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Development of Learning Media Assisted by Geogebra and Interactive Games on Cone Material

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Abstract

The swift advancement of *technology* offers significant opportunities for the field of education. Technological progress serves as a tool to facilitate teaching and learning processes. One notable application is in the selection of *learning media*, which plays a crucial role in ensuring that educational activities align with current needs. The aim of this study is the researcher will develop learning media assisted by Geogebra and Interactive Games that are valid, practical, and effective on cone material. This study utilizes a research and development (R&D) approach, applying Thiagarajan's 4-D model. The participants consisted of 26 students from class IX-B at the Laboratory Junior High School of Malang State University. The findings revealed that the media's validity scored an average of 80%, categorizing it as "Feasible," thus confirming its validity. Effectiveness was assessed by analyzing the test results of the 26 students, with an average score of 84, indicating strong effectiveness. Practicality was evaluated through a student feedback survey, which showed a practical rating of 80%. Based on these findings, the *online interactive* learning materials, utilizing *GeoGebra* and *Construct 2* to create interactive games on cone volume, were deemed valid, practical, and effective, making them suitable for use in educational settings.

1. Introduction

The swift progression of time demands the integration of science and technology, particularly within education. In this context, technological advancements serve as a crucial tool that supports and enhances the teaching and learning processes (Maritsa et al., 2021). In the context of education, Veletsianos defines technology as tools, technologies, innovations, and advances used in educational settings (Sembey et al., 2024). The advancement of information technology has transformed the way educational systems facilitate the communication and engagement between instructors, learners, and the learning process (Cai et al., 2023). The wide variety of modern information technologies has led to the development of numerous approaches aimed at enhancing student learning experiences. At the same time, educational institutions are striving to create cost-effective learning environments that continue to have a significant, positive effect on student achievement (Omirzak et al., 2022).

According to Ki Hajar Dewantara, "education is an effort to advance the character, mind, and body of children, in order to advance the perfection of life, namely life and life of children in harmony with nature and society (Sutirna & Samsudin, 2015). According to the "Law of the Republic of Indonesia Number 57 of 2021 concerning the National Education System states that Education is a planned effort to create an atmosphere and learning process so that students are able to develop their potential and have religious spirituality, self-mastery, personal intelligence, character, and skills needed by themselves, society, nation and State *(Peraturan Pemerintah Republik Indonesia Nomor 57 Tahun 2021 Tentang Standar Nasional Pendidikan, 2021)*. Education can be understood as a deliberate and structured endeavor aimed at nurturing the full potential of individuals, both on a personal and social level, to make meaningful contributions to society and the nation.

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Mathematics is a universal language that is the foundation for technological progress and various fields of science (Maulyda, 2020). Mathematics not only teaches about numbers and formulas, but also trains oneself to think logically, critically, and creatively. By studying mathematics, it can contribute more to the development of society. Mathematics can also be interpreted as a universal science that can provide opportunities for the formation of the ability to communicate, think, solve problems, and reason for students (Maesari et al., 2019). Mathematics plays a crucial role in enhancing students' cognitive abilities, and as such, it is essential for learners at all levels, from elementary to high school, to acquire a solid understanding of this subject.

However, not a few students have the perception that mathematics is a relatively difficult and complicated subject, so that it can form negative student impressions and experiences (Pasehah et al., 2020). Perception is one of the factors that can affect learning. If the student's perception is positive, it can foster student interest in learning. However, if students' perceptions are negative, it can have a negative impact, namely decreasing student interest in learning (Fitroh & Sari, 2018). Teachers are encouraged to enhance the teaching process to boost students' engagement in their studies. One way to foster this interest is by incorporating *learning media* into educational activities (Nurfadhillah et al., 2021).

