experiences. According to Bush and Karp (2013), this explained why many students lack in their mathematical development.

1.1.1 Malaysian Secondary School Mathematics Curriculum

Malaysia mathematics curriculum has evolved significantly within the past five decades. In terms of content perspective, the curriculum has been transformed from traditional (absolutist) to modern mathematics, then to constructivist (Ernest, 1998). This transformation of Malaysian mathematics education is largely influenced by the global trend. During the era before 70's, mathematics education was focussed on students' abilities to compute fast and accurate. This approach is highly influenced by Behaviourist Theory which postulated that human behaviour inclined by a or a set of stimuli (Skinner, 1953). However, this teaching and learning approach is not effective in promoting students mathematical thinking (Law & Shahrill, 2013; Sarwadi & Shahrill, 2014). Piaget (1973) proposed that learning is to allow students to construct their own ideas individually through their interactions with environment not by merely imparted knowledge to them. Therefore, the later curriculum focussed interactions among teachers and students around content toward accomplishment of students' learning goals. Teachers assume a significant position in determining students' learning opportunities.

Mathematics is a compulsory core subject in Malaysian Secondary School Integrated Curriculum in which all secondary school students must enrol. Malaysian mathematics education is aims to make certain that every student graduated from school are equipped with the knowledge and skills in Mathematics which eventually will benefit them, the society and the nation in future run. The Secondary School Mathematics Curriculum provides a framework which emphasized on learning outcomes, the acquirement of knowledge and skills, and development of students' personal values and positive attitude for all students to success in life. There are five principles of learning Mathematics are being emphasized namely, problem solving, making connection, reasoning, communication in mathematics, and the usage of technology in teaching and learning of mathematics. The syllabus of mathematics is developed based on three major areas, number, shape, and relations in topics of number, algebra, trigonometry, geometry, functions and graphs, statistics and probability.

Algebra is one of the topics that introduced to secondary school when they entered Form One and it is taught across educational level up to Form Five. According to Malaysian secondary school mathematics syllabus, the algebra topics for Form 1 are algebraic expression I, patterns and sequences; topics for Form 2 are algebraic expression II, linear equation I; topics for Form 3 include algebraic formulae, linear equation II, linear inequalities, and graphs of functions; topics for Form 4 cover quadratic expressions and equations, and the straight line; topics for Form five are graphs of functions II, gradient and area under a graph (Ministry Of Education, 2004).

Students must acquire good mastery in mathematics knowledge and skills to excel in life. The challenge in education today is to effectively teach students of diverse abilities, different pace of learning, and from different culture context so that all of them are able to learn mathematics concepts with understanding and develop positive values towards mathematics learning. To achieve that, teachers are expected to be equipped with good content knowledge and effective instruction strategies in conducting mathematics lessons.

1.1.2 Mathematics Learning Theories

There is a long tradition of teachers adopting an essentially behaviourist approach in their mathematics teaching. Behaviourism is established on the notion that learning is the outcome of behavioural changed as a result of a response to a stimulus (Skinner 1953). It regards learning as a system of behavioural responses to physical stimuli, driven by reinforcement, practice and external motivation. In this framework, mathematical knowledge is external, absolute and teaching is didactic (Klinger, 2009). Learning is seen as the correct application of appropriate algorithms to obtain correct answers, practice and by studying worked examples, with behaviour conditioned and reinforced positively by "rewards" of success. This direct instruction such as lectures, whole class discussions, examinations, assignments, tests, and grading were used in behaviourist classrooms. The teacher is the authoritative possessor of knowledge, and students are passive recipients of selected aspects of that knowledge. The knowledge is reinforced by drills for memorisation and through practices with resources from the

textbooks. The use of textbooks constitutes a further authoritative source of knowledge (Ewing, 2011).

Malaysian school students were exposed to behaviourism teacher-centred learning such as rote learning styles and an examination-oriented system in their formative school years (six years of Primary School and seven years of Secondary School). Trends in International Mathematics and Science Study 2011 (TIMSS 2011) reported the fact that the most dominant activities in mathematics classroom were teacher lecture, teacher-guided and textbook as the primary material of their lessons (Mullis, Martin, Foy, & Arora, 2012). In such a teaching and learning environment, students become passive learners and resort to rote learning. In fact, students resorted to memorizing facts to excel in their examinations and tests which were carried out on a monthly, semester, and annual basis. The over-emphasis on examination results has led to the adoption of certain teaching and learning strategies such as rote learning and spoon feeding rather than the acquiring of critical mathematical skills.

