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Enhancing Algebraic Conceptual Knowledge with Aid of Module Using Mastery Learning Approach

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Abstract

This paper discusses the effect of Algebraic Mastery Learning Module (AMaLM) usage on mathematics achievement of low achievers with high anxiety in mathematics. In this quasi-experimental study, 50 low achievers in Form Four from a secondary school located in a rural area were involved. Target participants were divided into two groups: an experimental group with AMaLM and conventional instruction strategy group. The content of activities for two the groups was the same but differed in its structure of teaching. The activities were carried out for about three weeks of intervention period. The activity papers for conventional instruction (CI) strategy group were solved with the use of only paper-and pencil and compared with the solutions presented by the teachers. The experimental group solved algebra problems also as paper-and pencil activities but utilizing the AMaLM. AMaLM is a self guided book to ease the learning of mathematics for low achievers with mathematics anxiety. It was developed based on constructivist learning theory and mastery learning theory**.** The material to be learned is subdivided into small units, covering from one lesson to another. The two groups completed Algebraic Comprehension Test (ACT) before and after the intervention period. The mean scores of ACT 1 and ACT II for the AMaLM group and CI group after the intervention were 58.32, 36.88 and 25.8, 22.96 respectively. Results showed that the experimental group improved considerably better than control group. The preliminary findings of this pilot study provided evidence that the construction and mastery of the algebraic concepts assist students towards positive attitude in mathematics learning. AMaLM as self-guided learning tools has favoured the learning process specifically in reinforcing algebraic knowledge for low achiever with anxiety towards mathematics.

Keywords: Algebraic Mastery Learning module; Self guided book; Algebraic knowledge; Anxiety towards mathematics

1. Introduction

The objectives of education have become more complicated. It is no longer sufficient to teach certain body of knowledge and skills. Teachers are expected to help students to acquire higher levels of cognitive skills as problem solving, synthesis and above all apply that knowledge to new situation (Darling & Hammand, 2000). For learning to take place, learners have to be active; learning has to be meaningful but not stressful. Unfortunately for most of students, learning mathematics is stressful and meaningless (Minsky, 2008). For numerous students, it is both

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emotionally and cognitively dreary when attending to mathematics teaching and learning. These students might be affected by the phenomenon called mathematics anxiety, which can greatly affect student's success throughout their education and their adult life. Many researchers have seen mathematics anxiety as a serious phenomenon (Tobias, 1993; Burns, 1995; Ascraft & Mark, 1998; Phillips, 1999; Stuart, 2000; Marzita Puteh, 2002; Arem, 2003; Shore, 2005) in mathematics learning and suggested taking this anxiety factor into consideration during teaching and learning. The mathematics teachers can help the children with the mathematics anxiety by helping the students to approach mathematics with confidence (Shores, 2005) while concurrently assist them in developing their basic mathematical understanding and concepts.

In Malaysia mathematics subject is perceived as important subject in general and very often it is looked upon as an indication of intelligence. Moreover mathematics is compulsory in accomplishing upper secondary level in Malaysian Education System. The subject is evaluated through Mathematics 1449/1 and Mathematics 1449/2 in Sijil Penilaian Malaysia (SPM – the Malaysian School Certificate Examination). The students need to perform well to obtain distinction as a condition to ensure placement in university or higher learning before one start their career. Therefore everybody is trying to score well in the Mathematics 1449/1 examination. This 'paper chase' ends up with theory that 'learning mathematics hard' and not everybody could make it'. As a result many students become anxious when facing mathematics subject as compared to other subjects. They feel tensed and dreadful when seeing the manipulation of numbers and symbols. Previous study had shown that most of students having problems in perceiving the abstract mathematical symbols that represented the unknowns (Elenchothy, 2007). In other words it was suggested that students need more algebraic scaffolding to build their mathematics skill to solve problems and perform better in mathematics.

