

# Algebraic Lab: Pedagogical Tool to Teach and Learn Algebra through Game

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## Abstract

This study aims to examine the usability of 'Algebraic Lab' as a learning aid in learning Mathematics topic of Algebra for Form Two. The method used is product design and development research by using ADDIE model. The approach of this study is quantitative. A total of 100 Form Two students around Perak were randomly selected for this study. Before the questionnaire was distributed, students were taught how to use the 'Algebraic Lab'. Quantitative data were analyzed descriptively. Based on the mean analysis, the usability of 'Algebraic Lab' as a learning aid is 3.15 which is a moderate level. In conclusion, 'Algebraic Lab' is suitable for use as a learning aid for Algebra topics. The implication of this study shows that the process of teaching and learning in Malaysia through games can increase the understanding and attract students' attention to learn the topic of Algebra. In addition, the 'Algebraic Lab' gives positive impact to students, teachers, schools and the Ministry of Education Malaysia in an effort to make changes in terms of learning from conventional to nowadays modern learning techniques.

## Keywords

Usability, Pedagogical Tool, Algebra, Game, Teaching Tool, Manipulative

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## Introduction

Mathematics is one of the most important subjects in the education system of Malaysia. In daily routine, we cannot run away from not using mathematics. Mathematics education is filled with abstract concept so the use of suitable teaching aids is important in order to help students understands better [1]. Algebra is a branch of mathematics that uses letters and signs or symbols to represent numbers and quantities. According to the Ministry of Education, Malaysia (1998) algebra was first taught in Form Two and began to be taught in Form one after realizing that the topic of algebra is critical and needed more attention. Algebra is a "gatekeeper" because it is a condition in most fields of education and employment opportunities [2]. Most students faced difficulty in learning the topic of algebra. In the topic of algebra, sentence-based mathematical problems are involved and the problem-solving process is used in solving the mathematical problem [3]. Although the topic of algebra has been introduced to students as early as primary and secondary school in most countries, many students are still not interested and students are worried about learning algebra topics that are considered too abstract [4].

21st century education highlights the globalization and internationalization. Implementing technology helps theoretical constructs and realistic insights in the development and improves knowledge, skills and attitudes among students and teachers [5]. Majority of Mathematics teachers in school uses ICT in their lesson [6]. One of the initiatives attempted by the Ministry of Education is to present the utilization of ICT in instructing and learning process [7]. Using ICT to teach mathematics in this 21st century helps students to enjoy the lesson but it will be uninterested for students who are not familiar with ICT [8]. In this case, teacher should implement new method to teach the students. Based on a research done, Ministry of Education Malaysia suggested to use Flipped Classroom as it much related to the concept of 21st century Classroom that emphasize good communication, collaboration, critical as well as creative thinking [9].

According to Einstein, the key to one's success is to be able to think flexibly, be able to construct and trigger new questions, and create new problems from an angle that requires a creative and imaginative approach. Teachers have the option to use creative teaching and learning methods so that it can be entertaining and fun. This can be applied in learning through games. Game-based learning is a pleasure in early childhood education where by playing, they can feel their own experience in learning [10]. Fun in play causes students not to feel they are learning. This situation can generate students' skills and motivation will increase where it can attract students' interest and make the learning more meaningful and effective [11]. Focus will also be given entirely to what they learn further helping in improving student learning strategies and abilities [12]. Even though the classroom atmosphere is cheerful and fun, mathematical information and concepts can still be mastered by students in a calm and relaxed learning.

## Background

According to [13] algebra problems are problems or questions related to symbols (usually in the form of letters), variables, and equations that do not directly have rules or algorithms that can be used to determine the answer. Siswono, T (2008) argues that the steps to solve algebra problems do not need to be clear but they need to know how to solve the problem. Solve algebraic problems is how to get answers to questions that related to symbols (usually in the form of letters), variables, and equations that requires indirect steps to solve methods or algorithms that can be used to determine answers using concepts, knowledge, formulas, and calculations owned by students.

