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Development of GeoGebra-Based Learning Media for Flat Field Analytical Geometry Courses for Students of the Mathematics Education Department

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ABSTRACT

All aspects of life, including the education system, have undergone many changes due to the Covid-19 pandemic. We need media that can facilitate and attract students to carry out learning activities. This study aims to develop GeoGebra-based mathematics learning media. The method used in this research is Research and Development (R&D) with the ADDIE model (Analysis, Design, Develop, Implement, and Evaluate). The research was carried out at UIN Sayyid Ali Rahmatullah Mathematics Study Program in semester 3. The research subjects for the small-scale field test were class A, which had 32 students; for the large-scale field test, there were 132 students in Mathematics Education 3rd Semester. The results of research on the development of GeoGebra-based learning media in the Flat Analytical Geometry course for students majoring in Mathematics Education at UIN Sayyid Ali Rahmatullah Tulungagung were declared valid, practical and effective. The future hope for developing similar media is to expand the scope of the material discussed because the media developed is limited to flat analytic geometry operations.

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INTRODUCTION

The emergence of COVID-19 has had a tremendous impact on the world of education in Indonesia. Learning done face-to-face is now shifting to a combination of face-to-face and virtual. We usually call this virtual face-to-face learning with online learning. This is done to prevent crowds and transmission of the coronavirus 19. This change forces teachers, students and parents to adapt to changes in stark contrast to their previous comfort zones. Many things must be changed, starting from teaching materials, learning methods, teaching methods and many more.

As an educator, a teacher must act professionally in the current situation. According to Karo-Karo and Rohani (2018), a professional teacher can manage information and its environment to facilitate student learning during today's rapid development of science and technology [1]. So, teacher professionalism is not enough if it is only seen from the point of view of students' teaching abilities. The teacher must be a good facilitator and mentor in every learning process. In addition, teachers must be able to create various learning innovations, such as using learning media that keep abreast of technological and information developments.

The use of information technology-based learning media must be accompanied by teacher competence in designing, applying and evaluating media that is used properly, wisely and intelligently. This is because information technology, which is developing quite rapidly, is allegedly capable of

upgrading the quality of human resources. However, the facts shown on the ground are quite the opposite. Many teachers feel reluctant to take advantage of the latest technology. In other words, they are unwilling to take advantage of the newest software in learning (Elizabeth, 2019). One factor that makes teachers act this way is that they tend to feel comfortable using the chat application, namely WhatsApp alone, without being combined with other media. This shows the reluctance of teachers to learn the latest, more innovative learning media.

Innovative learning is learning that directly solves the problems the class faces based on class conditions. So innovative learning is learning oriented towards strategies, methods or efforts to increase all positive abilities in developing students' potential or skills and the role of students as the most involved parties and teachers as mentors in student learning activities.

Innovative learning should contain several important aspects, such as interactive, challenging, motivating, and fun, and provide more space for students to develop creativity and independent learning according to students abilities. Even though the teacher is only a facilitator in a lesson, a pleasant atmosphere should be created by a teacher to stimulate students to be more active. For students to be more involved in learning, teachers are expected to be able to choose or develop interesting and interactive learning media for students but not reduce the essence of the material presented [2].

One of the technologies that teachers can use in designing instructional media is the GeoGebra software. One of the advantages of the GeoGebra application is that the development always updates regularly so that it is not eroded by the times. In addition, this application is distributed free of charge so that all parties can access it. Dynamic means users can generate interactive math applications. Free means that GeoGebra can be used and reproduced for free and includes open-source software so everyone can change or improve the program. Multi-platform means that GeoGebra is available for all types of computers, such as PCs, tablets and various computer systems such as Windows, Mac OS, Linux and so on.

GeoGebra was first developed by Markus Hohenwarter as his master thesis project in 2001, with the basic idea being to create software that combines the ease of use of dynamic geometry software (DGS – Dynamic Geometry Software) with the power and features of a computer algebra system or CAS. (Computer Algebra System) for learning mathematics.

GeoGebra is equipped with quite sophisticated features that can be used to create various kinds of animations in the form of images or text online or offline. The research results by Jamaludin et al. (2020) show that GeoGebra is very effective when applied as teaching material. The response given by students was very positive, so it influenced their learning outcomes. In line with Jamaludin, Apriliani et al. (2020) also showed a positive result from their research. In addition to positive responses and increased learning outcomes, students' ability to visualise images also increased.[3] This is what encourages researchers to utilise GeoGebra in developing geometry teaching materials.

