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Flip-based e-comic media: Enhancing HOTS in elementary mathematics learning

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ABSTRACT

This study aims to develop a flip-based e-comic as a learning medium and analyze its impact on the HOTS (Higher-Order Thinking Skills) of fourth-grade students in mathematics, specifically on the topic of calculating the area of plane figures. The study employs the Research and Development method using the Borg and Gall model. Data analysis techniques include media feasibility tests, t-tests, and N-Gain tests. The results indicate that the e-comic is highly feasible for use, as evidenced by feasibility ratings from media experts (90%), content experts (89.2%), and language experts (87.5%). Based on the t-test, the e-comic was proven effective in learning, with a sig. (2-tailed) value of 0.000 < 0.05, indicating that Ho is rejected and Ha is accepted. Furthermore, the N-Gain test results show an improvement in students' abilities, with scores of 0.7164 for the small scale and 0.8307 for the large scale, both categorized as high. Thus, the e-comic positively impacts students' ability to solve HOTS questions. This study implies the provision of an alternative learning medium that supports the development of students' higher-order thinking skills while facilitating educators' integration of technology into modern learning practices.

Media e-komik berbasis flip: Meningkatkan HOTS dalam pembelajaran matematika di sekolah dasar

Keywords:

pembelajaran matematika sekolah dasar, e-komik berbasis flip*, kemampuan berpikir tingkat tinggi, media pembelajaran inovatif, pendidikan matematika*

ABSTRACT

Penelitian ini bertujuan untuk mengembangkan media pembelajaran berupa e-komik berbasis flip dan menganalisis pengaruhnya terhadap kemampuan HOTS (Higher Order Thinking Skills) *siswa kelas IV pada mata pelajaran matematika materi luas bangun datar. Penelitian ini menggunakan metode* Research and Development *dengan model Borg and Gall. Teknik analisis data yang digunakan meliputi uji kelayakan media, uji t, dan uji N-Gain. Hasil penelitian menunjukkan bahwa media e-komik sangat layak digunakan, dengan tingkat kelayakan yang diperoleh dari ahli media sebesar 90%, ahli materi sebesar 89,2%, dan ahli bahasa sebesar 87,5%. Berdasarkan uji t, media e-komik terbukti efektif digunakan dalam pembelajaran, dengan nilai sig. (2-tailed) sebesar 0,000 < 0,05 yang menunjukkan Ho ditolak dan Ha diterima. Selain itu, hasil uji N-Gain menunjukkan peningkatan kemampuan siswa pada skala kecil sebesar 0,7164 dan skala besar sebesar 0,8307, yang termasuk kategori tinggi. Dengan demikian, e-komik memberikan dampak positif terhadap kemampuan mengerjakan soal HOTS siswa. Penelitian ini berimplikasi dalam menyediakan alternatif media pembelajaran yang mendukung pengembangan berpikir tingkat tinggi siswa sekaligus*

memfasilitasi pendidik untuk mengintegrasikan teknologi ke dalam pembelajaran abad ke-21.

Contribution to the literature

This research contributes to:

- Providing flip-based e-comics as an alternative digital learning medium that is engaging and relevant to support mathematics education at the elementary level.
- Integrating technology into learning to enhance student engagement and address boredom often associated with conventional teaching methods.
- Supporting educational practices that align with the learning needs of the digital era.

1. INTRODUCTION

One of the Indonesian nation's national goals is to make the nation's life more intelligent [1]. To realize this goal, an initial step can be taken, namely by improving the existing education system. Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have spiritual and religious strength, self-control, personality, intelligence, noble morals, and the skills needed by themselves, society, nation, and state [2].

The learning process regulated by law in Indonesia in each primary and secondary education unit must be interactive, inspiring, challenging, and fun, motivating students to participate actively in developing creativity and independence according to the student's talents, interests, physical development, and psychology, one of the laws in question is Minister of Education and Culture Regulation Number 22 of 2016 concerning Process Standards in Primary and Secondary Education Units [3]. Based on these regulations, it can be concluded that developments in the learning tools used by teachers are very important because they will greatly influence the process of students' understanding of learning material [4].

In the current era, technology has become our daily food in carrying out all activities [5]. Technology can be like a product or process; apart from that, technology can also act as a tool or media that can broaden our horizons, which we can reach without the limitations of space and time [6]. In the realm of education, the learning process must also be adapted to the rate of development of existing technology. Therefore, a teacher must be able to follow the flow of existing technological developments, which, of course, must also be adapted to the conditions and characteristics of their students [7].

