THE EFFECTIVENESS OF AN INTERACTIVE COURSEWARE USING THREE DIFFERENT STRATEGIES IN THE LEARNING OF MATRICES

by

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ABSTRAK

Penyelidikan ini mengkaji kesan kognitif yang diukur dari skor perolehan dan juga masa melakukan kerja melalui tiga strategi pembelajaran, iaitu '*Computer-assisted Cooperative Learning*' (CCL), '*Computer-assisted Mastery Learning*' (CML) dan '*Computer-assisted Cooperative Mastery Learning*' (CCML). Sejumlah 262 pelajar Tingkatan Empat dari empat buah sekolah di Malaysia telah berinteraksi dengan satu siri pembelajaran berbantukan komputer untuk pembelajaran matriks. Isi kandungan dalam ketiga-tiga strategi pembelajaran adalah sama. Tetapi strategi yang digunakan untuk pembelajaran adalah berlainan. Strategi CML menggunakan pembelajaran individu, sementara strategi CCML dan CCL menggunakan pembelajaran koperatif. Elemen pembelajaran masteri dimasukkan ke dalam koswer untuk digunakan dalam strategi CML dan CCML. Strategi CCL menggunakan pembelajaran koperatif berserta dengan koswer tanpa elemen pembelajaran masteri. Pembolehubah tidak bersandar dalam kajian ini adalah tiga strategi pembelajaran. Pembolehubah moderator adalah kebolehan akademik dan gaya pembelajaran. Pembolehubah bersandar adalah skor perolehan dan masa melakukan kerja. Dalam kajian ini, model rekabentuk pengajaran Alessi and Trollip digunakan dalam rekabentuk makro bagi koswer CCL, CML dan CCML. Sembilan adegan pembelajaran Gagné untuk pembelajaran masteri digunakan dalam rekabentuk mikro. Keputusan menunjukkan bahawa pelajar dalam kumpulan CML dan CCML menunjukkan prestasi lebih tinggi secara signifikan berbanding dengan kumpulan CCL. Begitu juga, pelajar yang berkebolehan akademik rendah dalam kumpulan CML menunjukkan prestasi lebih tinggi yang berbeza secara signifikan daripada kumpulan CCL. Namun demikian, bagi pelajar berkebolehan akademik tinggi, tidak terdapat perbezaan dari segi skor perolehan dalam strategi

pembelajaran. Kajian ini menunjukkan bahawa kedua-dua kategori pelajar, berkebolehan akademik tinggi dan rendah dalam kumpulan CML dan CCL, menggunakan masa yang kurang secara signifikan berbanding dengan CCML. Keputusan ini adalah konsisten dengan keputusan keseluruhan bagi masa membuat kerja dalam kajian ini. Kajian ini menunjukkan bahawa tidak terdapat perbezaan skor perolehan dan masa melakukan kerja untuk gaya pembelajaran yang berbeza dalam strategi CCL, CML dan CCML. Terdapat empat dapatan dari hasil kajian ini. Pertama, kajian ini menunjukkan bahawa strategi CCML dan CML adalah lebih baik daripada strategi CCL. Kedua, antara ketiga-tiga strategi pembelajaran, strategi CCML adalah pilihan utama untuk memperolehi skor perolehan yang lebih tinggi. Akan tetapi, strategi CML adalah pilihan utama jikalau golongan pelajar adalah pelajar-pelajar berkebolehan akademik rendah. Dapatan ini juga mencadangkan bahawa pelajar-pelajar berakademik tinggi memperolehi skor perolehan yang tinggi dalam sebarang strategi pembelajaran. Ketiga, tentang gaya pembelajaran, keputusan skor perolehan dan masa melakukan kerja adalah konsisten dalam ketiga-tiga strategi pembelajaran di antara gaya pembelajaran yang berlainan. Pelajar-pelajar dengan gaya pembelajaran yang berlainan dalam strategi CCML memperolehi skor perolehan yang lebih tinggi berbanding dengan strategi CML dan CCL. Maka, strategi CCML adalah sesuai kepada pelajar-pelajar yang berlainan gaya pembelajaran. Keempat, dapatan yang utama dan umum tentang masa melakukan kerja ialah masa melakukan kerja bagi pelajar dalam strategi CCL dan CML adalah lebih rendah berbanding dengan strategi CCML.

THE EFFECTIVENESS OF AN INTERACTIVE COURSEWARE USING THREE DIFFERENT STRATEGIES IN THE LEARNING OF MATRICES

ABSTRACT

This study examined the cognitive effects, in terms of the gain scores and time-on-task of three learning strategies, namely the Computer-assisted Cooperative Learning (CCL), Computer-assisted Mastery Learning (CML) and Computer-assisted Cooperative Mastery Learning (CCML). A total number of 262 Form Four students from four Malaysian schools interacted with a series of computer-based assisted learning for the learning of matrices. The contents of the three learning strategies used were the same, but the strategies used for learning were different. The CML strategy was based on individual learning, while the CCML and CCL strategies were based on cooperative learning. Certain elements of mastery learning were added to the courseware, which were used in the CML and CCML strategies. The CCL strategy was based on cooperative learning and used the version of the courseware without the elements of mastery learning. The independent variables in this study were the three learning strategies. The moderator variables were the academic ability and learning styles. The dependent variables were the gain score and time-on-task. In this study, the Alessi and Trollip's instructional design model was used in the macro design of the CCL, CML and CCML courseware. The Gagné's nine events of instruction for mastery learning were used in the micro design. The results showed that the students in the CML and CCML group significantly outperformed the students in the CCL group. Also, the low academic ability students in the CML group significantly outperformed their counterparts in the CCL group. However, for the high academic ability students, there were no significant differences in terms of gain scores among the learning strategies. This study revealed that both categories of students, high and low academic ability in the CML and CCL groups spent significantly less time-on-task compared to the CCML group. The results were

