INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 13, Issue 4, (2024) E-ISSN: 2226-6348

The Effect of Manipulative Aided Learning Module on form One Student's Achievement in Algebraic Expressions

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To Link this Article: http://dx.doi.org/10.6007/IJARPED/v13-i4/23823 DOI:10.6007/IJARPED/v13-i4/23823

Published Online: 25 November 2024

Abstract

Mathematics is divided into several branches including geometry, algebra, statistics, and probability. Out of these branches, algebra is considered difficult for many students. Mastering the rules of algebraic expressions is the foundation of learning algebra. However, due to its abstract nature, many lower secondary school students find it difficult. The purpose of this study is to identify the effect of manipulative aided learning module on form one student's achievement in algebraic expressions. A quasi-experimental study was conducted involving a treatment group and a control group where the treatment group used the manipulative aided learning module to learn algebraic expressions. The instrument of this study is a pre-test and a post-test on algebraic expressions. The results of the pre-test and post-test analysis show that the module help to close the achievement gap between the intervention group, where the intervention group also showed better results. This research paper suggests that using learning module that includes manipulative materials can be effective to improvement student's achievement in algebraic expressions.

Keywords: Module, Manipulative Materials, Achievements, Algebraic Expressions.

Introduction

One of the difficult branches of mathematics is algebra (Marpa, 2019). Algebra uses a combination of letters and numbers to represent number or quantity (Manandhar, Pant & Dawadi, 2022). Algebra is a mathematical science that needs to be taken seriously by both students and teachers because it is considered to be a gatekeeper in mathematics and other fields of study such as science and engineering (Rittle-Johnson & Star, 2007). The topic of algebraic expressions is a basic topic of algebra that is taught to form one students (Malaysia Curriculum and Assessment Standard Document, 2015). Teh, Shah and Idrus (2021) showed that the topic of algebraic expressions is a difficult topic for form one and form two students. In addition, upper secondary school students also face difficulties in mathematics and additional mathematics subjects (Yahya & Amir, 2018) because their algebraic foundation is weak (Daud & Ayub, 2019).

Nowadays, conventional methods are no longer suitable for teaching and learning mathematics (Abdul Rahman, 2017) because students need to build their thinking skills especially in learning algebra (Jahudin & Nyet, 2021). To improve student achievement in algebraic expressions, teachers need to utilize effective teaching methods and tools to support students learning (Omar, Saad & Dollah, 2017). Learning methods that use teaching aids can have a positive effect on student achievement in mathematics (Alshatri et al., 2019). According to Yao (2021), modules are an effective tool in improving student achievement in algebraic expressions. In addition, modules are materials that students can explore in pairs to share experiences and ideas. Manipulative materials are also seen to be effective in improving student achievement in the topic of algebraic expressions (Farah et al., 2022; Bone, 2020; Abdullah et al., 2022).

Literature Review

Learning Algebra in Form One Mathematics

Algebra is a mathematical science that uses symbols to represent numbers and it is important till the higher education level (Tajudin et al., 2015). The topic of algebraic expressions is a topic involves arithmetic operations that are considered difficult by students (Adnan et al., 2021). Previous research shows that many students have a low achievement not only in algebraic expressions but also in mathematics (Bakar & Samah, 2021). For example, quantitative research has been conducted with 386 respondents who were selected by stratified random sampling from seven secondary schools in Sabah showed that students have not mastered algebraic expressions (Baco, 2021). Other than that, a test was given to a secondary school students in Selangor and the result showed that the students had moderate achievement in algebraic expression (Bajuri & Othman, 2021).

Unfortunately, mathematics performance at higher level is similarly impacted by low achievement in algebraic expressions (Daud & Ayub, 2019). Bakar and Samah (2021) shows that the reasons behind the low achievement of form four students in additional mathematics is because of students was struggling with algebraic expressions skills. This is also supported by Ibrahim (2016) who showed that students' deficiencies in algebraic expressions have an impact on their performance in solving differentiation and the students who perform poorly in algebraic expression also perform poorly in other mathematical topics.

In the Malaysian mathematics curriculum, algebraic expressions are the basic algebra topic introduced to form one student. This algebraic expression topic is divided into two subtopics, which variable for the first subtopic and algebraic expressions involving arithmetic operations for the second topic. In algebraic expressions, students learn about variables, coefficients, algebraic expressions, and arithmetic operations of algebraic expressions. Form one students were exposed to the addition, subtraction, multiplication, division and problem-solving involving brackets.