According to Arem (2003), students' have difficulty in connecting symbols with the proper referent; in other words, students have a hard time comprehending the exact meaning of a variable, and especially with viewing expressions as objects. Most students feel anxious and tense when manipulating numbers and solving mathematical problems. Mathematics anxiety is a psychological state engendered when a student experiences or expects to lose self-esteem in confronting a mathematical situation. Such anxiety prevents a student from learning even the simplest mathematical task (Arem, 2003; Greg & Fiore, 1999). It has been found that negative feelings and attitudes toward mathematics intruded on the development of formal reasoning powers. Studies have documented the negative effects of mathematics anxiety on mathematics performance. However not many instructors take this phenomenon in consideration during the discussion on poor performance in mathematics during the mathematics' panel meeting. The actions such as organising activities as extra classes to accomplish the syllabi and drill the students with exam oriented questions have become usual solution. However these activities may train the students to work on algorithmic works without the construction of concepts and ends up with low impact towards better performance.

Today there are numerous types of technologies considered relevant to help the low achievers. These range from very powerful computer software to less powerful as the use of 'paper and pencil' (Norain, 2007). The basic comprehension of mathematics skills among the low achievers in school were seldom recognized hence these low achievers continue to develop negative attitude towards mathematics. Seeing this scenario as mathematics teacher in a rural area for 19 years, this study was done in a school mainly with critical students, to explore the actual problems among low achievers and by taking mathematics anxiety and algebraic skills in consideration.

A pilot study was conducted and the preliminary data review was done to achieve the following objectives:

i. To investigate the effectiveness of AMaLM in improving students' performance and anxiety
ii. To investigate relationship between mathematics anxiety and their performance in mathematics

2. Theoretical Framework of the study

The mastery learning and the theory of constructivism provides the background basis for this study. Mastery learning theory is based on the assumptions that individuals differ in their intellectual abilities and was reflected in the outcomes. Theorists such as Bloom (1974) and Block (1971) claimed that individual differences in learning ability can approach equality in their achievement outcomes if given needed time (Block, 1974; Bloom, 1971). Mathematics as a hierarchical and sequential material subject should be taught using the mastery learning theory. It is an instructional method that presumes all children can learn if they are provided with the appropriate learning conditions. It does not focus on content, but on the process of mastering learning.

AMaLM based on well-defined Algebraic learning objectives specifically organized into smaller, sequentially organised units. Material to be learned is subdivided and students are given a test at the end of every unit. If they do not achieve a mastery grade on the test (typically 80% - 95%) they are provided with more time and more teaching until they can achieve a mastery grade on a retest (Guskey, 2005). This strategy captures many of the elements of successful tutoring. The teacher provides frequent and specific feedback by using diagnostic, formative tests, as well as regularly correcting mistakes students make along their learning path. Teachers evaluate students with criterion-referenced tests. The most important benefit of using this model is that all students can progress and every time they begin with a new unit of instruction, the students may feel confident to embark on new learning. The advantage of applying the mastery learning model enables to produce strong gains in overall achievement and allows low achievers an opportunity to master critical concepts before a new content is introduced. Diagram 1 shows how the model was used in this study.

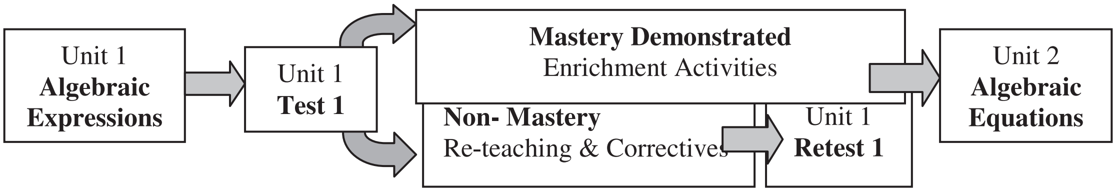


Diagram 1: The Mastery Learning Model

Constructivism is a psychological theory of knowledge which argues that humans generate knowledge and meaning from their experiences. Over years, mathematics has been taught as a fact that was transmitted and those who did not succeed were left behind with a mythological theory that, "only certain good at it". In contrast, constructivism focuses on how people can learn. It suggests that mathematical knowledge results in people forming models in response to the questions and challenges that come from activities involving mathematical problems and environment, not simply taking information, nor as merely the blossoming of an innate gift. Mathematics teachers should inculcate the situational experiences that the students need to construct their own understanding of each mathematical concept. Teacher's role is not only to observe and assess but also to involve with the students while they are completing activities, and posing questions to the students for promotion of reasoning.