Although the mathematics instruction which adopted behaviourism is considered a not-so-good strategy by many educators, community and schools however, many researchers have provide positive evidence of this strategy when used and integrated with other upcoming strategies. The upcoming strategies are self-learning element (Ziegler & Stern, 2014), self-explanation strategy (McEldoon, Durkin & Rittle-Johnson, 2013; Mokmin & Masood, 2015), and web-based homework (Leong & Alexander, 2014). All these studies have shown positive improvement of mathematics after the combined treatment. Evidences also showed this practice had been effective in remedial instructional program for students with learning difficulties and mainstream students (Ewing, 2011).

In pursuant, cognitivism surfaced in response to behaviourism (Ertmer, & Newby, 2013). Cognitive theories focus on constructing meaningful knowledge and assisting students to organize and connect newly learned knowledge to existing knowledge in learners' memory (Ertmer, & Newby, 2013). For mathematics learning, cognitivism stresses on algorithm process through activity of problem solving. While in cognitive load studies, cognitivist proposed to reduce cognitive working memory load to assist learner to acquire mathematical concept (in specific, the algebraic concept). For example, studies used correct and incorrect examples in algebra (Guo & Pang, 2011; Mceldoon et al., 2013; Booth, Lange, Koedinger, & Newton, 2013) to improve students' algebraic achievement. Thus, cognitivists studies persist as one of the instructional modes in current mathematics classrooms.

On the other hand, constructivism describes students as an active participator in constructing knowledge (Piaget, 1974). The central principle of constructivism is that knowledge cannot be transmitted thus inferred learners have an active role in building understanding with skills such as exploring, hypothesizing, creating, reflection and etc. The teacher surrenders the role of didactic authority to become a facilitator of the learning process by providing students with opportunities to discover, explore and apply ideas that will satisfy their learning objectives. It focuses on general aspects like the types of activity; mastery learning (Abakpa &Iji, 2011), inquiry learning methods

(Kogan & Laursen, 2014), to assist students to grasp certain concepts. While social constructivism proposed teaching and learning is an interaction among teacher and students around the learning contents toward accomplishment of students' learning goals. Social constructivism maintains that knowledge must be socially situated and knowledge is developed through interaction with others from guided learning within the zone of proximal development (Vygotsky, 1978). This view is different from Piaget's idea which centred on individual cognitive development and learners construct knowledge of their own. Though these activities are much student centred but they do not focus on ways of dealing with the specific features and structure of content of learning such as algebra.

In accordance, Variation Theory proposes that learning only occurs when a person went through different ways of perceiving things or learning in essence, learners can only experience different perceptions or learning by seeing how the different features differ (Marton & Booth, 1997). Marton and Tsui (2004) described that a person must discern a variety of features to see something in a certain manner; being told or taught to look for is not sufficient for a learner to be learnt. This is what Bowden & Marton (1998) specified about, 'what is learned' signifies, 'what variation is learned'. Lo and Marton (2012) indicated that the primary part of Variation Theory is to improve the quality of teaching by assisting teacher to focus on 'necessary conditions of learning'. Teachers must carefully decide what the object of learning is; its critical features and how students' will understand an object of learning. Teachers are also required to determine what their intended objects of learning are and later enact them in the classroom (Lo, Chik, & Pang, 2006). Awareness, discernment and experiencing variation are important for students' learning. Thus, educators are urged to come up with conducive learning environment which encourage students to discern critical features of the object that they are supposed to learn with deliberately used of variation as a pedagogical tool which should be tailored to the students' needs.

1.1.3 Students' Achievement in Algebra

Malaysian students' achievement in algebra is not as excellent as educators or society in general would like to see. Ameer and Parmjit (2013) found that secondary school students performed weakly in the Numeracy Test even though they managed to obtained grade A in their mathematics examination. They were unable to make sense of number, reasoning and making comparison which caused the deficiency in numeracy skills. Report from Trends in International Mathematics and Science Study (TIMSS) in year 2011 also indicates Malaysian students scored the least in algebra among the five content areas that been assessed. This report evoked the urgency to sought and effective algebra improvement instruction specifically in Malaysia.

