EFFECTS OF COMPUTER-BASED TESTING FEEDBACK ON STUDENTS' ACHIEVEMENT AND ERRORS IN ALGEBRAIC EXPRESSIONS.

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EFFECTS OF COMPUTER-BASED TESTING FEEDBACK ON STUDENTS' ACHIEVEMENT AND ERRORS IN ALGEBRAIC EXPRESSIONS.

by

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CBT	Computer-based testing (CBT)	2
PPT	Paper-and-Pencil Test	2
AEET	Algebraic Expression Errors Test	67
XAMPP	Cross-platform Apache HTTP Server MySQL PHP Perl	76
SPSS	Statistical Package of Social Sciences	85
PCA	Principal Component Analysis	89

KESAN MAKLUMBALAS BERASASKAN KOMPUTER TERHADAP PENCAPAIAN DAN KESILAPAN PELAJAR DALAM UNGKAPAN ALGEBRA.

ABSTRAK

Algebra adalah satu cabang matematik yang menggantikan nombor dengan perkataan. Ia merupakan kursus asas bagi pengajian lanjutan dalam matematik. Namun demikian, pelajar-pelajar sentiasa menghadapi kesukaran dan kesilapan semasa mempelajari ungkapan algebra dan ia menjejaskan perkembangan kognitif mereka. Di samping itu, teknologi pendidikan memainkan peranan yang penting dalam memperbaiki proses pengajaran dan pembelajaran, termasuklah Ujian Berasaskan Komputer (UBK), di mana pelajar-pelajar dapat menerima maklumbalas yang bermakna tentang pencapaian mereka dalam masa yang singkat. Kajian ini bertujuan mengkaji kesan maklumbalas berasakan ujian komputer terhadap pencapaian dan kesilapan pelajar dalam ungkapan algebra. Pada masa yang sama, ia mengkaji pandangan pelajar terhadap maklumbalas berasakan ujian komputer. Tambahan pula, ia mengkaji samaada terdapat perbezaan antara jantina atas kesan maklumbalas berasakan ujian komputer terhadap pencapaian dan kesilapan pelajar dalam ungkapan algebra. Reka bentuk kuasi eksperimen (ujian pra/ujian pos) telah digunakan dalam kajian ini. Keputusan kajian ini mencadangkan bahawa terdapat kesan maklumbalas berasakan ujian komputer terhadap pencapaian dan kesilapan pelajar dalam ungkapan algebra. Selain itu, tiada perbezaan yang signifikan bagi pencapaian antara pelajar lelaki dan perempuan. Tambahan pula, perbezaan bagi kesilapan antara jantina adalah tidak selaras dan ia bergantung kepada kesilapan yang

berbeza. Akhir sekali, persepsi pelajar terhadap maklumbalas berasakan ujian komputer yang disampaikan telah dikaji. Kajian ini menekankan kepentingan struktur dan kriteria maklumbalas dalam keberkesanannya, peranan Teori Ohlsson – Belajar Daripada Kesilapan Prestasi (1996) dalam maklumbalas dan kelebihan menggunakan maklumbalas berasakan ujian komputer.

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ABSTRACT

Algebra is a branch of mathematics that substitutes letters for numbers. It is the gatekeeper course to advanced study in mathematics. However, students always face difficulty and have misconceptions in learning algebraic expression and it influences their cognitive development. Meanwhile, educational technology has served as an important tool in improving teaching and learning process, including computer-based testing (CBT), which students can be accessed and receive valuable timely feedback on their performance. This study aimed to determine the effects of computer-based testing (CBT) feedback on students' achievement and errors in algebraic expressions. At the same time, it contributed to build a richer picture of students' view of feedback, by finding out how the CBT feedback delivered was perceived by students. Moreover, it explored if there is any significant difference between genders of the effect of CBT feedback for students' achievement and errors in algebraic expressions. A pre-test/post-test quasi experimental design was adopted in this study. The findings suggest that there are significant effects of CBT feedback on students' achievement and errors in algebraic expressions. Besides, there is no significant difference in achievement between male and female students. Meanwhile, there is inconclusive difference of the effects of CBT feedback between genders on students' errors and it varies according to different errors. Lastly, students' perception towards the CBT feedback delivered was revealed. This study highlights the important of feedback's structure and criteria for it to be effective, the role of