GeoGebra can also be used to solve various kinds of math problems such as geometry, statistics, algebra, and many more. In geometry, students often find it difficult to visualise or describe the shape of an equation referred to by the problem. This is also supported by Kariadinata's research (2010), which suggests that various kinds of geometric problems require visualisation in their completion. In general, students have difficulty constructing geometric shapes.[4]

Facts on the ground also show the same problem. The results of observations of researchers while teaching analytic geometry in the Mathematics Education UIN Sayyid Ali Rahmatullah Tulungagung often encounter students having difficulty visualising equations into a correct picture.

Moreover, constructing an equation of what is known as a geometric shape or image. This happens because mathematics is abstract. Students and students often have difficulty understanding mathematical material if no tools can be available to construct mathematical abstractions into a real picture.

Based on the explanation above, the development of GeoGebra-based learning media needs to be done to get valid, practical and effective media with the hope that this media can make it easier for students to understand analytic geometry courses. In addition, with this media, students are expected to be able to improve their learning outcomes and skills in drawing geometric shapes.

METHODS

Research and development or Research and Development (R&D) is the type of research used. According to Borg and Gall, development research is a process used to develop and validate a product in education. Meanwhile, Seals and Richey stated that development research is a systematic review of the design, development and evaluation of programs and learning products that must meet the criteria of validity, practicality and effectiveness [5].

This research and development methodology is closely related to learning technology. According to Seels & Richey, learning technology is the theory and practice of design, development, utilisation, management, and evaluation of processes and resources for learning [6]. So, based on this theory, researchers are trying to develop learning media that suit the needs of students.

The product produced in this research and development is GeoGebra-based mathematics learning media. The development model used in this research is the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model.

This research was conducted at UIN Sayyid Ali Rahmatullah Tulungagung for 3rd-semester Mathematics Education Undergraduate students. The research location was chosen because UIN Sayyid Ali Rahmatullah had adequate facilities but had not been utilised optimally, such as a stable internet network and data projector.

The research subjects for the small-scale field test were class A, which had 32 students; for the large-scale field test, there were 132 students in Mathematics Education 3rd Semester. Meanwhile, the object of this study is GeoGebra-based mathematics learning media with the ADDIE development model on flat analytic geometry material that focuses on conic sections.

The development model used in the development of this media is the ADDIE model. In terms of development research procedures, ADDIE revealed that the R&D cycle comprises several research steps: Analysis, Design, Development, Implementation, and Evaluation. According to the product development steps, this research and development model is more rational and complete.

RESULTS AND DISCUSSION

1. Activity Analyze

a. Student Character Analysis

Characteristics are the characteristics displayed by a person. In this case, the ones being reviewed are undergraduate students, namely individuals who are currently studying at the undergraduate level of tertiary institutions. In Indonesia, the average undergraduate-level students are 18-24 years old. Early adulthood is a period of transition from adolescence to adulthood itself. Early adulthood occurs in the late teens to the 20s and ends around 30 [7].

College students have a different way of thinking than school-age children. Their learning styles are also different. Some tend to study in groups, and some tend to study individually. In addition,

they always identify the characteristics of lecturers in teaching. This is done so that it is easy to follow lectures properly. Students also learn based on manuals, questions, and notes. With the development of technology, students began to study digital media. Therefore, it is necessary to develop blended learning assisted by GeoGebra-based media to support more varied learning.

b. Material analysis

The material chosen in this study is flat analytic geometry with a focus on conic sections. Based on the results of the interviews and observations of the lecturers teaching this course, the conic section material is one of the materials that are often difficult for students to understand. Therefore, GeoGebra-based media-assisted blended learning is expected to overcome the difficulties experienced by students' difficulties in understanding the material and lecturers' difficulties in teaching conical slices.

2. *Design*

a. Designing Lecture Materials

For material displayed in lectures using GeoGebra media, namely conic slices.

b. Designing Lecture Devices

The lecture tools prepared in this study are lesson plans and tests.

1) Semester Learning Plan
2) Course Description

This course is a compulsory subject that discusses coordinate systems, straight lines, and various types of conical cross-sections. A conical section is a cross-section between the plane and the curved surface of a vertical cone. The conic sections studied in this course include circles, parabolas, ellipses, and hyperbolas. Each meeting in this course is held for 100 minutes or two credits.