According to [15], Game-Based Learning (GBL) has various definitions according to many authors and does not have a specific definition. Game types can be divided into two categories, namely digital and non-digital games. According to [16] "games" are intended for entertainment only while "Digital Game-Based Learning" aims to cultivate skills and improve knowledge to players or students. According [17], GBL refers to the use of card games in lessons and can improve interpersonal relationships in the learning process. In the study of [18], GBL is a learning environment that integrates games and facilitates students to collaborate with each other and organize the knowledge learned during the learning process. According to [19], the use of technology helps in improving students' understanding especially in mathematics and can increase student motivation. Students should be exposed to the use of more interactive

Farah, R. N.; Amarpreet, K.; Zuraida, R. L.; Muzirah, M.; Ayub, A. F. M.; Nida, S. U.; Rejeki, S.; and Irwan, N. technology in providing exposure to solve non-routine questions in situations where the method of solution is still unknown at an early stage given the question. Among the technologies that can help students increase creativity in solving non-routine problems is by introducing games that involve technology in learning.

Symbolab Mathematical Solver application can be interpreted as software used to aid Mathematics learning so that students can more easily understand the topic. Symbolab is a Mathematics software that allows students to learn and practice Mathematical topics using mathematical symbols and notation and scientific texts [20]. Through the study of [20] it shows that learning using Symbolab application is more effective than using conventional methods seen from improving learning outcomes. GBL is an approach that uses games for educational purposes. A study on GBL have shown that GBL can increase student interest, student achievement in subject and problem-solving skills [15]. To attract the interest of students in learning, the learning process should be meaningful especially in learning environment [21]. These studies show that games in learning can not only increase students' enjoyment in learning, but it can also increase content mastery among students, increase student interest, student motivation in learning and can also change students' perceptions of Mathematics [15]. A study showed that the use of electronic teaching tool that can be used in Mathematics is Geometer's Sketchpad (GSP). Based on the study, GSP can be a platform to show early indications that there are indeed some topics that need animation and visualization to help improve understanding of learning [22]. The use of Color Triciare Model helps students of low perform to score more in the topic of addition and subtraction of algebra [23]. The Chip Mental Arithmetic Kit as a new teaching aid, may defeat the conventional method and other teaching methods since it fills the requirements of teachers needed in teaching and learning addition and subtraction [24].

## Methodology

This study is a product Design and Development Research (DDR) that can be used for teaching and learning session. It is designed based on technology and its usability test is conducted by using quantitative design. This study uses the questionnaire form method to assess the level of usability of 'Algebraic Lab' as a learning aid. This questionnaire was distributed to 100 Form Two students around Perak. The students were randomly picked from two school which was also randomly picked from Mukim Kampar. This questionnaire was distributed after the students had used the 'Algebraic Lab'. The data collected from the questionnaire is quantitative data and analyzed using SPSS version 23. The data obtained were analyzed through descriptive statistics, namely frequency, percentage, mean and standard deviation. The mean score interpretation scale taken from [25] is as Table 1:

**Table 1.**  
Interpretation of Mean

Mean	Mean Interpretation
0.00-1.66	Low
1.67-3.33	Moderate
3.34-5.00	High

## Development of 'Algebraic Lab'

The 'Algebraic Lab' game consists of two main materials, namely the 'Algebraic Lab' board which has the concept of 'monopoly' game as well as Symbolab software. The name 'Algebraic Lab' is a combination of Algebra and Symbolab. The 'Algebraic Lab' board has small boxes of different colors according to the level of the question while Symbolab acts as an aid to solve the question. In Symbolab, the steps for solving the question are clearly provided. 'Algebraic Lab' can be used as a learning aid so that students can learn actively by comparing answers obtained through self-calculation and Symbolab. This can also help students to solve problems perfectly. Therefore, the main objective of the 'Algebraic Lab' is to help students to master and strengthen their knowledge of the concept of Algebra. Algebraic Lab is developed using the ADDIE model. According [26], [27], [28], the ADDIE model is suitable because it is one of the teaching designs models or systematic design in the production of effective and user-friendly learning tools. In general, this

model consists of five main phases, namely analysis, design, development, implementation and evaluation.