consistent with the overall results of time-on-task in this study. This study showed that there were no significant differences on the gain scores and time-on-task for different learning styles in the CCL, CML and CCML strategies. Four conclusions can be drawn from the findings in this study. Firstly, this study showed that the CCML and CML strategies are superior compared to the CCL strategy. Secondly, the CCML strategy is the best choice among the three learning strategies to obtain a higher gain score. However, if most of the students have low academic ability, the CML strategy would be the best choice. This finding also suggests that high academic ability could obtain high gain scores regardless of learning strategies. Thirdly, pertaining to learning styles, the results in the gain scores and time-on-task were consistent in the learning strategies across the different learning styles. The students with different learning styles in the CCML strategy obtained higher gain scores compared to the CML and CCL strategies. Hence, the CCML strategy could accommodate students with different learning styles. Fourthly, the major and general finding for the time-on-task was that students' performance for this variable as founded in the CCL and CML strategies was significantly lower than the CCML strategy.

CHAPTER ONE
INTRODUCTION

1.0 Background of the Study

One of the major problems among the mainstream secondary school students is the performance difference between the low achievers and their peers. To overcome this problem, various interventions have been offered including curriculum-based assessment (Fuchs, Fuchs and Tindal, 1986), direct instruction curriculum design (Engelman and Camine, 1982), mastery learning (Bloom, 1984), tutoring (Sleeman and Brown, 1982), learning strategies (Mason, Burton and Stacey, 1982), and so forth. Unfortunately, most of these interventions require additional scarce resources such as teachers' efforts and time needed to use them.

However, the advent of the Information and Communication Technology (ICT) in the last few years has eased the burden on the resources needed for the teaching and learning process. The use of computer as an ubiquitous teaching tool has become very prevalent in Malaysian schools. As a result, the use of computers in conjunction with effective teaching strategy has tremendous potential in the teaching and learning process.

One of the most successful teaching strategies is mastery learning (Guskey, 1997; Guskey and Gates, 1986; Kulik, Kulik, and Bangert-Downs, 1990). The theoretical foundation of the mastery learning was first introduced by Carroll (1963). According to Carroll (1963, 1989), if the student uses the time appropriately and is given the time needed to learn a particular subject, every student is able to attain a specified level of achievement. Carroll believed that every student has the potential to learn well but differs in the time needed to do so. Carroll (1989) further identified that the characteristics of a learner and the instruction are among the influencing

factors on the time spent and time needed for a student to learn the material. However, Carroll did not elaborate on how to provide the sufficient time or to improve the instructional quality in mastery learning.

Bloom (1968,1976) later refined and developed the model by including four components into the mastery learning model which consists of (1) Learning Goals and Objectives, (2) Instruction, (3) Feedback and Correctives and (4) Competent Learners. He suggested that the critical elements of the individualized instruction could be transferred to group-based instructional settings by organizing the concepts and material to be learned into small learning units and checking on students' learning at the end of each unit. Then, he identified and distinguished the activities that would help high-achieving and low-achieving students. He believed that quizzes could serve as a valuable learning tool to determine appropriate feedback, corrective and enrichment activities.

However, educators interested in applying Bloom's ideas often have difficulty finding a concise description of the essential elements of mastery learning and the specific changes required for successful implementation. Guskey (1997) filled this gap by providing the essential elements in applying mastery learning. These two elements are: (1) the feedback, corrective, and enrichment process; and (2) congruence among instructional components, or alignment. Guskey (1997) also described on how mastery learning could be brought together with other innovations or integrated with other existing strategies. He suggested that a few innovative strategies could be incorporated into mastery learning to enhance cues, participation and increase students' engagement in the process of learning. Guskey emphasized that the instructional strategies involving mastery learning need to be comprehensive and must be seen as an integral part of a coherent framework for improvement.

Mastery learning provides an environment, which help students in the learning of mathematics. Educators placed a lot of emphasis on the use of the mastery learning. There have been a number of studies applying several teaching and learning strategies as well as incorporate instructional design principles into mathematics teaching in order to enhance students' learning. For instance, a mathematical software using the mastery approach was used to help the students in learning fractions (Olive, 2002). Mastery learning became one of the several innovations in the learning process. The results of the application were impressive as several studies showed professional improvement when mastery learning was combined with other strategies, which leads the educators to view that the learning does not happen in isolation (Guskey, 1989a; Grossman, 1985; Mevarech, 1985, 1991; Mevarech and Susak, 1993).