Learning is a process of interaction between students and students with learning resources. Interaction can be done face-to-face or remotely [8]. The existence of insufficient sources of learning information can hinder the achievement of the objectives of the learning process itself [9]. Therefore, strategies are needed in the learning process, including utilizing technology-based learning media as a tool for conveying information.

Students' learning success can also be seen from their ability to solve problems given by the teacher through various questions. However, in reality, the ability to work on questions, especially hot questions for students in Indonesia, is still relatively low. Researchers also discovered this problem based on observations at SDN 2 Ngabean (one of the elementary schools in Yogyakarta Province, Indonesia). This happens because of the lack of technological developments in the use of learning media, which makes the media used less interesting and very boring for students. This happens because the media used only relies on reading books in which there are only explanations and pictures that

are less interesting. Until now, Public attention to developing critical thinking skills is still relatively low, and therefore, development innovation is needed to explore critical thinking skills [10]. Facing global competition also requires improvements in the human development sector [11]. This can be done by developing students' ability to work on hot questions as the next generation of the Indonesian nation so that they are trained to find alternative solutions to problems.

Mathematics is the science that underlies the technological developments that we are targeting today. Apart from that, mathematics also plays an important role in various scientific disciplines which aim to advance the human mind [12]. This quote shows how important mathematics subjects are for survival. Mathematics subjects are given to all children from elementary school, which is useful for equipping them to have critical, logical, analytical, and creative thinking skills from an early age for the future [13]. However, in reality, many of them still think mathematics is scary and boring; this can happen because the learning process does not attract their interest in learning [14].

There are efforts that teachers can make to arouse students' interest in learning, including (1) the need for a warm and cooperative attitude, (2) trying to start impressive learning activities, (3) contextual, (4) varying learning methods, (5) use learning media, (6) ice-breaking when bored, and (7) giving rewards [15]. In this regard, it can be concluded that the use of learning media plays an important role in attracting students' interest in learning mathematics. It is not just the learning media that is used, but it must still be relevant to 21st-century learning, which suggests that teachers use technology as an innovation in making learning media [16]. The meaning of digital-based learning media is media used to create audio-visual media [17]. Digital-based learning media also has many types in electronic form, such as ebook, web, e-module, flash, interactive multimedia CD, and so on [18].

Researchers at SDN 2 Ngabean also discovered problems regarding interest in studying mathematics subjects. Through an interview with the homeroom teacher of the fourth-grade students at SDN 2 Ngabean, students were only enthusiastic in the first minutes of learning. Still, when learning had progressed for a long time, the students were bored and busy themselves or talking with their friends and no longer paying attention to the material being presented by the teacher. This problem occurs due to the lack of use of interesting and interactive learning media. Apart from that, the use of inappropriate learning methods is also one of the factors causing this problem. Based on observation data at SDN 2 Ngabean, several students have not passed the minimum competency criteria. At SDN 2 Ngabean, 60% of students have passed the minimum competency criteria, so it can be concluded that 9 out of 23 students have not passed the minimum competency criteria. Students who have not passed the minimum competency criteria have the same problem, namely a low ability to work on hot questions, so their ability to understand story questions and hot questions is still relatively low.

Based on these problems, the researcher chose a high class, namely the fourth-grade students at SDN 2 Ngabean, because it has a range of problems that are appropriate to what will be researched and will be useful for carrying out feasibility and effectiveness tests in it. Researchers focus on overcoming the problems that occur by using development strategies for technology-based learning media that will be used in the form of flip-based e-comics. This can also help teachers optimize the learning process and improve students' ability to work on hot questions in mathematics subjects.

Previous studies have been conducted on the development of digital learning media using various approaches, including the development of Android-based mathematics learning media for elementary school students [19], interactive problem-solving-based

learning media using Lectora Inspire [20], the development of digital learning media [21], and the development of e-comics using the ADDIE model to increase students' learning interest [22]. However, these studies mostly focused on the development of media without deeply exploring their effectiveness in improving students' abilities in HOTS-related tasks.