3. Methodology

This study employed the quasi-experimental design. Quasi-experimental design was chosen as the design of this study random selection of subjects was not feasible and only random assignment of groups (experimental versus control) can be done. According to Fraenkel and Wallen (2006), this design is most appropriate in investigating the effectiveness of an intervention with availability of intact groups. One approach to make the groups comparable is to choose homogeneous sample by selecting the subjects who very little in their personal characteristics or attributes (Cresswell, 2002). Steps were taken to ensure the groups' initial equivalence based on school reports and data obtained from diagnostics test through Algebraic Comprehension Test (ACT) and Revised Mathematics Anxiety Scale (RMARS). School report from the midyear examination were analysed to ascertain that the students in both groups were similar in their mathematics ability. In this study, the independent variable that was manipulated was the instructional intervention (use of AMaLM versus conventional instruction strategy) and the dependent variable is the measures of performance and anxiety level. The performance (cognitive effort) measured together with the anxiety towards mathematics (affective factor) as an indicator of an instructional strategy.

3.1 Instruments

Diagnosis Module

The instructional materials for diagnosis test consisted of two sets of Algebraic Comprehension Test (ACT) namely ACT I and ACT II based on the usage of Algebraic in Mathematics 1449. The time allocated to do the test was one hour. ACT I comprised 10 items and the total score was 100. It was designed based on lower secondary syllabus (Form one to Form Three) to diagnose students' knowledge in applying Algebra in problem solving in topics such as Algebraic Expressions, Linear Equations, Quadratic Equations, Linear Inequalities, Geometry Coordinates, Solid Geometry, Perimeter and Area. Students have to show their solution steps beside the correct answers. The scores for each problem were allotted one mark for each correct step in the solution. Scores for question one to ten is 3, 3, 2, 3, 3, 2, 2, 3, 3 and respectively as indicated in ACT I. Later the total score was converted to percentage to standardise the scores. Thus overall diagnose test for ACT I ranged 0 to 25. Meanwhile ACT II comprised 20 items with multiple choice answers to diagnose the students understanding on usage of Algebraic rules and concepts, which result in total score of 20. Each item carries one mark for correct answers.

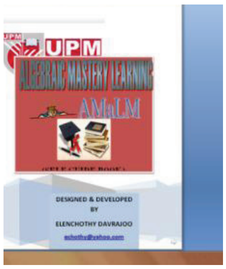
RMARS

RMARS is a set of questionnaires with forty eight items focusing four divisive dimensions was developed for the purpose of gathering data about feeling of anxious in mathematical situation. The four dimensions of mathematics anxiety are; mathematics class room environment, inability in working on problems, abstract of mathematics and test. Meanwhile, the attitude towards mathematics measured through twelve items at the second part of RMARS. Each item was measured using the Likert scale ranging from strongly disagree (1) to strongly agree (5). The reliability of the instrument had been tested using Cronbach's alpha coefficient. The computed indices of reliability is 0.97, showing high degree of internal consistency (George & Mallery, 2001). This indicated the instrument was acceptably reliable and suggested that it was capable of measuring students' mathematics anxiety.