A study led by Ministry of Education Malaysia reported in Organisation for Economic Co-operation and Development (OECD, 2013) report discovered that half of the lessons in the classroom were on superficial content understanding, instead of acquiring mathematical skills. Several Malaysian local studies reported similar findings as OECD's. Nadirah et al. (2012) reported students have a tendency to repetition learning guidelines, definition without comprehend the genuine ideas; Lim (2010) likewise

uncovered that numerous students still fail to offer a proper understanding of algebraic expressions. The same finding disclosed by Abdullah (2010) that majority of students participated in her study on the topic of function have yet to master basic operations of algebra and they seem to be operating superficially with the symbols. Reports from Jamaliah (2001), Ruzlan (2007), and Lim & Hwa (2011) showed teachers still compel the students to follow algorithms rigidly without a session for student to explore, experience and to understand concepts. Students passively accepted doctrines and techniques without any effort to explore the properties and relationships in numbers and operations. These studies provided evidences that "drill and practice" and memorization of facts and procedures were the common approach in teaching and learning in mathematics in Malaysia.

1.1.4 Predicaments in Learning Algebra

Most of the problems which students encountered when they were first introduced to algebra were the different set of rules employed in algebra as compared to in arithmetic (Kieran, 1992). At the same time, they must acquired skills in conducting algebra operations with appropriate rules, pattern construction and analyses. These components are the foundation of algebra structure which is abstract to students. The abstractness of algebra structure exaggerated the difficulties in learning algebra (Kieran, 1992; Bush & Karp, 2013). It becomes the stumbling block for a great numbers of students to develop the algebraic concepts or representations (Kieran, 1992).

Furthermore, algebra notation functions as a language of its own. Students also wrestled with algebra notation and symbolism (Bush & Karp, 2013). Students find algebra is difficult because they are required to learn the syntax of symbolic representation as well as dispose their preceding understanding and practices in arithmetic (Byrd, McNeil, Chesney, & Matthews, 2015).

Kieran (1992) attributed various misunderstandings perpetrated by students while learning algebra being due to their unawareness of the structure of expressions and equations. These structural features of algebra refrains students from being familiar with algebra to establish the numerical relationships which disrupted students' algebra development eventually.

In algebra learning, teachers should help students in making relationships between the symbols used in different context. The algebraic structure of terms and symbol should be identified so that students can gain intuition on structural understanding before proceed to procedural thinking. However, the instructional approach used in the classrooms often worsens algebra learning difficulties (Rakes, Valentine, McGatha, & Ronau, 2010). Teaching strategies that over emphasis on procedural skills fall short to tackle the foundational understandings of algebra and therefore unsuccessfully to endow students with the essential tools to support students in their understanding of algebra (MacGregor & Stacey, 1993; Rakes et al., 2010; Yahya & Shahrill, 2015). To

these students, algebraic rules were perceived as operational procedures (formulas) to be memorized with or without fully in algebraic conceptual. As a result, many students had difficulty keeping track of algebraic rules and using it appropriately. These students did not have ample time to develop good intuitive foundation of algebra ideas, or to relate the algebraic ideas with pre-algebraic ideas which they learned in primary school. Thus, they were unable to construct understanding of new symbolism used in algebra and reduced to perform operations on symbols without understanding (Drijvers, Goddijn, & Kindt, 2011).

The above literature revealed that students faced difficulties in learning algebra because most of them only acquired surface (instrumental) understanding of algebra instead of relational understanding (Skemp, 1985) in their algebraic lessons. Teaching method used in the algebra classes influenced students understanding of algebra. Inadequate knowledge of algebra probably would have caused students make errors. Students need to fully grasp the key features of the instructional information. Therefore, appropriate instructional strategy to promote students' understanding of algebra is important. The knowledge of the common algebra learning difficulties can provide teachers with insights into students' thinking thus provide appropriate remedial measure to tackle the problems.

Despite all, students' achievement in mathematics is known to be influenced by psychosocial factors as well, such as self-confidence (Stankov, Lee, Luo, & Hogan, 2012), self-concept (Seaton, Parker, Marsh, Craven, & Yeung, 2014), attitude (Bhowmik & Roy, 2016), anxiety (Beilock & Maloney, 2015), self-efficacy (Skaalvik, Federici, & Klassen, 2015; Guo et al., 2015; Marsh et al., 2013). Other socio-cultural factors include parental involvement (Karbach, Gottschling, Spengler, Hegewald, &Spinath, 2013), teacher, school characteristics (Petty, Wang, & Harbaugh, 2013), educational aspirations (Guo, Marsh, Parker, Morin, & Yeung, 2015), gender and socioeconomic background (Guo et al., 2015). These factors have impacted students' achievement in mathematics.