This study aims to develop a flip-based e-comic as a learning medium that is not only visually appealing and relevant but has also proven effective in enhancing students' ability to solve HOTS problems in mathematics. The findings of this study make a significant contribution to supporting technology-based learning that is not only innovative but also measurable in its effectiveness while also opening opportunities for broader applications in 21st-century education.

2. METHOD

The type of research used by researchers is Research and Development. This research focuses on developing a product or improving a product as well as testing a product, the product in question being hardware or software. Hardware can be in the form of books, learning aids, and modules, while products in the form of software can be in the form of programming designed using applications, for example, learning games that are accessed online, library, or laboratory data processing computer programs. There are various kinds of research models in development research, namely, among others, the Borg and Gall development model, the 4D development model, and the ADDIE development model [23].

In this research, product needs analysis was carried out by direct observation of research subjects and interviews, as well as based on literature studies used by researchers as reference sources. After receiving ethics approval, the research was conducted. The research procedure used in this research is that there are 5 stages: (1) Analysis of product needs, this stage is carried out using interviews and giving questionnaires to research subjects directly related to learning media; (2) Developing the initial product, at this stage the researcher begins develop products that will be used based on known needs using various assistance from design applications on the internet; (3) Expert validation and revision, after the initial product development stage, the product before being tested on the subject must pass expert validation, this aims to provide input and evaluate the learning media developed; (4) Small scale trials and revisions, at this stage the product that has received validity from experts is feasible and can be tested on small scale subjects and carry out a second revision from the subjects to see whether it is appropriate with the needs of students or not, In this small scale test, data samples were taken using a method of selecting 9 students who had different academic levels ranging from low, medium and high with the help of the teacher; and (5) Large-scale trials and final production, at this stage, the revised product can be produced and is ready to be tested on subjects on a large scale, in this large-scale test, data is taken from all students. Researchers use this development stage because it has a series of measurable and clear system workflows. The following is a picture of the flow of the stages of media development by Borg and Gall [24] used by researchers.

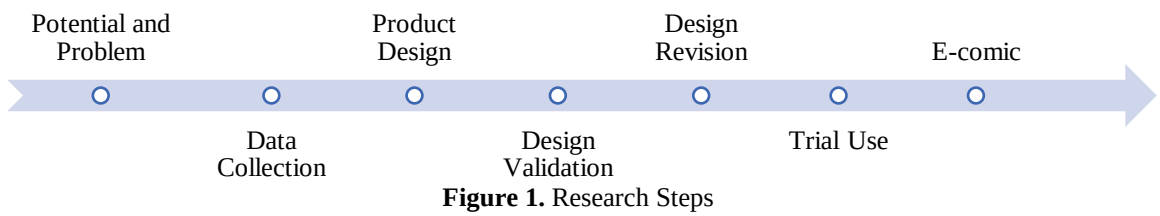

Figure 1. Research Steps

In this research, the students who were the subjects of data acquisition were fourth-grade students at SDN 2 Ngabean. After receiving consent from parents and students, the research was conducted. As many as 23 children were obtained for the large-scale test, while for the small-scale test, the data obtained was taken using a sampling technique, where only 6 to 9 were taken. Students from the total number of students in the class are selected based on recommendations from the class teacher and student report card data. Apart from that, teachers and expert validators are also among the subjects in this research. The data collection techniques used in this research are test techniques in the form of pretest and posttest questions, which will be carried out by fourth-grade students at SDN 2 Ngabean on a small and large scale, non-test techniques in the form of interviews by the homeroom teacher and questionnaires on product needs and product implementation.

The validation sheet regarding product development uses the Likert Scale, which contains four criteria that are translated in numbers from 1 to 4 representing: (1) not good, (2) quite good, (3) good, and (4) very good [25]. The calculation of the score for the media feasibility test in this study uses a percentage formula, namely the comparison of the score obtained with the maximum score. The assessment of the converted validation results is presented in the following table [26].

Table 1. Eligibility Criteria Percentage

Presentations	Criterion
76% - 100%	Very Worth IT
51% - 75%	Proper
26%-50%	Pretty Decent
0% - 25%	Less Decent

3. RESULTS AND DISCUSSION

The results of this research are more focused on the development of learning media in the form of flip-based e-comics in the mathematics subject area of plane figures for fourth-grade students, which aims to improve students' abilities in working on HOTS questions.