3) Reference Book

Thomas B. George & Finney L. Ross. 1993. *Kalkulus dan Geometri Analitik*. 6th Edition. Jakarta: Erlangga.

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c. Designing Prototypes

This GeoGebra-based media is designed in such a way that it fulfils the material concepts that have been planned. Prototypes are made using GeoGebra software first and then uploaded. The following is an example of a prototype of the media to be developed.

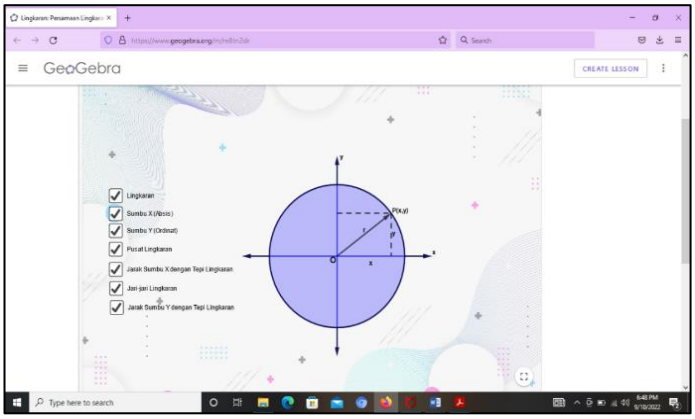

Figure 1. Circle Centered at (0,0)

3. Development

a. Product Development

The prototype made using the GeoGebra software is then uploaded on the GeoGebra Web so all class members can use it. This is also one way of utilising existing campus facilities and infrastructure. In addition, this can also familiarise students with using the internet wisely.

b. Validation Results

1) Media Expert Validation Results

The results of the validation of media experts on learning media are shown in Table 1 below.

Table 1. Results of Media Expert Validation

Number	Assessment Aspects	Average Score of Each Aspect ($\bar{A}i$)
1.	The effectiveness of learning design (interactive multimedia) in terms of the achievement of learning objectives.	3
2.	Advantages in terms of learning effectiveness from interactive multimedia compared to other media (textbooks, posters, radio, tape or film).	3,5
3.	Relevance of student goals as users with learning media.	3,5
4.	Relevance of lecturer goals as users with learning media.	3,5
5.	Ease of students in listening to the content of learning by using learning media.	3,5
6.	Allocation of time in achieving goals by using interactive multimedia learning.	3,5
7.	Display speed level on the use of interactive multimedia learning.	3,5
8.	Display of learning in multimedia learning.	3,5
9.	Ease of operating navigation on learning multimedia.	4
10.	Selection of image objects on the media according to the material.	3,5
	Average Score of All Aspects ($\bar{V}_a$)	3,50

Based on the results of media expert validation, the average score for all aspects ($\bar{V}_a$) is 3.50. According to the established validity criteria, the learning media can be valid. This means that the learning media is suitable for use, taking into account some of the input in the form of suggestions and comments from the validator and consulting with the supervisor.

2) Material Expert Validation Results

The results of the material expert validation of learning media are shown in Table 2 below.

Table 2. Material Expert Validation Results

Number	Assessment Aspects	Average Score of Each Aspect ($\bar{A}_i$)
1.	Suitability of content in learning multimedia with learning objectives.	3,5
2.	Clarity of description, discussion and examples of the material.	3,5
3.	Alignment of media use with learning needs.	3
4.	The accuracy of the use of evaluation tools in the form of questions.	3,5
5.	Suitability of questions with learning objectives.	3,5
6.	Ease of questions to understand.	4
7.	The level of accuracy of the information on the content of	4

	learning multimedia.	
8.	Appropriateness of images and illustrations used as material.	3,5
9.	The attractiveness of the display of learning content in learning multimedia.	3,5
10.	Ease of accessing and operating navigation (command buttons) on learning multimedia.	4
11.	Clarity of presentation of material through lectures and media.	3,5
12.	The attractiveness of the display composition and arrangement of the media.	3,5
13.	Appropriateness of time allocation with a media presentation.	3,5
14.	Relevance of learning objectives with the material presented in the media.	3,5
15.	The effectiveness of learning media as teaching materials in theory and practice.	3
	Average Score of All Aspects ($\bar{V}_a$)	3,53

Based on the results of the material expert validation, the average score for all aspects $(\bar{V}_a)$ is 3.53. According to the established validity criteria, the learning media can be declared valid. This means that learning media is feasible to use.