As indicated above, there is a strong relationship between students' affective disposition and mathematics performance, although the direction of causality between them is unclear. It is a known fact that students with positive views of themselves and their academic competences will engage in achievement-related activities. Students' beliefs, interests, views on mathematics influence the choices they make and thus, significantly determining students' achievement.

1.1.5 Motivation toward Learning

Many studies have been conducted on student motivation which is the foundation for teacher to make effort to improve student achievement in mathematics. The findings indicated that there is positive relationship between mathematical motivation and academic achievement (Keller, 2010; Plenty & Heubeck, 2013). To engage students and maintain their motivation at high level can be a challenging task as many intrinsic and extrinsic elements and factors can effect student motivation (Mueller, Yankelewitz,

& Maher, 2011). The relationship between motivation of learning and mathematics achievement had been a main interest in mathematics education research (Sartawi, Alsawaie, Dodee, Tibi, & Alghazo, 2012). International tests such as TIMSS have recognized a decline in the mathematics achievement and motivation of middle school students (Martin, Herd, Alagaraja, & Shuck, 2012). There was also other evidence showed that mathematics high achiever is not necessarily positively associated with their motivation to learn (Hardré, 2012; Murayama, Pekrun, Lichtenfeld, & VomHofe, 2013). Even high achievers may have doing great in mathematics but they may suffer from anxiety about disappointment and social pressure to perform at higher level mathematics (Stipek, 2002; Thien & Ong, 2015).

Although there are no definite findings in the relationship between students' motivation of learning mathematics and mathematics achievement, high motivation of learning mathematics is still documented as one of the critical component in mathematics learning. The challenge for teachers is to find effective way to provide the learning environment that will foster students' motivation toward learning mathematics. Hence, this motivated the researcher to investigate on effect of instructional strategy on students' achievement and motivation towards learning.

1.1.6 Location of School

Numerous studies have been conducted on factors influencing students' mathematics achievement such as age, gender, family structure, ethnicity, parents' educational level, socio-economic status, school location (Owoeye & Yara, 2011; Graham & Prokost, 2012), and parental involvement (Hui, 2014). D' Entremont (2015) proposes the importance of linking mathematics learning and cultural diversity of the students in the process of teaching and learning. This was supported by social-cognitive constructivist, Vygotsky (1978) who viewed students receives the knowledge initially through interactions with people, and then assimilates this knowledge with their own values. This emphasizes the important of culturally relevant pedagogy especially for the same group of students from similar background and community.

Studies have also shown that the geographical location of school has been debated as a factor that influenced students' mathematics achievement. The school location usually refers to schools that are located urban or rural areas (Orji, 2013). Owoeye and Yara (2011) asserted that school location is one of the important factors that determined the distribution of learning resources, academic achievement, enhanced social and physical environment, teacher quality and academic support systems, than those in rural schools. The issue of less well performance of rural students compared to their urban counterparts in has been highly debated among scholars in academic field.

Rural school in many developing or under developed countries is often synonymous with disadvantages for learning. Owoeye and Yara (2011) observed that many parents prefer their children to attend schools in urban areas because they believe that students from urban schools perform better than their counterparts from rural schools.

Therefore, it is important to provide similar instructional strategy to reduce urban-rural disparities in student learning;

1.2 Statement of the Problem

Study suggested students had incomplete and poor mastery of related algebraic concepts (Nadirah et al., 2012). Other studies cited that students also had difficulties in understanding structural concept of equality and function (Tossavainen, Attorps & Väisänen, 2011; Viirman, Attorps & Tossavainen, 2011). Accordingly, Malaysian teachers are urged to incorporate various teaching approaches in the teaching of mathematics. However reports from local studies had indicated that "drill and practice" was still the most common teaching approach used by mathematics teachers in Malaysia. These teachers believed that the most efficient way to deliver mathematics lesson is to get familiar with routine problems which are given repeatedly (Zanzali, 2012). The situation illustrated practices contradicted to Piaget's (1964) constructivism learning theory which postulated students learn best when they are fully involved in the construction of knowledge themselves and not from transmission of knowledge imparted by teachers (Piaget, 1964). According to Vygotsky (1978) students must be a active participant in learning, and that is is essential of students to experience variation during mathematics learning (Marton & Booth, 1997). If this situation is not deal properly, our students will be lagging behind not only to the developing countries but further to less developed countries like Vietnam and Indonesia.