Ohlsson's Theory - Learning from Performance Errors (1996) in feedback, and the advantage of using CBT in giving immediate feedback to students.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Algebra is a branch of mathematics that substitutes letters for numbers. It uses common arithmetic operations that deals with signs and symbols. In algebra, symbolic variables such as x, y, z are used to symbolize general numerical relationships and mathematical structures. Thus, it is regarded as generalized mathematics as well (Ilyas, Rawat, Bhatti, & Malik, 2013; Katz, 2007). It is synonymous with variables, a quantity that changes and varies. It can be replaced by any number from some set. Simply say, algebra is about finding an unknown by putting a problem into equations and then solve it. It has long been recognized by educators as playing a fundamental role in the exploration of most areas of mathematics (Carraher & Schliemann, 2007; Kieran, 2007). It is the gatekeeper course to advanced study in mathematics (Robelen, 2013; Welder, 2012). Through algebra, reasoning, thinking, problem solving, patterns and other skills can be developed.

To achieve learning objectives in algebra, it is important to ensure the effectiveness of students' learning process and identifying the learning barriers. McNeil et al. (2010) stated that learning barriers are formed by students' incomplete existing knowledge or misconceptions. Students always face difficulty and having misconceptions in learning algebraic expression. Algebraic misconceptions can inhibit students from attaining the necessary concepts that are needed to be successful in algebra (Russell, O'Dwyer, & Miranda, 2009). Misconceptions occur when students fail to link new knowledge to previous knowledge for which the brain

has established cognitive networks (Hiebert & Carpenter, 1992). Once misconception is rooted in students' memory, it is hard to erase. As a result, students are not able to conceptualize the concept well and it influences their cognitive development (Cepni, Tas, & Kose, 2006). According to Hansen (2005), misconceptions usually leads to errors occurring.

In mathematics, an error means the deviation from the correct solution of a problem (Egodawatte, 2011). Students' errors will remain hidden unless specific efforts are made to address them effectively (Chow, 2011). It is important to let students know what they did well and what they need to improve. Students should reflect on what they learned, how they learned, why they learned, whether the learning experience could have been more effective and so on. This can build connections between new and existing knowledge, maximize opportunities for learning and avoid past mistakes. To achieve this, feedback plays an important role. It has been identified as one of the most powerful influences on the learning process (Hattie, 2009). Meanwhile, educational technology has served as an important tool for both educators and learners in improving teaching and learning process (Van der Kleji et al., 2012). One of the notable use of educational technology is computer-based testing (CBT), a form of assessment in which students answer questions by using computer instead of taking a traditional paper-and-pencil test (PPT). Through CBT, it is possible to provide students with feedback in a timely fashion which leads to better learning outcomes.

1.2 Research Background

In Malaysia, mathematics is a compulsory core subject for all students. A list of algebra topics taught in Malaysian secondary schools mathematics syllabus shows

much depth and breadth required in this area. For example, Form One syllabus (Year 7 equivalent) covers algebraic expressions I, and patterns and sequences; Form Two syllabus covers (Year 8 equivalent) algebraic expressions II with two or more unknowns, linear equations I with one variable, and patterns and sequences; Form Three syllabus covers algebraic formulae, linear equations II, linear inequalities and graphs of functions; Form Four syllabus covers quadratic expressions and equations, and the straight line (linear function); and Form Five syllabus covers graphs of function II, variations, and gradient and area under a graph (Ministry of Education, 2006).

Algebra covers one third of the secondary school mathematics curriculum in Malaysia and considered as an important topic in the Lower Secondary School Evaluation and Malaysia Certificate of Education examinations (Lim, 2010). Therefore, students' proficiency in solving algebraic items is pertinent to overall mathematics achievement in Malaysia national examinations. It is necessary for students to master algebra especially starting from the fundamental level during Form One lessons. Through algebra, reasoning, thinking, problem solving, patterns and other skills can be developed. It is the gatekeeper course to advanced study in mathematics (Welder, 2012; Robelen, 2013). Therefore, it is important for students to master algebra.

Traditionally, large number of students has found that studying algebra is difficult (Carey, 2000). Many researches had been carried out to investigate the learning difficulties of students related to algebra (Chow, 2011; Lim, 2010). The identification of students' difficulties is significant for leading to a better understanding of students. Due to the abstract properties of algebra that include unknowns and variables, expressions and equations, and the expansion of the

meaning given to the equal and minus signs, many students find algebra is difficult (Kieran, 2007). It requires students to learn the language of mathematical symbols that is completely foreign to their previous experiences. Students are having difficulties on different aspects of algebra, such as: the meaning of letters and variables; the use of notation and convention in algebra; the kinds of relationship and methods used in arithmetic (Booth, 1988). Meanwhile, the difficulties in algebra are usually formed by the existing knowledge possessed by students, that may be incomplete or misunderstood (McNeil, 2005). This leads them to perform errors in solving algebra. Students must be given opportunity to identify their errors so that they will be able to correct the errors accordingly.