3) Results of the Validation of the Observation Sheet on the Implementation of Learning Media

The results of the validation of the observation sheet on the implementation of learning media are shown in Table 3 below.

Table 3. Validation Results of the Observation Sheet on the Implementation of Learning Media

Number	**Rated Aspect**	**Average Score of Each Aspect ($\bar{A}_i$)**
1.	Filling instructions are clear	4
2.	The aspects of being assessed are clear	3,5
3.	Questions are not ambiguous	4
4.	Questions already cover all aspects that are assessed	3,5
	Average Score of All Aspects ($\bar{V}_a$)	3,75

Based on the results of the two validators, the average score for all aspects $(\bar{V}_a)$ is 3.75. According to the validity criteria set, the observation validation sheet of the implementation of learning media can be said to be valid. This means that the observation sheet of the implementation of learning media is feasible to use.

4) Student Response Questionnaire Validation Results

The results of the student response questionnaire validation are shown in Table 4 below.

Table 4. Student Questionnaire Validation Results

Number	**Assessment Aspects**	**Score Average of Each Aspect ($\bar{A}_i$)**
1.	Filling instructions are clear	4
2.	The questions asked are clear	4
3.	Questions are not ambiguous	3,5
4.	The statement includes all aspects assessed	3,5
	Average Score of All Aspects ($\bar{V}_a$)	3,75

Based on the results of the two validators, the average score for all aspects $(\bar{V}_a)$ is 3.75. According to the established validity criteria, the student response questionnaire validation

sheet is valid. This means that the student response questionnaire sheet is feasible to use. Complete validation results of student response questionnaires can be seen in the attachment to the validation results.

5) Material Mastery Test Validation Results

The results of the material mastery test validation are shown in Table 5 below.

Table 5. Material Mastery Test Validation Results

Number	Indicator	Average Score of Each Indicator ($\bar{I}_i$)
1.	Average Score of Each Indicator	3,5
2.	Items in accordance with the material	4
3.	The instructions for working on the questions are clear	4
4.	The terms used are communicative	4
5.	The questions are multiple-choice	3,5
6.	Use good and correct sentences in accordance with the rules of the Indonesian language	4
	Average Score of All Indicators ($\bar{I}_i$)	3,83

Based on the results of the two validators, the average score for all indicators ($\bar{I}_i$) is 3.83. According to the established validity criteria, the validation results of the material mastery test can be said to be valid. This means that the material mastery test is feasible to use.

4. Implementation

a. Small Group Trial

The small group trial in question is a small-scale field trial. This trial was conducted to test the feasibility of the media before the actual trial. This trial was carried out on Mathematics Education students in semester 3 of class A and was carried out for 4 (four) meetings. Three meetings were used for learning and one for material mastery tests.

Small group tests were conducted on 32 (three) students. The trial took place from August 22 2022, to August 25 2022. Face-to-face activities in class were carried out four times a week, Monday to Thursday, from 13.00-15.30 WIB. Each meeting is 150 minutes long. The trial implementation schedule is presented in Table 6 below.

Table 6. Field Trial Implementation Schedule

Meeting			
I	**II**	**III**	**IV**
Monday, August 22 2022, 7-9 hours	Tuesday, August 23 2022, 7-9 hours	Wednesday, August 24, 2022, 7-9 hours	Thursday, August 26 2022, 7-9 hours

The results of the small group test, the responses from class 3A TMT students, were positive. There were two responses/notes to the small group tryout: the lack of discussion of the media during the lesson and the lack of students being able to play an active role. The mean score of the small group trial was 78.375. Because the score is more than 70, it can be said to have received a positive response. Because it meets a positive response, it can proceed to field trials with the abovementioned notes.

b. Product Trial in Actual Conditions

This trial was conducted to assess the practicality and effectiveness of learning media. This trial

was carried out on Mathematics Education students in semester 3 of classes B, C, D, and E and was carried out in 16 (sixteen) meetings with two tests.

A large group test was conducted on 132 (three) students. The trial will take place from September to October 2022. Face-to-face or online learning activities are carried out in two weekly meetings, Monday and Sayyid Ali Rahmatullahrday, at 3 to 10 hours. Each meeting takes 100 minutes.