From the basic that student learn in form one, they continue to learn about algebra in form two which is involving expansion, factorisation, algebraic fractions, and algebraic formulae. In form three mathematics curriculum also has an algebraic topic such as straight lines. Students will also learn algebra in mathematics and additional mathematics till form five. All algebra topics are related to the algebraic expressions (Malaysia Curriculum and Assessment Standard Document, 2015-2018). Other mathematics topics also use algebraic expressions methods in

problem solving. When students are weak in algebraic expressions, it will affect their mathematics achievement (Bakar & Samah, 2021).

Based on the results of the previous study, there is a need to develop a learning module to help students learn algebraic expressions. It is also an effort in diversify teachers' teaching methods. This student-centered approach has to be developed as an effort to improve mathematics achievement. Although previous studies such as those by Yao et al. (2022), Tajudin, Zamzamir and Othman (2018), Yao et al. (2021), and Sam (2017) have also focused on learning algebra, but the existing modules are more focused on the use of I-Think maps in problem solving. Therefore, the learning module for algebraic expressions needs to be further expanded to help improve student achievement.

Learning Algebra with Manipulative Aided learning module

Nowadays, conventional learning methods are still used in algebraic expressions learning and it causes to students' low achievement (Wei, 2020). In the context of this study, the use of learning modules is seen to have a good effect in reducing mistakes and improving students' mathematics achievement (Radzuan, 2019). Aliza and Zamri (2016) state that the purpose of the learning module is to help students improve their skills to achieve learning objectives. Modules also used as a reference materials in learning sessions (Nik Azis, 2014) and it is a student-centered approach in classroom (Abdullah & Leow, 2017).

In learning mathematical concepts, manipulative materials act as the main learning material and are used to further strengthen students' skills (Yan, 2020). Using manipulative materials is a simple and practical approach to improve the learning of mathematics (Zuhan & Shaharuddin, 2021). This is because the manipulative materials are able to build new ideas to the cognitive structure of students (Golafshani, 2013). Manipulative materials are student-centered approach which provides opportunity for students to explore and develop their own cognitive and motor skills (Supriyanto et al., 2019) in improving mathematics learning (O'Meara, Johnson & Leavy, 2020).

Yulia, Sripatmi and Baidowi (2021), state that using manipulative materials can increase achievement among form two students in algebraic expression. This also supported by Memolo (2018), who used envelopes, pens and sweets as manipulative materials for 21 form one students in understanding the concept of algebraic expressions. Students were asked to use manipulative materials in group and as a result students were seen to be more active and 100% of students were able to use manipulative materials well in solving algebraic expressions. The results of Abdullah et al. (2022), show that the algebraic box manipulative material is able to increase the level of mastery of form one students related to the problem of adding algebraic expressions.

Despite the positive results of these studies, there were some shortcomings such as a group of students who still lack the skill level in algebraic expression when using manipulative materials such as envelopes, sweets and pens in the study of Memolo (2018). Besides that, the instructions provided to students using manipulative materials are unclear, which disrupts the smoothness of the learning session (Abdullah et al., 2022). However, manipulative aided learning module are seen as students' choice because they are exploratory and student-centered (Teh, Shah & Idrus, 2020).

In this current study, clay is used as a manipulative material on form one student. Clay is seen as an effective material because it can contribute to build skills and achievement effectively (Roberts et al., 2020). Rahayu et al. (2022) and Bryan (2017) show that clay has the potential to reduce student errors and increase student achievement in mathematics. In the context of this study, although the learning module for algebraic expressions has been developed, the manipulative aided learning module for form one in algebraic expressions is still not widely used.

Research Objective

The objective of this study is to:

1. Identify the effect of manipulative aided learning module on form one student's achievement in algebraic expressions.

Research Question

Based on the research objective, the research question developed is:

1. What is the effect of manipulative aided learning module on form one student's achievement in algebraic expressions?

Theoretical Framework

This study uses two theories to support the manipulative aided learning module which is Vygotsky's Social Constructivism Theory (1978) and Bruner's Cognitive Theory (1964). These theories focus on student-centered learning. Figure 1 shows the theoretical framework for this study.

