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Development of Mathematics Learning Media Using STEM Approach on Linear Programming Material

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Abstract

This study aims to develop mathematics learning media using STEM approach on linear programming material that is valid, practical, and has a potential effect on student responses. This development research uses a research design that is a design research development study type. The research subjects were students of class XI MIPA 5 at SMA Negeri 14 Kota Tangerang. The research subjects were students of class XI MIPA 5 at SMA Negeri 14 Kota Tangerang. Based on the research results, the learning media is suitable for use in the learning process because it fulfills the indicators of validity, practicality, and potential effects. The validity of learning media based on the evaluation of education experts is 86% and the evaluation of media experts is 86%. The practicality of learning media is 94%. The potential effect of learning media is seen from the student's response by 95%.

Abstrak

Penelitian ini bertujuan untuk mengembangkan media pembelajaran matematika dengan pendekatan STEM pada materi program linear yang valid, praktis, dan memiliki efek potensial terhadap respon siswa. Penelitian pengembangan ini menggunakan desain penelitian yaitu design research tipe development study. Subjek penelitian adalah siswa kelas XI MIPA 5 di SMA Negeri 14 Kota Tangerang. Berdasarkan hasil penelitian, media pembelajaran layak untuk digunakan dalam proses pembelajaran karena memenuhi indikator kevalidian, kepraktisan, dan efek potensial. Kevalidan media pembelajaran berdasarkan penilaian ahli pendidikan sebesar 86% serta penilaian dari ahli media sebesar 86%. Kepraktisan media pembelajaran sebesar 94%. Efek potensial media pembelajaran dilihat dari respon siswa sebesar. 95%.

***Keywords**: Learning Media; STEM; Linear Program.*

INTRODUCTION

The development of the 21st century, which is often called the era of industrial revolution 4.0, is increasingly competitive and continues to develop. Educational institutions are responsible for producing students who are ready to face the challenges of the 21st century. The efforts made by educational institutions to respond to the demands of an increasingly competitive and growing era are shown in the 2013 curriculum, which implements 21st century learning. 21st century learn-

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ing paradigm emphasizes students' critical thinking ability, connects science with everyday life, masters in technology, information, communication, and collaboration. One of learning that is able to connect science with everyday life is an integrated approach. An integrative approach is a learning approach that links several scientific disciplines.

STEM (Science, technology, engineering, and mathematics) is a learning approach that combines four disciplines that are interrelated with each other (Becker & Park, 2011). The integration of STEM education according to Pangesti, Yulianti, & Sugianto (2017) refers to four disciplines that can equip students to compete in the 21st century. In line with this, Bybee (2013) stated that STEM learning is a reform of the development of education in various developed countries as a solution to the challenges of the 21st century. Several developed countries that had implemented STEM are the United States, Japan, Finland, Australia, and Singapore (Carin, A.A. & Sund, 2016). The STEM approach can encourage students to recognize, apply, and integrate concepts or components of science, technology, engineering, and mathematics to understand problems and solve them innovatively and creatively (Jalil, 2016).

The STEM approach cannot stand alone in learning, there needs to be integration with learning models that are in accordance with the problems raised. In line with this, the researcher applied the Problem Based Learning (PBL) model in learning with a STEM approach. This is because through PBL students gained experience in dealing with realistic problems and emphasized the use of communication, collaboration and existing sources to formulate ideas and develop reasoning skills. Wisudawati (2018) stated that the combination of the STEM approach with curriculum will help teachers in the learning process in the classroom. In line with this, the STEM-PBL learning approach is an approach that met the criteria in accordance with the implementation of 21st century learning in 2013 curriculum.

The development of 21st century cannot be separated from the use of technology, information, and communication in all aspects of life. All life activities cannot be separated from the use of technology. According to Regulation of Minister of Educattion and Culture number 22 of 2016 concerning the standard of primary and secondary education processes, which are in accordance with graduate competency standards and content standards, one of the learning principles used is the use of technology, information, and communication to improve efficiency and effectiveness of learning. Thus technological advances must be optimized in 21st century learning. In line with this, Bakri (2016) stated that learning media is an integral part of educational institutions. Therefore, the use of technology in the field of education, especially in the field of mathematics, can absolutely be used.