AMaLM

AMaLM is a tutoring module to help student's master Algebraic concepts. AMaLM, which incorporates mastery learning concepts and constructivism learning theory strategies, designed to take into account individual differences among learners in such a way to help struggling students to master the concepts before they prepare themselves capable to receive new concepts. AMaLM is a guide module that includes e*x*planation, e*x*ploration and e*x*ercise in. AMaLM consists of four units namely, Algebraic Expressions, Algebraic Equations, Algebraic Inequalities and Application of Algebraic in Straight Line and others. It starts with users choosing what topic they choose to master followed by an achievement test (refer Diagram 2).

Diagnosis Module



Guide Module (Explanation, Exploration and Exercise)

Diagram 2: The AMaLM

The CI strategy group was also guided by the same instructional format with conventional whole class instruction without incorporating the use of AMaLM. The following are the activities used by the teacher in the classroom:

i. Teacher explains the mathematical concepts using only white board.

ii. Teacher explains on how to solve mathematical problems related to the concepts explained
iii. Students are given activity papers to be solved individually compared with the solutions presented by the teachers
iv. Teacher gives the conclusion of the lesson

The target population for this study was Form Four (11^{th} grade level or 16 year old) students in National Secondary schools in Malaysia whilst the accessible population was Form Four students from one selected school in Selangor. Diagram 3 shows the flowchart of research and teaching activities of the study.

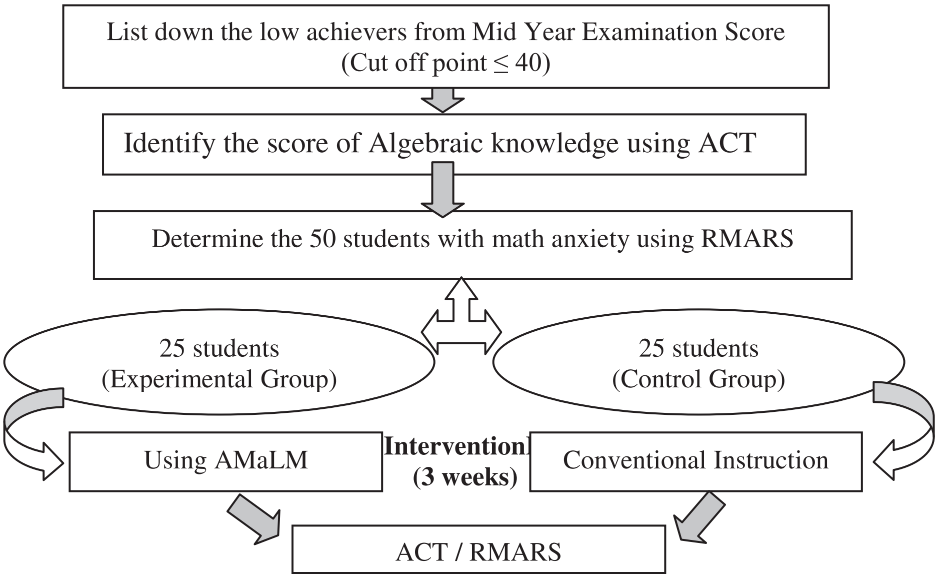


Diagram 3: The working process of study

4. Findings and Discussions

The findings of this study were mainly based on the quantitative data gathered from the respondents using the ACT 1 and ACT 2 and RMARS questionnaires. The exploratory data analysis was conducted for all collected data. Descriptive statistics procedures were adhered to in reporting the findings. Data were analysed using Statistics Package for Social Science (SPSS) Version 16. Students' comprehensions on Algebraic concepts before and after using AMaLM were assessed by ACT I and ACT II. Students' anxiety towards mathematics before and after using AMaLM was assessed by RMARS.

As can be seen from Table 1, the overall mean for midyear examination of AMaLM group was 29.88 (SD = 8.64) compared to control group was 23.56 (SD =10.23). The *t* test analysis for mathematics anxiety showed that there was significant difference in anxiety level between the two groups, t = 2.36; $p < 0.05$.

