

# Ginger's Adventure

Low Jie Ying

**Abstract** – Teaching Linear Algebra is a challenging task for Mathematics teachers as students are introduced with complex and abstract mathematical concepts of Linear Algebra. Additionally, students have been struggling with the concepts of algebra for a long time. The same situation is faced by the Form 1 students from SMK Seri Intan because students could not deal with the transition from arithmetic to algebra. They failed to perform meaningless operations on the symbols that they do not understand where they faced difficulty in solving linear equations with one variable. Conceptual knowledge occurred when the ideas and concepts make sense to the students. Hence, it is important to turn the abstract concepts of Linear Algebra into concrete concepts which make sense to the students. In order to increase students' ability in solving linear equations with one variable, one innovation on conceptual teaching and learning has been created, which is Ginger's Adventure. Ginger's Adventure approach applied the Concrete-Representational-Abstract (CRA) method where students are exposed to the conceptual understanding on linear algebra together with the procedural learning on the steps which should be taken in solving linear equations. The purpose of this action research is to investigate the effectiveness of Ginger's Adventure approach towards the mastery of skills in solving linear equations for 22 Form 1 students in SMK Seri Intan. The diagnostic of the problem is conducted via observations, interviews, surveys and pre-test. The outcome is judged based on the post-test conducted. Ginger's Adventure approach has been used for five lessons within two weeks time. The research outcome shows that Ginger's Adventure approach has been proven to be effective and it showed positive impacts on helping the students in solving linear equations and at the same time students are more motivated and confident in solving linear equations with one variable as never before.

**Keywords** – Linear equations, Ginger's Adventure, Conceptual understanding, Concrete-Representational-Abstract (CRA) method

## I. INTRODUCTION

According to Andam et al. (2015), algebra is a mathematical field where students need to deal with symbols, generalise numerical relationships and carry out operations within the structures given. Hence, Dikovic (2007) claimed that linear algebra is a complex and abstract mathematical concept which caused a lot of problems to the teachers during the teaching and learning process. This statement is supported by Radford (2000) where he added that teachers have been facing problems in teaching algebra since it was introduced.

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Additionally, Linsell (2009) stated that students faced difficulties in dealing with linear algebra because they could not make sense of the abstract concepts of Linear Algebra since they are exposed to the transition from arithmetic to algebra when they are enrolled in secondary schools (Kieran, 2006). Similarly, the same situation is faced by the Form 1 students from SMK Seri Intan, Ipoh where they failed to perform meaningless operations on the symbols that they do not understand and they are unable to solve linear equations with one variable.

According to Herscovics and Linchevki (1994), students faced difficulties while dealing with linear equations because they could not understand the unknown symbols given in the equations. At the same time, Andrew and Sayers (2012) added that the confusion about the expressions on both sides of the equal sign in linear equation is another reason why students could not solve linear equations. In order to help students to link the abstract concepts of linear equations many different embodiments were created and one of the embodiments created was the balance scale model (Fillooy & Rojano, 1989).

However, Warren and Cooper (2005) pointed out that even though balance scale is one of the most frequently used models for equation solving yet it is also the most criticized model as well. On the other hand, Paulsen and the IRIS Center (2006) suggested that by using concrete materials would be able to help the students to understand abstract concepts of linear algebra and they introduced the concept of Concrete-Representational-Abstract (CRA) method to teach abstract concept of algebra.

After all the considerations, in order to increase students' ability in solving linear equations with one variable, one innovation on conceptual teaching and learning is created, namely Ginger's Adventure. Since Andrew and Sayers (2012) suggested that in order to help the students to solve linear equations, first must help them to make connection between arithmetic and symbols of mathematics. Thus, Ginger's Adventure approach is created to help students to make sense of the abstract concept of linear algebra where the students are exposed to a situation which they are familiar with.

## II. PROBLEM STATEMENT

In the research conducted by Samuel, Mulenga and Angel in year 2016, most of the students failed to solve linear equations as their conceptual mastery on linear equations is weak. Moreover, students face difficulties in grouping the like terms together and manipulating the positive and negative signs in linear equations. The same situation is faced by the Form 1 students from SMK Seri Intan, Ipoh.

Furthermore, Kilpatrick & Izsák (2008) stated that due to the lack of symbolic understanding of variables and coefficients in a linear equation, again students failed to

solve linear equations. Besides, another factor of students' failure is their lack of understanding of the meaning of the equal sign in an equation (Knuth et al., 2006). Moreover, Atteh et al. (2017) claimed that most of the students are mainly taught to solve linear equations by an abstract way without using concrete examples.

However, for the students from SMK Seri Intan, different methods of teaching linear equations such as the balance scale model has been used during lessons, yet they are still confused with the meaning of equal sign in linear equations. Apart of that, they still have difficulties in gathering the like terms and manipulating the signs in linear equations. They are confused with the steps that should be taken while solving linear equations with one variable.