However, in reality, the use of technology as learning media, especially in mathematics learning, was still low. Amir (2016) said that the mathematics learning process in the classroom was more centered on the teacher. Therefore, the teacher was still considered the only main source of knowledge that affects learning less interesting and challenging for students. In line with what Amir said, Sutama (2013) stated that mathematics learning in schools tends to be text box oriented and less related to students' daily lives, and learning tends to be abstract, which made academic concepts difficult to understand. This condition tends to be boring. Therefore,

it is necessary to use ICT which aimed to reduce learning difficulties caused by the abstraction of the object of study in mathematics (Putrawan & Suharta, 2014). This is in line with what was said by Falahudin (2014) that media can make learning process clear, interesting, not boring, and can foster student positive attitude in materials and learning process.

Learning that utilized technology is mobile learning, as Astra, et all (2012) stated that mobile learning is learning media that whose use utilizes mobile device technology such as smartphones. In this case, the smartphone used is based on android because it is based on teacher statements at the time of the research even though the average of student has a lower middle economy, almost the majority of students have an android-based smartphone.

Android is an operating system used to support smartphone devices. In line with Hendikawati, Zuhair, & Arifudin (2019) said that android provided open platform for developers to create their own applications that a variety of mobile devices can use. Android-based mobile learning applications found in smartphones innovatively can be used as mathematics learning media that brings mathematical skills and proficiency, especially in linear programming material.

Linear programming material is a new learning material for senior high school students equivalent to class XI in accordance with 2013 curriculum. Niswarni (2012) stated that the problem related to linear programming is to maximize and minimize something. The material is also one of learning materials that are difficult for students to understand. Based on the results of research conducted by Sanhadi, Mardiyana, & Pramudya (2016) there were still many students who had difficulty in translating linear programming problems in everyday life into mathematical models so that it affected to determination of the solution set area and the intersection point on the graph drawn. According to Puspitasari, Purwasih, & Nurjaman (2017) this is usually caused by a lack of practice on various questions related to linear programming. In line with this, teachers also had not utilized technology such as mobile learning in linear programming learning which results in a lack of motivation to learn (Sirwanti, 2017).

One way to improve students' ability to understand and solve problems related to linear programming is by changing the paradigm in the learning process, which was originally teacher-centred to student-centered (Arifin, 2017). One of the interesting innovations that accompanies this paradigm shift is by using learning media technology, namely smartphones. This is because smartphones are practical, can be used anywhere and anytime. Students can manage when they want to learn and where they want to learn from.

Along with technological developments, students had a tendency towards smartphones compared to textbooks. Based on survey results of Basya, *et al* (2013) on mobile device analysis states that most students use smartphones for entertainment purposes, such as chatting and games. This is the basis for researchers to develop learning media that utilized an Android-based smartphone, in line with this I. W. Sari & Sumuslistiana (2018) stated that students in senior high school level at the age of teenagers between 15-18 years can use technology as a learning media. Therefore, researchers aimed to produce mathematics learning media using a STEM approach on linear program material that was valid and practical and had potential effects that were packaged in applications installed

on Android-based smartphones.

METHOD

The research design used in this study was a development study type design research, which aims to produce learning media using STEM (Science, Technology, Engineering, and Mathematics) approach on linear programming material that were valid, practical and had a potential effect on student responses. Based on Octaria, Zulkardi, & Somakim (2013), Tessmer's development research is focused on two stages, such as preliminary stage (preparation and development stage) and formative evaluation stage (evaluation and revision stages), which includes self-evaluation, expert review, and one-to-one, small group, and field tests.

In the **preliminary stage**, researchers prepared and designed. The preparation activity is the activity for determining the location and subjects of research. In this case, researchers contacted the mathematics teachers at SMA Negeri 14 Kota Tangerang. Furthermore, the researchers made preparations such as arranging the research schedule and explaining the research procedures to be carried out with the class teachers who would be used as a research place, analyzing the class to be used ,and conducting analysis of the curriculum used. Whereas in designing activities, researchers designed learning media using STEM approach on linear programming material.