Mastery learning fits well and complements cooperative learning (Guskey, 1997). Cooperative learning has been strongly recommended to be used in the teaching and learning process to improve students' cognitive performance, social relationships, positive attitudes and learning skills (Dansereau, 1988; Gunderson and Johnson,1980; Hooper, Temiyakarn, and Williams, 1993). Cooperative learning provides opportunity for low academic ability students to model the study skills and work habits of high academic ability students. Mathematics learning skills can be easily learned in a cooperative setting. With the help of high academic ability students by explaining in detail the steps in the worked-out examples, the low academic ability students are then convinced on the use of these skills in the mathematical solution. On the other hand, during the discussions, high-ability students often develop greater mastery by developing a deeper understanding of the task (Becker, Silver, Kantowski, Travers, and Wilson, 1990; Stigler, Lee, Lucker, and

Stevenson, 1982). With mastery learning, cooperation needs were structured and guided through systematic instruction and feedbacks.

1.1 Statement of the Problem

Matrix is one of the basic topics in Mathematics that provides the necessary background for higher level mathematics. However, according to a performance report by the Malaysian Examination Board (*Laporan Lembaga Peperiksaan,* 1995), only 20% of the students could correctly answer the 'Multiplication of Matrices and Solution of Matrices' questions in the SPM Modern Mathematics examination. Although students could perform simple calculations in a rote manner, they were not able to correctly answer questions concerning determinants and inverse matrices (*Laporan Lembaga Peperiksaan,* 2003).

A diagnostic test was conducted on 56 students (Teoh, 2003). In the diagnostic test, students with difficulties in matrices were also weak in the basic skills of mathematics, such as solving equations. Specifically, students who experienced difficulties in matrices would find performing multiplication of two matrices confusing.

Since mathematical concepts build upon one another, the basic skills in mathematics become a necessity to solve problems and to understand other concepts in mathematics (Wu, 1999). Furthermore, to avoid omission of important processing skills, students are trained to master the basic skills in the early stages of the learning experience, provided they are given enough time and quality instruction (Bloom, 1968). Mastery learning is much more important when it was found that a lack of time might be a factor leading to the omission of important processing skills that would occur in the later stages of the learning experience (Harrell, Walker, Hildreth and Tayler-Wood, 2004). Without this awareness, students who were weak

continuously find no improvement in their skills for mathematics. On the other hand, if teachers tend to only focus on the weak students, then the good performance students will not be able to get the teachers' attention in the learning process. Mastery learning plays an important role to provide an environment for all the students to be involved with their study.

Mastery learning is a learning strategy to help students to master the basic facts in mathematics. It focuses on high and low abilities students and enables learners with high and low abilities to learn at their own pace (Bloom, 1974). If they cannot master the learning unit, feedback corrective activities are provided. If they have mastered the learning unit, they can enrich and enhance their understanding on the concepts.

As stated in the introduction earlier, research has shown that mastery learning has been successfully implemented. Recently, many school workbooks and exercises were set according to mastery learning design (as done by Anne, 2005; Lim, 2004; Muhammad Ali and Saifullah, 2005). However, there are claims that mastery learning is not applicable with respect to the manageability and constraints relating to time (Anderson and Jones, 1981; Levine, 1985). Mastery learning involves a lot of work in each component of mastery learning materials. As an example, an excessive amount of testing, corrective and enrichment activities are needed during 'feedback', an important component in mastery learning. The time allocation for subjects in the normal school curriculum is evidently not sufficient to apply mastery learning. Currently, using the e-learning platform to teach developmental mathematics in a mastery learning format was promoted to overcome this obstacle (Boggs, Shore and Shore, 2004).

With the advent of the ICT as a teaching tool and the availability of computer hardware in the schools, the problem in applying mastery learning could be improved by using interactive courseware. Feedback activities could also be easily conducted by using computers. In addition to recordkeeping of students' performance, the technology could also reduce the time and effort required to implement comprehensive interventions needed in mastery learning materials.

As suggested by Guskey (1997), there is a need for a comprehensive framework in using the instructional strategies in mastery learning. One of the learning and teaching strategies suggested by Guskey for mastery learning is cooperative learning. Over the years, studies by Guskey and other researchers (Atkinsola, 1996; Mevarech, 1985) found that cooperative learning could be incorporated into mastery learning to give a different environment to students. Results from these studies have shown that the combination of mastery learning and cooperative learning is found to be superior to the traditional lecture teaching format. Specifically, these studies indicate that mastery learning and cooperative learning have an impact on affective and academic outcomes of the students. Hence, it is believed that with a systematic design and integration of cooperative learning strategies, mastery learning and interactive multimedia have the potential to impose a great impact on the teaching and learning of subjects, such as Mathematics, where hierarchical knowledge is the requirement of the field.

1.2 Purpose of the Study

The main aim of this study is to integrate cooperative learning strategies, mastery learning and interactive multimedia to improve the students' performance in Mathematics, specifically in the topic of matrices. The integration of cooperative learning, mastery learning, and interactive multimedia environment will provide a

comprehensive framework needed for an effective and efficient teaching and learning of mathematical concepts.

A computer-based systematically designed interactive courseware was created to test the hypotheses of this study. The effects on the gain scores and time-on-task will be investigated to determine the effectiveness of using the courseware in three different strategies, namely, Computer-assisted Mastery Learning (CML), Computer-assisted Cooperative Learning (CCL), and Computer-assisted Cooperative Mastery Learning (CCML). The students in all the three learning strategies used the same instructional materials. The CML strategy was based on individual learning, while the CCML and CCL strategies were based on cooperative learning. Certain elements of mastery learning were added to the courseware, which were used in the CML and CCML strategies. The CCL strategy was based on cooperative learning and used the version of the courseware without the elements of mastery learning. The effects of the three learning strategies on the gain scores and time-on-task were investigated. Thus, the study investigated:

(1) The effectiveness of using the computer courseware employing three learning strategies namely, CCL, CML and CCML.