The problem now is what should be done to help the Form 1 students from SMK Seri Intan, Ipoh to understand the abstract concept of Linear Algebra in solving linear equations with one variable and to improve their ability and skills in grouping the like terms together and carrying out mathematical operations of the unknowns and numerical numbers.

### **Research Objectives**

This action research is aimed at implementing the innovation of Ginger's Adventure approach to improve students' understanding, skills and performance in solving linear equations with one variable. It is hoped that, Ginger's Adventure would provide a simplified, concrete material on conceptual understanding in solving linear equations with one variable.

## **III. LITERATURE REVIEW**

### **Algebra in Schools**

According to the Ministry of Education Malaysia (2016), there are five main mathematical learning areas which students need to cover within the curricula, namely:

- (i) Number and Operations
- (ii) Measurement and Geometry
- (iii) Relationship and Algebra
- (iv) Statistics and Probability
- (v) Discrete Mathematics

The topic of Linear Equations is under the learning area of Relationship and Algebra. In the first subtopic of Linear Equation, students are required to demonstrate the understanding of linear equations, apply the understanding of the solution for linear equations and finally solve linear equations with one variable.

### **Linear Equations with One Variable**

The first subtopic of Linear Equations for Form 1 Mathematics is Linear Equation with One Variable where students learn how to solve linear questions by finding the value for the unknowns given. According Huntley and Terrel (2014), linear equation with one variable is the basic which

must be mastered in the field of algebra. Wati, Fitriana and Mardiyana (2018) added that the concepts of linear equations are essential for more advance mathematics in higher level. Within the secondary school standard-based curriculum for Form 1 Mathematics, students are exposed to mainly two types of linear equations which are one-step and multi-steps linear equations with one variable.

### **Strategies to Solve Linear Equations with One Variable**

According to Linsell (2008) and Kieran (1992), students used several strategies to solve linear equations with one variable, namely:

- (i) Guess and check
- (ii) Counting techniques
- (iii) Inverse operations
- (iv) Working backwards then guess-and-check
- (v) Working backwards then known facts
- (vi) Working backwards
- (vii) Transformations

All the strategies used were solely based on the teaching methods and students' ability as well as students' prior knowledge and prerequisite knowledge.

### **Balance Scale Model**

Vlassis (2002). stated that using balance scale model in solving linear equation was not something new and based on the concept of balance scale it enabled students to observe and see directly how algebra works within the equation. At the same time, some studies found that balance scale model is useful in bridging students' procedural knowledge to structural understanding (Khuluq, 2015).

However, some studies found that students faced difficulties solving linear equations by using the balance scale model (Boulton-Lewis et al., 1997). Additionally, the finding of the studies by Ngu and Phan (2016) showed that students who used balance scale model in solving linear equations did not perform well compared with those who used other strategies. Moreover, most of the studies conducted mainly focused on teaching linear equations with positive values instead of negative values (Otten, Heuvel-Panhuizen, & Veldhuis, 2019).

### **The Concrete-Representational-Abstract (CRA) Method of Teaching Mathematical Concepts**

According to Paulsen and the IRIS Center (2006), CRA method is used to assist students to make connection between conceptual and procedural mathematics knowledge where students are guided with concrete and visual representations or materials in order to understand abstract concepts. Sencibaugh, Callan, and Almus (2017) claimed that in order to guide the students to solve linear equations, there are three stages:

- (i) Concrete stage: A stage where students are exposed to the mathematical concepts with concrete materials

- (ii) Representational stage: The concrete materials are transformed into representational level where the concrete materials are represented with some pictures or drawing.
- (iii) Abstract stage: A stage where students are exposed to numbers, symbols, operation symbols and notations which are used to solve linear equations.

CRA helps students to understand the concepts better instead of just memorising the algorithms.

#### IV. METHOD

##### Research Design

This research employs a quantitative approach by using pre-test and post-test design together with cross-sectional survey instruments in order to find out the effectiveness of implementation of Ginger's Adventure approach in improving students' understanding, skills and performance in solving linear equations with one variable.

In the cross-sectional survey, data are collected from the selected students before the implementation of Ginger's Adventure approach to get their perspectives about linear equations. According to Zahner and Steedle (2015), cross-sectional survey could provide researchers with a snapshot in a specific time about the behaviours, attitudes and perspectives of the respondents about the matter being investigated.

##### Sampling

This research involved 22 female students from Form 1 Anggerik in SMK Seri Intan, Ipoh. There are 14 Malays students and 5 Chinese students and 3 Indian students. The participants for this research were not chosen at random as author was assigned to teach Mathematics for this particular class.