Meanwhile, technology has been integrated in teaching and learning process to improve students' algebraic achievement. The notion of integrating technology into mathematic curriculum is not new. In ancient Greece, the term "*techne*" refers to the process of applying knowledge systematically to the practical art of instruction. The word "*technology*" has become significant over the last century. It refers to the collection of techniques in producing desired products to fulfill desired needs. Nowadays, educational technology is used widely all around the world to facilitate teaching and learning process. It is the study and ethical practice of facilitating learning process by using appropriate technological resources (Richey, 2008).

The application of technology in educational field offers powerful pedagogical tools. Educators have familiarized in using technology-based tools in their teaching such as computer, projector, PowerPoint presentation, videos, animations and many others. In general, these tools are proven effective in enhancing the quality of teaching activities than the traditional ways such as chalk and talk method.

In mathematics education, educational technology has served as an important element, not only in administration and instructional aspects, but also in assessment aspect. Assessment is an important factor that reflects the outcomes of teaching and learning process. Many assessments are administered every year in every corner of the world. Historically, testing is an old practice in mathematics education that intended to measure examinee's knowledge and skill in certain topics. Paper-and-pencil test (PPT) has been the traditional and common testing platform. Thus, it is also being called as conventional test or traditional test. It is a method of assessment in which items are presented and answered in written form (Sax, 1997).

In line with the development of educational technologies, the trend of assessment is moving from PPT to computer-based testing (CBT). It refers to any application of computers within the testing process. It has become one of the most common forms of testing since 1990s (Wang et al, 2012). It could facilitate teaching and learning process in ways that traditional PPT cannot (Bennett, 2002). It also can reduce the burden of teachers and facilitate to conduct examinations purposely. Moreover, it has the potential to promote more effective learning by testing a range of skills, knowledge and understanding associated with the use of educational technology (Jamil, Tariq, & Shami, 2012).

One of the key advantages of CBT is students can be assessed and receive valuable feedback on their performance. Feedback is the information presented to a learner in response to some actions on the learner's part. It can be provided by an agent, such as teachers, friends, parents, books, experience regarding one's performance. In education, feedback is crucial in improving and has powerful influences on students' knowledge and skill acquisition. It can reduce the discrepancy between students' current and desired understanding (Hattie & Timperley, 2007;

Matthews et al., 2012). There are different types of feedback. For instances, verbal feedback, written feedback, immediate feedback, delayed feedback, critical feedback, affirming feedback, instructive feedback and many more. The type of feedback reflects its properties that might be the same, or slightly different from each other. The role of feedback is notable in learning as it informs students about their errors (Epstein et al., 2002).

1.3 Research Problems

Algebra is an important topic in making generalization and interpretation of patterns and relationship. It is a tool for problem solving, a method of expressing relationship (Lim & Idris, 2006). It has long been recognized by educators as playing a fundamental role in exploration of most areas of mathematics (Carraher & Schliemann, 2007; Kieran, 2007). Through algebra, reasoning, thinking, problem solving, patterns and other skills can be developed. Thus, there is a worldwide push to make algebra a required part of most mathematics curricula in the world. However, students always face difficulties in learning algebraic expression (Luka, 2013; Russell, O'Dwyer, & Miranda, 2009; Tsai et al., 2008).

Algebraic expression is an expression that contains at least one variable (Merlin, 2008). It is a challenge for students to shift their thinking from arithmetic to algebra. Many of the countless errors made by students in algebra are due to their errors in overgeneralization of certain arithmetic concepts to their new experiences in algebra. This causes students to write algebraic expression inappropriately and make false generalization from a concept that is true arithmetically (Titus, 2010). They are lacking good conceptual understanding of algebraic expressions and having misconceptions in solving algebraic expressions questions. In turn, they tend to have

errors in solving the questions. For example, Lim (2010) investigated the errors made by students in algebraic expression and found 12 types of errors made by students in simplifying algebraic expressions.

