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Digital Media Innovation Based on Multimedia Cognitive and Constructivist Theory in a Cultural Context: Encouraging Students' Higher Order Thinking Skills

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ABSTRACT

The high-order thinking skills of students in Indonesia are classified as low, this is in line with the results of diagnostic tests conducted in class IX junior high school. Thus, it is necessary to develop digital media based on multimedia and constructivist cognitive theory with cultural context as one of the alternative solution. This study aims to (1) develop digital learning media based on constructivist and cognitive multimedia theories with a cultural context that fulfills the categories of validity, practicality and effectiveness; and (2) improve students' high-order thinking skills after using these media in the learning process. The research subjects were 30 students in class IX junior high school and the research objects were digital learning media based on constructivist theory and cognitive multimedia with a cultural context to improve students' high-level thinking skills on the topic of dilation. This is a research design with the Plomp model, which consists of (1) Preliminary research; (2) Prototyping phase; and (3) Assessment phase. The research instruments used were interviews, questionnaires and tests. The results showed that the product developed was included in the very valid, very practical, and effective category, where: (a) classical learning completeness reached 97%; (b) positive response by product users reached 97%; and (c) the N-Gain value was 0.791 in the very high category. Thus, it can be stated that the product meets the quality standard criteria, where the product can be used to improve students' high-level thinking abilities.

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A. INTRODUCTION

The use of multimedia in the teaching and learning process is increasingly intensive due to advances in science and technology. The need for technology has greatly increased in today's modern era. Optimization of learning can be measured from the use of technology to develop media that is relevant to student learning needs (Siregar et al., 2022). Thus, réate nl teachers are required to be able to utilize technology to réate digital media to support the learning process, so that it has a positive réate n improving students' higher-order thinking skills needed to solve complex problems.

Higher order thinking skills (HOTS) are very important skills for someone to be able to solve non-routine problems. HOTS is needed to solve complex problems Resnick (1987);

Siregar et al. (2019), it' includes the ability to analyze (C4), evaluate (C5), and réate (C6) solutions to complex problems (Anderson & Kratwohl, 2001). HOTS is the ability to solve complex problems by conducting in-depth analysis and critical evaluation (Conklin, 2011). HOTS is an individual's ability to process their thoughts analytically, critically Sternberg (1986), and creatively Brookhart (2010) to solve complex problems. With this ability, someone can formulate, plan, and réate solutions of problems (Conklin, 2011). With HOTS, students can generate new ideas to solve complex problems, which cannot be solved by algorithms (Siregar, Kairuddin, & Mansyur., 2021).

Higher-order thinking skills can be improved through the learning process (Miri et al., 2007). An individual need to improve their critical and creative thinking skills in order to be able to make decisions in solving complex problems (Marzano, 2017; OECD, 2021; Siregar, Kairuddin, & Mansyur., 2021). The ability to solve problems and develop creativity is required to be able to adapt in the 21st century (OECD, 2021). Technological advances have led to more complex challenges and problems, so critical and creative thinking skills are needed to solve them Driana & E. (2019); Marzano (2017), so that these skills have become an integral part of classroom learning in various countries (Musrikah, 2018). In addition, in learning mathematics, these skills are needed to solve unusual problems (Siregar, Kairuddin, & Mansyur, 2021). How students learn a lesson or solve math problems can affect their thinking skills (Brookhart, 2010).

The use of high-quality media in the learning process can stimulate an increase in students' higher-order thinking skills (Clark & Mayer, 2016; Siregar et al., 2022). High-quality media is media that is designed by considering aspects of cognitive multimedia theory Bhatti et al. (2017); Clark & Mayer (2016), constructivist theory Duffy & Jonassen (2013); Jiang et al. (2020) with a cultural context Hung (2020), then aligning it with the principles of higher order thinking (HOTS). High-quality media can be used to stimulate students' higher-order thinking skills (McCarron, et al., 2021).

Digital media includes the use of hardware and software specifically designed to support the learning process. Digital learning media refers to the use of digital technology to facilitate the learning process (Dabbagh & Kitsantas, 2012). Digital learning media is an integration of image, video, audio, diagram, infographic, and animated elements in an electronic media to lighten students' cognitive load to achieve learning goals (Castro-Alonso, et al., 2019; Clark & Mayer, 2016; Siregar et al., 2022). Components of digital media can be in the form of images, infographics, audio, video, and animation which can lighten students' cognitive load (Moreno & Mayer, 1999).