### Analysis

Phase Analysis is the basis for the next phases in the production of effective learning tools. Analysis of students helps in determining the skills or knowledge that should be learned while identifying existing knowledge and skills and attitudes of students or teaching goals [29]. At this stage, analysis of problems faced by students in learning topic Algebra as shown in Figure 1 was carried out by using questionnaires.

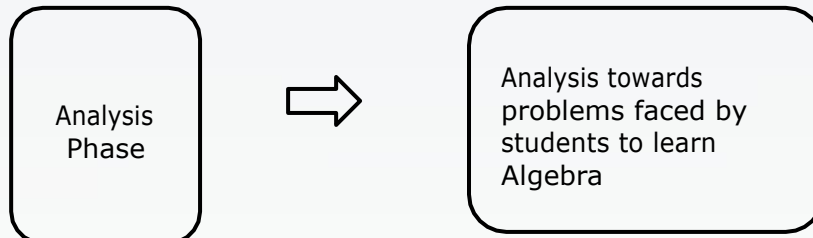


Figure 1: Analysis Phase

### Design

Based on Figure 2, three main elements were designed in this stage which are 'Algebraic Lab' board, software selection and the game questions. 'Algebraic Lab' site is creatively and uniquely designed to attract students as shown in Figure 3 and Symbolab software is chosen because it is easy to use compared to other software. "Symbolab" was chosen because it is simple and easy to use. The solution shown in "Symbolab" is step-by-step and well explained. Algebra questions were selected according to *Dokumen Standard Kurikulum dan Pentaksiran (DSKP) Mathematics Form 2* along with the reference textbook *Kurikulum Standard Sekolah Menengah (KSSM) Mathematics Form 2*. The question was selected according to its level easy, moderate and hard.

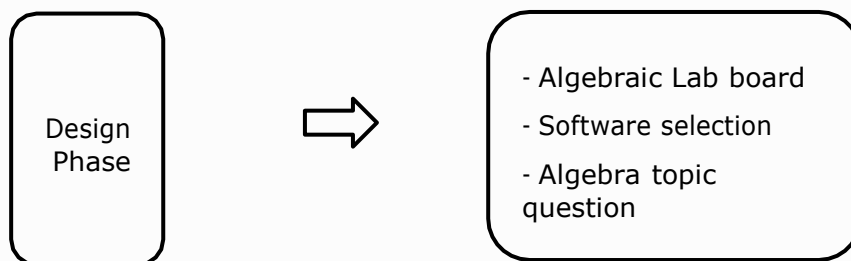


Figure 2: Design Phase

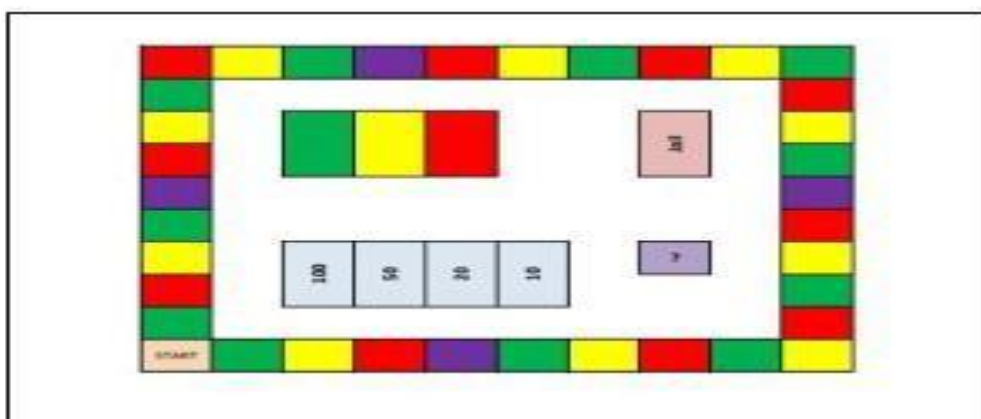


Figure 3: Prototype of "Algebraic Lab"

## Development

Based on Figure 4, the development of 'Algebraic Lab' includes several aspects and guidelines for equipment requirements such as site types (as in Figure 5), tokens (as in Figure 6) and question cards (as in Figure 7). The 'Algebraic Lab' site is made of banner fabric so it is light and easy to carry anywhere. Question cards have been printed and laminated so that they are not easily torn. While tokens are purchased online after price and quality comparisons are made.