Majority of the students (50%) only mastered the minimum level (36.4%) or at the satisfactory level (13.6%) for Mathematics in the UPSR exam which is equivalent to grade D and C respectively. 18.2% of the students did not master the minimum level for Mathematics in the UPSR exam where they scored grade E for Mathematics.

Thus, the mastery level for Mathematics for students in Form 1 Anggerik can only be considered as moderate. Additionally, only students who are excelled in Mathematics (13.6%) could solve the linear equations with one variable and the others were unable to.

##### Research Instruments

In order to carry out this study, the research items comprise of two parts: performance test and survey items. In order to measure students' mastery level of the concepts in solving linear equations with one variable, pre-test and post-test (performance test) are administered to the students. Both pre-test and post-test consist of 24 questions which are

adapted from Modul HEBAT JPN Perak for the chapter of Linear Equations and the allocation of time is 60 minutes.

Meanwhile, for the survey part, there are a total of 11 questions and the items are developed based on three criteria: students' perception, root cause of students' weakness and teacher's teaching method.

##### Data Collection Procedure

In order to diagnose the problems faced by the students, useful information and data are collected via classroom observation and through their homework and exercises. Informal interviews are carried out with 5 randomly picked students from Form 1 Anggerik to understand how students' feel about the abstract concept of Linear Algebra. Besides, questionnaires are distributed to the students to understand in depth the reasons why the students are unable to master the concept of Linear Algebra before the implementation of Ginger's Adventure approach.

Pre-test is administered before the implementation of Ginger's Adventure approach in order to test the students' mastery level of the concept of Linear Algebra. After the implementation of Ginger's Adventure for a period of two weeks, a similar post-test is administered to the students. The results of pre-test and post-test are compared within the same sample.

##### Implementation of Ginger's Adventure Approach

Ginger's Adventure approach is implemented within a period of two weeks for five lessons based on stages in Concrete-Representational-Abstract (CRA) method.

- (i) Concrete stage:

Students are exposed with the concrete material of Ginger's Adventure which consists of two worlds namely 'Wonderland' and 'Kinderland' as shown in Figure 2. Students pointed out that Ginger Bread Man belongs to Wonderland while kids belong to Kinderland.



Figure 2. Situation where students are exposed to the concrete material of Ginger's Adventure

- (ii) Representational stage:

Students managed to find out that every card given has both sides where numerical numbers are represented by pictures of different kids, meanwhile alphabets (unknowns) are represented by pictures of

Ginger Bread Man, and each operational mathematical symbol have both sides as well, as shown in Figure 3.



Figure 3. Each of the cards given has both sides

(iii) Abstract stage:

During this stage, students are briefed with the story of Ginger’s Adventure and how to apply the simplified concept of Ginger’s Adventure in order to solve linear equations. Figure 4 shows a group of students discussing and trying to apply the Ginger’s Adventure approach to solve a linear equation.



Figure 4. Students are trying to solve linear equations in groups by using the representational cards which consist of numbers, operational mathematical symbols and alphabets (unknowns)

V. FINDINGS

Based on the classroom observations via students’ work and verbal responses during lessons, it is found that  $\frac{3}{4}$  of the students did not master the concepts of Linear Algebra.

Through the informal interviews, students admitted that they are weak in Mathematics and they tense to forget the concepts. Moreover, they claimed that they are confused with the unknowns and mathematical operational symbols. Hence, they faced difficulties in putting the like terms together.

The outcomes of the surveys regarding students’ perception, root cause of students’ weakness in Linear Algebra and teacher’s teaching methods are as shown in Table I.

TABLE I: OUTCOMES OF THE SURVEYS BEFORE THE IMPLEMENTATION OF GINGER’S ADVENTURE

Item of questionnaire	Percentage %	
	Yes	No
<b>Students’ Perception</b>		
1 In your opinion, do you think it is difficult to master the subject of Mathematics?	72.8	27.2
2 Do you think it is hard to understand the concepts in Mathematics?	81.8	18.2
3 Are you interested in Mathematics?	77.3	22.7
<b>Root Cause of Students’ Weakness</b>		
1 Have you learnt algebra before in primary schools?	0	100
2 Does the abstract concept of Linear Algebra make sense to you?	9.1	90.9
3 Are you confused with the concept of Linear Algebra?	90.9	9.1
4 Do you always forget about the concept of Linear Algebra?	86.4	13.6
5 Does the balance scale model help you in solving Linear Equations?	27.2	72.8
<b>Teacher’s teaching method</b>		
1 Did your teacher use different approach to teach the concepts of Linear Algebra during the lessons?	100	0
2 Did your teacher give you exercises after lessons?	100	0
3 Are the exercises given too much as your homework?	13.6	86.4

The pre-test results are as shown in Chart I. Based on Chart I, it is clearly shown that out of 22 students, only 3 students passed and 19 students failed the pre-test. In another words, 86.4% of the students did not master the learning standard for Linear Equations. Additionally, those who passed the pre-test are the students who scored grade A in UPSR for Mathematics.