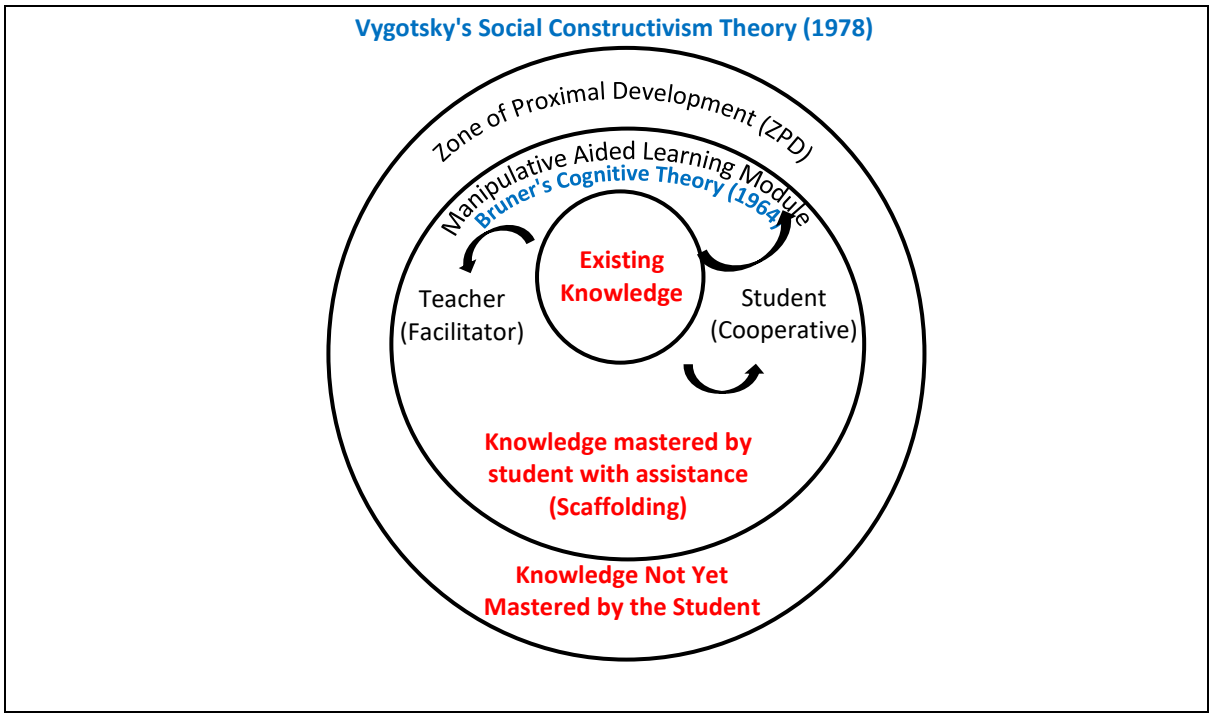

Figure 1 Theoretical Famework

Vygotsky's Social Constructivism Theory states that the construction of student knowledge is through interaction between students and the environment with the help of teachers as the more knowledgeable other (Fosnot, 1996). Therefore, manipulative aided learning module is used with other students in pairs with the help of the teacher as a facilitator. This step also improves students' social and communication skills when they build their skills and knowledge (Gardenia, 2016). The two main concepts in Vygotsky's (1978) Social Theory of Constructivism are the Zone of Proximal Development (ZPD) and Scaffolding. In building knowledge, students go through the Zone of Proximal Development (ZPD) where students build knowledge by themselves or with help from teachers, friends and learning materials (Belland, 2017). Teacher will be a facilitator to scaffold and help students. Students will also use the module and manipulative materials in pairs. According to Rahmawati and Purwaningrum (2022), friends and manipulative materials are also a form of scaffolding for students where knowledge is built and student achievement is improved through social interaction and the use of manipulative materials.

Bruner's Cognitive Theory states that students build knowledge and translate that knowledge through three stages, namely (i) Enactive Stage (concrete); (ii) Iconic Level (picture) and (iii) Symbolic Level (abstract) (Mohamed & Chew, 2021). This theory is used when students solve abstract problems with the help of manipulative materials that are concrete materials (Bruner, 1964). At the enactive (concrete) level, students actively build their cognitive skills through the activity of seeing, touching, and holding a concrete material. Then, in the second stage, which is the iconic stage (picture), students build their understanding through images based on the results of the manipulation of concrete materials in the previous stage. The last stage, which is the symbolic (abstract) stage, is the stage where students build their understanding through abstract symbols based on images translated from the iconic stage (Azmi, 2017).