(2) The effects of the three learning strategies employed in the courseware on the time-on-task.

(3) The effects of the three learning strategies employed by different students with different abilities and learning styles on the gain scores and time-on-task.

1.3 Research Questions

Specifically, the study will answer the following questions:

(1) Is there a difference on the gain scores among students using the three learning strategies, namely Computer-assisted Mastery Learning (CML), Computer-assisted Cooperative Learning (CCL) and Computer-assisted Cooperative Mastery Learning (CCML)?

   (a) Is there a difference on the gain scores among students using the three learning strategies, namely CML, CCL and CCML, with different learning styles?

   (b) Is there a difference on the gain scores among students using the three learning strategies, namely CML, CCL and CCML, with different academic abilities?

(2) Is there a difference on the time-on-task among students using the three learning strategies, namely Computer-assisted Mastery Learning (CML), Computer assisted Cooperative Learning (CCL) and Computer-assisted Cooperative Mastery Learning (CCML)?

   (a) Is there a difference on the time-on-task among students using the three learning strategies, namely CML, CCL and CCML, with different learning styles?

   (b) Is there a difference on the time-on-task among students using the three learning strategies, namely CML, CCL and CCML, with different academic abilities?

1.4 Research Framework

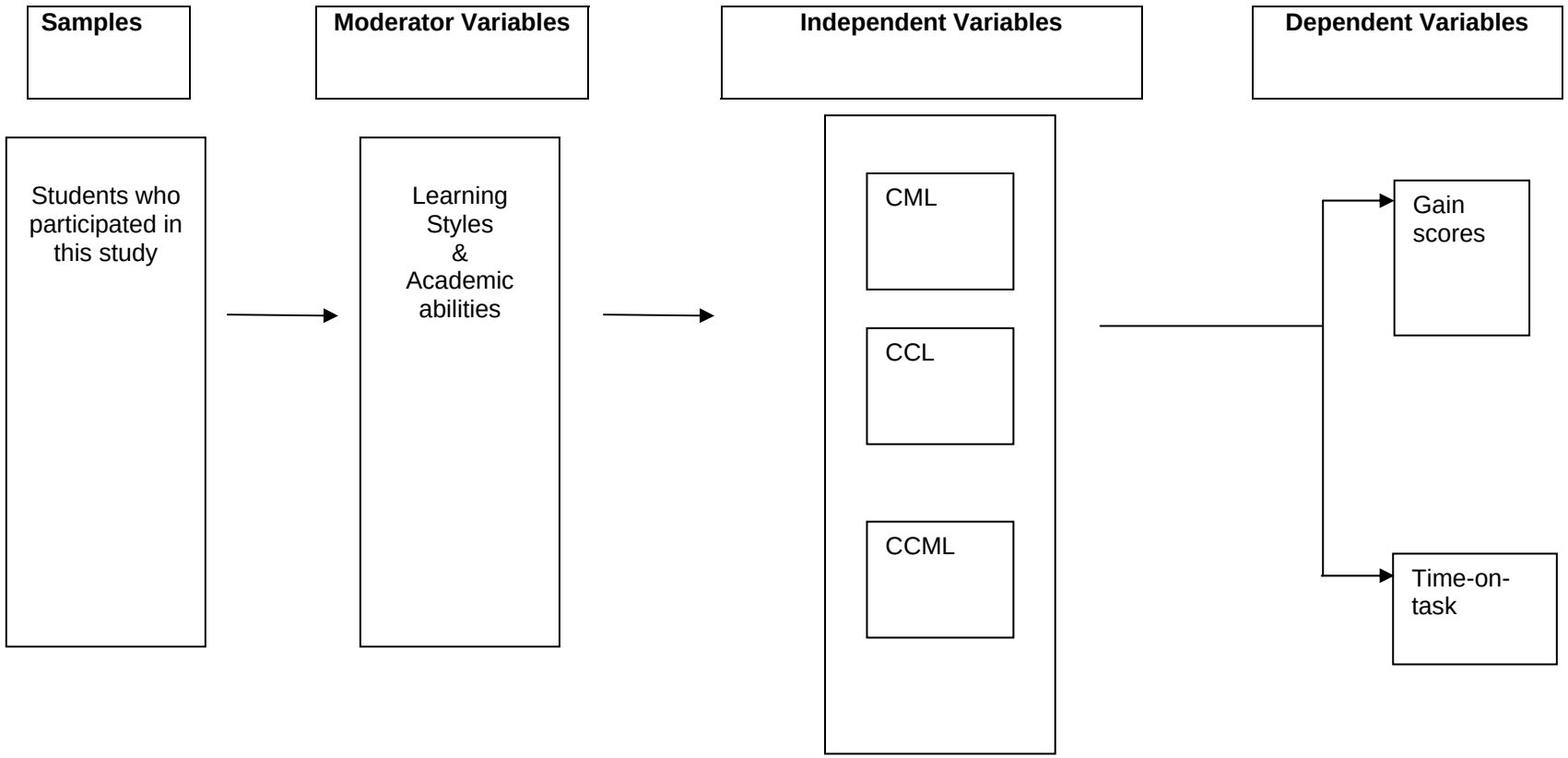
This study examined the effects of the three learning strategies, Computer-assisted Cooperative Learning (CCL), the Computer-assisted Mastery Learning (CML) and the Computer-assisted Cooperative Mastery Learning (CCML), which were measured using gain scores and time-on-task. The moderator variables were the academic abilities and the learning styles. The dependent variables were the gain score and time-on-task. As evidences from the past social and cognitive psychology research, academic achievement outcomes (gain scores) had been a significant variable in learning success within education classroom (Schwarz, 1998). In addition, many researchers (Schremmer, Hortz and Fries, 2001; Toh, 1998) used gain scores to investigate the effectiveness of treatment in instruction.

