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Development of the GeoGebra Guidebook in Creating Mathematics Learning Media Based on Ethnomathematics

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ABSTRACT

This research aims to develop a guidebook for the use of GeoGebra in creating mathematics learning media based on ethnomathematics for university students in mathematics education study program at Pattimura University PSDKU Maluku Barat Daya. The method used in this research is Research and Development (R&D) with 4D model developed by Thiagarajan et al. (1974) which consists of 4 stages, namely Define, Design, Develop and Disseminate. This method and model are very feasible and systematically supports the development of the guidebook. By involving 2 validators, namely material experts and linguists, the draft of the guidebook was then revised and tested on a small limited group. Furthermore, based on descriptive statistical analysis and qualitative descriptive analysis, it can be concluded that the reference book using GeoGebra has been successfully prepared and meets the criteria of valid and effective. In addition, the use of this guidebook can also increase students' knowledge in understanding material related to cartesian coordinates, especially in drawing graphs of linear functions, quadratic functions, polynomials, trigonometric functions, exponent functions, and logarithms.

Introduction

Mathematics is an important science in the advancement of technology and various other scientific disciplines. However, mathematics is often seen as a difficult and unpleasant subject by many students. Purnomo (2021) states that this is influenced by several factors, such as the dificulty to understand the subject, less varied learning methods, a lack of interesting and interactive learning media, and a lack of student motivation and interest in mathematics.

Learning media is one solution that can help teachers and students overcome these problems. Because learning media are teaching aids that contain learning material that can stimulate students to understand better, improve their motivation, critical thinking skills, and help them simplify the learning process (Eliyanto et al., 2022; Mohamad et al., 2023; Sa'diyah et al., 2021; Suhaifi & Karyono, 2022; Tanggoro, 2015). For teachers, learning media can help them to achieve attention,

interest, adjusting the learning climate, and promoting acceptance of an idea (Tanggoro, 2015). Furthermore, Lestari et al. (2018) added that learning media can be in print, audio, visual, audiovisual, or electronic form.

One of the learning media that is very useful and easy to use in mathematics is GeoGebra (Abadi, 2020; Azizah, 2022; Ekawati, 2016; Erlinawati, 2018; Noer Hidayat & Muh Tamimuddin, 2015; Purnomo, 2021; Suhaifi & Karyono, 2022; Tanzimah, 2019). Gökçe & Güner (2022) stated that GeoGebra is a free and multi-platform mathematics software that can be used for learning and teaching mathematics from basic to advanced levels. GeoGebra allows users to create and manipulate geometric, algebraic, graphical, statistical, calculus, etc. objects dynamically and interactively. GeoGebra also has advanced features such as 3D, CAS, and VR which can enrich the mathematics learning experience.

GeoGebra has many advantages as a mathematics learning media, including as follows. GeoGebra can be used to demonstrate or visualize mathematical concepts, as well as as a means of constructing mathematical concepts. Purnomo (2021) explained that using GeoGebra in mathematics learning can improve mathematical reasoning, increase creativity, support collaboration, involve students more in the learning process so that learning can be effective and efficient.

GeoGebra can be used as a presentation media, visualization media, construction, and discovery aids. Suhaifi & Karyono (2022) stated that GeoGebra can produce geometric drawings quickly and accurately compared to using a pencil, ruler or compass; provide a clearer visual experience for students in understanding geometric concepts because it is equipped with animation and manipulation movements (dragging); used as feedback/evaluation to ensure that the painting that has been created is correct; makes it easier for students to investigate or demonstrate the properties that apply to a geometric object

GeoGebra can be used as a learning media, a tool to help create teaching materials, and solve mathematics problem. Students can create their own mathematical problem constructions and solve them using GeoGebra. Ekawati (2016) explains that GeoGebra makes mathematics more interactive and interesting.

GeoGebra has a large and active user community consisting of teachers, students, researchers, and developers from all over the world. Gökçe & Güner (2022) added that this learning resource can be used as a reference or inspiration for other users.

Apart from that, GeoGebra also has offline feature which are very suitable for campus and school environments, especially in Maluku Barat Daya, which has limited internet coverage. The offline feature in GeoGebra makes both teachers and students do not have to depend on the stability of the internet network.