The Concrete Representational Abstract (CRA) method is a learning method developed in 1966 based on Bruner's Cognitive Theory to support students' cognitive construction through three stages, namely enactive (Concrete), iconic (Representational), and symbolic (Abstract) (Julie, 2010). Just as stated in Bruner's Cognitive Theory, in the enactive stage problem solving begins with the use of concrete materials such as wooden blocks, clay and so on. Then at the iconic level, the solution to the problem was changed to a semi-concrete solution, which is with the image representation. The third stage is the symbolic stage where the semi-concrete solution is translated into an abstract problem solution through the representation of mathematical symbols (Azmi & Salam, 2019). In conclusion, cognitive and social elements are interconnected in the interaction of students with their environment. The module that will be developed in this study includes manipulative material by which will be used cooperatively with friends to combine cognitive and social elements in the learning process. The development of this module aims to improve student achievement in the topic of algebraic expressions.

Methodology

This is quantitative research which was conducted in a secondary school in Alor Gajah, Melaka. In this study, a manipulative aided learning module for the topic of algebraic expressions was used as an intervention together with a pre-test and post-test instrument in a quasi-experimental study. The pre-test and a post-test contained 10 questions each were

conducted on 62 form one students where 31 students form the intervention group and 31 students form the control group. The treatment group used manipulative aided learning module while the conventional learning method was for the control group. Respondents were selected by purposive sampling where the 62 students were selected by the school's administration to avoid disrupting the school classes. The data of this study was analyzed using the Statistical Package for Social Science (SPSS) Version 29 software. A descriptive test was used to obtain mean values and standard deviation of both groups. While, Wilcoxon T test and Mann Whitney U test were used to identify the relationship of both groups. Figure 2 shows a sample of the questions from pre-test.

Simplify $(5a+3b+10) - (2a+2b-2)$
Simplify $-5(4p+5)$
Simplify $5x - 2(4-3x)$

Figure 2 A Pre-test Questions

Manipulative Assisted Learning Module

According to Bone (2020), manipulative materials are effective for abstract topics such as algebra. A manipulative aided learning module such which is clay has been developed in this research. This learning module was developed based on the ADDIE model. Clay was chosen as a manipulative material because clay is proven can help improve student achievement in mathematics (Rahayu et al., 2022). Also, the development of these materials also helps teachers in preparing materials because it does not burden the teacher, is cheap, saves time and is easy for students to use in the class.

The Concrete Representational Abstract (CRA) method has been chosen to use in this research because three stages in CRA help constructs student's cognitive which are in sequence by starting from the sensory motor stage to the visualization stage and finally to abstract ideas (Mohamed & Chew, 2021). This method begins with the concrete stage where the use of manipulative materials that can be seen, touched, and explored. Then students represent what they did in the concrete stage earlier with sketch and then from the representational stage, they learn how to solve algebraic expressions in the abstract stage. Figure 3 shows the CRA method used in this manipulative aided learning module.