In **the formative evaluation stage, the first stage was self-evaluation stage. T**he researchers provided an assessment of mathematics learning media using STEM approach on linear programming material with the assistance of supervisor. Researchers assessed or re-evaluated material and steps of STEM on student activities contained in learning media with the characteristics of STEM-PBL as well as the design, content, and placement of buttons in learning media. The revision result is called the first prototype. The first prototype would be given to expert review in next stage later.

In the **expert review stage**, researchers tested the first prototype with several experts as validators to see the validity of the first prototype. The design results of the first prototype developed on the basis of self-evaluation were given to education experts and media experts to test its validity. The validator was given validation sheets that researchers had compiled, then asked to rate and provide suggestions and comments on the first prototype that had been developed. The validation results in the form of input such as comments and suggestions from education experts and media experts will be used to revise the first type.

Simultaneously with the expert review stage, researchers conducted the first prototype practicality test on several students one-to-on**e**. Then students were asked to provide input in the form of comments and suggestions regarding the first prototype. Input in the form of comments and suggestions from students in this stage will be taken into consideration for revising the first prototype. The revision result of the first prototype was the second prototype which would be tested at the small group stage later. The student questionnaires results in this stage would be used to determine the practicality of learning media, combined with the student questionnaires results obtained in small group stage.

The third stage was the formative evaluation stage, namely the **small group stage**. At this stage, researchers tested the second prototype to several students. Then students were asked to provide input in the form of comments

and suggestions regarding the second prototype. Input in the form of comments and suggestions from students at this stage will be taken into consideration for revising the second prototype. The revision result of the second prototype was the third prototype which would be tested in the field test stage later. Student questionnaires result in small group stage would be used to determine the practicality of learning media, combined with student questionnaires results obtained in one-to-one stage. The revision results of the second prototype were the third prototype which would be tested in field test stage later.

Then the last stage of this research was the **field test stage**. The third prototype learning media which was revision of the second prototype learning media would be tested on the research subject to see the potential effects of learning media developed by researchers on student responses.

RESULTS AND DISCUSSIONS

Preliminary Stages

The first stage of application development started from the preliminary stage, which included preparation and design. The preparation activities carried out were arranging the research schedule, explaining the research procedures to be carried out on mathematics teachers whose class was used as a research location, namely students of class XI MIPA 5 SMA Negeri 14 Kota Tangerang, amount of 34 students, and conducting analysis of students ability of class XI MIPA 5 SMA Negeri 14 Kota Tangerang which turned out to have heterogeneous abilities. Then the researchers also analyzed the curriculum used in schools, namely the 2013 curriculum on linear programming material.

While in design activity, the researchers designed learning media using STEM approach on linear programming material. The learning media was made in the form of Android application with the help of Android Studio. Android Studio is software that is open source or free. This application was named PROGLIN, which was the acronym for Linear Programming and was developed for the android platform. The steps taken by researchers included: (1) Collected materials on linear programming material; (2) Developed the structure of student activities using STEM-PBL steps; (3) Designed icons, buttons, backgrounds using Adobe Illustrator CC 2017; (4) Created graphics using Geogebra application; (5) Carried out initial design. Thus, the learning media developed by researchers contained material, competency standards, student activities based on STEM stages with PBL characteristics, instructions, settings, profiles, and evaluation in the form of quizzes. After completion, the initial design of the mathematics learning media using STEM approach was obtained on linear programming material made by researchers. The initial design of mathematics learning media with the STEM approach can be seen in Figure 1.

Figure 1. Initial Design of Learning Media

The PROGLIN application made it easy for students to use where users could download this application at *http://bit.ly/Proglin_ProgramLinear*. Then the user was asked to install the application to an Android-based smartphone with a minimum version of Android 4.2 or Jelly Bean. This is in line with Zarkasyi (2015), which stated that one of the characteristics of learning media is the ease of use. Several factors that made learning media easy to use were that the instructions used are clear and simple, used standard commands, and could be downloaded for free and installed easily.