Besides utilizing learning media, mathematics will also be easier to understand if it is associated with life and culture that is close to students. This association between culture and mathematics is also called ethnomathematics. By optimizing the use of geogebra and optimizing ethnomathematics in learning, it is hoped that student learning outcomes will be more optimal.

However, there are many teachers and students who do not know or use GeoGebra. Developing a guidebook for the use of GeoGebra in creating mathematics learning media based on ethnomathematics for university students is one of the efforts that can be taken to solve the problem above. This book aims to provide guidance for students in using GeoGebra to create mathematics learning media that are in accordance with the curriculum, materials, and learning objectives. This guidebook is also expected to increase student motivation and interest in mathematics through interesting and interactive learning media.

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Method

Development research is a scientific method that aims to produce products and test the effectiveness of these products. Development research is usually conducted in the fields of education, technology, or industry. In this study, the product to be produced is a guidebook for using GeoGebra in creating mathematics learning media based on ethnomathematics. According to this objective, the development model used in this research is the 4-D model developed by Thiagarajan et al. (1974). The 4D model is a learning device development model consisting of four stages, namely Define, Design, Develop, and Disseminate.

The define stage establishes and defines the learning requirements. This stage includes five main steps, namely front-end analysis, learner analysis, task analysis, concept analysis and specifying instructional objectives.

The design stage aims to design the learning tools, in this research it is the guidebook prototype. Four steps must be taken at this stage, namely: (1) criterion-test construction, (2) media selection that is suitable for the characteristics of the material and learning objectives, (3) format selection, which is to review the formats of existing teaching materials and determine the format of teaching materials to be developed, (4) make an initial design according to the selected format.

The development stage aims to produce development products that are carried out through two steps, namely expert appraisal followed by revision and development testing. The purpose of this stage is to produce the final form of a guidebook after going through revisions based on feedback and data. The steps taken at this stage are as follows.

Expert appraisal

The expert appraisal includes validation of the material expert and validation of the linguist. Validation from material experts assessed the material organization (suitability of title, material, examples, illustrations, and language), depth, currency, context, application, and exercises. The validation results will be used to revise the initial product. The material experts in this study were lecturers who taught Analytical Geometry of the Field in the PSDKU Mathematics Education Study Program at Pattimura University, Maluku Barat Daya. While validation from linguists assesses the suitability of language rules, consistency of paragraph structure, digestibility of explanation, coherence, and linkage of thought flow to conformity with correct Indonesian. Conducted by lecturers who taught Indonesian in the Mathematics Education Study Program at Pattimura University, PSDKU Maluku Barat Daya. The results of this validation are used as feedback for the perfection of the developed guidebook. The guidebook prototype is valid if the average percentage score of validation results (SV) in formula (1) meets the criteria valid based on the term in table 1.

$$SV = \frac{Sr}{Sm} \times 100\% \qquad (1)$$

With: SV = average percentage score of validation results; Sr = average validation score of each validator; Sm = maximum score that can be obtained

Table 1. Validity Criteria

SV	Criteria	Description
$75\% \leq SV \leq 100\%$	Valid	No revision required
$50\% \leq SV < 75\%$	Quite Valid	Minor revisions
$25\% \leq SV < 50\%$	Not eligible	Major revisions
$0\% \leq SV < 25\%$	Very poor	Cannot be used

Adopted from Kristanti & Julia (2017)

Developmental testing

The revised draft from the expert appraisal was then tested on students in a developmental testing. This limited test was used to obtain feedback on the level of readability and interest in the prototype. To obtain responses and perceptions from students, an instrument in the form of questionnaire 1 was used to identify typing errors, errors in the use of punctuation marks, and errors in the use of capital and small letters. Furthermore, questionnaire 2 consists of 12 questions by ticking the checklist in the available column. The highest score of the instrument is four (4), while the lowest score is one (1). Descriptive statistical analysis was used to process the data obtained in the form of Likert scale criterion scores. The results of the analysis were used to revise and describe the development product. The answer score for each instrument item is calculated the level of achievement using a percentage formula on each subject's answer with the formula (2), as follows.

$$Percentage\ (x) = \frac{\sum assessment\ score\ for\ each\ item}{n \times the\ highest\ score \times number\ of\ respondents} \times 100\% \quad (2)$$

with: n = total number of items in the questionnaire

The guidebook is valid if it receives the criteria of "very good/valid/eligible", based on the interpretation and decision-making about the quality of the development product using the eligibility level criteria in table 2.