Table 7. Field Test Results

Number	Class	Score	Criteria
1.	B	84	Positive
2.	C	87	Very Positive
3.	D	88	Very Positive
4.	E	85	Positive
Rata-rata		86	Very Positive

Based on the field test results table above, it can be concluded that the development carried out received a good response. Apart from student test results, researchers also collected data from questionnaires. The following are the results of a student response questionnaire to the development carried out.

Table 8. Student Response Questionnaire Results

Aspect	Score	Criteria
Language	84	Positive
Material	83	Positive
Renewal	83	Positive
Media	85	Very Positive
Average	83,75	Positive

Based on the summary analysis of the trial results and the student response questionnaire presented in Table 8, the learning media meets the criteria of practicality and effectiveness. In addition, the developed media is also valid because it has passed validation from experts so that it can be concluded that the development carried out is valid, practical and effective.

5. Evaluation

The evaluation of each stage above is in the form of a conclusion that there is a need for an update of the teaching materials used in the learning process, so the researcher develops blended learning based on GeoGebra media which is integrated with the internet on flat analytic geometry material. This development is declared feasible and interesting and has a positive influence when applied to learning. The drawback to the development of this media is that it only focuses on one material, so this learning media only helps students understand flat analytic geometry material. It is hoped that there will always be updates in developing learning media for subsequent materials.

Based on the summary analysis of the trial results and the student response questionnaire presented in the table, the learning media meets the criteria of practicality and effectiveness. In addition, the developed media is also valid because it has passed validation from experts so that it can be concluded that the development carried out is valid, practical and effective.

The stages researchers used in this development research were using the ADDIE development model, which consisted of 5 stages: analysis, design, development, implementation, and evaluation. At the analysis stage, the researcher determines and formulates the objectives of the development carried out [8]. To determine the direction of research, a preliminary study was carried out and obtained results indicating that during the learning process, there were no specific instructional media

applied in the learning process. The ability to understand concepts in analytical geometry courses is still low. This can be seen from the results of the preliminary studies conducted, so the researchers chose to develop GeoGebra-based blended learning integrated with the internet.

Next is the design stage (design). The framework and ideas for blended learning were prepared at the design stage. The researcher designed and compiled the learning media at this stage. The arrangement is made so that the researcher has an overview of the appearance, content and flow of the blended learning that will be made. At the design stage, validation instruments were also prepared, namely validation on media experts and material experts, as well as questionnaires on student responses to media use [9].

Next is the development stage. The development stage is the stage in making learning media. After the product has been made, the next step is to ask for an evaluation from experts of the product that has been made, where the process is called validation. The purpose of validation is to find out the media's shortcomings and weaknesses and obtain input to improve the media being developed [10]. In addition, validation also aims to obtain an assessment of whether the media is feasible or not. The results of the experts' assessment stated that the development of instructional media design was valid and ready to be tested.

Next is the trial or implementation stage. Based on the results of data processing obtained from field research on small-scale trials, which 32 students attended, the learning media developed obtained an average score of 78.375 where this value has a "positive" assessment criterion, while the field trials which 132 students towards the media learning attended obtained an average of 86 and obtained the "very interesting" assessment criteria. The results of the student response questionnaire distributed to the subjects also showed a positive response, so it could be concluded that this development was valid, practical and effective.

Based on the large-scale trial table, it was noted that 82 out of 132 students met the completion criteria in the flat analytic geometry course with a score of ≥ 70. The average percentage also showed a figure of 62.1% in the range of 60% - 80% by obtaining effective criteria. Based on the small-scale tests that were carried out previously, it can be seen that there are differences in the results of the difficulties with large-scale trials. Completeness in large-scale tests shows the improvements made by researchers during the development process.

The evaluation stage is the last process in the development with the ADDIE model. The evaluation stage is in each process in the previous stage, starting from analysis to implementation. Based on the results of the development carried out by going through the five stages above, it produces the final product, namely GeoGebra-based blended learning, which is integrated with the internet, which has qualified properly based on the results of expert validation and has very attractive qualifications based on the results of small and large class trials.

CONCLUSIONS AND SUGGESTIONS

Based on the results of this research and development, it can be concluded that the development of GeoGebra-based learning media in the Flat Analytical Geometry course for students majoring in Mathematics Education at UIN Sayyid Ali Rahmatullah Tulungagung is declared valid, practical and effective.

In essence, the developed media is limited to the material on flat analytic geometry operations, so it is hoped that the development of this media will be even more complex in terms of material so that the media can be used to make it easier for students to learn other sub-chapters.

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