The term *media* originates from Latin, where it is the plural of *medium*, signifying something that serves as an intermediary or a conduit. According to Russell, “the media is a communication channel that mediates between the message source and the message receiver” (Fadilah, 2020). In Law No. 20 of 2003 concerning the national education system Article 1 paragraph 20 "Learning is the process of teacher interaction with students and learning resources in a learning environment” *(Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional, 2003)*. Learning media refers to various resources that educators utilize to communicate instructional content to their students. These resources can include tangible items, *sounds*, *videos*, and other forms.

According to the findings from observations and interviews with a mathematics teacher from class IX, conducted on February 22 and 23, 2024, at the Laboratory Junior High School of Malang State University, it was revealed that the available learning resources primarily consist of modules developed by the school and the materials presented by the teacher. The learning media employed so far have been limited to *PowerPoint* presentations and blackboards, which the teacher uses to explain the math content. Throughout the lessons, students mainly listen to the teacher's explanations and transcribe what is written on the blackboard. In reality, encouraging active student engagement during the lesson plays a crucial role in improving their grasp of the concepts being taught (S. Susanti et al., 2024). In optimizing teaching and learning activities, technology-based innovative strategies are needed to improve the quality of learning in the classroom (Suryawan & Permana, 2020).

Geogebra software is a valuable tool for enhancing the learning experience, particularly in the field of mathematics. It helps students grasp complex, abstract concepts more easily. As a mathematical application, Geogebra supports the teaching and learning process, especially when it comes to tackling geometry-related problems (Wulandari, 2019). According to Suryawan & Permana, *GeoGebra* is an application used to visualize mathematical concepts with complete features in mathematics learning and is suitable for teaching mathematics material that is still abstract (Suryawan & Permana, 2020).

Some previous studies that successfully used learning media assisted by *Geogebra software* in the learning process, including Simbolon in his research stated that using *GeoGebra software* can improve mathematical abilities (Simbolon, 2020). Furthermore, Suryawan & Permana in their research showed that students' understanding of mathematical concepts obtained 93.33% of students were in the complete category after participating in learning using the learning media developed (Suryawan & Permana, 2020). Gustin, et al in his research showed that using *GeoGebra software* can improve students' mathematical representation skills (Gustin et al., 2024). And Afhami in his research states that using *Geogebra Classic* can improve the ability to understand mathematical concepts (Afhami, 2022)

One of the mathematical materials studied in class IX is the curved side of space, namely cones. The material requires learning media that is easy to understand and is concrete so that students can easily understand the material provided by the teacher. Based on the description above, the researcher will develop learning media assisted by Geogebra and Interactive Games that are valid, practical, and effective on cone material.

2. Methods

This study was classified as a development study, specifically Research and Development (R&D), as it focused on creating Geogebra-based teaching tools to serve as learning resources for 9th-grade students, particularly for the topic of three-dimensional figures with curved surfaces (cone). Borg and Gall stated

that, "*educational research and development is a process used to develop and validate educational products*", research and development was a process used to develop and validate educational products (Gumanti et al., 2016). The (R&D) model that will be used in this study was the 4D model. According to Thiagarajan "consists of four stages of development, namely *Define*, *Design*, *Develop*, and *Disseminate*" (Thiagarajan, 1974).

The process begins with the *Define* phase, which focuses on recognizing the challenges encountered in the learning process. Following that is the *Design* phase, where media are created based on the insights gathered from the previous stage. The third phase, *Develop*, encompasses the validation by experts as well as conducting trials in a classroom setting. Expert validation was performed by university lecturers, while classroom trials took place with 26 students from class IX-B at the Laboratory Junior High School of Malang State University. For the expert validation, a four-point scale was employed: score 4 indicates very suitable (very good), score 3 indicates suitable (good), score 2 indicates not suitable (not good), and score 1 indicates very unsuitable (very bad). The data obtained from the expert validation results were analyzed using a percentage technique (Arikunto, 2010).

$$Score = \frac{number\ of\ scores\ obtained}{maximum\ number\ of\ scores} \times 100\%$$