In mathematics, there is much less room for error. If a student makes an error at the beginning of the solution, the remaining parts might be rendered completely deviated from the stated problem. Understanding students' algebra errors could provide insight into students' thinking and future focus for teaching and learning (Chow, 2011). In an effort to understand the errors made by students in algebraic expression, many studies were carried. For examples, meaning of algebraic letters, misapplication of algebraic rules, conjoining errors, order of operations, negative integers and bracket usage (Chow, 2011; Eccius-Wellmann, 2012; Lim, 2010; Luka, 2013; McNeil et al., 2010; Welder, 2012). Apparently, considerable research has documented those identifying and explaining causes for errors in algebraic expression (Egodawatte, 2011). However, how to resolve it is still under-researched.

A possible way is by utilizing feedback. Feedback is an essential element in learning that enables students to raise their level of awareness in relation to their strength and also identify weakness which require further attention. Frequent and immediate feedback is critical for learning (Narciss & Huth, 2004). It is widely recognized as one of the most powerful influences on students' learning (Johnson, Reisslein & Reisslein, 2015). With feedback, clear explanation can be given to students, they will be having more opportunity to reflect and be aware of their errors. Therefore, the focus of this study lies in the effect of feedback on students' errors and also their achievement in algebraic expressions.

Nevertheless, the existing findings on the effectiveness of providing learners with different feedback content are rather inconclusive (Narciss et al., 2014).

According to the critical review done by Shute (2008), there is large variability of feedback effect on students' learning. The use of feedback comes with its own challenges: how much feedback is needed? When should it be given? (Bokhove & Drijvers, 2012; Marsh, 2012). One of the research gaps to be filled is the mode of feedback presentation. Nowadays, the application of educational technology is spreading fast, various powerful educational tools have been used, including computer-based testing (CBT), which students can access and receive valuable timely feedback on their performance. Present available research does not provide evidence regarding how to integrate feedback in CBT so that it contributes positively to students' achievement (Van der Kleij et al., 2012). As learning environment continues to grow in this digital age, this motivates the following research question: is there any effect of CBT feedback on students' achievement and errors in algebraic expressions?

Moreover, gender has been identified as an important students' characteristic that influences their learning activities in mathematics (Narciss et al., 2014). For example, McCarty (1986) found that men and women showed the same trends when receiving feedback. However, Djamasbi and Loiacono (2008) found that women's moods become less positive as they receive failure feedback then men's moods. Nevertheless, Rowe and Wood (2008) found that women valued feedback more important than man. Similarly, another research suggests that male students tend to skip or not engage seriously into the feedback than female students. Accordingly, the benefit of learning with feedback has been larger for female than for male students (Arroyo et al., 2001). This indicates that gender differences do not occur consistently, but rather under certain condition. Hence, it is worth exploring is there

any difference between genders of the effect of CBT feedback on students' errors and achievement in algebraic expression.

Meanwhile, every person tends to view things in different ways and with their own perspective. Understanding how students perceive their learning is vital (Tudor, Penlington, & McDowell, 2010). What students perceive from their learning situation will influence their performance and also their motivation in learning (Annie, 2011). Moreover, the condition for feedback to be effective can be better understood when students' opinions are taken into account. However, students' perception of feedback is under-researched (Annie, 2011; Poulos & Mahony, 2008; Randall & Zundel, 2012) and how the perceptions are related to students' performance have not been addressed explicitly (Strijbos, Narciss, & Dunnebier, 2010). Therefore, this study aims to contribute to build a richer picture of students' view of feedback, by finding out how the CBT feedback delivered is perceived by students to accomplish meaningful intended objectives.

1.4 Research Objectives

This study aims to:

(a) Identify the effect of CBT feedback on students' achievement in algebraic expressions.

(b) Identify the effect of CBT feedback on students' errors in algebraic expressions.

(c) Investigate the difference between genders of the effect of CBT feedback in algebraic expressions, in terms of:

   a. Achievement

   b. Errors

(d) Investigate the interaction effect between CBT feedback and gender in algebraic expressions, in terms of:

   a. Achievement

   b. Errors

(e) Investigate students' perception on the CBT feedback in algebraic expressions.

1.5 Research Questions

(a) Is there any significant effect of CBT feedback on students' achievement in algebraic expressions?

(b) Is there any significant effect of CBT feedback on students' errors in algebraic expressions?

(c) Is there any significant difference between genders of the effect of CBT feedback in algebraic expressions, in terms of:

   a. Achievement?

   b. Errors?

(d) Is there any interaction effect between CBT feedback and gender in algebraic expressions, in terms of:

   a. Achievement?

   b. Errors?

(e) What is students' perception on the CBT feedback in algebraic expressions?

1.6 Null Hypotheses

$H_0$1: There is no significant effect of CBT feedback on students' achievement in algebraic expressions.