Analysis of lessons held in Asian nations that performed well in Trends in International Mathematics and Science Study such as Japan (Stigler & Hiebert, 1999), South Korea (Park, 2012), and China (Li, Peng & Song, 2011) demonstrated that teachers in mathematics classrooms enacted features of the content in a systematic way with consideration of variation and students' capabilities. Park (2012) reported rich variations in instruction and practice; and found that a "systematic" and "continuous" variation can lead students to understand the concept.

Several studies have proved that instructional design based on variation theory demonstrated potential in assisting students in concept understanding (Marton & Pang, 2013). However, there is limited number of accessible empirical data to substantiate the undertaking of teaching with variation (Cai & Nie, 2007). Most of the studies in Variation Theory have been conducted in the structure of Learning Studies (Wood, 2012; Lai & Lo-Fu, 2013; Holmqvist Olander & Nyberg, 2014), a hybrid of lesson study and design experiments research (Brown, 1992). Only a handful of experimental studies have evidence that the use of patterns of variation would uphold students' learning in algebra. For example, Al-Murani (2006) studied the integration of dimension of variation in teacher awareness framework to improve students' algebra achievement, Choy (2006) and Guo & Peng (2011) examined the separate and contrast variation in geometry topics. There is no known studies examine the effectiveness of Variation Theory in developing algebraic competency in Malaysia. A study of the effects of Variation Theory using teaching and learning modules on Malaysian students' achievement needs to be undertaken so that clearer picture of appropriate instruction can be used in classroom.

Fostering good feelings in learning mathematics is still greatly acknowledged as one of the important elements in building students' mathematical ability and understanding. The challenge in education today is how to teach students with different abilities and learning paces effectively, assist them to learn mathematics concepts with understanding and the same time enjoy the process of learning mathematics. While previous studies indicates that there were positive effects of variation theory teaching on students' performance however there was lack of evidence of students' motivation towards learning (Wong, Kong, Lam & Wong, 2010). The group of researchers found that some students' motivation in learning mathematics declined after the experimental phase. The researchers attributed this affective reaction to difficulties of problem solving questions which created frustration among low performance students. However, there is no evidence of effects of Variation Theory on both performance and learning motivation. Therefore, it would be essential to find the effects of integrating Variation Theory strategy in mathematics instruction in promoting motivation besides enhanced performance in mathematics among Malaysian students.

Despite the enormous literature on students' difficulties in mastering basic concepts, principles and appropriate order of operation in algebra (Kieran, 1992; Bush & Karp, 2013; Byrd et al., 2015) yet the knowledge on types of difficulties were not available to teachers. Without these knowledge, they might have underestimated the complexity of the individual learning process of mathematics and take an immature approach to teaching those concepts. If those difficulties in learning algebra can be identified, it would be possible to design effective instructions to overcome learners' difficulties, specifically in learning algebra.

There is still short of empirical data on types of students' difficulties in algebra especially in different school locations in Malaysia. The existing research is mostly about examining, identifying and explaining causes for specific difficulties. Hence, if researcher can identify students' difficulties in learning algebra and extend it to the area (topic) of algebra, it will be easier to identify types of difficulties based on pattern of errors that spread through the topics and make suggestions for remedial instruction.

One of the focal in education studies conducted by researchers in developing countries is regarding the rural disadvantages in education quality. Existing literature have centralized on disparities of mathematics achievement among students in different school locations in developing countries and the findings did not favour the rural schools (Singh, Rahman & Teoh, 2010; Ijenkeli, Paul, & Vershima, 2012; Uwaezuoke and Ekwueme, 2015). The differences in academic achievement may be related to insufficient of learning resources such as infrastructure and facilities, teaching and learning materials, teacher quality and academic human resources in those schools, which affects students' academic achievement (Graham & Prokost, 2012). However, reports on teaching quality in the classroom (Othman & Muijs, 2013) showed that this is not the only pertinent factor. Therefore, the effects of instructional strategy conducted in the classroom are crucial to be known to educators so that appropriate actions corresponding to the teaching and learning process can be taken.

To improve mathematics learning, recent studies in Malaysia have focused on technology tool related mathematics learning; effects of graphic calculator (Tan, 2012; Idris & Meng, 2011), Geometer's Sketch Pad (Leong & Alexander, 2014), Geogebra (Shadaan & Leong, 2013), spreadsheet (Chin, 2015) on students' achievement across all grade levels. Even though these studies yielded with significant results, however the utilization of technological tools in Malaysian rural schools are rather difficult. The availability of the technological tools and the accessibility to the teaching resources is one of the main challenges particularly in the rural areas.