Formative Evaluation Stage - *Self Evaluation*

The researchers conducted a formative evaluation stage in the next stage, which consisted of a self-evaluation, expert review, and one-to-one, small group, and field test stages. In the self-evaluation stage, researchers assessed learning media that was developed with the help of supervisors.

Researchers looked back on materials and steps of STEM on student activities contained in learning media with STEM-PBL characteristics as well as design, content and placement of buttons on learning media. The supervisors also provided input in the form of comments and suggestions for revising. After the revision of self-evaluation stage was carried out, the first prototype was produced. The following part had been revised, which can be seen on Table 1.

Table 1. First Prototype Snippet

Before Revision	After Revision
	

Validation and Revision of First Prototype

Expert Review

In expert review stage, the researchers tested the first prototype to education experts and media experts to see the validity of the first prototype. Validation in the **education field** was carried out by involving three mathematics education experts from FKIP environment and there were two aspects of assessment adapted from Ramadan & Arfinanti (2019) with modifications, such as content aspect and language aspect. Inputs in the form of comments and suggestions from education experts would be used to revise the first prototype to improve media development.

The data obtained shown that mathematics learning media with STEM approach on linear programming material met the criteria of validity and with slight revision based on the acquisition of the percentage content aspect of 86% with very valid category and 89% in language aspect with very valid category. Such that, mathematics learning media with STEM approach on linear programming material according to educational experts was valid to use in mathematics learning process, especially on linear programming material.

Based on the average results from the assessment of education experts, the final score of mathematics learning media validity with STEM approach on linear programming material was 86%, exceeding the minimum percentage of validity of 70.01%, which means that the media developed by researchers was very valid. (Akbar, 2015). The validity results obtained by education experts are summarized on the following table.

Table 2. Education Experts Test Results

Aspect	Validity Percentage	Note
Content	86%	Very Valid
Language	89%	Very Valid
Final Score	86%	Very Valid

Validation in **media field** also involved three mathematics education experts from FKIP environment and two aspects of assessment adapted from Ramadan & Arfinanti (2019) with modification. Assessment aspects contained in media validation are presentation aspects and graphic aspects. Inputs in the form of comments and suggestions from media experts would be used to revise the first prototype so that the developed media would be even better.

The data obtained shown that mathematics learning media with STEM approach on linear programming material met the criteria of validity and with slight revision based on the percentage acquisition of presentation aspects of 86% and graphic aspects of 86% with very valid category. Such that, learning mathematics media with STEM approach on linear programming material according to media experts was valid to use in the mathematics learning process, especially on linear programming material.

Based on the average results from the assessment of media experts, the final score of mathematics learning media validity with the STEM approach on linear programming material was 86%, exceeding the minimum percentage of validity of 70.01%, which means that the media developed by the researcher was very valid. (Akbar, 2015). The validity results obtained by educational experts are summarized on the Table 3.

Table 3. Media Experts Test Results

Aspect	Validity Percentage	Note
Presentation	86%	Very Valid
Graphic	86%	Very Valid
Final Score	86%	Very Valid

One-to-One Stage

Simultaneously with the expert review stage, researchers conducted the first prototype practicality test to three students in one-to-one stage. In this activity, students were asked to install the application using the link provided and used the application. Then students were asked to provide input in the form of comments and suggestions about the first prototype in a questionnaire that the researchers had made. Inputs in the form of comments and suggestions from students in one-to-one stage would be taken into consideration for revising the first prototype. The revised result of the first prototype was called the second prototype which would be tested in small group stage later.

The practicality percentage in one-to-one stage would be used to determine the practicality of learning media which would be combined with the practicality percentage obtained in small group stage. The data obtained shown that mathematics learning media using STEM approach satisfied practicality criteria with slight revision based on the percentage of attractiveness aspect of 87% with very practical category, convenience aspect of 95% with very practical category, and assistance aspect of 93% with very practical category. This is shown based on statement of one of respondents, namely Kafijaya, a class XI MIPA 5 student that material in application is easy to understand. In learning, there is triad relationship between teachers, students, and materials or is called the didactic triangle. Suryadi (2011) stated that the

most important role of the teacher in didactic theory was to create a didactic relationship between students and learning materials so that learning fun and easy to understand.