$H_0$2: There is no significant effect of CBT feedback on students' errors in algebraic expressions

$H_0$3: There is no significant difference between genders of the effect of CBT feedback on students' achievement in algebraic expressions.

$H_0$4: There is no significant difference between genders of the effect of CBT feedback on students' errors in algebraic expressions.

$H_0$5: There is no interaction effect of the combination of CBT feedback and gender on students' achievement in algebraic expression.

$H_0$6: There is no interaction effect of the combination of CBT feedback and gender on students' errors in algebraic expression.

1.7 Significance of the Study

The findings of this study contribute to researchers, educators, teachers and students in several ways. Firstly, this study might pinpoint the potential use of feedback in improving students' achievement and solving students' errors in algebraic expressions which has been focused in previous researches. In mathematics, there is much less room for errors. Mathematics interventions should be able to allow students to confront their own misconceptions and errors (Bell, 2005). Research has shown that teaching becomes more effective when common errors and misconceptions are systematically exposed (Swan, 2005). Through feedback, students can reflect back, know about what they are doing well and what do they need to improve. Without exposure of their errors, they may not know why an error occurred and same error will be repeated in future. The feedback delivered in this study is not limited to identify answers as correct or incorrect, instead, informative enough to give explanation and supporting rationale within an effective timeframe. This could provide valuable information to students, and help them to be aware of the errors in algebraic expressions.

Besides, feedback is an important key component in determining students' successfulness in learning. Although feedback offers numerous advantages, feedback between teachers and students does not occur enough in schools (Hattie & Timperly, 2007). The frequency of feedback given by teachers to students is quite low. When feedback occurs, it is more likely about the accuracy of the tasks and influenced by teachers' perceptions on students' needs (Boling & Beatty, 2010). Besides, most secondary teachers have far too many students to make it realistic to provide individual, face-to-face feedback, so they rely on simple written feedback to do the heavy lifting (Fisher & Frey, 2012). By investigating the potential use of feedback in solving students' errors in algebraic expression, this study might raise the awareness of teachers on the importance of utilizing feedback to maximize its potential advantages in teaching and learning process.

Moreover, integrating technology into education can produce a powerful educational tool. This study might promote the use of CBT as a useful educational tool in which students can be assessed, receive valuable and timely feedbacks on their performance. It is supported by Boling and Beatty (2010) that technology can increase the amount and quality of feedbacks that students give and receive. In previous and current educational practice, paper-and-pencil test (PPT) has been used widely. However, there are many potential advantages that PPT cannot offer but only can be obtained through CBT, such as cost saving, improvement of test security, efficient in test administration, instantaneous evaluation, automated data storage and others (Askar et al., 2012; Cernich et al., 2008; Papanastasiou, 2003; Shapiro & Gebhardt, 2012). Students enjoyed in doing test through CBT than PPT, thus they were motivated to perform better (Haahr & Hansen, 2006).

1.8 Limitations of the Study

There are some limitations in this study. Firstly, this study involves only Form One (Grade Seven in United States) secondary school students in Lahad Datu, Sabah, Malaysia. Besides, even though there are many subtopics in algebra, this study focuses on algebraic expressions, which is one of the topics in Form One Mathematics syllabus.

Second, feedback is a powerful tool that provides information to students regarding their performance on certain tasks given. When feedback is given to students, certain criteria need to be met for it to be effective, especially promptness and timeliness. Therefore, computer-based testing was used as the medium of test in this study. For some students who are not computer literate, they might find difficulty in answering questions through computer. The effect of computer literacy on students' performance is beyond the scope of this study.

Besides, to ensure the consistency of feedback given to students, selected-response items is used in this study instead of open-ended questions. Students can only choose an answer from the distractors given, in which were designed by the researcher by referring to previous literature review and pilot study. The potential to investigate deeper about the errors is limited. Only targeted errors in this study can be included in the distractors.

Moreover, psychometric properties of the test used in this study were examined to ensure the validity and reliability of the test. Instructions were given before the start of the test, to remind students to pay attention on the feedbacks given. However, it is very hard to control and ensure that every student read the feedback given carefully and seriously. Furthermore, students' language proficiency is one of

the limitations too as they might be facing difficulties in understanding the feedbacks given.

Furthermore, many researchers have investigated students' learning difficulties in algebra (Fujii, 2003; Lim, 2010; McGregor & Stacey, 1997; Russell, O'Dwyer, & Miranda, 2009). Therefore, the focus of this study is not to find out what type of errors that students are having in algebra expression. Instead, this study focuses on the effect of CBT feedback on students' achievement and errors in algebraic expressions. There might be other factors that affecting the result of this study, such as students' self-awareness, motivation, effort, or time allocation in own study time which cannot be avoided and controlled.