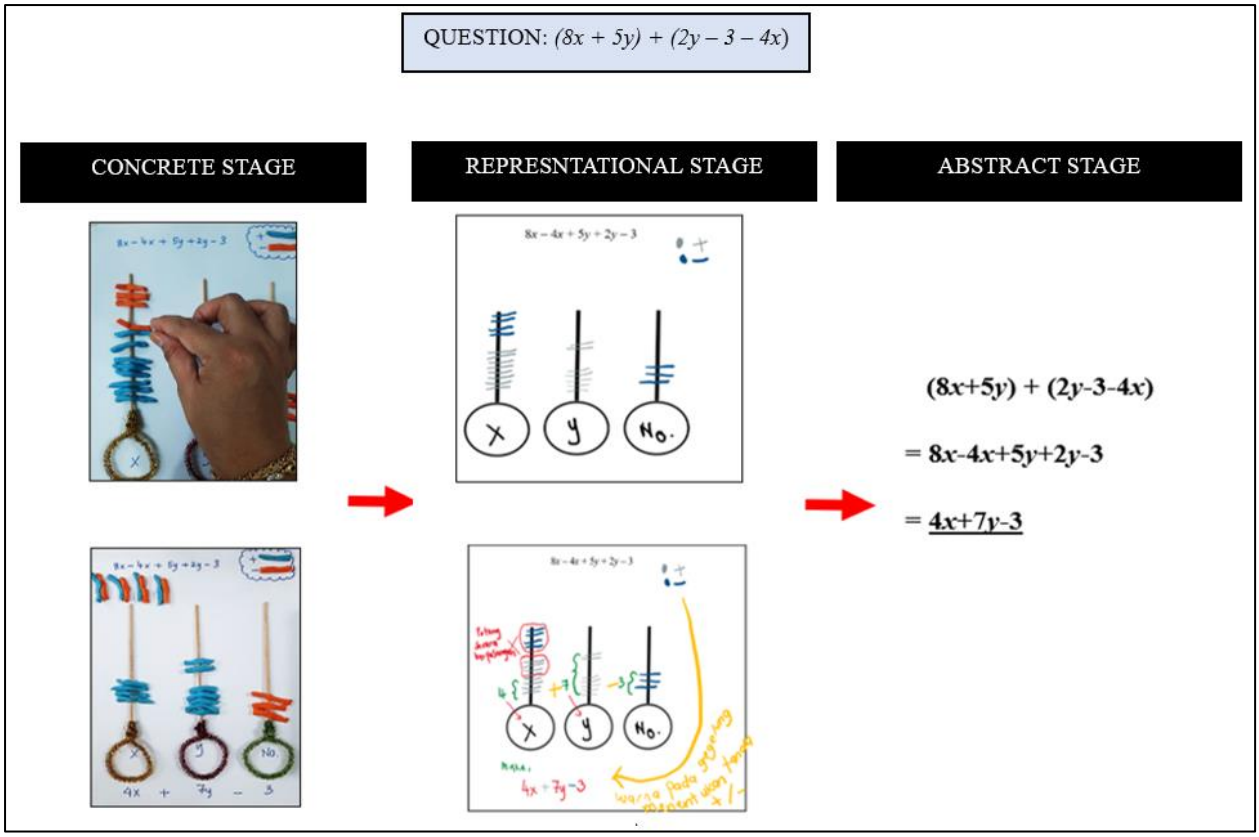

Figure 3 Concrete Representational Abstract (CRA) in Manipulative Aided Learning Module

A manipulative aided learning module was tested for validity and reliability. The content validity of the module was done by selecting five experts consisting of university lecturers and mathematics teachers with experience in the field of algebra, especially the topic of algebraic expressions. Content validity was found to have a Content Validity Index (CVI) value of 0.98 which shows that the content validity of this clay manipulative learning module is high and accepted. While the Cronbach's alpha value of the reliability of this learning module obtained from the pilot study is 0.872.

Findings

The pre-test and post-test instruments were analyzed using Statistical Package for Social Science (SPSS) Version 29 software. This study used descriptive and inferential analysis to identify the effectiveness of manipulative aided learning module on treatment group and control group. Table 1 shows the mean value and standard deviation of student's achievement for both tests that have been conducted.

Table
Mean and Standard Deviation of Treatment Group and Control Group

Group	N	Test	Mean	Standard Deviation
Treatment	31	Pre	52.87	27.921
		Post	77.97	20.901
Control	31	Pre	67.03	19.558
		Post	74.55	19.430

Based on Table 1, there is difference of mean and standard deviation of the treatment group and the control group for the pre-test and post-test. The mean of the pre-test of the treatment group was lower than the control group which was 52.87 with a standard deviation of 27.921. While the mean of the control group for the pre-test is 67.03 with a standard deviation of 19.558. While, the post-test analysis shows that the mean increase can be seen for the treatment group which is 77.97 with a standard deviation of 20.901. The mean of the control group for the post-test also increased to 74.55 with a standard deviation of 19.430. However, a higher increase can be seen in the treatment group.

This analysis shows that the manipulative aided learning module can help improve the achievement of form one students in algebraic expressions. The results of the pre-test and post-test show that form one students can improve their understanding and skills when using manipulative aided learning module. Manipulative aided learning module had a positive impact on improving student achievement in abstract topics such as algebraic expressions. This statement is supported by Abdullah and Leow (2017) and Rahayu et al. (2022).