Carroll (1989) emphasized that if a student really spends time in learning as needed, then he will achieve competence in learning. Bloom (1984) described that mastery learning will take more time than the normal teaching. It also depends on the learners' learning styles. In view of the students' learning styles, one might find difficulties on some methods of learning. Frequently, students might find their preferred learning style or method to learn, and try to change or adapt the material in order to understand it better. Mastery learning is a method of learning that makes students successful regardless of their learning styles. With high quality of instruction, a variety of methods are included that make learning easier for students to understand and remember. Thus, the students can learn differently with their individual abilities and work at their own pace through planned sequence of lessons. This helps to motivate them to learn important concepts in order to proceed to the subsequent learning units. In this condition, the different learning styles among learners will not affect much on their learning. Mastery learning could be easily adapted to differences in classes and students. On the other hand, time-on-task for a

student could be shorter if a student is provided with an opportunity to learn through a series of quality instruction. With quality instruction, students will be more persistent in learning and increase their ability to understand.

In mastery learning, students were grouped into high and low academic abilities. The main essence of mastery learning is to ascertain whether the learners acquire a certain level of competency in learning a particular task. If the learners failed to acquire this competency, they are classified as low ability and the prescribed mastery learning will be administered. On the other hand, if the learners have acquired the desired competency, they will be directed to other mastery learning task which are more challenging to the learners. PMR Mathematics results were used to classify the students into high and low academic abilities. PMR Mathematics is a standardized examination used to gauge the students' abilities after nine years of education in Malaysia. It is an accurate representation of the students mathematical ability vis-à-vis the national norm. Hence, it is used to classify the students into different academic abilities.

In this study, the theoretical framework for the teaching and learning strategies were integrated from Carroll's model of school learning (Carroll, 1963) and Bloom's model of learning for mastery (Bloom, 1968). In addition, the design and implementation of teaching and learning strategies employing cooperative mastery learning was based on Guskey's model on the principal strengths of selected innovative strategies (Guskey, 1997). All these models would be further discussed in Chapter Two.



Note: Students with different learning styles and academic abilities were put into three different experimental conditions. The performances were measured using the gain score and time-on-task.

Figure 1.1 Research framework

1.5 Limitations of the Study

This study sought to investigate the effects of the three learning strategies (CCL, CML and CCML) on the gain scores and time-on-task. The study was conducted in a computer laboratory. The followings are some limitations that may restrict the probability of generalizing the findings:

First, the courseware specifically dealt with mathematical matrices. The subtopics of matrices are addition and subtraction, identities, multiplication and inverse matrices. This might restrict the generalization of the findings of this study to other mathematical concepts and other subjects.

Second, the respondents of the study were from four suburban schools in Seberang Perai. Findings of this study were restricted to suburban schools. Thus, the findings might not be generalized for all types of schools in Malaysia.

1.6 Definition of Terms

The following define the terms used in this study:-

Ability to understand instruction:

In Carroll's model of school learning (Carroll, 1963), ability to understand instruction refers to the possession of the prerequisite concepts and skills necessary to understand a current unit of instruction.

Academic ability:

Academic ability is measured based on the student's achievement in PMR (*Penilaian Menengah Rendah*) Mathematics. High academic ability refers to those who

obtained Grade A or Grade B in their PMR Mathematics. Low academic ability refers to those who obtained Grades C or D in their PMR Mathematics.

Aptitude:

In Carroll's model of school learning, aptitude refers to the general or global skills that are helpful in learning something (as opposed to specific, prerequisite concepts and skills necessary to understand a current unit of instruction).

Computer-assisted Cooperative Learning (CCL):

CCL is computer-assisted instruction employing non-mastery learning through the courseware in an environment of cooperative learning.

Computer-assisted Cooperative Mastery Learning (CCML):

CCML is computer-assisted instruction employing mastery learning through the courseware in an environment of cooperative learning.

Computer-assisted Mastery Learning (CML):

CML is computer-assisted instruction employing mastery learning through the courseware in an environment of non-cooperative learning.

Enrichment activities:

Enrichment activities refer to students' activities on the successful completion of a formative test within a time period. All the activities were conducted through the computer, in the form of games, quizzes and further exercises on application of the concepts. The activities related to the concepts were found in particular units.

Feedback:

Feedback is conducted through the corrective actions for students who were not able to achieve the target of the formative assessment. It was also conducted through the enrichments for the students who have achieved the target of the formative assessment.

Gain score:

Gain score refers to the difference between the pretest score and posttest score.

Learning Styles (LS):

One's preferred methods of perceiving and processing information (Kolb, 1984).