Based on the average results of one-to-one stage, the final score of the practicality of mathematics learning media with STEM approach on linear programming material was 93% exceeding the minimum practicality percentage of 70.01%, which means that media developed by researchers was very practical (Akbar, 2015). The practical results in one-to-one stage are summarized in the Table 4.

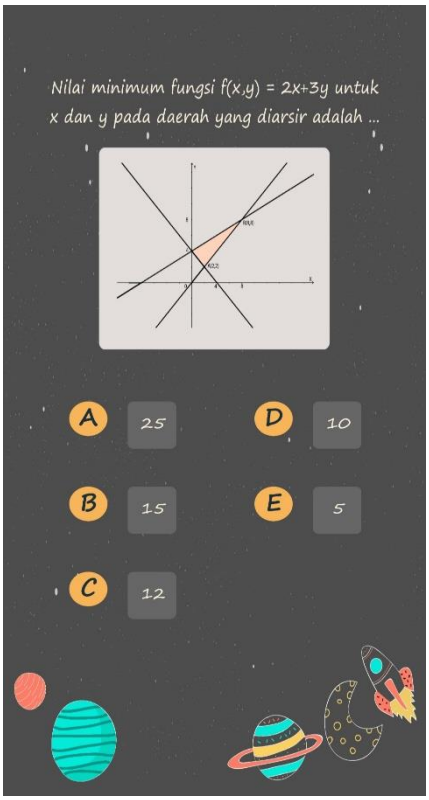
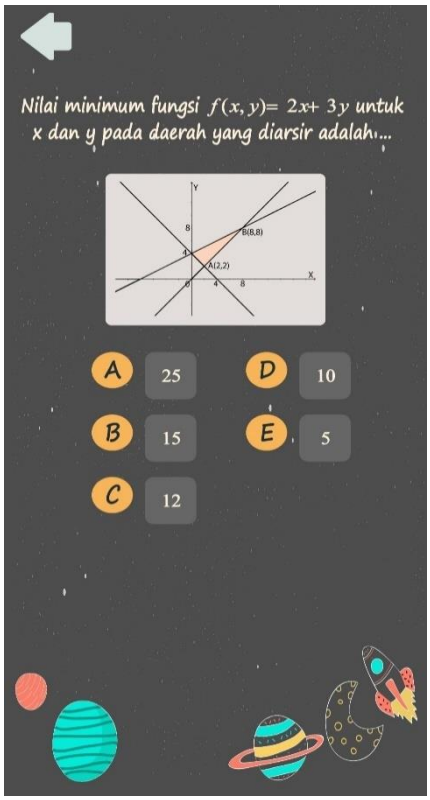
Table 4. Practicality Test Results in One-to-One

Aspect	Practicality Percentage	Note
Attractiveness	87%	Very Practical
Convenience	95%	Very Practical
Assistance	93%	Very Practical
Final Score	93%	Very Practical

First Prototype Revision

After respondents assessed the first prototype in expert review and one-to-one stages, the next stage was the first prototype revision based on inputs in the form of comments and suggestions. The first prototype revision was called the second prototype. The following was part that had been revised from the first prototype to the second prototype learning media, which can be seen on Table 5.

Table 5. First Prototype to Second Prototype Revision

Before Revision	After Revision
	

Second Prototype

Small Group

The third stage is the formative evaluation stage, namely small group stage. In this stage, researchers tested the second prototype on nine students. Nine students were asked to install an application using the link provided and used the application. Then students were asked to provide inputs in the form of comments and suggestions about the second prototype in questionnaires that researchers had made. Inputs in the form of comments and suggestions from students in this stage would be taken into consideration for revising the second prototype. The second prototype revision results were the third prototype which would be tested in the field test stage later.