In the process of developing digital learning media, it is necessary to integrate constructivist theory Yeravdekar, V. (2022) and multimedia cognitive theory with a cultural context (Hung, 2020). Constructivist learning theory interprets learning as a process of knowledge construction by the students themselves Jones et al. (2020) so that it requires students to think actively, construct ideas, and make meaning of what they learn (Schunk, 1986). Multimedia cognitive theory is a mental representation of images, audio, video, animation, infographics, motion graphics and words (Mayer, 2014; Sweller, 2020). The human brain has two channels for receiving and processing information based on how the information is presented, the first channel is vision and the second is hearing (Mayer, 2014; Paivio, 1986). When visual information in the form of images, videos, charts, infographics, or writing is

presented to someone, then that information will be received and processed to the visual channel Mayer (2020), then if the information is in the form of audio, narration, or words spoken to someone, then all that information will be received and processed to the audio channel (Mayer, 2014; Paivio, 1986). By optimizing these two separate channels, an individual can absorb more information (Mayer et al., 1995; Mayer & Estrella, 2014; Siregar et al., 2022).

Furthermore, the integration of cultural contexts such as cultural artifacts, cultural values or habits of certain communities in compiling digital media can support achieving learning goals (Haryana, et al., 2022). This integration aims to make the subject matter in the media more relevant, effective, inclusive, interesting, and in accordance with the needs of students in constructing new knowledge (Pradhan, J. B., 2020). In addition, the integration of cultural contexts can increase students' active participation in learning (Kong et al., 2022). Based on this perspective, integrating constructivist and multimedia cognitive theory with the cultural context in the development of digital learning media can create high-quality media, then it can be used to support the learning process to become more meaningful Shonfeld et al. (2021), can reduce students' cognitive load Reeves (2019) and it has a positive impact on improving students' higher-order thinking skills.

Digital media plays an important role in improving students' higher-order thinking skills in learning mathematics (Meryansumayeka, et al 2022). Digital media can help students to see a clearer and dynamic visualization of an object such as graphs, diagrams, infographics, motion graphics, animation, and three-dimensional objects Reeves (2019), so that this can help students to understand an abstract concept easily (Mayer, 2019; Mayer et al., 1996). With interactive visualization, students can develop a deeper understanding Reeves (2019) of mathematical relationships and patterns, as well as improve visual-spatial thinking skills (Mayer & Moreno, 2003). Digital media can provide interactive simulations that allow students to explore mathematical concepts directly (Siregar et al., 2022). This simulation can allow students to change parameters, monitor the results visually, and observe the impact of changes on the treatment being carried out. This can help students to master mathematical concepts in depth and strengthen their higher order thinking skills. Through digital media, students can collaborate with their friends to solve complex mathematical problems Kukulska-Hulme & Shield (2018), they can share ideas, thoughts, and strategies through online learning platforms or other collaboration tools (Li et al., 2019). This encourages the ability to think critically, argue, and communicate effectively in the context of mathematics. Thus, the use of digital media based on constructivist theory and multimedia cognitive theory that is relevant to the characteristics of the material and students can be an alternative solution to improve students' higher-order thinking skills. In conclusion, this research aims to develop constructivist-based learning media and multimedia cognitive theory integrated with culture that meets the criteria of validity, practicality and effectiveness, so that it can be used to improve students' high-level thinking abilities.

B. METHODS

This research was conducted at Junior High School in Deli Serdang Regency. The subjects of this study were 30 students in class IX of junior high school and the object of this research was digital media which was designed based on constructivist and cognitive multimedia theories with a cultural context to improve students' higher-order thinking skills. This is design research with the type of development study. The procedure for developing digital media based on constructivist and cognitive multimedia theory with a cultural context refers to the Plomp development model procedure which is divided into 3 main stages, namely (1) preliminary research; (2) prototyping phase; and (3) assessment phase (Plomp, 2008). The type of evaluation applied in this study was formative Tessmer consisting of: (1) self-evaluation or screening; (2) expert review; (3) one-to-one evaluation; and (4) small group or micro-evaluation, and field tests or try out (Tessmer, 1993). Product quality standards were measured based on the level of validity, practicality, and effectiveness (Nieveen & Folmer, 2013; Van den Akker, J. et al., 1999). The flow of this research can be seen in Figure 1.