Learning strategies:

Learning strategies are instructional strategies, which compose of components of mastery learning, cooperative learning or both.

Prior knowledge:

Prior knowledge refers to students' knowledge on arithmetic and solutions of equations as in the entry test (Chan, 1996).

Time-on-task or engaged rate:

Time-on-task refers to the time utilized by the student working on a task given by the teacher. This includes the total time taken in using the courseware, formative test, discussions and retest.

1.7 Organization of Chapters

This thesis is organized into six chapters. Chapters one to six present an introduction, literature review, methodology, courseware development, result and discussion respectively. Chapter one describes the research background, problem, purpose, significance, research question, framework and limitations. The chapter ends with the definition of terms. Chapter two presents the literature review of the research. The chapter reviews past research from various perspectives. The literature serves as the backbone of this research to construct the research framework. The chapter covers the literature on the model used in the study, instructional strategies, computer as a medium, feedback, corrective activities and enrichment activities, learning process and learning styles, prior knowledge, learning matrices, instructional design and conceptual framework of the study. Lastly, the chapter ends with the hypotheses. Chapter three describes the research methodology, design, samples, development of the multimedia courseware, research instruments and procedures. Chapter four describes the courseware development in detail. Chapter five presents the results of the research. This chapter deals with data analyses and findings. Chapter six discusses and concludes the whole research. It begins with an overview of the research findings. It is then followed by discussion, implication, future study and conclusions for the research.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

The purpose of this chapter is to establish the foundation for the specific objectives of this study. It reviews past and contemporary literatures pertaining to the model used in the study, instructional strategies, computer as a medium, feedback, corrective activities and enrichment activities, learning process and learning styles, prior knowledge, learning matrices, instructional design and conceptual framework of the study. The chapter ends with the research hypotheses.

The conceptual framework of this study stresses more on the application and procedures of innovative strategy in the instruction and learning. These procedures are crucial to determine the success of mastery learning as well as cooperative learning. The procedures are not isolated from learning theories. Learning theories emerge from various disciplines, such as human development and the nature of learning (Bloom, 1976), learned behavior (Linville, 2004), reinforcement (Gagné, 1985), motivation (Keller and Suzuki, 1983), retention (Gagné, 1985) and concept formation. However, definitions of learning differ only in a few perspectives. In a causal perspective, learning is a change in behavior or performance because of additional experience or practice (Sahakian, 1976). In perspective for the promotion of learning, assumptions for learning to occur are focused. Besides, educational theories of instruction seek to discover the instructional environments and methods that enable optimum learning to happen. This educational approach to learning theories refers to learning in a school environment and becomes the basis for this investigation. In this study, the Carroll's model of school learning (Carroll, 1963), the Bloom's model of learning for mastery (Bloom, 1968) and Guskey's guidelines in his

principal strengths of selected innovative strategies (Guskey, 1997) provide the underpinnings of the theoretical framework.

Carroll's model (Carroll, 1963) had significantly influenced the development of mastery learning. With some changes in Carroll's model of school learning (Carroll, 1963), Bloom (1968) developed 'Learning For Mastery' (LFM) Model. Later, 'Learning For Mastery' was abbreviated to 'Mastery Learning' (Bloom, 1974). In brief, the strategies in Bloom's model of 'Learning for Mastery' (Bloom, 1968) apply the Stimulus-Response (S-R) theory that focuses on practice with question and answer while students are exposed to the subject in gradual steps. During the procedures of Stimulus-Response, the learner makes a response for every question and receives immediate feedback. Those learners who do not achieve a mastery level will be given a reinforcement lesson. In contrast, those learners who achieve a mastery level will be given an enrichment lesson (Markle, 1969; Ormrod, 1995; Skinner, 1968). Extended from Skinner's idea (1968), Gagné (1985) used the task analysis idea that referred to events of instruction. In the events of instruction, an individual will solve problems while getting feedback on some tasks taking place.

At the same time, Bloom (1968) used Skinner's theory (1968) and Carroll's model of school learning (Carroll, 1963) to develop the model of learning for mastery. Bloom (1968) noted that mastery learning has some excellent features, which could be effectively applied in classroom learning. These features can help teacher to effectively apply mastery learning in classroom such as enhanced prerequisites, enhanced cueing, student participation and feedback in order to provide reinforcement and correction. Likewise, the designers of instruction can use the same excellent quality features to be built into the instruction. In fact, these are the factors of instructional quality that Gagné (1985, 2000) applied in the events of

instruction. He combined the mastery learning procedure to enable students to accomplish a higher achievement as required in mastery learning. Therefore, Bloom's learning for mastery (1968) and Gagné's events of instruction (1985, 2000) appear to be relevant. Both provide guidelines on how to facilitate learning based on external factors in the learning process. On the other hand, together with Skinner's theory (Skinner, 1968) and Carroll's model of school learning (Carroll, 1963), Bloom's learning for mastery (1968) and Gagné's condition of learning (Gagné, 1985, 2000) frequently include internal and external factors that incur learning.

Guskey (1997) devised an innovative program for mastery learning that provided detailed guidelines to apply mastery learning in a more concrete manner. Guskey's guidelines were developed coherently with Bloom's model in which Bloom identified that students need a learning environment with optimizing quality of instruction for each component, whereas Guskey (1997) endorsed incorporation of other strategies into mastery learning as an innovative process of learning.