The practicality percentage in the small group stage would be used to determine the practicality of learning media which would be combined with the practicality percentage obtained in one-to-one stage. The data obtained shown that mathematics learning media with STEM approach on linear programming material met the practicality criteria with slight revision based on the acquisition of the attractiveness aspect percentage of 92%, convenience aspect of 95% and helpfulness aspect of 93% with very practical category. It is shown based on the statement of one of the respondents, namely Rifdah Silawarti, a class XI MIPA 5 student that PROGLIN application was very interesting and help to repeat the learning. In line with Thomdike's theory of the law of exercise, the formation between the relationship of stimulus and response and the repetition process can potentially emerge as a correct response. The more often a lesson is repeated, the stronger the student's knowledge will be got from the lesson (Dina Amsari, 2018).

Based on the average results of small group stage, the final score of the practicality of mathematics learning media with STEM approach on linear programming material was 94% exceeding the minimum practicality percentage of 70.01% which means the media developed by researchers very practical (Akbar, 2015). The practical results in the one-to-one stage were summarized on the Table 6.

Table 6. Practicality Test Results in Small Group

Aspect	Practicaly Percentage	Note
Attractiveness	93%	Very Practical
Convenience	94%	Very Practical
Assistance	93%	Very Practical
Final Score	94%	Very Practical

The practicality of mathematics learning media with STEM approach on linear programming material developed by researchers is obtained based on the percentage in one-to-one stage of 93% with very practical category and the percentage in the small group stage of 94% with very practical category. The mathematics learning media with STEM approach on linear programming material was practically used in the mathematics learning process.

Based on the results of the average practicality test score of mathematics learning media with STEM approach on linear programming material of 93% exceeding the minimum practicality percentage of 70.01%, which means the media developed by researchers was very practical (Akbar, 2015). The practical results are summarized on Figure 1.