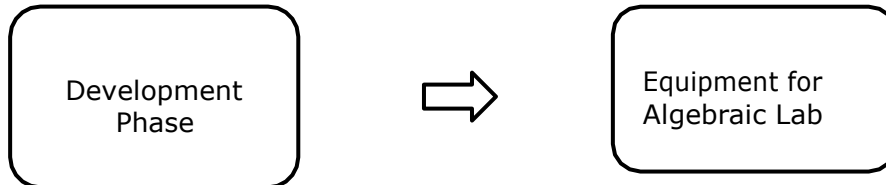


Figure 4: Development Phase

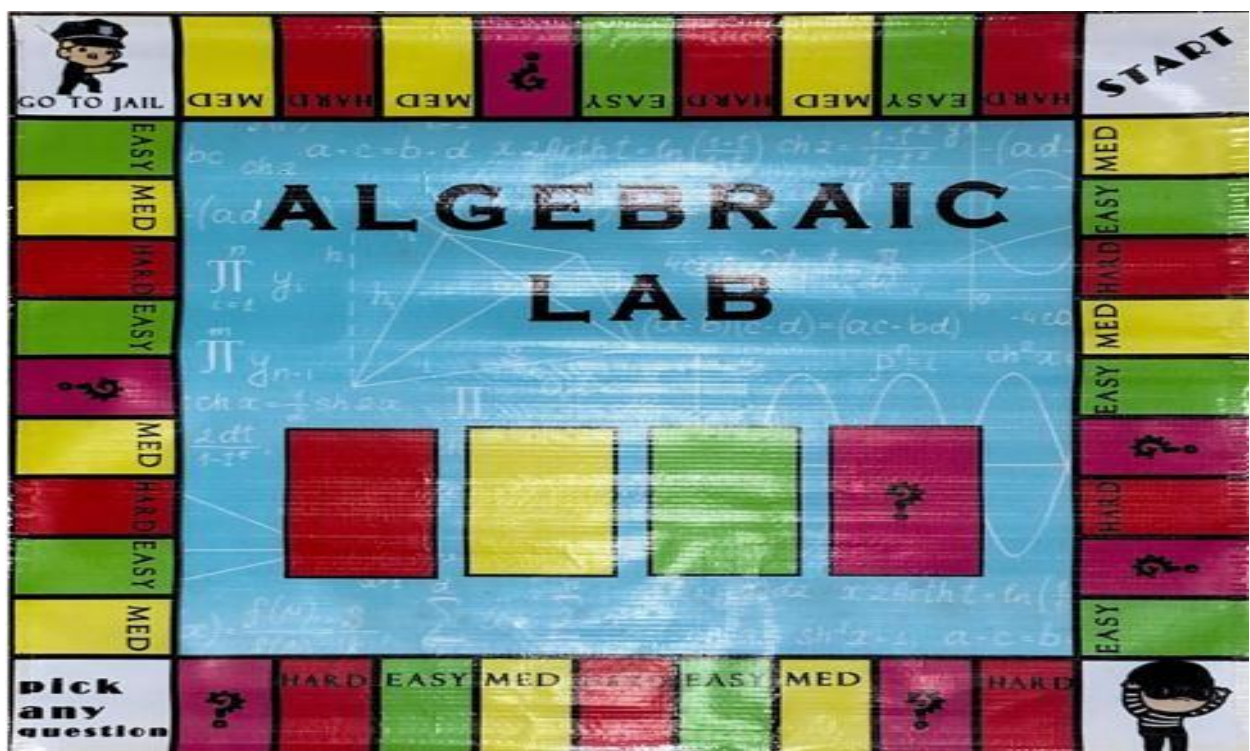


Figure 5: Site of "Algebraic Lab"