Table 1. Validation Result Criteria

Score in percentage	Validation Criteria
$100\% - 81\%$	Very Feasible
$80\% - 61\%$	Feasible
$60\% - 41\%$	Decent Feasible
$40\% - 21\%$	Less Feasible
$< 20\%$	Not Feasible

This trial was conducted with the aim of measuring the practicality of the media in learning and analyzing the effectiveness of the media. To measure the effectiveness of the media, it will be taken through working on test questions in *Construct* 2 by 26 students of class IX-B in the 2023/2024 school year at the Laboratory Junior High School of Malang State University. For reference, the media is said to be effective if the average score of the 26 students in class IX-B gets an average score above the KKTP, namely 75. To measure the practicality of the media using a student response questionnaire. The response questionnaire contains 8 questions about *Geogebra-assisted* media and interactive games developed by researchers. The student response questionnaire uses a scale with four assessment scores, namely score 4 means very suitable (very good), score 3 means suitable (good), score 2 means not suitable (not good), score 1 means very unsuitable (very bad). The media is effective if students are able to find and apply the concept, the average student learning score meets the minimum completeness criteria, and gets a positive response from students. The formula used to calculate data on student answers is the percentage analysis technique (Arikunto, 2010).

$$Score = \frac{number\ of\ scores\ obtained}{maximum\ number\ of\ scores} \times 100\%$$

Table 2. Practicality Score Criteria

Percentage	Criteria
$100\% - 81\%$	Very Practical
$80\% - 61\%$	Practical
$60\% - 41\%$	Practical enough
$40\% - 21\%$	Less Practical
$< 20\%$	Not Practical

The fourth phase, *Disseminate*, involves sharing the developed products to ensure they reach users and are embraced by them.

3. Results & Discussions

This research develops *online* interactive learning media assisted by *Geogebra* and *Interactive Games*. The development model used is the Thiagarajan model which consists of four stages, namely the *defining* stage (*define*), the *design stage (design*), the development stage (*develop*), and the *dissemination* stage (*disseminate*).

3.1 Define stage

The purpose of the defining stage is to develop *online* interactive media assisted by *GeoGebra* and *Interactive Games* as a tool and as an independent or guided learning media for curved-sided space building material, especially on cone volume material. Learning goals can be established through various methods, including analyzing the desired outcomes and starting points, examining the students, studying the concepts, evaluating the tasks, and specifying the objectives for learning. Based on the results of interviews with class IX-B teachers, learning mathematics uses module learning media that has been made by the school and *powerpoint*. The assignment system is done *offline* based on paper or directly on the module, so math *software* such as *Mathlab*, *Maple*, *GeoGebra*, and so on have never been used as supporting learning media in the classroom. This makes students less excited when the learning process takes place, especially cone volume material. Therefore, practice and development research is carried out using *online* learning media.

3.2 Design stage

At this point, the process of creating educational media takes place, which includes GeoGebra-based learning tools and *interactive games*. This phase involves choosing the appropriate media, selecting the format, creating a preliminary design for the media, and preparing assessments for the learning materials. Learning media developed through *construct* 2 then inserted *GeoGebra links* as a medium to support the concept of material. There are several components in this media design, namely 1) Instructions, 2) Learning outcomes and learning objectives, 3) Material, 4) Game 1, 5) Game 2, 6) Profile, and 7) Exit. The following is described in the things that are contained in the learning media for the curved side of the cone volume material briefly.

When the learning media is run, it will appear as in Figure 1. To start learning students can choose "Material". As for the practice questions, you can choose "Game 1". Then for the *post-test* in choosing "Game 2". Finally, to see the developer's identity, students can select the "Profile" menu.