With the advent of powerful microcomputer, it is envisaged that mastery learning can be applied through the computer because it has many attributes such as interactivity, feedback and capability to support individual learning; thus, making it more effective as a learning tool.

The following conceptual framework will briefly describe how computer can be used to bind the process of teaching, learning, conditions of learning and mastery learning in order to successfully turn the model of mastery learning into a working model.

2.1 Models Used in the Study

Carroll's model of school learning (Carroll, 1963), Bloom's model of learning for mastery (1968), Gagné's conditions of learning (1985) and Guskey's guidelines in his principal strengths of selected innovative strategies (1997) have provided a base for the theoretical framework of this study.

2.1.1 Carroll's Model of School Learning

Carroll's Model of school learning (Carroll, 1963, 1989) focused on time as the principal constituent to learning. The model emphasized on the basic principle that a learner could succeed in learning for a given task to the extent of the amount of time he needed to spend in order to learn the task. Specifically, the model implied that the degree to which an individual would attain success in learning a given task depended on the amount of time he spent for learning in relation to the amount of time he needed for learning a particular task, which was named as the degree of learning. The degree of learning could be expressed in the following equation:

$$\begin{aligned}&\text{Degree of Learning}\\&= f\left(\frac{\text{time spent}}{\text{time needed}}\right)\\&= f\left(\frac{\text{Perseverance or Opportunity}}{\text{Aptitude} + (\text{Quality of Instruction Events} \times \text{Ability to Understand Instruction})}\right)\end{aligned}$$

Carroll further explicated five constructs as determinants of time spent and time needed for learning. These constructs were manipulated in terms of time as the determinant relationship in the degree of learning formula. An overview of Carroll's model had revealed certain interrelationships of the five constructs that contribute to learning. The numerator of this quotient comprised constructs of opportunity and perseverance as determinants of time spent in learning. The denominator was

determined by the aptitude construct plus increase in time needed attributed to the interaction of the ability to understand instruction with the quality of instruction. There are strong relationships among the constructs. Perseverance or the amount of time an individual is willing to spend in learning is influenced by the individual's internal conditions such as motivation, desire, interest and emotional variables. Carroll further defined that students' aptitude, ability to understand, the quality of instruction and the opportunity to learn will also affect the student's perseverance with a learning task.

2.1.1 (a) Determinant of Time Spent

The opportunity to learn and perseverance are the constructs for determining the amount of time spent in learning. The opportunity to learn in the school setting is determined by external conditions, for example, the school environment. However, the amount of opportunity directly relates to the degree of learning. Particularly, inadequate time for learning can result in insufficient amount of learning. On the other hand, adequate opportunity could produce the amount of learning necessary for mastery (Stuck and Wyne, 1982). In schools, the time allowed for learning any specific task is normally limited and often turns out to be less than what a student needs. The reasons for this lack of time are due to: (1) the large amount of materials students are expected to master (Kendall and Marzano, 1994), (2) the great disparity among students in the amount of time they need in order to learn (Chickering and Ehrmann, 1996; Cross, 2001; Graham, Cagitay, Lim, Graner and Duffy, 2001). Nevertheless, some teachers do make some efforts to adapt instruction to the special needs of individual students although the classroom structure is geared towards meeting the needs of groups of students, and (3) the structure of the school day places a constraint upon how much time a student is allowed to work on a learning task in a particular subject.

2.1.1 (b) Determinants of Time Needed

Carroll (1963) established three constructs in determining the amount of time needed in learning. They were aptitude, ability to understand and quality of instruction. Aptitude referred to the amount of time the learner would need to learn a task under ideal conditions. It is considered as function of several contributing factors. These contributing factors to aptitude comprise of prior knowledge or learning that is particularly related to the learning task and basic aptitudes in which are relevant to a particular subject or content area.

The ability to understand instruction is one of the most complex constructs in the model. Nonetheless, Carroll indicated that the ability was a combination of ‘general intelligence’ and ‘verbal ability’. Furthermore, he emphasized that the greater the learner’s ability to understand and interact with the quality instruction, the less the amount of time that was needed for learning. Besides, McLaren (1999) and Walts and Demana (1992) supported this scenario and agreed that a person's intelligence or ability to solve mathematical problems could be increased through appropriate education, training and experience. Subsequently, if students were provided with appropriate instruction and tools such as a calculator and a computer, they would improve their ability to solve certain mathematical problems. Likewise, the degree to which the quality of the instruction approaches an optimum level would directly determine the amount of time needed for learning. In other words, the instructional quality that interacted with an individual’s ability to understand could decrease the amount of additional time needed for learning with the condition that the quality of the instruction approached its optimal conditions.

Aptitude, ability to understand and perseverance are concerned with the internal aspects of an individual learner, while opportunity and quality of instruction

are the external influences to learning. Figure 2.1 shows that external constructs are influenced by the quality of instruction and opportunity to learn. The internal constructs are directly affected by the manipulation of external constructs. Changes in the quality of instruction would interact with perseverance and the ability to understand instruction. From this figure, it is obvious that high quality instructional programs can enhance students' perseverance, and ability to understand, which are the internal constructs.