Table. 2 Eligibility Level Criteria

Percentage (%)	Qualification
$80 \leq x \leq 100$	Very good/valid/eligible
$60 \leq x < 80$	Quite good/quite valid/quite eligible
$50 \leq x < 60$	Not good/not valid/not eligible
$0 \leq x < 50$	Very poor (changed)

Adopted from Juliari et al. (2021)

Furthermore, the effectiveness analysis was used to test the level of effectiveness of the prototype, by asking students to solve one of the practice problems in the guidebook. The determination of the percentage of learning effectiveness is determined by the formula (3).

$$SE = \frac{t}{N} \times 100\% \quad (3)$$

(Kristanti & Julia, 2017)

with SE = percentage of learning effectiveness; t = many students achieved more than or equal to 75; N = total number of students. The prototype is categorized as effective if the SE is at least 70%. Which means, at least 70% of the students who took the test scored greater than or equal to 75 (Kristanti & Julia, 2017). Besides descriptive statistical analysis, this research also used qualitative descriptive analysis. Using this analysis, the data was processed by analyzing notes, suggestions or comments based on the assessments contained in the validation sheet, observations, interviews, and questionnaires.

The disseminate stage is the final stage of development. The dissemination stage aims to promote the development of product to make it acceptable to users, whether individuals, a group, or a system. Developers must be selective and work together to present the learning tools in the right form.

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Results and Discussion

Based on the 4-D development model, the development process includes define, design, develop, and disseminate stages as follows.

Define

The development process of the guidebook begins with observations in the matriculation class of new students in the Mathematics Education study program at Pattimura University, PSDKU Maluku Barat Daya and conducting unstructured interviews with several lecturers. Based on these results, it was found that students' ability to understand basic mathematics, such as cartesian coordinates, was still very poor. Moreover, from the lecturers, there has been no significant effort that can fix this problem. Therefore, students need media that can help them understand basic mathematics and can be studied independently. One of the media that meets these criteria is GeoGebra, but students are still constrained by the unavailability of a guidebook for introducing the GeoGebra application that is relevant to their lives.

Observations and interviews conducted with 3 students of the mathematics education study program, Pattimura University PSDKU Maluku Barat Daya. The results of this observation showed that students' understanding of material related to the coordinate plane, especially drawing graphs of functions such as linear, quadratic, polynomial, trigonometric, exponential and logarithmic functions, is still very lacking. Therefore, students need to be introduced to GeoGebra as an interactive learning media that can be learned independently. The guidebook of using GeoGebra which is completed with examples of problems related to their cultural life is expected to help students in understanding mathematical materials independently.

Observations and interviews conducted with 3 lecturers of the mathematics education study program, Pattimura University PSDKU Maluku Barat Daya. Based on the results of this interview, it is known that the content that needs to be presented in the GeoGebra guidebook is about how to install the application, the introduction of existing tools, how to use the application in drawing graphs of equations in various types of functions, and how to apply GeoGebra in everyday life.

Based on the results of observations and interviews, it is known that the main concepts in the guidebook are learning objectives for each chapter, main content, practical instructions for using geogebra in solving mathematics problems, student activities, math problem exercises, story problems related to ethnomathematics, and story problem exercises related to ethnomathematics.

The learning objectives to be achieved are that students can run the GeoGebra application independently and utilize this application in understanding mathematical concepts and can apply it in the teaching and learning process.

Design

During this step, a prototype of the guidebook was prepared, which included media selection, format selection and initial design. It was found that students are not able to meet their lecturers all the time, so they need a guidebook that can help them understand the mathematical concepts independently. Therefore, the selected media in this research is a guidebook that contains installation steps completed with explanations and pictures so that it can be independently used by students, as shown in Figure 1. To support this goal, the content design and learning approach uses an interactive format where each sub-chapter contains instructions for students to practice (Figure 2) and each chapter is equipped with exercises (Figure 3).