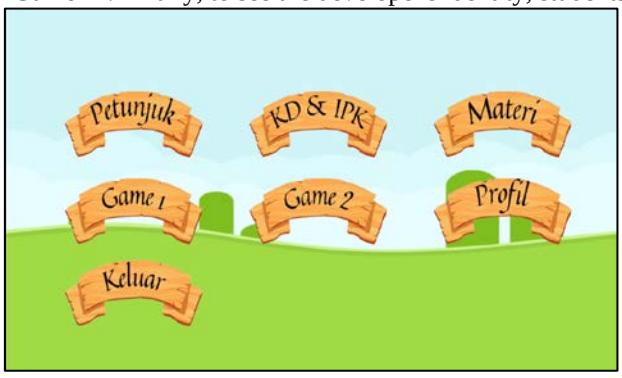

Figure 1. Learning Media Home Page

When students select "Material", a display like Figure 2 will appear. Where students can see and analyze what will happen to 3 cones and 1 tube when the cone 1, cone 2, and cone 3 buttons are played.

Figure 2. GeoGebra-assisted material display

Furthermore, students can see what questions are available on *GeoGebra*. The questions available on *GeoGebra* are like Figure 3. The question aims to enable students to find the formula for cone volume by themselves.

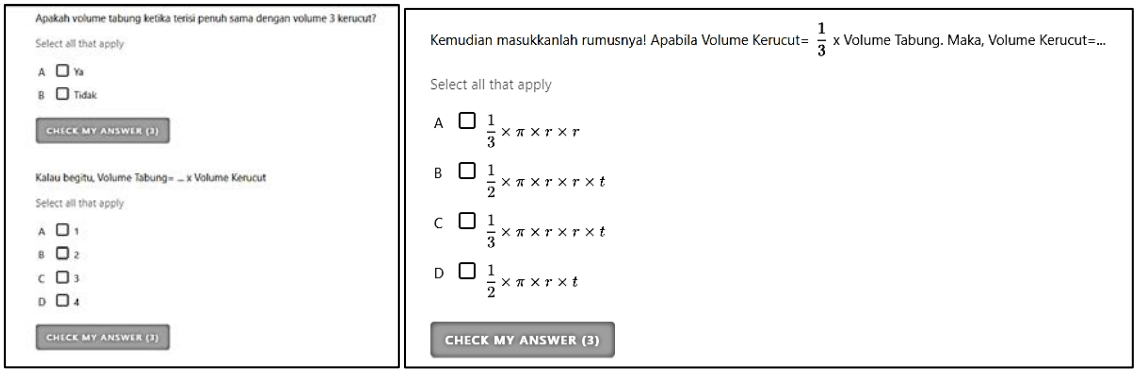

Figure 3. Display of Available Questions on GeoGebra

After students analyze and find the formula for cone volume, students can do practice problems in groups, where each group consists of 3-5 students. The practice problems available on the *construct* 2 page are as in Figure 4.

Figure 4. Display of Game 1 (Practice Problem) Available in Construct 2

After students work on the practice questions together with their group mates, followed by students working on the *post-test* which consists of 7 questions and can be done individually. Students can do the *post-test* by selecting "Game 2". The display on Game 2 is as shown in Figure 5.

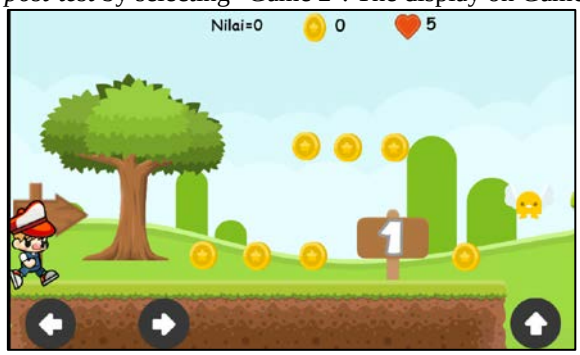

Figure 5. Game 2 (Post-test) View Available on Construct 2

The use of interactive games can be played by grade IX students, so that the interactive game is expected to help students understand cone volume material. This interactive game also provides experience for grade IX students, because the interactive game contains several questions related to cone volume that can be done by students so that they can improve students' understanding abilities. In addition, Geogebra-assisted learning media and interactive games can be used as a reference and learning resource for teachers in using learning media, especially cone volume material.