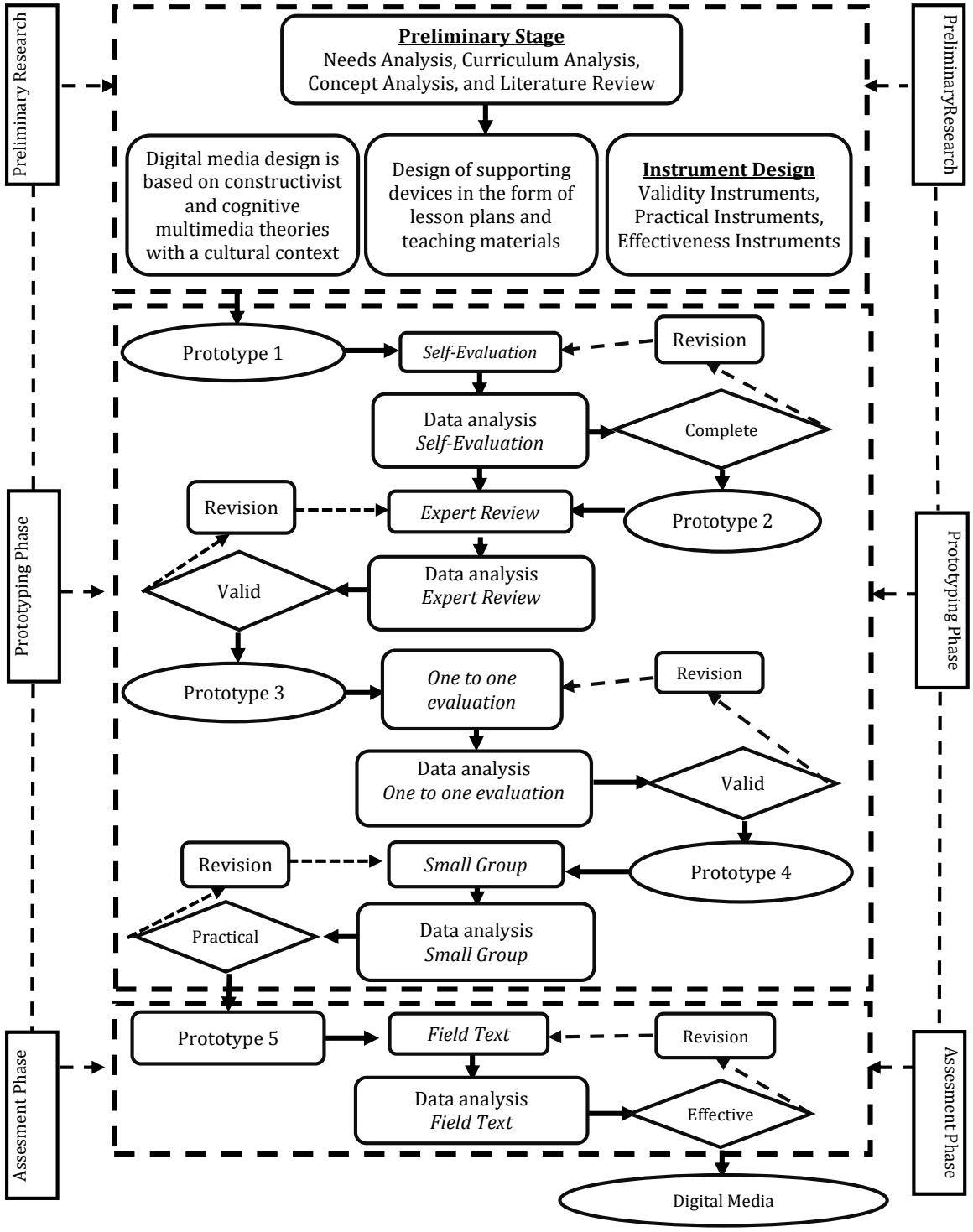

Figure 1. Digital media design flow (Plomp, 2008)