4.1 Students' anxiety towards mathematics before and after using AMaLM

Through the administration of the RMARS among the low achievers, the 25 most mathematically anxious students were identified. As far as the effects of intervention on students' performance in mathematics are concerned, this study found significant differences between the experimental and control groups in favour of the group that was exposed to the intervention. The overall mean for mathematics anxiety of AMaLM group was 3.51 (SD = 0.27) compared to control group was 2.40 (SD =0.38). The *t* test analysis for mathematics anxiety showed that there was significant difference in anxiety level between the two groups, t = 11.86; $p < 0.05$. The magnitude of the differences was large based on Pallant (2007) with eta squared = 0.75. Further the planned comparison test showed that there overall mathematics anxiety was significantly lower from those in CI group, $F (1, 48) = 17.80$, $p < 0.05$. This finding indicated that AMaLM group is less anxious towards mathematics after the intervention period.

Table 1. Mean, standard deviations, independent t-test and planned comparison for Mid Year Exam, ACT I, ACT II Before and After the Intervention Period

	GROUP	N	Mean	SD	SEM	t	df	p
MID YEAR	AMaLM	25	29.88	8.64	1.73	2.36	48	0.022
EXAM	CI	25	23.56	10.23	2.04			
ACT 1 (PRE)	AMaLM	25	32.84	20.70	4.14	2.52	48	0.015
	CI	25	18.88	18.41	3.68			
ACT II (PRE)	AMaLM	25	9.27	13.50	2.70	1.74	48	0.086
	CI	25	3.84	9.93	1.99			
RMARS (PRE)	AMaLM	25	3.51	0.30	0.14	11.86	48	0.000
	CI	25	2.40	0.38	0.06			
RMARS (POST)	AMaLM	25	2.51	0.30	0.14	9.53	48	0.000
	CI	25	2.40	0.38	0.06			
ACT 1 (POST)	AMaLM	25	58.32	19.57	3.19	6.44	48	0.000
	CI	25	25.80	15.93	3.18			
ACT II (POST)	AMaLM	25	36.88	14.14	2.82	4.10	48	0.000
	CI	25	22.96	9.40	1.88			
DIFFERENCE	AMaLM	25	52	18.62	3.70	5.59	48	0.000
in ACT	CI	25	26	14.90	2.98			

4.2 Students' comprehension on Algebraic concepts before and after using AMaLM

The overall mean for ACT I (Pre) is of AMaLM group was 32.84 (SD = 20.70) compared to control group was 18.88 (SD =18.41). Mean while the overall mean for ACT II (Pre) is of AMaLM group was 9.72 (SD = 13.50) compared to control group was 3.84 (SD =9.93). The *t* test analysis for the performance of ACT I and ACT II showed that there was significant difference in anxiety level between the two groups, $t = 2.52$ and $t = 1.75$ respectively with $p < 0.05$. The magnitude of the differences for ACT I was showing moderate effect with eta squared = 0.12. Though, the magnitude of the differences for ACT II was in moderate level with eta squared = 0.05. Further the planned comparison test showed that there overall performance in tests (the total scores of ACT 1 and ACT II) was significantly higher from those in CI group, $F (1, 48) = 0.690$, $p < 0.05$. This finding suggested that using module as an aid in teaching enhanced the performance on problem solving skills as compared to the conventional teaching. These findings confirmed that there were differential effects on Algebraic knowledge which lead to better performance between AMaLM and CI groups.