3.3 Development stage (develop)

At this stage, it produces media in the form of *GeoGebra* which has been uploaded and linked in *Construct* 2 which is validated by experts who produce revised learning media based on input from experts. The validator in this study is one of the mathematics education lecturers at the State University of Malang. The validators will provide values and suggestions as revision material in order to produce quality learning media and be suitable for testing. The media in this study can be said to be feasible if it meets three criteria, namely validity, practicality, and effectiveness criteria (Mahardika et al., 2022).

Table 3. Validator Assessment Results

No.	Aspects	Value	Validation Criteria
1	Learning Media Content	88%	Very Feasible
2	Images and Animations	75%	Feasible
3	Uses of Learning Media	83%	Very Feasible
4	Language and Symbols	75%	Feasible
	Average	80%	Feasible

Based on the results of the media expert validation above, the content aspect of the learning media scored 88% with very decent criteria. The image and animation aspect scored 75% with decent criteria. The usability aspect of learning media scores 83% with very decent criteria. The language and symbol aspects scored 75% with decent criteria, so the average validation score from media experts is 80% with decent criteria.

Based on the average media expert obtained a score of 80% with decent criteria. Because *GeoGebra-assisted* media can be said to be feasible, *GeoGebra-assisted* media is suitable for use or testing with students. A tool with high validity is considered a reliable instrument. On the other hand, an instrument that lacks validity is regarded as having low validity (Arikunto, 2010). In addition, teaching materials are said to be valid if the teaching materials can show a condition that is in accordance with the content and construct (Arikunto, 2008). This can be seen from each aspect that is assessed to get very valid criteria from media experts. If *GeoGebra-assisted* media is valid, it can later measure what should be measured in learning activities later. This is in line with the opinion of Hadinata, et al, that *GeoGebra-assisted* media can be said to be valid if the *GeoGebra-assisted* media is precise, valid, can measure what should be measured (Hadinata et al., 2024).

After the learning media is said to be valid, then trials are carried out with class IX-B students at the Laboratory Junior High School of Malang State University to analyze effectiveness and practicality. To get these results, researchers gave test questions contained in *Construct* 2 to 26 students of class IX-B at the Laboratory Junior High School of Malang State University as a result of its effectiveness and for the results of practicality, researchers will give a questionnaire to 26 students of class IX-B.

Table 4. Media Effectiveness Assessment Results

	Grade IX-B	Effectiveness Criteria
Highest Score	100	
Lowest Score	55	
Average Value	84	Effective

From the results in Table 4, obtained after working on evaluation questions on the researcher's learning media to 26 students in class IX-B in the 2023/2024 school year at the Laboratory Junior High School of Malang State University. As the researchers have stated in the method section, that the value reference used for assessing this media is declared effective if the average of the overall score is obtained above the KKTP, which is above 75. In accordance with this statement, this learning media can be said to be effective because from the results of Table 4 the average of the overall score is 84.

This is in accordance with Mulyasa's opinion, “that learning media as an independent learning package is systematically designed to help students achieve learning objectives” (Sholihah, 2023). Because the average value of the overall score is 84, where the average value is above the KKTP value, the *GeoGebra-assisted* media on cone volume material can improve math learning outcomes. This is in accordance with the research of Mutrofin, et al. who concluded that *GeoGebra-assisted Easyclass* learning media can improve student learning outcomes compared to traditional learning (Mutrofin et al., 2020). Thus, *GeoGebra-assisted* learning media on cone volume material can be said to be effective when applied in learning activities.

After going through the media trial stage to see the effectiveness of the media, the researcher proceeded to the media practicality assessment stage. The practicality assessment of this learning media was obtained

through distributing questionnaires to 26 students of class IX-B in the 2023/2024 school year at the Laboratory Junior High School of Malang State University. The following Table 5 contains the results of the practicality assessment from students.