3.1 Potential and Problems

Based on data from interviews with the fourth-grade teacher at SDN 2 Ngabean, it is known that students tend to get bored easily when carrying out learning activities in class, especially in mathematics; this is because the media used is less interesting, so their interest in learning is still relatively low. As a result of these problems, their ability to work on HOTS questions is still relatively low. Therefore, researchers want to provide a solution to overcome this problem by developing more interesting learning media that can increase students' interest in learning, especially in mathematics, which, of course, has also been adapted to current technological developments.

Learning media is a tool that aims to convey messages from teachers to students so that students are stimulated in their thoughts, feelings, and willingness to participate in learning [27]. There are four classifications of learning media, namely visual media, audio media, audio-visual media, and multimedia [28]. In terms of digital-based learning media, there are still many teaching staff who do not understand this [29]. It is not just the learning media that is used, but it must still be relevant to 21st-century learning, which suggests that teachers use technology as an innovation in making learning media [16]. E-comics comes from the word comic, which Is a combination of art in the form of images arranged in such a way as to form a storyline. E-comics in question are visual

media packaged in electronic form and operated using electronic media [22]. Based on this, the researcher developed learning media in the form of flip-based e-comics in mathematics subjects, material in the area of plane figures, which aims to overcome problems that occur and adapt to existing technological developments.

3.2 Data Collection

In this research, the development of learning media begins with analyzing teacher needs and fourth-grade students at SDN 2 Ngabean, which was carried out using a needs questionnaire. The results of the needs questionnaire show that fourth-grade students at SDN 2 Ngabean feel that the learning that has been taking place so far has not gone well because they feel that the learning media used has not attracted their interest enough in learning. After all, the learning media used is still too monotonous. So, they really agree with the development of digital-based learning media, which includes material and practice questions covered with attractive pictures. The same results were also seen in the questionnaire regarding the needs of class teachers who felt that students easily get bored when participating in classroom learning activities, especially in mathematics subjects. So, the class teacher really agrees and needs help to innovate existing learning media into learning media that suits what students want and is, of course, adapted to current technological developments.

3.3 Product Design

The process of developing learning media carried out by researchers is digital-based learning media designed using Canva and Flip software.

This learning media is designed in the form of an e-comic, which contains extensive fourth-grade material wrapped in a storyline and pictures that are interesting to look at and are adapted to the PBL syntax. Apart from that, this learning media is also equipped with example questions and practice questions, which are included in the HOTS question criteria to measure and train students' understanding which can be accessed anywhere and at any time using electronic devices in the form of cellphones, laptops or computers [30]. Figure 2 displays the results of the development of learning media in the form of flip-based e-comics in the mathematics subject area of plane figures for fourth-grade students.

(a)

(b)

(c) (d)

Figure 2. (a) Problem Orientation, (b) Material Discussion, (c) Example Questions, and (d) Practice Questions

3.4 Design Validation

The results of media development that have been made according to the needs of teachers and students are then tested for suitability first before being used for research in accordance with the development flow of Borg and Gall. The matters whose suitability is tested are related to the material presented in the learning media by material experts, the media display design by media experts, and the language used in the media by linguist experts. From the results of product feasibility tests by experts, a percentage of product feasibility assessments is obtained, which is expressed in Table 2.

Table 2. Expert Assessment Results

Validator	Validation Device	Percentage	Criteria
Material Validator	Material Validation	89.2%	Very Worth It
Media Validator	Media Validation	90%	Very Worth It
Language Validator	Language Validation	87.5%	Very Worth It

The results of the percentage of product feasibility provided by expert experts in Table 2 state that the results of the assessment by material experts were 89.2% with very feasible criteria because the material contained therein was complete and appropriate. The assessment results by media experts were 90% with very feasible criteria because the product display design was very proportional and attractive. The results of the assessment by language experts were 87.5%, which was based on very appropriate criteria because the use of language in the product is in accordance with linguistic rules and is easy to understand. So, it can be concluded that product development that is tailored to the needs of teachers and students is very suitable for use in the teaching and learning process in the classroom.

3.5 Design Revision

After the media developed has been tested for suitability by media, material, and language experts, the next step is to carry out revisions provided by these experts. Because, of course, in the assessment questionnaire given, there are criticisms and suggestions given by experts to researchers with the aim of making the media developed better and more suitable for use. These revisions are crucial to ensure that the final product meets the desired quality standards and effectively supports the intended learning outcomes.

