Dienes AEM as an alternative mathematics teaching aid to enhance Indonesian students’ understanding of algebra concept

S Soro¹, S Maarif², Y Kurniawan¹ and A Raditya²

¹Departement of Mathematics Education, Universitas Muhammadiyah Prof. DR. HAMKA, Indonesia.
²Departement of Mathematics Education, Universitas Muhammadiyah Tangerang, Indonesia.

E-mail: slamet.soro@yahoo.co.id

Abstract. The aim of this study is to find out the effect of Dienes AEM (Algebra Experience Materials) on the ability of understanding concept of algebra on the senior high school student in Indonesia. This research is an experimental research with subject of all high school students in Indonesia. The samples taken were high school students in three provinces namely DKI Jakarta Province, West Java Province and Banten Province. From each province was taken senior high school namely SMA N 9 Bekasi West Java, SMA N 94 Jakarta and SMA N 5 Tangerang, Banten. The number of samples in this study was 114 high school students of tenth grade as experimental class and 115 high school students of tenth grade as control class. Learning algebra concept is needed in learning mathematics, besides it is needed especially to educate students to be able to think logically, systematically, critically, analytically, creatively, and cooperation. Therefore in this research will be developed an effective algebra learning by using Dienes AEM. The result of this research is that there is a significant influence on the students’ concept comprehension ability taught by using Dienes AEM learning as an alternative to instill the concept of algebra compared to the students taught by conventional learning. Besides, the students' learning motivation increases because students can construct the concept of algebra with props.

1. Introduction
Education is a dynamic process and always required to adjust to the needs of society and technological developments. It also has a major contribution in preparing quality human beings and directing students to understand their role as human beings who are responsible for continuing and improving development. To improve the development of education is needed a system that can affect the system of teaching and learning such as curriculum, books, learning facilities, teachers and students, and evaluation of learning outcomes. Therefore, it is required adjustment in all aspects that affect the implementation of the education system in order it can be achieved optimally.

Mathematics is a universal science underlying the development of modern technology in education in Indonesia, it has an important role in various disciplines and the development of human mind power.
Mathematics can develop logical, systematic and careful thinking. This is because of the hierarchical, dynamic, deductive, and generative nature of mathematics.

The ability to understand students’ math concepts in schools should always be improved. This is based on the findings of research conducted by PISA (Program for International Student Assessment) in 2012 which states that Indonesia is ranked 64 out of 65 countries, while in the previous year Indonesia ranked 61 out of 65 countries, it shows Indonesia has more than 80% of students who do not like learning math at school [1]. It can happen because students think that math is difficult, both difficulty in calculating, understanding and solving mathematical problems so they do not like mathematics. In addition, mathematics too many symbols and terms, sometimes make students confused in interpreting it. It is common for students to take math lessons in the classroom without knowing what they are learning, because they are rarely asked to communicate what they have learned.

Difficulties experienced by students especially in understanding the concept of algebra. As in the settlement of algebraic forms $x + x = 2x; \ x \times x = x^2; \ (x + 1)(x + 2) = x^2 + 3x + 2; \ and \ (x - 2)(x - 3) = x^2 - 5x + 6$. The completion of the algebraic form is only understood that the rules are abstract by the students. This is because the concept of algebra is often presented in abstract in classroom learning. This difficulty occurs because the ability of students in understanding abstract mathematical concepts is very limited.

According to The Great Dictionary of the Indonesian Language of the Language Center “understanding” means “really understand”. Understanding is an important aspect of learning. Sumarno states that understanding is the second cognitive level in Bloom's taxonomy that describes mastery using the relevant rules without connecting it with other ideas and all its implications [2]. Understanding here is a low-level understanding, where in this case each individual can be said to understand only by memorizing the existing formula and using the rules of processing or algorithm. Such understanding is the same as instrumental understanding and mechanical understanding. In learning mathematics understanding of the material is necessary. This is because mathematics is not a rote subject, so it takes an understanding. Ruseffendi said understanding is classified into three parts, among them: (a) Understanding of translations is used to convey information in other languages and forms, and concerning the giving of meaning from a variety of information; (b) Understanding of interpretation (explanation) is used to interpret the point of reading, not only with words and phrases, but also includes understanding an information from an idea; (c) Extrapolation (expansion); includes estimations and predictions based on a thought, an overview of an information, also including conclusion [3].