1.9 Definition of Terms

Feedback – the information presented to a student in response to his / her action immediately after he / she answers a question (Black & William, 1998; Conroy et al., 2009). It is delivered by computer-based testing (CBT) in a written form, clear and easy to be understood, and positive statement. There are four major components in feedbacks: (a) Correctness – tells students about the correctness of the question; (b) Information – tells students about the learning outcome of the question; (c) Reinforcement – reinforces what the student did well / weakness needs to be improved; and (d) Directive guide – shows the correct solution.

Computer-based testing (CBT) – a selected-response assessment that is administered by using computer as the delivering platform, in which students need to answer questions in the electronic form. At the same time, students' answer will be marked automatically and recorded (Lau et al., 2011; Wang et al., 2012).

Achievement – An evidence of students' performance which is represented by their mean scores in a mathematical test. The higher the mean score, the higher the performance / achievement.

Error – A deviation from choosing the correct solution of a mathematical problem from responses / distractors given, which can be systematic or non-systematic (Egodawatte, 2011).

Misconceptions – a conception that is incorrect because of faulty thinking or understanding, which is not compatible with the accepted meanings in algebraic expression (Tai & Malone, 1996).

Algebra – a branch of mathematics that substitutes letters for numbers. Relations and properties of numbers are represented by general symbols. It uses common arithmetic operations that deal with signs and symbols (NCTM, 1989).

Algebraic expression – an expression that contains at least one variable, typically denoted by literal symbols such as *x*, *y*, and *z*, which represent an unknown (Chow, 2011). It is not a statement nor contains any relation symbols such as equal and minus sign. It is one of the topics in Form One Mathematics syllabus, in Malaysia. It covers the concept of unknowns, algebraic terms and algebraic expression. In this study, there are three learning outcomes involved in algebraic expression: (a) Recognize algebraic expressions; (b) Determine the number of terms in given algebraic expressions; and (c) Simplify algebraic expressions by combining the like terms.

Perceptions – understanding, interpretation or meaning perceived by a student about the feedback delivered in this study through CBT (Lewis, 2001). It includes students' personal opinion, attention, understanding, usefulness, and feeling towards the feedback. For example, what is his/her opinion about the feedback; and is the feedback perceived as useful in improving his/her performance.

1.10 Conclusion

This chapter had discussed the background, objectives, questions, significance and limitations of the study. Also, definitions of terms involved. The next chapter will discuss the related theories and literature review of previous studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, algebra, algebraic expressions, feedback, computer-based testing (CBT), achievement and errors are described and elaborated. Lastly, this chapter ends with the theoretical framework of the study.

2.2 Algebra

Algebra is not a new topic in mathematics. Many definitions have been proposed to describe it. From Britannica World Language Edition of the Oxford Dictionary, algebra is defined as "*the part of mathematics which investigate the relations and properties of numbers by mean of general symbols*." In Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989, p.159), algebra is described as "*the language through which most of mathematics is communicated*." It was restated later as:

> Algebra can be seen as a language—with "dialects" of literal symbols, graphs, tables, words, diagrams, and other visual displays.… Algebra is a way thinking about and representing many situations. It has a language and syntax, along with tools and procedures that promote this thinking and modeling (NCTM, 1998, p.163)

Algebra deals with generalized numbers and studies the relationship among these numbers that are changing quantities. It can be referred as general expressions and general results too, allows one to express in a short form relationships that might

otherwise need long sentences. It includes unknowns and variables, expressions and equations, and the expansion of the meaning given to the equal and minus signs (Chow, 2011). A working group at the 2001 International Commission on Mathematics Instruction (ICMI) conference came up with six descriptions of algebra (Stacey & Chick, 2004, p.335):

(a) A way of expressing generality and pattern.

(b) A study of symbol manipulation and equation solving.

(c) A study of functions and their transformations.

(d) A way to solve problems beyond the reach of arithmetic methods.

(e) A way to interpret the world through modeling real situations.

(f) A formal system, possibly dealing with set theory, logical operations, and operations on entities other than real numbers.

Generally, algebra is an important topic in making generalization and interpretation of patterns and relationship. By understanding algebra, we can know the relationships among the language elements and where to use these relationships in solving problems. It is about what is true in general for all numbers. For example:

$a^2 + 2ab + b^2 = (a + b)^2$, where a and b can be any number.