Figure 1. Shows the GeoGebra installation steps with written explanations.

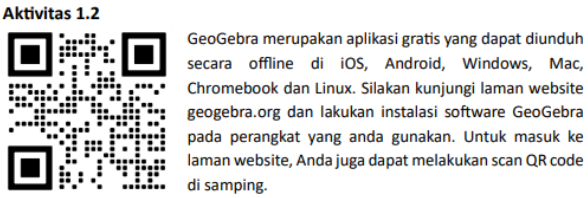

Figure 2. Depicts a section of the guidebook that uses an interactive format with practical instructions for students.

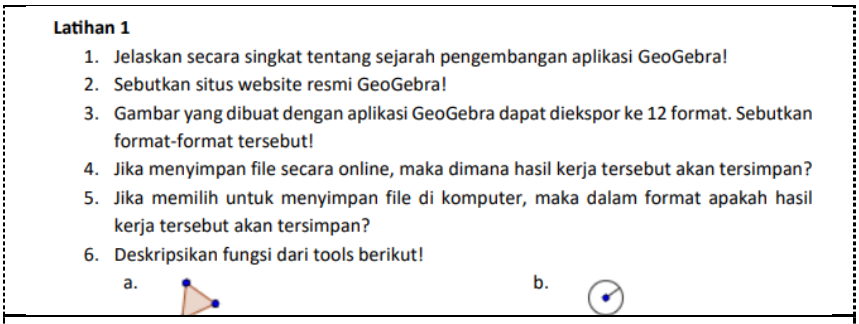

Figure 3. Shows that each chapter in the guidebook comes with exercises to test students' understanding of the material studied.

Based on front-end analysis, learner analysis, task analysis, concept analysis and specifying instructional objectives at the defines stage, the general structure of the Geogebra guidebook is shown in Table 3.

Tabel 3. Structure of GeoGebra's Guidebook in Creating Mathematics Learning Media Based on Ethnomathematics

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The layout and design of the contents are made by using Calibri font size 12. Pictures in it are made from screen captures on the GeoGebra application on a laptop. The initial design of the guidebook that has been made then commented on by two validators which are then discussed at the develop stage.

Develop

At this step, a revised prototype was produced based on expert appraisal followed by revision and development testing. The validation results of the guidebook in this study showed that the average percentage score of the validation results (SV) was 93%, which based on table 1 was categorized as valid. Material experts suggest that the use of terms should be consistent, such as the terms window bar, tool bar, and so on. Furthermore, advice from the second validator, the linguist, was that the language needed to be simpler, even though the prototype was already good. After revising the guidebook prototype based on suggestions and feedback from both validators, development testing was then conducted. Based on the results of student questionnaires 1 and 2, it is known that the percentage of the quality of the development product is 85%, which when adjusted to the table of eligibility level criteria is in the valid qualification.

In development testing, based on the results of student questionnaires 1 and 2, the percentage of learning effectiveness of the development product is 85%. If adjusted to the table of

eligibility level criteria (table 2), then the product is in the valid qualification. Additionally, based on the students' scores on the completion of the exercise questions in chapter 1, the percentage of students' learning effectiveness is 90%. This means that 90% of the students who took the test scored greater than or equal to 75. This indicates that the Geogebra guidebook has met the valid and effective criteria (Kristanti & Julia, 2017).

Conclusion

The findings of this development research can be concluded that the GeoGebra's guidebook in creating mathematics learning media based on ethnomathematics for university students has been successfully prepared and meets the valid and effective criteria.

The authors propose suggestions for students, teachers, and other researchers. For the students, the authors encourage them to read, understand, and practice the instructions in the guidebook. Through this process, they will be able to improve their math skills. Meanwhile, teachers can use this guidebook to teach and introduce the concept of graphs to students. This can help teachers motivate students to learn mathematics concepts. Furthermore, for other researchers, it is necessary to do a better validation in all aspects.

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