Many teachers teach without using mathematical tools, whereas they are able to visualize mathematics, also make the students interested in learning mathematics because with a real object students explore the concept directly without just the symbols. As in algebra learning, there are many symbols that require students to understand the meaning of the symbols. In learning it, sometimes students are confused to perform the operation. Hence, students are asked actively to solve problems of operation on algebra. One of the solutions is to use instructional media that is also a tool in learning mathematics. Students are asked to explore algebra directly by using mathematical tools dienes Algebraic Experience Models (AEM). Use of this tool is to encourage the ability of students to understand the concept of algebra in order to be more developed. It can be effectively given and instilled through learning in school. Learning algebra aims to make students able to think logically, systematically, analytically, critically, creatively, and cooperation. Based on these description, the authors are interested to conduct research on how to instill the concept of algebra by using Dienes AEM in learning mathematics students in Indonesia.

2. Methods
This research was done by Quasi-Experiment method. The samples taken were high school students in three provinces namely the provinces of DKI Jakarta, West Java, and Banten. From each province was taken one school, which is SMA N 9 Bekasi, West Java, SMA N 94 Jakarta and SMA N 5 Tangerang, Banten. The number of samples in this study was 114 high school students of tenth grade as experimental class and 115 high school students of tenth grade as control class.
3. Results and Discussion
Before performing hypothesis testing, it was carried out the normality and homogeneity test. A normality test is assumed that the populations from which the samples are taken are normally distributed \[4\]. Homogeneity test is an inferential statistic used to assess the equality of variances for a variable calculated for two or more groups \[5\].

3.1. Test of Normality
Testing of normality carried out by using Lilliefors test with SPSS 19 for windows. The result can be seen in Table 1.

| Class     | Kolmogorov-Smirnov\(a\) Statistic | df | Sig. | Shapiro-Wilk Statistic | df | Sig. |
|-----------|------------------------------------|----|------|------------------------|----|------|
| Experiment| .124                               | 114| .162 | .955                   | 114| .166 |
| Control   | .094                               | 115| .073 | .979                   | 115| .068 |

From Table 1, p-value (Asymp Sig) of the experimental class is 0.162 > 0.05 = \(\alpha\), and p-value (Asymp Sig) control class is 0.073 > 0.05 = \(\alpha\), hence \(H_0\) is accepted. From the result of the calculation, it can be concluded that the ability of understanding concept for experimental class and control class are normally distributed at the level of significance \(\alpha = 0.05\).

3.2. Test of Homogeneity
The homogeneity test is performed by using Cronbach Alpha test. The result can be seen in Table 2 below.

| Levene Statistic | Degree of Freedom sample 1 | Degree of Freedom sample 1 | Sig. |
|------------------|-----------------------------|-----------------------------|------|
| 6.782            | 1                           | 227                         | .010 |

Based on Table 2, p-value (Asymp Sig) of the experimental class is 0.162 > 0.05 = \(\alpha\), and p-value (Asymp Sig) control class is 0.013 < 0.05 = \(\alpha\). The value of significance is more than the significance level \(\alpha = 0.05\), so it can be concluded that \(H_0\) which states the population variance of both groups is accepted. That is, both groups of data are homogeneous.