3.6 Trial Use

After the product has been tested for suitability by expert experts, the next stage is to test its effectiveness, whether it can improve students' abilities in working on HOTS questions, by carrying out two tests, namely a small-scale test and a large-scale test using pretest and posttest questions that have been accredited to the HOTS questions. Table 3 shows the results of the pretest and posttest of the small-scale test.

Table 3. Pretest Posttest Results of the Small Scale Test

No	Pretest	Completeness	Posttest	Completeness
1	50	Not Completed	85	Complete
2	55	Not Completed	80	Complete
3	65	Not Completed	90	Complete
4	63	Not Completed	90	Complete
5	70	Complete	100	Complete
6	50	Not Completed	85	Complete
7	65	Not Completed	90	Complete
8	60	Not Completed	80	Complete
9	70	Complete	95	Complete

Based on data from Table 3, which contains the results of the pretest and posttest of the small-scale test of fourth-grade students at SDN 2 Ngabean, it can be concluded that there has been an increase in their learning outcomes, which is characterized by the completeness obtained after using the product. The increase in learning outcomes, which is marked by the mastery achieved by students after using the product, can also be seen in Table 4, which contains the pretest-posttest of the large-scale test for fourth-grade students at SDN 2 Ngabean. This indicates that the product is effective in improving students' understanding and mastery of the material. Further research could explore its application in different educational contexts to validate its broader impact.

Table 4. Pretest Posttest Results of the Large-Scale Test

No	Pretest	Completeness	Posttest	Completeness
1	50	Not Completed	85	Complete
2	50	Not Completed	87	Complete
3	55	Not Completed	80	Complete
4	70	Complete	100	Complete
5	65	Not Completed	90	Complete
6	45	Not Completed	96	Complete
7	63	Not Completed	90	Complete
8	50	Not Completed	95	Complete
9	70	Complete	100	Complete
10	66	Not Completed	100	Complete
11	50	Not Completed	85	Complete
12	45	Not Completed	89	Complete
13	65	Not Completed	90	Complete
14	46	Not Completed	89	Complete
15	60	Not Completed	80	Complete
16	54	Not Completed	97	Complete
17	70	Complete	95	Complete
18	64	Not Completed	95	Complete
19	55	Not Completed	98	Complete
20	50	Not Completed	100	Complete
21	40	Not Completed	91	Complete
22	53	Not Completed	95	Complete
23	60	Not Completed	100	Complete

After the results of the pretest posttest, small—and large-scale tests are obtained. The next step is to carry out the results of the pretest posttest with a normality test, which aims to determine whether the data is normally distributed or not. Table 5 is a table of small-scale and large-scale normality tests.

Table 5. Small Scale Normality Test

No	Test	Significance	Criteria
1	Pretest	0.252	Normal
2	Posttest	0.545	Normal

In the normality test with the Shapiro-Wilk test, the data will be normally distributed if the calculated value is > 0.05, then (Ho is accepted), but if the calculated value is ≤ 0.05, then the data is not normally distributed and (Ho is rejected) [31]. Based on Table 5, it can be seen that the small-scale pretest-posttest significance values are 0.252 and 0.545, so both data have normal distribution criteria.

Table 6. Large Scale Normality Test

No	Test	Significance	Criteria
1	Pretest	0.180	Normal
2	Posttest	0.058	Normal

In Table 6, it can be seen that the pretest and posttest significance values on a large scale are 0.180 and 0.058; both data are normally distributed because both are > 0.05. Based on the data above, it can be concluded that the pretest and post-test data on small and large-scale tests are both normally distributed. So, it can be continued with the next stage, namely the t-test using SPSS, which aims to determine the influence of using the product that has been developed. Table 7 is a small-scale and large-scale t-test.

Table 7. Small Scale and Large Scale T Test

No	Test Type	Mean	Sig (2-tailed)	Information
1	Small Scale	-27.44444	0,000	Ha accepted
2	Large Scale	-36.34783	0,000	Ha accepted

Decision-making in the paired sample t-test is if the sig value. (2-tailed) < 0.05, then Ho is rejected, and Ha is accepted, but if the value is sig. (2-tailed) > 0.05, then Ho is accepted, and Ha is rejected [32]. Based on Table 7, the results of sig. (2-tailed) the small- and large-scale tests both show a value of 0.000 < 0.05, meaning that Ho is rejected and Ha is accepted. So, from the results of these calculations, it can be interpreted that the flip-based e-comic learning media in the mathematics subject area of plane figures for fourth-grade students influences increasing students' abilities in working on HOTS questions.