While integrating variation theory in teaching and learning in the classroom showed improvement in many learning subjects, there were no known studies investigated the effectiveness of this instructional strategy in different school location. As it is asserted by D'Entremont (2015), different culture in different location contributed to the learning of mathematics. Derive from these issues, this study seeks to investigate the effect of algebra instruction incorporating Variation Theory-Based Strategy on student's algebraic achievement, motivation of learning and subscales, and students difficulties in learning algebra among secondary two (Form Two) students in Malaysia.

1.3 Objectives of the Study

The effectiveness of VTBS was examined based on students' algebraic achievement, motivation and subscales (attention, relevance, confidence, and satisfaction). Difficulties of learning algebra among all groups of students were also examined at the end of the study. The objectives of this study are to:

1. Compare the effects of Variation Theory-Based Strategy (VTBS) and Conventional Teaching Strategy (CTS) on algebraic achievement among Form Two students in urban and rural schools.
2. Compare the effects of Variation Theory-Based Strategy (VTBS) and Conventional Teaching Strategy (CTS) on motivation among Form Two students in urban and rural schools and its four subscales (attention, relevance, confidence, satisfaction).
3. Determine the difficulties in learning Form Two algebra among (VTBS) and Conventional Teaching Strategy (CTS) students in urban and rural schools.

1.3.1 Research Hypotheses

The null hypotheses were derived based on the above research objectives:

$H_0$1: There is no significant difference in the means of students' algebraic achievement test between VTBS and CTS groups in urban school while controlling Pre-test scores.

$H_0$2: There is no significant difference in the means of students' algebraic achievement test between VTBS and CTS groups in rural school while controlling Pre-test scores.

$H_0$3: There is no significant difference between the means algebraic achievement of urban and rural school students taught algebra using VTBS while controlling Pre-test scores.

$H_0$4: There is no significant difference between the means algebraic achievement of urban and rural school students taught algebra using CTS while controlling Pre-test scores.

$H_0$5: There is no significant interaction effect in students' motivation of learning algebra mean scores for different instructional strategy (VTBS and CTS) and school location (urban and rural).

$H_0$6: There is no significant difference in students' students' motivation of learning algebra mean scores between instructional strategy (VTBS and CTS) groups.

$H_0$7: There is no significant difference in students' students' motivation of learning algebra mean scores between school location (urban and rural).

$H_0$8: There is no significant interaction effect in students' attention mean scores for different instructional strategy (VTBS and CTS) and school location (urban and rural).

$H_0$9: There is no significant difference in students' attention mean scores between instructional strategy (VTBS and CTS) groups.

$H_0$10: There is no significant difference in students' attention mean scores between school location (urban and rural).

$H_0$11: There is no significant interaction effect in students' relevance mean scores for different instructional strategy (VTBS and CTS) and school location (urban and rural).

$H_0$12: There is no significant difference in students' relevance mean scores between instructional strategy (VTBS and CTS) groups.

$H_0$13: There is no significant difference in students' relevance mean scores between school location (urban and rural).

$H_0$14: There is no significant interaction effect in students' confidence mean scores for different instructional strategy (VTBS and CTS) and school location (urban and rural).

$H_0$15: There is no significant difference in students' confidence mean scores between instructional strategy (VTBS and CTS) groups.

$H_0$16: There is no significant difference in students' confidence mean scores between school location (urban and rural).

$H_0$17: There is no instructional strategy (VTBS, CTS) and school location (urban, rural) on students' satisfaction subscale.

$H_0$18: There is no significant difference in students' satisfaction mean scores between instructional strategy (VTBS and CTS) groups.

$H_0$19: There is no significant difference in students' satisfaction mean scores between school location (urban, rural).

1.3.2 Research Question

In line with the above research objectives in this study, the following research question was considered:

What are the difficulties in learning algebra among students in urban and rural based on their responses on the post-test scores?

1.4 Significance of the Study

Most studies on Variation Theory were conducted in the structure of Learning Studies; a hybrid of Lesson Study (Fernandez & Yoshida, 2004) and Design Experiment (Brown, 1992). While Lesson study is a systematic approach by a group of teachers to improve instruction through school-based professional development, learning study is a variety of this lesson study with an explicit learning theory, the Variation Theory of Learning (Pang, 2009). There were only a few studies carried out in the structure of experimental or quasi-experimental. The product of this study can be replicated for future research which aims to analyze the effectiveness of Variation Theory of Learning in lower secondary education with Variation Theory-Based Strategy Model as a feasible research framework.