Table 5. Practicality Assessment Results

No.	Aspects	Practicality Percentage	Criteria
1	The math learning media is easy for me to use.	84%	Very Practical
2	The presentation of problems in math learning media helps me understand the concept of Mathematics.	78%	Practical
3	I enjoy learning math through this learning media because it is interesting.	83%	Very Practical
4	This learning media makes me love math.	76%	Practical
5	This learning media makes me actively learn math.	77%	Practical
6	This learning media makes me want to understand more about math.	75%	Practical
7	The instructions and information presented are easy for me to understand.	84%	Very Practical
8	The appearance of the learning media is interesting.	88%	Very Practical
Average		80%	Practical

According to Susanti and Sholihah, “the teaching materials developed can be said to be practical if experts and practitioners state that the teaching materials are theoretically applicable and the level of implementation is in the good category and the student response questionnaire includes practical criteria” (E. D. Susanti & Sholihah, 2021). Based on the student response questionnaire listed in Table 5, where the average percentage is **80**% , so that *GeoGebra-assisted* learning media can be categorized as "practical". Thus, *online* interactive learning media using *Construct* 2 assisted by *GeoGebra* can be said to be practically practical.

Learning media is said to be practical if the media can be used easily and pleasantly and can increase student motivation to be more enthusiastic about learning. This is in line with research which reveals that the use of learning media can affect student learning motivation, because with the selection of various media teachers can be more skillful in choosing media according to learning materials and methods, and because the learning process can take place pleasantly and students feel motivated (Panggabean & Shaleha, 2022). Therefore, the study on the creation of online interactive learning tools utilizing Construct 2 with the support of GeoGebra has successfully fulfilled the three essential criteria: validity, practicality, and effectiveness. As a result, these online interactive learning tools are now prepared for teachers to implement in their teaching activities.

3.4 Disseminate stage

During the distribution phase, the packaging and delivery of the educational media that have been created are executed. The developed product, which has fulfilled the requirements of being valid, practical, and effective, is presented as a *learning website* (https://bit.ly/43s4XqB). The product was provided to a *mathematics* instructor who was teaching 9th-grade students at the Laboratory Junior High School of Malang State University.

The results of this development research have similarities with several previous studies including (Anggraeni et al., 2021); (Badriyanto & Qohar, 2022); (Masliah et al., 2023); (Puspaningrum & Istihapsari, 2023). The similarity of the research is to develop *GeoGebra-based* learning media that meet the criteria of valid, practical, and effective. Although the type of research and media used are the same, there are differences including the development model used, the location of the research, the test subjects and the material on the learning media.

The advantages of learning media produced by researchers compared to other studies are that the learning media developed by researchers cover the volume material of curved side spaces on cones. In addition, in terms of the appearance of learning media such as *websites* with interactive menu selection buttons. The learning media developed by researchers can be used *offline* and *online*. So that it can be used in the classroom or self-study at home flexibly anywhere and anytime.

4. Conclusion

The creation of online interactive learning tools focused on Cone Volume material utilizes Construct 2, GeoGebra, and Interactive Games, following a four-phase approach: defining, designing, developing, and distributing. The outcomes of this development include: 1) Validity, as determined by the validator's evaluation, with an average score of 80%, categorized as "Feasible" 2) Effectiveness, based on the students' performance in learning outcome tests, resulting in an overall average score of 84, which places it in the effective category. 3) Practicality, based on feedback from student response surveys, yielding a practical rating with a percentage of 80%.

In addition, researchers also have several suggestions for *online* interactive mathematics learning media using *Construct* 2 assisted by *GeoGebra* and *Interactive Games* on cone volume material, namely that it should be used by junior high school (SMP) level students, especially class IX and if there are deficiencies, it can be refined again so that this media is better and more useful. Furthermore, the need for the development of similar media but with diverse materials such as equations and quadratic functions, trigonometry, curved side spaces in tubes and spheres, and so on.

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