Preparation and design are two activities carried out in the preliminary phase. At this stage, needs analysis, curriculum analysis, concept analysis and literature review were carried out. Then, at the design stage, digital media was designed and developed based on the principles of constructivist theory, multimedia cognitive theory, HOTS-based learning, and the culture. The prototyping phase is the second step in developing constructivist-based digital media and cognitive multimedia. At this stage a formative evaluation was carried out which consists of self-evaluation, expert review, one-on-one evaluation, and small group trials. In the Self-

evaluation phase, researchers conducted an assessment of digital media designs. Where the researchers evaluated the content, construction, and language aspects of the media, the results of this evaluation produce prototype 1. Furthermore, this prototype was validated by 5 multimedia and mathematics learning experts to produce prototype 2.Then a one-to-one evaluation was carried out. Where digital media was tested on 3 students with specified criteria, namely students with high, medium and low abilities. At this stage, the researchers collected all the necessary information such as: (1) how students use digital media; (2) the readability of the text contained in the media; (3) students' difficulties understanding animated media content, etc, all information obtained was analyzed, then used to revise digital media to produce prototype 3.The next evaluation was a limited trial of 12 students, each consisting of 4 students with high, medium and low abilities. At the end of the trial, the teacher and students filled out a practicality questionnaire, this aims to determine the level of usability and ease of use of digital media Nieveen & Folmer (2013), if the digital media is declared feasible or practically expected, then prototype 4 is obtained.

The third phase of this research is the assessment process. In this phase a field trial was carried out, where the test instrument was tested on the target group to determine the actual level of practicality and effectiveness. Field trials were conducted on class IX students consisting of 30 students. The quality standard of a product in this study uses Nieveen's definition. He argues that the standard quality of interventions can be viewed from three aspects, namely: (1) validity, which consists of: (a) content validity (relevance/content validity); and (b) construct validity (consistency/construct validity); (2) practicality (practically); and (3) effectiveness (Nieveen & Folmer, 2013).

In this study, data was collected through observation, interviews, questionnaires, and tests Creswell & Creswell (2022) after the learning process uses digital media based on constructivist theory and cognitive multimedia with a cultural context. Data was collected using research instruments that aimed to measure the validity, practicality, and effectiveness of intervention products and improve students' higher thinking skills which consisted of validation sheets, response questionnaires and students' higher thinking skills test instruments which were divided into pretest and posttest which were developed according to learning indicators on the topic of dilation.

Qualitative and quantitative data analysis techniques were applied in this study. Qualitative data analysis techniques were obtained from interviews, observations, criticism and suggestions from experts and practitioners Creswell & Creswell (2022); Sugiyono (2022), then quantitative data analysis techniques were applied to analyze the validity, practicality, and effectiveness of intervention products (Creswell, J. W., 2013; Siregar et al., 2022). The validity of the intervention product is measured using the following formula:

$$V_a = \frac{\sum_{i=1}^{n} A_i}{N} \tag{1}$$

where Va is the total average score for all aspects; A_i is the average for the i^{th} aspect; and N is the number of aspects. Furthermore, the V_a value or the total mean value is interpreted in the following Likert 5 scale measurement range, as shown in Table 1.

Table 1. Validity Criteria with a Likert scale of 5 (Sugiyono, 2022)

Likert Scale	Likert Scale Intervals	Description of Likert Scale 5
5	4.20 <Va ≤ 5.00	Very Valid
4	3.40 <Va ≤ 4.20	Valid
3	2.60 <Va ≤ 3.40	Neutral
2	1.80 <Va ≤ 2.60	Invalid
1	1.00 ≤ Va ≤ 1.80	Totally Invalid

Practicality analysis in this study applies the formula:

$$V_p = \frac{TSE_P}{S_{max}} x100\% \quad (2)$$

where: V_p = Practicality; TSE_p=Practicality total empirical value; S_{max}=The maximum expected value. Then, the Criteria for the practicality of digital media shows in the Table 2.

Table 2. Practicality Criteria

Score Range	Category
$76\% - 100\%$	Very Practical
$51 - 75\%$	Practical
$26\% - 50\%$	Less Practical
$0\% - 25\%$	Impractical

Effectiveness analysis was obtained based on data: (1) increasing students' higher-order thinking skills in the high category; (2) percentage of classical completeness at least 85%; and (3) at least 85% of users give a positive response to a digital book.

1. The improvement of students' high-level mathematical thinking skills refers to the N-Gain analysis using the formula:

$$Normalize\ g = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}} \quad (3)$$

where: S_{max}= The maximum value that can be obtained (Meltzer, 2002). Then gain category is displayed in the Table 3.

Table 3 Gain Criteria (Hake & Reece, 1999)

ScoreRange	Category
$g > 0{,}7$	High
$0{,}30 \leq g \leq 0{,}7$	Medium
$g < 0{,}3$	Low

2. To find out the percentage of completeness classically, the following formula is used.

$$PCC = \frac{the\ number\ of\ students\ who\ complete}{Total\ number\ of\ students} x100\% \quad (4)$$

it is complete when PCC≥85%.