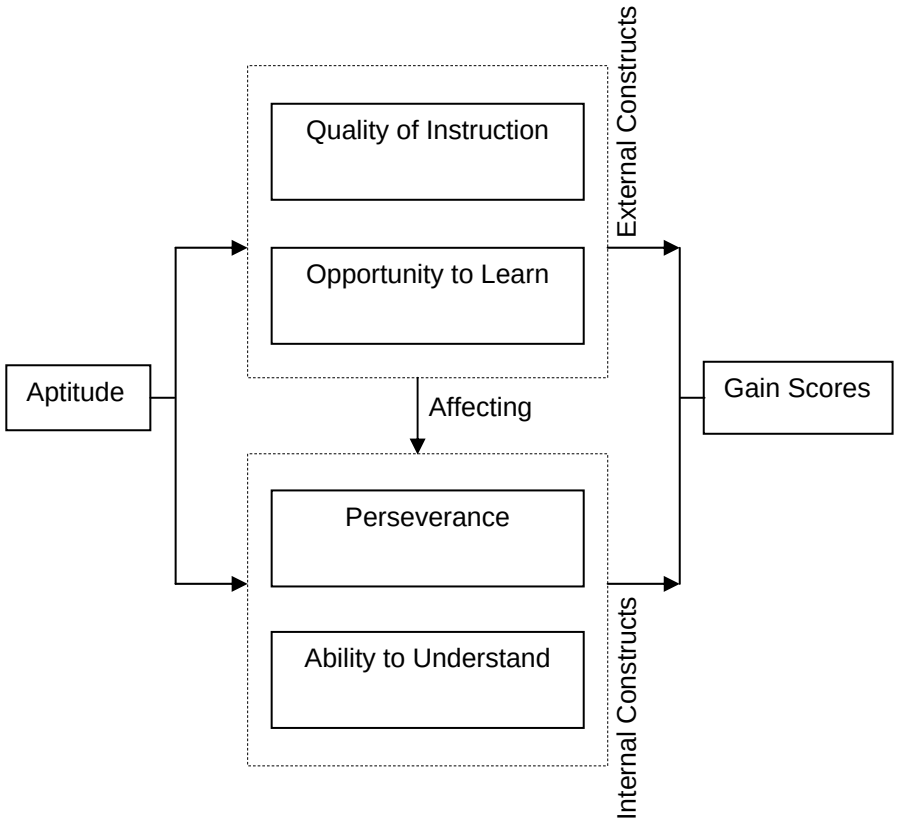


Figure 2.1 The constructs in Carroll's model of school learning adapted from Carroll's model of school learning (Carroll, 1963)

The distinctive features of Carroll's model of school learning (Carroll, 1963) are that it provides guidelines on proper design of instruction and offers opportunity to learn that promotes high perseverance and ability to understand. Lastly, it

promises complete learning. Consequently, learners could take different times to achieve the criterion of 100%.

Consequently, the content is presented through high quality instructions where time is a variable and the presented content is a constant within the mastery learning environment. This means that students are presented with consistent input and the outcomes are achieved at the rate according to individual needs, initial competency level and learning styles of students.

2.1.2 Bloom's Model of Learning for Mastery and Gagné's Nine Events of Instruction

Bloom's theory of learning for mastery (Bloom, 1968) was developed from Carroll's model (Carroll, 1963, 1989). Bloom (1976) and other researchers (Anderson and Jones, 1981; Block, 1974) had wisely incorporated mastery learning into a series of instructions. The instructions were based on the idea to substantially reduce the huge differences on achievement in typical school classes by allowing more time for slower students. In addition, it assured students to receive feedback together with corrective instructions.

Of late, problems of large achievement variance became a popular issue of current studies (Elley, 1992; McLaughlin and Drori, 2000). Bloom (1976) postulated that variations in school learning were determined by three interdependent constructs as determinants of learning, namely (1) the learners' cognitive entry behavior, (2) the learners' affective entry behavior, and (3) the external instructional influences.

The first construct was the learners' cognitive entry behavior. It was referred as the prerequisite learning, which was required for the subsequent learning task,

and common learning behaviors. The common learning behaviours include verbal ability, reading comprehension and general learning styles. Variations in cognitive entry behaviors of learners would produce variations in learning outcomes. Accordingly, those learners who had accumulated the necessary prerequisites for a learning task would be able to learn a new task with little or no variation in the degree of mastery or time required for mastery. On the other hand, those learners who had varying amounts of prior or prerequisite learning would demonstrate substantial variations in the degree of mastery or on the amount of time required for mastery.

The second construct was the affective entry behavior that had three sub-components, namely, subject-related affect, school-related affect and academic self-concept. Subject-related affect referred to attitudes or interests that were related to particular courses of study in the school setting. School-related affect referred to general attitudes or interests towards school and school learning. Academic self-concept referred to the individual attitudes about himself as a learner. These affective entry behaviors were separate determinants to learning. Each of the determinants would affect the learners' motivation in learning.

Outcomes of learning were determined by two kinds of students' characteristics upon entry into instruction, namely, cognitive capabilities and affective characteristics as internal influences. However, external influences also played an important role to incorporate mastery learning into a system of instruction that complement internal influences. Other educators (Bransfold, Brown and Cocking, 1999; Ericsson, Krampe and Tesch-Romer, 1993) believed that although internal influences such as talent played a role in achievement, there were still many seemingly talented individuals that required a great deal of good practices and quality instruction in order to develop their learning skills. The main idea of mastery