After the t-test, the next step is to carry out the N-Gain test, which aims to determine the effectiveness of using flip-based e-comic learning media in the mathematics subject area of plane figures for fourth-grade students. Table 8 presents data on the small-scale and large-scale N-Gain tests. The N-Gain test results provide insight into the improvement in students' understanding and learning outcomes after using the e-comic learning media.

Table 8. N-Gain Test of the Trials

No	Test Type	Mean	Information
1	Small Scale	0.7164	Tall
2	Large Scale	0.8307	Tall

The criteria taken for the N-Gain test are if the mean > 0.7, then the product effectiveness has high criteria; if 0.3 ≤ mean ≤ 0.7, then the product effectiveness has medium criteria; and if the mean < 0.3, then the product effectiveness has low criteria [33]. In Table 8, it can be seen that the mean values in the small-scale test and the large-scale test are both > 0.7, namely 0.7164 and 0.8307, so it can be concluded that the use of flip-based e-comic learning media in mathematics subjects on the area of plane figures for fourth-grade students is very effective to improve students' abilities in working on HOTS questions. When viewed as a whole through various tests that have been carried out by researchers, starting from the normality test, T-test, and N-Gain test, it can be concluded that the learning media developed is in the form of flip-based e-comics in the mathematics subject area of plane figures for fourth-grade students was successfully used to improve the ability to work on HOTS questions for fourth-grade students at SDN 2 Ngabean. This is also in line with previous research conducted by Dini *et al.* [19] and Hasbullah, which validated that the development of digital-based learning media is very influential in improving student learning outcomes and student interest in learning. This e-comic will also, of course, be very helpful for the world of education, especially for teachers and students in the learning process, because it has various benefits, one of which is improving students' abilities in working on HOTS questions in mathematics.

This study aligns with the findings of Irwansyah *et al.* [34], which demonstrate that the development of technology-based learning media, such as Augmented Reality (AR), is effective in enhancing students' understanding of abstract concepts through interactive and engaging visualization. This supports the findings of this study, where flip-based e-comic media facilitated not only the delivery of content but also improved student engagement and thinking skills, as shown in the enhancement of students' HOTS in mathematics. However, this study has several limitations. First, its scope is limited to a single class in one elementary school, making the results less generalizable. The flip-based e-comic media developed was also focused solely on the topic of calculating the area of plane figures, leaving its effectiveness for other topics or subjects untested. Additionally, the study has not evaluated the long-term impact of the media on students' critical thinking skills. It requires electronic devices, which could pose challenges for schools with limited access to technology.

Future research is recommended to expand the scope to include multiple schools and classes at various educational levels to improve generalizability. Developing similar media for other topics or subjects is also important to test its flexibility. Furthermore, conducting long-term studies to measure the sustained impact of this media and creating more interactive or adaptive versions for schools with technological limitations could enhance its broader effectiveness.

4. CONCLUSION

In this research, the development of learning media that has been carried out in the form of flip-based e-comics in the mathematics subject area of plane figures for the fourth-grade students at SDN 2 Ngabean has proven to be able to improve students' abilities in working on HOTS questions. This can be proven by the final results given by students who experienced an increase before and after using flip-based e-comic learning media. Apart from that, flip-based e-comic learning media has also been proven to be very effective based on the N-Gain test that has been carried out. Based on the T-test also shows that there is an influence on the use of learning media. Data from the pretest and post-test also shows that the data is normally distributed in both small-scale and large-scale trials. Based on the results provided by teachers and students through response

questionnaires, they also showed satisfaction with the use of flip-based e-comic media because 95% of students said that flip-based e-comic media was very interesting and could attract their interest in learning about subjects. Mathematics and the material, example questions, and practice questions can also help them understand, which really helps them improve their ability to work on HOTS questions. This research has implications in providing alternative innovative learning media that can increase learning interest, student engagement, and critical thinking skills in mathematics subjects while supporting educators in integrating technology into 21st-century learning.

AUTHOR CONTRIBUTION STATEMENT

BH contributed to designing the study, conducting the research, processing the data, and drafting the article. NN contributed to providing direction and guidance during the research process, including refining the methodology and ensuring the alignment of the study with its objectives.

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