It is a tool for problem solving, a method of expressing relationship (Lim & Idris, 2006). There is a worldwide push to make algebra a required part of most mathematics curricula in the world. Students are required to have strong background in algebra by Grade 8 (NCTM, 2000).

2.3 Algebraic Expression

In algebra, an *expression* is a single/multiple variable or number linked by one or more arithmetic operations. Expression is not a statement and does not contain any relation symbols such as equal and minus sign. It is simply an unknown structured explicitly by the use of parentheses, and implicitly by assuming conventions for the order in which we perform arithmetic operations. Algebraic expression is an expression that contains at least one variable (Merlin, 2008). Variables are typically denoted by literal symbols such as *x*, *y*, and *z*. Meanwhile, the relationship between these variables is linked by some operations. For example, $2x + y$, where two distinct symbols system (letter and numeral) are used together in an algebraic expression (Chow, 2011).

Algebraic expression is one of the topics in Form One (Grade Seven in United States) Mathematics syllabus in Malaysia. It covers the concept of unknowns, algebraic terms and algebraic expressions. The learning objectives and learning outcomes are as follow in Table 2.1 (Ministry of Education Malaysia, 2002).

Table 2.1

Learning Objectives and Outcome for Mathematics (Form One) in Malaysia

Learning Objectives	Learning Outcomes
1. Understanding the concept of unknowns	(a) Use letters to represent unknown numbers. (b) Identify unknowns in given situations.
2. Understand the concept of algebraic terms.	(a) Identify algebraic terms with one unknown. (b) Identify coefficients in given algebraic terms with one unknown. (c) Identify like and unlike algebraic terms with one unknown. (d) State like terms for a given term.
3. Understand the concept of algebraic expressions.	(a) Recognise algebraic expressions. (b) Determine the number of terms in given algebraic expressions. (c) Simplify algebraic expressions by combining the like terms.

Source: Ministry of Education Malaysia (2002)

In the context of this study, Learning objectives 3: Understand the concept of algebraic expression is focused, as it involves higher algebraic skills which has focused in previous studies and students always face difficulties and having errors and misconceptions in learning algebraic expressions (Tsai, 2007).

(a) Recognise algebraic expressions

An algebraic expression is a combination of numbers, unknowns and operational signs such as "–" or "+". For examples: (a) $2x + x$ is an algebraic expression, and (b) $(7 – 2) + 5$ is not an algebraic expression.

(b) Determine the Number of Terms in Given Algebraic Expressions

An algebraic term consists of a product of a number and an unknown. For example: $2x$, $4y$ and $8h$. However, a number in an expression is considered as a term too. For examples: (a) $2x + x$ is an algebraic expression with two terms, and (b) $2x + x + 5$ is an algebraic expression with three terms.

(c) Simplify Algebraic Expressions by Combining the Like Terms

Like terms are terms with the same unknown. For examples: $2x$ and $4x$; $–m$ and $5m$. Meanwhile, unlike terms are terms with different unknowns. For examples: $2x$ and $4y$; $–m$ and $5n$. Algebraic expressions with like terms can be simplified by adding or subtracting the coefficients of the unknowns in algebraic terms. For example: $2x + 4x = 6$. An algebraic expression consisting of two unlike terms cannot be simplified. For example: $2x + 4y$ cannot be simplified.

2.3.1 Errors in Algebraic Expressions

Strong understanding of order of operations is essential for many concepts in Algebra (Glidden, 2008). However, students always face difficulties and having errors and misconceptions in learning algebraic expression (Tsai, 2007). It is a challenge for students to shift their thinking from arithmetic to algebra. Students seem to find learning algebraic expressions difficult due to the lack of the basic knowledge needed. Many of the countless errors made by students are due to their overgeneralization of certain arithmetic concepts to their new experiences in algebra. This causes students to write algebraic expressions inappropriately and make false generalization from a concept that is true arithmetically (Titus, 2010). For example, they tend to write $5x + 4$ as $9x$ or 9.

Previous researches highlighted some particular difficulties in which students are facing when learning algebraic expressions in school. According to Lee (2007), the difficulties can be broadly classified under three main categories:

(a) Students are not familiar with the syntax of algebra.

(b) Students are confused over the different uses of letters in algebra.

(c) Students find algebraic procedures too abstract.