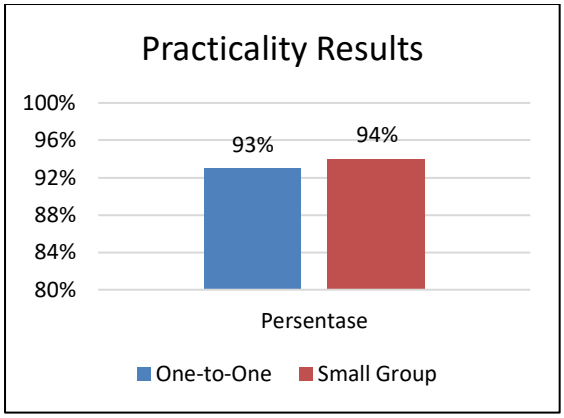


Figure 1. Practicality Results

Second Prototype Revision

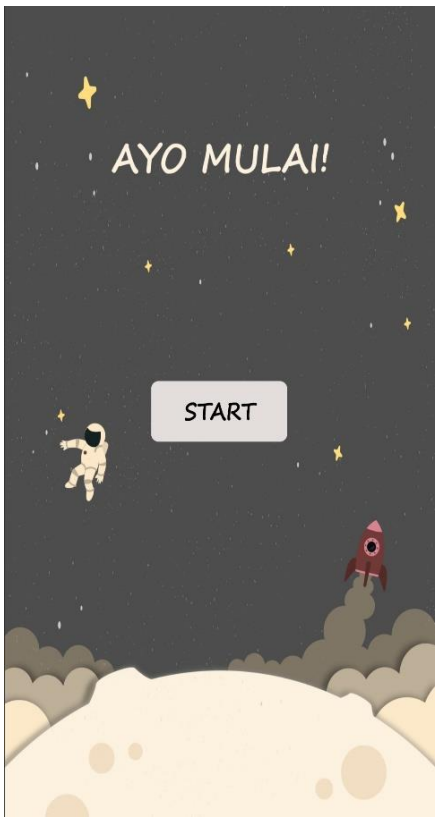
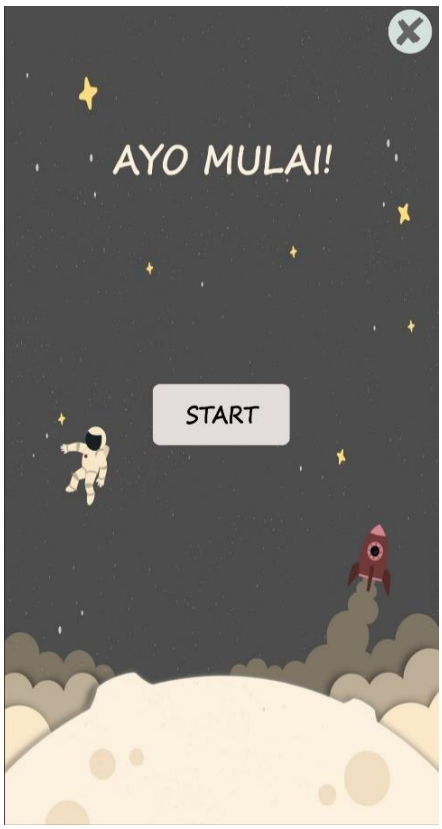
After the second prototype was given in the form of assessments by respondents in a small group, the next stage was a revision of the prototype based on comments and suggestions. The revision of the first prototype was called the second prototype. The following was part that had been revised from the first prototype to become the second prototype learning media, which can be seen on Table 7.

Field Test

After obtaining the third prototype's valid and practical, the last stage of this research was the field test stage. In this stage, researchers tested the third prototype to 34 students of class XI MPA 5 SMA Negri 14 Kota Tangerang, which aimed to see the potential effects of mathematics learning media using STEM approach on linear programming material developed by researchers on student responses. In this stage, students were asked to install the application using the link provided and used the application.

The data obtained shown that mathematics learning media with STEM approach on linear programming material

Table 7. Revision of Second Prototype to the Third Prototype

Before Revision	Afer Revision
	

had attractiveness aspect gain of 87% with very effective category, convenience aspect of 95% with very effective category, and assistance aspect of 93% with very effective category. During the working process, students were directed to build their own knowledge. This is in line with constructivism theory that knowledge was obtained in the form of students themselves and transfers complex information into simple ones (Kurniawati, 2013). By building their own knowledge, the knowledge gained becomes a solid foundation for building subsequent knowledge. The mathematics learning media with STEM approach on linear programming material was effectively used in the mathematics learning process.

Based on the results, the average score of the potential effects of mathematics learning media with STEM approach on linear programming material on student responses, it resulted in a score of 93% exceeding the minimum percentage of potential effects, namely E > 60.01% means that the media developed by researchers wa very effective (Akbar, 2015). The results of the potential effects on student responses can be seen on Table 8.

Table 8. Practically Test Results in Field Test Stage

Acpect	Practicaly Percentage	Note
Attractiveness	97%	Very Practical
Convenience	94%	Very Practical
Assistance	95%	Very Practical
Final Score	95%	Very Practical

CLOSING

Conclusion

Mathematics learning media using STEM approach (Science, Technology, Engineering, and Mathematics) on linear programming material developed with Tessmer development procedure obtained scores that fall into the feasible category to be used as learning media on the mathematics learning process. It was because it satisfied the indicators of validity, practicality, and potential effects. The validity of learning media based on the assessment of education experts was 86% with very valid category, and assessment of media experts was 86% with very valid category in the formative evaluation stage, namely the expert review stage. The practicality of learning media based on the assessment of formative evaluation stages, such as one-to-one stage and small group stage, received the assessment of 94% with very practical category. The potential effect of learning media was seen from student responses to learning media in the formative evaluation stage, namely the field test stage, which obtained an assessment of 95% with a very effective category.

Suggestion

Based on the research results that had been done, researchers provided several suggestions, as follows: (1) It was needed material updates, developed technology, and learning media design using STEM approach, so they were in accordance with the needs and applicable curriculum; (2) Further research needs to create applications that smartphones could use with the iOS platform; (3) Provided learning videos on learning media that could increase student interests in learning.

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