The results of this study contributed to the pool of pedagogical knowledge in implementing variation theory based for teaching and learning algebra. The utilization of Variation Theory-Based Strategy enhanced students' conceptual understanding and developed their procedural skills through activities in varying ways. The teaching and learning lessons were designed catered to the ability of the students. While the learning tasks were designed involved groups, pairs and individual. It promotes students' cognitive, affective and social experience.

The modules developed by researcher, provided guidelines for teachers to possibly use Variation Theory in their lessons, especially in the topic of algebra. Subsequently, the instruments of the study might also be used as assessment tool to evaluate the strengths and weaknesses of the students' understanding of algebra and motivation. The results of this study also provided indispensable information about teaching instruction in algebra skills. By analyzing students' difficulties in algebra regarding variable, algebraic function, solving equation, and word problems, it provide teachers insight into the content of the topic, plan their teaching accordingly and enhance the effectiveness of algebra teaching by eliminating the difficulties. This study also benefits the fields of secondary education and cognitive psychology since it addresses the motivational aspects in mathematics learning.

It also serves as a starting point, to evoke awareness for policymakers and educators to look for useful strategy to be used in Malaysia. The findings of this study may also indicate new grounds for Curriculum Development Section in Ministry of Education Malaysia and mathematics textbook writers on the need and necessity to incorporate Variation Theory based instructional strategies in the planning and writing of mathematics textbooks. To conclude, this study is beneficial to students, teachers and educators, Ministry of Education who are seeking for alternative instruction strategy.

1.5 Limitations of the Study

This study limits itself to conducting instruction and gathering survey data from secondary two students in Kuching and Samarahan Division in Sarawak in late March to early May. The results of this study were indications of effects of Variation Theory Strategy on students‟ algebraic achievement, motivation toward learning in compare to conventional teaching strategy.

By nature of quasi-experimental studies, the generalizability was decreased. The findings of this study cannot be counted as a true experimental design to evaluate the effectiveness of VTBS. Therefore, the findings of the study limited to population in the similar settings.

This study also focused specifically on algebra learning (two chapters in Form Two syllabus) not whole course of lower secondary school algebra (Form One till Form Three). When a whole course of algebra is studied, different results could occur due to different degree of difficulties in each level of algebra. This Form Two algebra chosen for this study could have been more or less difficult than other level which could have affect algebraic achievement and students' motivation of learning toward algebra. Students in a different grade level, at a different school, in a different geographical location, or in a different subject area could have different academic strengths and weaknesses. Therefore, the findings of this study were limited to Form Two algebra.

This study engaged different teachers from urban and rural schools in the classroom. Their characteristics, teaching style, teacher support might have affect students' motivation of learning toward algebra. Thus, the purpose of the study is not to evaluate the effectiveness of VTBS but to provide evidence of interaction of participants in learning algebra.

1.6 Definitions of Terms

The definitions of terms used in this study are as follows:

1.6.1 Variation Theory-Based Strategy

The Variation Theory-Based Strategy is an instructional strategy which focuses on variations of a critical aspect of an object of learning through a deliberate and systematic handling of content which is called dimension of variation (Marton & Booth, 1997). The variation within the dimension of variation is called the range of change (Watson & Mason, 2005). By systematically and deliberately controlling the variation in gradually developed learning tasks, teacher directs students' attention on

particular aspects of algebra, thus increasing opportunities of students to experience the variation.

In this study, the Variation Theory-Based Strategy was provided in the form of instruction in the classroom, learning tasks, and material of Form Two algebra topics with references to Teacher's Module and Students' Module. Teacher's module consists of lesson plans and suggested learning activities which incorporated dimensions of variations and range of change while Students' Module comprises of practices with the similar features of variations. Variation Theory-Based Strategy is used in this study for the algebraic learning in Form Two mathematics classes to achieve learning outcomes. The scope of the topics include; Algebraic Expressions and Linear Equation. These two topics were planned for 25 lessons (40 minutes per lesson).

1.6.2 Conventional Teaching Strategy

Conventional Teaching Strategy is a classroom which used direct instruction; traditional teacher-centred approaches that focus on transmission of knowledge, algorithms, and drill and practice (Ewing, 2011). The teacher dominates the discussions in the classroom, and focus on content based knowledge provided by textbooks. The role of students during the process of learning is minimal as a knowledge receiver (Ewing, 2011).