4.3 Relationship between students' mathematics anxiety and mathematics performance

The correlation coefficients were calculated for following relationship. A correlation coefficient of $r = -0.524$, $p < 0.05$, was obtained between overall mathematics anxiety and in the mathematics of lower secondary (ACT I- pre) (ACT). Cohen (1988) suggested that value of correlation from 0.01 to 0.29 consider small strength; 0.03 to 0.49 is medium strength and 0.5 to 1.0 considered large strength. This indicated that the correlation between students' anxiety towards mathematics and their mathematics performance was large and negative. Table 2, showed the matrix of relationship between all performances in mathematics that have been taken consider for this study. Findings indicated that there were a significant relationship (medium) between students' midyear examination scores in mathematics ($r = -0{,}365$, $p < 0.05$), the pre test of ACT I ($r = -0{,}484$, $p < 0.05$) and the pre test of ACT II ($r= -0{,}492$, $p < 0.05$). This finding confirmed with the literature that there was a significant correlation between anxieties towards mathematics and the performance. These identified low achievers with mathematics anxiety have negative attitudes towards mathematics and tend to avoid mathematics in their life. Thus this avoidance of mathematics can contribute to low performance in mathematics (Marzita Puteh, 2002; Ashcraft, 2002; Arem, C. 2003).

Table 2. Matrix of relationship,between mathematics anxiety and mathematics performance

		exam	ACT1PRE	ACT2PRE	PRETEST	ANXIETY
exam	Pearson Correlation	1	.289(*)	.492(**)	.420(**)	-.365(**)
	Sig. (2-tailed)		.042	.000	.002	.009
ACT1PRE	Pearson Correlation		1	.462(**)	.926(**)	-.484(**)
	Sig. (2-tailed)			.001	.000	.000
ACT2PRE	Pearson Correlation			1	.764(**)	-.402(**)
	Sig. (2-tailed)				.000	.004
PRETEST	Pearson Correlation				1	-.524(**)
	Sig. (2-tailed)					.000
ANXIETY	Pearson Correlation					1
	Sig. (2-tailed)					

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Overall, the result showed that AMaLM as a teaching aid to learn Algebraic performed better on low achievers with mathematics anxiety. The strategy was designed to enable students to learn the concepts of Algebra and solve selected types of word problems that would be assessed in Mathematics 1449 at Sijil Penilaian Malaysia (SPM – the Malaysian School Certificate Examination). For all these variables, the effect size using eta squared indices ranged from 0.05 to 0.12 which indicated a moderate to large effects based on Cohen (1988), implying that the AMaLM was effective in improving students' performance in topics that involving use of Algebraic. On average the AMaLM perform better than CI groups. The study discovered that the low achievers have preference to use module as an aid in learning. This finding supports the earlier findings. Many researchers agreed that using 'chalk and talk' by teacher centre approach as a traditional way to teach mathematics is not very helpful in enhance students' abilities (Ashcraft and Kirk, 2001). This conventional instruction strategy is limited in its effectiveness to reach today learners. Further this method also lead to passive learning environment and students' attitude towards learning mathematics. Phillips (1999) believed that much of this anxiety happens in the classroom due to the lack of consideration of different learning styles of students by the mathematics teachers Wigfield and Meece (1998) suggested that intervention programs to alleviate the negative effects of mathematics anxiety must deal. Study showed the strategy of using AMaLM to be an effective intervention for this sample with deficits in Algebraic based problem solving. Overall the instructed students demonstrated improved performance on mathematics 1449.

The result also found that the experiment group attained statistically higher mathematics performance than control group. That is low achievers were positively affected by learning with AMaLM than just paper and pencil activities. Furthermore, if general students used AMaLM, they would show more improved achievement than learning only through paper and pencil procedure. The choice of AMaLM is based mainly on its availability and accessibility with special consideration for cost and ease to use. In fact, AMaLM was built as a guide to see the connections of that can draw on topics Algebraic Expressions, Linear Equations, Quadratics Equations, Inequalities, Straight Lines and others.

5. Conclusion

From this preliminary study, there was a significant relationship between mathematics anxiety and performance in mathematics. Researcher believed that the performance of students can be improved if the students' anxiety is reduced. The result from this experiment provided the evidence that the use of AMaLM had resulted significant improvement in achievement in secondary algebra topics among students. To fulfil the need to overcome mathematics anxiety and assist the students for better performance, this study will attempt to identify the factors of mathematics anxiety in daily schools with related to their performance. The effectiveness of the AMaLM in improving students' performance and reducing mathematics anxiety will be investigated further.

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