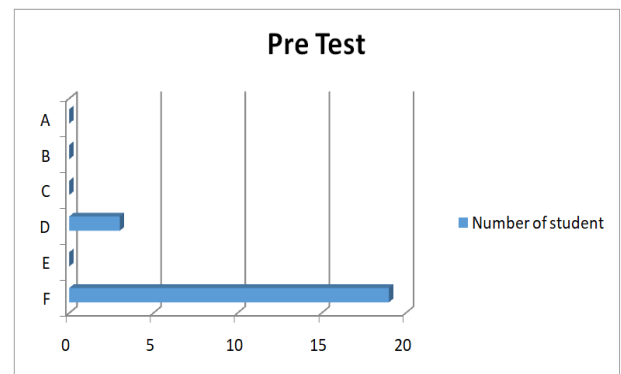


Chart I. Pre-test results

The comparison between Form 1 Anggerik students’ achievement in the pre-test and post-test is as shown in Chart II.

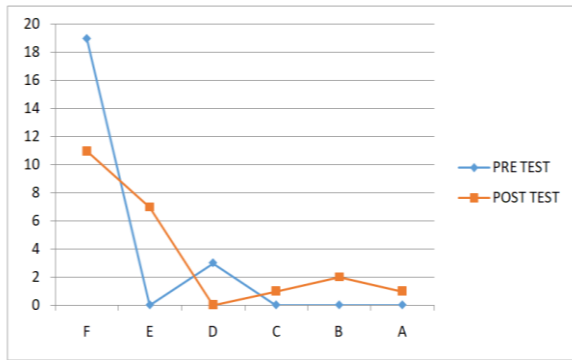


Chart II. Line graph on the comparison between the achievement of Form 1 Anggerik students for pre-test and post-test.

Based on Chart II, it is clearly seen that the number of students who failed the post-test has dropped from 19 students to 11 students. At the same time, students' grades have improved. This indicated that 50% of the students have mastered the learning standard for Linear Equations.

Table II shows the analysis of marks for pre-test and post-test done through SPSS software.

TABLE II: PAIRED SAMPLE MEAN FOR PRE-TEST AND POST-TEST (ONE SAMPLE)

	Mean	N	Std. Deviation	Std. Error Mean
Pre-Test Scores 100%	16.55	22	17.129	3.652
Post-Test Scores 100%	38.77	22	20.066	4.278

PAIRED SAMPLE T-TEST

	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Pre-Test Scores 100% & Post-Test Scores 100%	-22.227	8.869	-11.755	21	.000

Table II shows the mean scores for pre-test and post-test which is 16.55 and 38.77 respectively with standard deviation (SD = 17.13) and (SD = 20.07) respectively with the sample of 22 students. The standard deviation (SD) shows that the post-test scores deviate more than the pre-test scores, with a difference of 2.94. In the paired samples test as shown in Table 2, the "Sig. (2-tailed)" value is 0.000 ( $p < 0.05$ ), this shows that there is a significant difference in the pre-test scores and post-test scores.

Based on the results above, it showed that students performed significantly better in the post-test after the implementation of Ginger's Adventure approach compared to the pre-test.

## VI. DISCUSSION

Statistical results showed that, by implementing Ginger's Adventure approach in teaching and learning the concepts of Linear Algebra in solving linear equations has a positive effect on students' performance.

Students scored significantly better in the post-test after the usage of Ginger's Adventure approach. Even though there are a handful of students who failed the post-test yet their marks improved from single digit to double digits. This indicates that Ginger's Adventure approach managed to help

the students to understand the abstract concept of Linear Algebra, then they are able to group the like terms together and finally solve the linear equations with one variable.

## VII. CONCLUSION (OR LIMITATION OR SUGGESTION FOR FURTHER STUDIES)

Based on the analysis of this research, it is proven that the implementation of Ginger's Adventure approach gives a positive impact in helping the students to master the concepts of Linear Algebra. After the implementation of Ginger's Adventure approach in five lessons, students managed to solve linear equations with one variable correctly without much help from the teacher. Students are able to group the like terms together and carry out mathematical operations correctly within the linear equations given. At the same time, students are more motivated to learn Mathematics as they are no longer confused with the operations or steps to be taken to solve linear equations with one variable. It is hoped that this innovation would be able to help the students in learning of the abstract concept of Linear Algebra especially in solving linear equations with one variable. Concurrently, it is hoped that Ginger's Adventure approach would be an alternative strategy in helping teachers to teach the concepts of Linear Algebra in order to improve students' skills and ability in solving linear equations with one variable.

### Limitation

This study only involved one Form 1 class which consists of 22 students from a school thus the findings of this study cannot be used to generalise for all students in Form 1 in Malaysia.

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