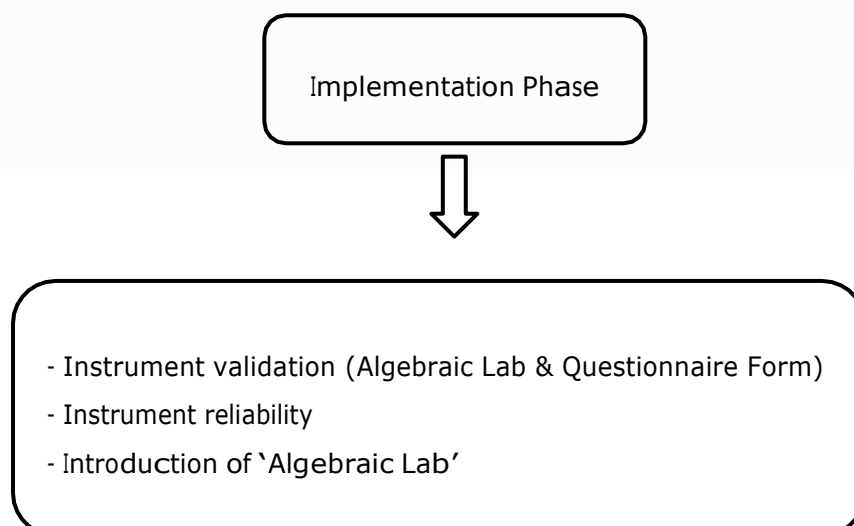
**Figure 6:** Tokens

## Implementation

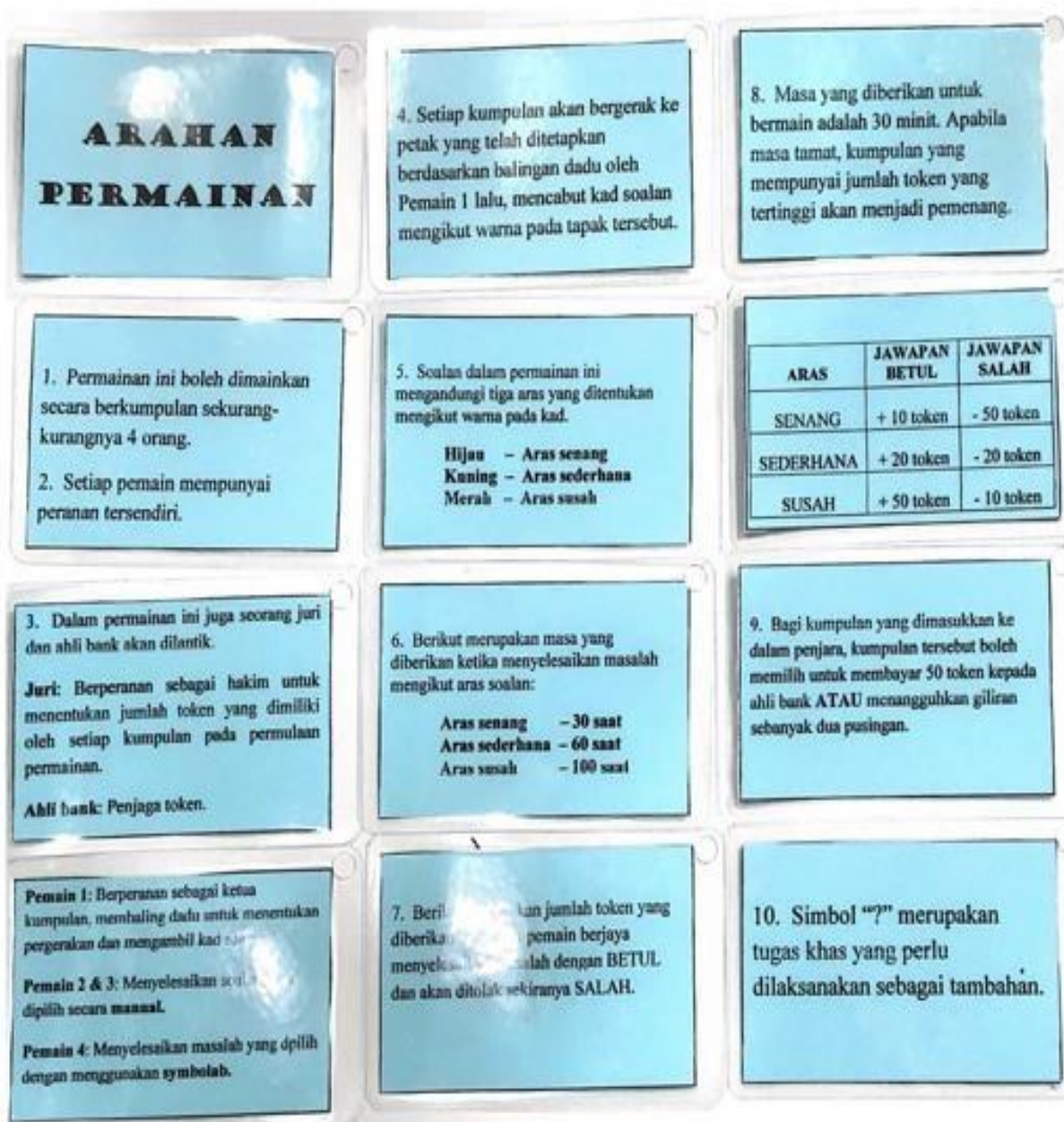


**Figure 7:** Question Cards and Instruction

The researcher conducts a pilot study in terms of the qualifications and potential of the actual study that will be done to improve the validity of the research instrument as shown in Figure 8. Researcher introduced the courseware to several faculty lecturers who are experienced in teaching Algebra courses and specialize in the education and development of courseware to identify potential problems.



**Figure 8:** Implementation Phase

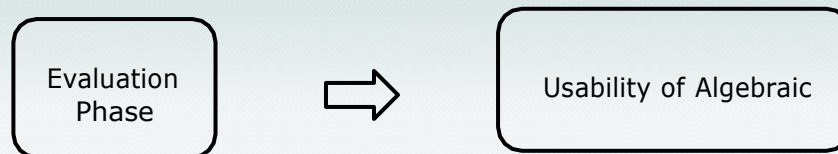


**Figure 9:** Instruction of 'Algebraic Lab'

Based on Figure 9, each group must have 4 people with each of them have their own duty. 1st member is known as group leader and will throw dice and pick the questions. 2nd and 3rd member will solve manually meanwhile the 4th member will solve using Symbolab. After times up, they are required to present their answer. The correct answer will earn token and if the answer is wrong, they have to token. Each level has their own token amount and time to answer.

### Evaluation

Based on Figure 10, 'Algebraic Lab' is evaluated in terms of usability and evaluates the eligibility of this learning aid which involves a qualification assessment questionnaire for students. The data obtained were analyzed using SPSS 23.0 software.



**Figure 10:** Evaluation Phase

## Result

According to Table 2, the mean score for the problems faced by students in learning Mathematics Algebra is moderate. It's shows that students face problems in learning Algebra and solution to this problem should be figured out to help the students. Based on research [30], students' difficulties in learning algebra are understanding the problem [31] understanding meaning of variables and operation involving algebra [32].

**Table 2:**  
Descriptive Statistics

	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>
mean	100	2.6490	.35262
valid N (mean)	100		

According to [28], learning tools need to be evaluated to identify the extent of its use to users. In this study, usability refers to the relevance of content, accessibility of learning objectives in the teaching and learning process as well as the ability to attract students in Algebra learning. The usability of the 'Algebraic Lab' is assessed from several aspects namely understanding, interest, design, benefits to students as well as knowledge of 'Symbolab'. Table 3 below shows the results of the 'Algebraic Lab' usability study for learning Algebra topics evaluated using mean scores. The instrument involves the use of questionnaires. 100 Form 2 students from all over Perak answered the questionnaire.