3.3. Test of Hypothesis
The hypothesis of this research is that there is an influence of learning by using teaching aid Dienes AEM in the instilling of algebra concept against the ability for understanding students' mathematical concepts. The hypothesis proposed was tested by t-test. By using SPSS 19 for Windows program, the following is the t-test results:
Table 3. Test of Hypothesis

| Understanding of concept | F   | Sig. | t    | df  | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
|--------------------------|-----|------|------|-----|-----------------|-----------------|-----------------------|------------------------------------------|
| Equal variances assumed  | 6.782 | .010 | 6.980 | 227 | .000            | 3.501           | .502                  | 2.512 4.489                          |
| Equal variances not assumed | 6.987 | 216.696 | .000 | 3.501 | .501 | 2.513 4.488 |

Based on Table 3, p-value (Asymp Sig) of experimental class is $0.355 > 0.05 = \alpha$, and $p$-value (Asymp Sig) of control class is $0.000 < 0.05 = \alpha$, hence $H_0$ is rejected. This shows that there is an influence of learning by using teaching aid Dienes AEM in the instilling of algebra concept against the ability to understand students' mathematical concepts.

In this study, there are two techniques of learning applied, the first class uses teaching aid Dienes AEM and the second class does not. The first class is known as Experiment class and the second one is Control class.

Table 4. Recapitulation of Test of The Students' Ability Understanding Concept Algebra

| Class    | Ideal Score | Average Score | Average Grade | Percentage |
|----------|-------------|---------------|---------------|------------|
| Experiment | 24         | 16.564        | 69.1282       | 69.12%     |
| Control   | 24         | 14.775        | 61.55         | 61.55%     |

Figure 1. Comparison of ideal score and average score of students' ability to understand the concept of algebra of experimental and control class.

Based on Table 4, the average score of the students' ability to understand the concept of algebraic concepts obtained by the experimental class is higher than the control class and it is depicted in Figure 1. Figure 1 shows the ideal score is 24 and experimental class has score 16.564 or 16.564% of the ideal score, while control class has score 14.775 or 14.775% of the ideal score.
From the Figure 2, it can be seen that score for most item on experimental class is higher than control class. Items 1, 2 and 6 have more than 10% difference and item 4 have less than 10% difference between experimental and control class. In the other hand, items 3 and 5 have a slightly difference result, the control class score is higher than experimental score.

![Comparison Score of Experimental and Control Class for Each Item on Students' Ability to Understand the Concept of Algebra](image)

**Figure 2.** Comparison Score of Experimental and Control Class for Each Item on Students' Ability to Understand the Concept of Algebra

At the meeting, learning is quite good, because students are happy by learning using teaching aid Dienes AEM, which they have not known or seen before. Students pay attention when teacher is explaining how to use teaching aid Dienes AEM, but sometimes the class is crowded, this is because students are unusual to use teaching aid Dienes AEM so they are confused. However, students are interested in learning; they discuss to solve the problem given by using teaching aid Dienes AEM.

At the first meeting, we learn about forming the quadratic equation and determining the root of quadratic equation by factoring, and then the students are given the opportunity to organize the class by forming a group of 4 to 5 people. After that, each student is given activity sheet to be observed and solved before it is taken to group discussion; here is where the thought process occurs. Then each student gathered with the group to discuss their results whether true or not.

![Students are discussing to do worksheet](image)

**Figure 3.** Students are discussing to do worksheet
Figure 4. Students present their result of discussion

Then after students work on work sheets, they are given the opportunity to present their findings and other groups were given the opportunity to ask questions and respond to the presentation. Before the learning ends. Learners together with the teacher to draw conclusions from what has been learned at the first meeting. The learners are then instructed to return to their respective seats to prepare for a formative test of material they have learned.

4. Conclusion
From the result, it can be concluded that from the experimental data, it can be concluded that there is an positive influence of learning by using teaching aid Dienes AEM on high school students' ability to understand the concept. Obtained a learning module with Dienes AEM to understand the concept of algebra in high school, and Dienes AEM is appropriate for algebra learning in high school.

References
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