In arithmetic, the focus of activity is to find out the particular numerical answers. In algebra, the focus is on the relationships and expression in general form. Generally, students prefer non-algebraic representations than algebraic representations. Thus, they face difficulty when learning algebraic expressions (Toh, 2009). They tend to assume that what is required is a numerical answer (Booth, 1988). Since letters instead of numbers are used in operations, students did mistake easily. This is supported by Wagner and Parker (1999, p.328) that:

> Algebra is a language for describing actions on, and relationship among, quantities. As with any language difficulties may arise from feature of the language itself or in translating from one language to another. Within the language of algebra, most linguistic difficulties are related to variables and expressions; most translation difficulties arise in translating word problems into equations.

From their statements, one of the difficulties in algebra is caused by linguistic difficulties; usually arise at the turning points of the knowledge. To be specific, the process where forming an algebra expression from a word expression. Algebraic expression is different from arithmetic which is simpler. In arithmetic, a letter is used to denote an object. For example, "*a*" represents "*apple*". However, in algebraic expression, a letter is used to denote the number of an object. For example, "*a*" represents "*the number of apple*". Students learn arithmetic before algebraic expressions. Therefore, students tend to think that the letter is denoted for concrete things. For example, by referring to the examples mentioned, in arithmetic, "3*a*" means "*3 apples*" = *a* + *a* + *a*. But in algebraic expressions, "3*a"* means "3 x *a*". The operation sign for multiplication (x) is omitted. Students might not understand that "*a*" is an abstract number and it can denote any number (Wagner & Parker, 1999). This is supported by Kieran (2003) whereby students are having learning difficulties on the meaning of letters, the change from the arithmetical to algebraic conventions.

Another example, in arithmetic, when we calculate 2(3 + 4), we usually do it as: 2(3 + 4) = 2(7) = 14, rather than 2(3 + 4) = (2 x 3) + (2 x 4) = 14. When 2(3 + 4) is changed into 2(*a* + *b*), students tend to do it as: 2(*a* + *b*) = 2 (*ab*) = 2*ab*. Actually, in algebraic expressions, distributive law has to be used. Students have to do it as: 2

$(a + b) = 2a + 2b$. If a student does not know the distributive law well, the possibility of doing mistake is high (Wagner & Parker, 1999).

Besides, another difficulty occurred in student' learning of algebraic expressions is their wrong interpretation of algebraic objects (Kirshner, 1989). The wrong interpretation appeared to have resulted from the visual presentation of the algebraic objects. Kirshner (1989) suggested that algebraic skills developed not only from learning or practicing explicit rules but also from recognizing visual patterns on printed pages.

Lim (2010) investigated and identified 12 types of errors made by students in simplifying algebraic expressions. Based on the result, he pointed out several errors:

(a) Interference of newly learned mathematical concepts.

(b) Difficulty in operating with the negative integers, especially negative integers appeared as coefficients in algebraic expressions.

(c) Misconceptions of algebraic expressions, such as misinterpretation of the symbolic notation (symbols / unknown variables), conjoin errors, did not understand the concept of bracket in algebraic expressions, and unable to recognize like terms.

(d) Misapplication of algebraic rules, such as misapplied the distributive law by multiplying only one of the algebraic terms in bracket, multiplication of variable, and incorrect order of operations errors.

Besides, Luka (2013) investigated the misconceptions and errors in algebraic expression at Grade 11. He had pointed out several errors as follow:

(a) Variables in algebra. Students do not understand the meaning of letters as unknown but interpret them as standing for objects or words.

(b) Algebraic expressions. Students tend to interpret expressions wrongly, such as 6*a* as a short form for "*6 apples*", and transform an algebraic expression for 3*a* + 5*a* as "*3 apples*" added to "*5 apples*".

(c) Equations. Students usually have difficulties in solving linear systems of equations with two unknowns.

2.4 Feedback

Feedback is the information presented to a learner in response to some actions on the learner's part. It can be provided by an agent, such as teachers, friends, parents, books, experience regarding one's performance. There are some definitions about feedback:

(a) Conroy et al. (2009) defined feedback as "*information provided to children by teachers regarding their understanding or performance of academic or behavioral tasks*" (p. 21).

(b) Butler and Winne (1995) defined feedback as "*information with which a learner can confirm, add to, overwrite, tune or restructure information in memory*" (p. 263).

(c) Black and William (1998) defined feedback as "*any information that is provided to the performer about the performance*" (p.37).

2.4.1 Types of Feedback

The concept of feedback can be viewed widely. It can occur with or without assessment. In teaching and learning process, feedback without assessment can be given by teachers to students either orally or in written form. In class, teachers might ask students to answer some questions. Immediate *oral feedback* can be given to the