**Table 3.**  
Descriptive Statistics

	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>
mean	100	3.1495	.42191
valid N (mean)	100		

Based on Table 3, the mean score is a moderate score. The development and usability of the 'Algebraic Lab' for Algebra topics meets the needs of users, especially Form 2 students in their learning in applying basic concepts, training and guidance to improve their knowledge in Algebra topic. Its shows that it is suitable to use as a teaching tool by teachers.

## Discussion

The purpose and objectives are necessary to determine the direction of the learning process to ensure that the learning tools developed meet the pedagogy of learning, specific learning objectives based on the syllabus, curriculum of textbooks or textbooks [33]. In this study, the aspect "I can answer questions from various levels through the 'Algebraic Lab'" has obtained a mean score of 2.94, "I learned various ways of solving problems related to Algebra" obtained a mean score of 3.38. "I easily understand the topic of Algebra through this game" obtained a mean score of 3.66. "'Algebraic Lab' can improve my learning performance" obtained a mean score of 3.17. The study found that the learning objectives for topic Algebra have been achieved. Students think that the topics and content contained in this software meet the needs of course and are easy to understand. The 'Algebraic Lab' also meets the learning objectives. Thus, the 'Algebraic Lab' can help students to answer questions from various levels as well as learn many different solutions to



Farah, R, N.; Amarpreet, K.; Zuraida, R, L.; Muzirah, M.; Ayub, A, F, M.; Nida, S, U.; Rejeki, S.; and Irwan, N. solve the problem.

The use of 'Algebraic Lab' has many positive effects on users, especially on school students. The use of 'Algebraic Lab' as a learning tool in the teaching and learning process can attract students' attention compared to traditional learning methods. In this study, the aspect of "I enjoy learning using 'Algebraic Lab'" obtained a mean of 3.11 while "'Algebraic Lab' attracted my interest to learn Mathematics" obtained a mean of 3.70 and "I feel more relaxed with learning through the 'Algebraic Lab' compared to other method" got a mean of 3.91. According to the aspects and means obtained, it can be concluded that students prefer to learn while playing. This can help cultivate students' creativity and imagination. It also allows students to organize and control their own learning and build authentic learning environments that suit the learning of students of different styles. Game-based learning can generate students' skills and motivation will increase where it can attract students' interest and make the learning more meaningful and effective [34]. This study can also help students acquire knowledge about 'Symbolab'. "I got the knowledge of Symbolab software" obtained a mean of 3.70 and "I have known the ways of using Symbolab" obtained a mean of 3.20. Through the 'Algebraic Lab', students can learn about Symbolab software which can help them a lot for Algebra topics. The use of Symbolab is very simple and provides a very clear solution. The use of technology helps in improving students' understanding especially in mathematics and can increase student motivation. Knowledge of Symbolab software can be of great benefit to students in the future.

The 'Algebraic Lab' also has an attractive design. This study shows that the aspect of "'Algebraic Lab' can be played anywhere" obtained a mean of 3.10, "This game 'Algebraic Lab' is easy to understand and has clear instructions" obtained a mean of 3.17 while "I can learn independently through Algebraic Lab 'without being tied to the teacher's teaching' obtained a mean of 3.27. Therefore, creative design and easy to use can have a positive impact on a product. The 'Algebraic Lab' which can be anywhere also has an advantage because it can be played anywhere such as class, resource center, home and others.

## Conclusion

The use of 'Algebraic Lab' as a learning tool has positive implications for students. The introduction of new software (Symbolab) to school learners can be a catalyst for future development to solve the shortage of interactive learning tools and software. One way to meet the needs of students is to use multimedia courseware. 'Algebraic Lab' has many advantages for users, especially for students who are weak in the basics of Algebra. The use of 'Algebraic Lab' in education can benefit the teaching and learning process by providing better content and helping teachers to attract students and help them to focus more on learning. Teachers can also make improvements if needed.

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