In this study, conventional teaching strategy referred to instruction of algebra class which teachers used explicit explanations and demonstrations of concepts through examples without any particular or systematic way of variation in handling the content of algebra. Teachers used mathematics text book as main reference and students were provided a work book for practice. The topics also covered; Algebraic Expressions and Linear Equation. These two topics were planned for 25 lessons (40 minutes per lesson)

1.6.3 Algebraic Achievement

Algebraic achievement is conceived as students' abilities in acquisition of algebraic factual knowledge (concepts) and procedures, abilities (skills) in recognizing algebraic relation and functioning, and computing the values of algebraic expressions (Russell, Schifter, & Bastable, 2011). Thus, algebraic achievement is highly influenced by students' algebra experience and computational competency in algebraic thinking.

In this study, algebraic achievement referred to total scores of 24 items multi-choice (A, B, C, D) test on knowledge and skills (as a learning outcomes of instructional strategy) related to content in the topics of Algebra Expressions and Linear Equations in Form Two Syllabus. Algebra Test (AT) is curriculum-based achievement measurement adapted from Chow (2011) focussed on algebraic knowledge and skills related to content specified within the objectives of the Form Two syllabus in the topics

of Algebra Expressions and Linear Equations (Ministry of Education, 2004). Two measurements of algebraic achievement on Algebra Test were taken. The test measures; basic understanding of variables, use of letters, symbols or variables, appropriate rules to solve equations, solves problems by identifying a predictable visual or numerical pattern, translates words into algebraic expressions, analyses and generalizes number patterns and find the appropriate rule for the relationship, and solves problem using simple equations with symbolic expressions or words. The test consists of 24 item with four multiple-choice for each question. The total score was 100 for each test. Students' algebraic achievement reflected by the percentage of items answered correctly.

1.6.4 Motivation of Learning

According to Keller (2010), motivation is an individual desire to pursue a goal or perform a task (Keller, 2010). Keller (2010) proposes that instructional designer should always consider how to motivate learners while developing instructional, because learners' motivation can be influenced by external phenomenon. And, motivation can influence students' learning outcomes. Thus, teachers should create learning environment and materials which are presented in a way that is engaging and meaningful to the student thus motivate learning. Keller's motivation model, ARCS (Attention, Relevance, Confidence, and Satisfaction) is one of the most appropriate motivational instructional designs.

In this study, promoting students' motivation was considered as instructional strategy outcomes through instructional material. The Keller's Instructional Material Motivation Survey (IMMS) was used to measure students' motivation to learn Form Two algebra. The IMMS was adapted and used to measure students' motivation to learn algebra after the treatment. Students' motivation of learning referred to the total combined scores on 36 items that measure students' attention, relevance, confidence, and satisfaction subscale through instructional material.

1.6.5 Attention

Keller (1987) breaks down attention into three different types: perceptual arousal, inquiry arousal, and variability. A range of variety in activities should be included in instructions to sustain students' feelings of novelty thus the attention can be maintained throughout the lesson.

In this study the attention subscale referred to the total score on the 12 items that measure students' attention in perceptual arousal, inquiry arousal, and variability as a subscale of motivation toward learning.

1.6.6 Relevance

Keller (1987) defines relevance is a link between the instructional material with the learners wants and needs. It can be achieved three different ways: goal orientation, motive matching, and familiarity.

In this study, relevance referred to total score of nine items on students' experience in algebra learning in the aspect of goal orientation, motive matching and familiarity, as a subscale of motivation toward learning.

1.6.7 Confidence

Keller (1987) defines confidence as element that help students believe in themselves. This will help students believe they will do well and control their accomplishment. Student who believe in their potential in success are more motivated to wield efforts to be successful. Keller and Suzuki (1988) characterize its three most important aspects: perceived competence, perceived control, and expectancy for success.

In this study, confidence referred to the total score on nine items as subscale of students' experience in algebra learning in the aspect of perceived competence, perceived control, and expectancy for success, as a subscale of motivation toward learning.

1.6.8 Satisfaction

Satisfaction provides a positive feeling about the learners' accomplishments (Keller, 1987). Students must be satisfied with the learning experience in order to maintain motivation. The three types of satisfaction strategies are: intrinsic reinforcement, extrinsic rewards, and equity.

In this study satisfaction referred to the total score on six items as subscale students' experience in algebra learning in the aspect of intrinsic reinforcement, extrinsic rewards, and equity, as subscale of motivation toward learning.

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LIST OF PUBLICATIONS

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