In inferential analysis, the Wilcoxon T Test is used to compare whether there is a difference in the achievement of algebraic expressions before and after the learning session. While the Mann Whitney U Test was used to compare the achievement of algebraic expressions between the treatment group and the control group for the pre-test and post-test. Table 2 shows the results of the Wilcoxon T Test analysis for both groups.

Table 2
Wilcoxon T Test of Treatment Group and Control Group

Group	N	Test	Z	Sig.
Treatment	31	Pre-post	-3.301	< .001
Control	31	Pre-post	-4.707	< .001

Significance value, p <0.05

Data analysis shows that the treatment group and the control group have a value of $p < 0.05$. The results of this analysis show that there is a significant relationship between pre-test and post-test for both groups. Then, the results of the study were reanalysed using the Mann-Whitney U Test to identify the differences between the two study groups in pre-post-test. Table 3 shows the inference analysis of the Mann Whitney U Test for the treatment group and the control group.

Table 1
Mann Whitney U Test of Treatment Group and Control Group

Test	N	Group	Z	Sig.
Pre	31	Treatment Control	-2.196	.028
Post	31	Treatment Control	-.909	.363

Significance value, p <0.05

Based on Table 3, the significant value of the Mann Whitney U test of the pre-test for the treatment and control groups is 0.28 with a z value of -2.196. While the significant value of the post-test for the treatment and control groups is .363 with a z value of -.909. Based on the significant value of the pre-test, it shows that there is a significant difference between the treatment group and the control group before the students go through the learning session. However, based on the significant value of the post-test, shows that there is no significant difference between the two groups after going through the learning session. This means that the manipulative assisted learning module has helped to close the gap between the treatment and control group. The achievement of the treatment group has improved significantly such that their achievement is now higher, although not significant.

Discussions

Student achievement is based on the student's ability to answer pre-test and post-test questions. Pre-test and post-test were conducted to the treatment group and the control group before and after the learning sessions. The result shows that there is a significant difference in mean achievement of treatment group in pre-post-test. The mean of treatment group's pre-test was 52.87 and it was increase to 77.97 in post-test. The result also shows that there is a significant difference in mean achievement of control group in pre-post-test. The results of the study show that the mean pre-test achievement score of the control group is 67.03 and the mean post-test achievement score of the control group is 74.55. The finding showed that manipulative aided learning module helped to improve student's achievement in algebraic expressions higher compared to the conventional method. This supported by Abdullah (2022) stated that manipulative materials helped to enhance algebraic thinking. Roberts et al. (2020) also states that cooperative learning plays an important role in enhancing students' algebraic thinking skills.

Based on the analysis, shows that there is a significant difference in the mean achievement between the treatment group and the control group before students go through a learning session with manipulative aided learning module and conventional methods. Meanwhile, the post-test result shows that there is no significant difference between the two groups after going through the learning session. This post-test analysis showed that the mean achievement for the treatment group and the control group was increased but the mean achievement of the treatment group was seen to be higher than the control group. This supported by Jubri, Zakaria and Effendi (2020) stated that manipulative materials can help improve student achievement in algebra.

Therefore, manipulative aided learning module is suitable for use as a teaching aid to improve basic skills of algebraic expressions. Learning will be more effective if information is presented in a diverse to students. Compared to traditional teaching methods, teachers need to try more interesting and practical teaching method such as manipulative tools. Activities. Students also need to be exposed to cooperative, collaborative and interactive learning approaches (Voon & Amran, 2021). In this study, the cooperative and collaborative activities implemented when students using manipulative aided learning module. Placing weaker students with higher achieving students to enable exchange of ideas can also be beneficial. In addition, teachers need to be active facilitators to ensure that no students are left behind in the learning process.

The findings of this study only involved 62 form one students in secondary schools in Alor Gajah, Melaka. It is hoped that another study can be conducted for form two and form three students. This study was also conducted to test students related to the topic of algebraic expressions only. It is suggested that future studies can use clay manipulative materials with Concrete Representational Abstract (CRA) method in testing students related to other algebra topics.

Conclusions

This study is about the effect of manipulative aided learning module on form one students achievment in learning algerba. The results of this study show that the manipulative aided learning module with the integration of CRA is an tool for improving student achievement in the topic of algebraic expressions. In the future, it is suggested that teachers utilize more manipulative tools in order to teach other abstract concepts in mathematics.

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