C. RESULT AND DISCUSSION

The results of this study are described based on the stages of Plomp development and Tessmer's formative evaluation as follows.

1. Preliminary Research

At this stage, the process of preparing and designing digital media based on constructivists and cognitive multimedia with a cultural context was carried out. Before designing digital media, an analysis process was carried out on the curriculum, learning achievement goals, students and needs. At this stage an in-depth analysis was carried out regarding basic competencies, indicators, learning objectives, students' cognitive levels, curriculum, student characteristics, and alternative digital media needed to achieve these goals.

The results of interviews with curriculum representatives show that the school still uses the 2013 curriculum, especially in class IX. Based on the results of curriculum analysis, the Core Competencies and Basic Competencies shown in the teacher's lesson plan are relevant to the content standards set out in the Minister of Education and Culture Regulation No. 37 of 2018. In contrast, the process standards applied still tend to be teacher centered learning. Where teacher has not actively involved students to construct their knowledge. In addition, the media used as a support system was not yet relevant for implementing the 2013 curriculum process standards.

Based on an analysis of the intellectual aspect and the initial ability to think at a higher level, their intellectual development is at the formal operational stage with a minimum age range of 12 years. That is, they have the possibility to build their own knowledge based on what they have to improve higher-order thinking skills. Based on the diagnostic test, students' thinking skills are still in the low category. They have not been able to solve complex problems and construct new knowledge through the process of analysis, evaluation and creation. Instead, they are used to solving similar problems with available examples.

Furthermore, based on the results of the needs analysis, the lack of availability of support systems that are relevant to student needs, where the support systems used are in the form of printed teaching materials and slides consisting of text, images and diagrams. Support systems are not relevant yet to meet the needs of students with visual, auditory, or audiovisual learning styles, so they are less effective in building new knowledge through a meaningful learning process. In addition, the support system is not developed with the concepts of constructivist and cognitive multimedia theory, the support system is only a source of information. On the contrary, the results of the interviews show that students tend to prefer learning mathematics using digital learning media that contain videos, animations, infographics, audio and hyperlinks. They stated that the media could help them to imagine and understand abstract material to be more real. Therefore, based on needs analysis, digital media based on constructivist theory and multimedia cognitive theory with a cultural context needs to be developed as a support system to improve students' higher-order thinking skills. After concluding the results of curriculum analysis, learning outcomes, students and needs, digital media was designed based on constructivism and cognitive multimedia theory with a cultural context, then the initial design of digital media was created as shown in Figure 2.

Figure 2. The display of digital media

As shown in Figure 2, digital media can be accessed via a mobile phone or computer. Instructions for using digital media can be traced by accessing it through the buttons provided. In the second picture shows that the songket cloth with the Melur flower motif. Where, to find the concept of dilatation, students were asked to color or shade a sketch of a flower that fulfills and does not fulfill the nature of dilation, then students were asked to describe their reasons or arguments. At this stage, knowledge is not transferred directly from the teacher to students, however, students were asked to carry out an analysis process to construct their own new knowledge. Finally, with this activity, they discovered the general characteristics or concept of dilation. In the third picture, the students were asked to choose pairs of motives that meet the characteristics of dilation, then critically described arguments why they chose these pairs. This activity aims to enable students to construct their own knowledge and discover the concept of dilation. Then, the illustrations in the animated videos are not explanations of concepts or formulas, but illustrate complex contextual problems related to dilation. Where students were asked to observe carefully and identify known information. Then, students solved these non-routine problems, so they can find the dilation formula by themselves.

2. Prototyping Phase

In order to obtain high quality products, it is necessary to carry out a multilevel evaluation process consisting of self-evaluations, expert reviews, one to one evaluations, and small groups which are described as follows.

a. Self-Evaluation

Self-evaluation is an evaluation carried out by the researchers themselves by examining the consistency (construct validity) of digital media designs based on constructivist and cognitive multimedia theories with cultural contexts. The results of the self-evaluation are shown in Table 4.

Table 4. Self-evaluation results

Aspect	Checked Items	Evaluation result
content	Researchers have examined: • Relevance between digital media and learning goals, learning outcomes of geometry transformation materials, and learning indicators. • the length of time it takes to display digital media	Researchers have synchronized aspects of digital media content in the form of learning objectives, learning outcomes, indicators and duration of time
Display and language	Researchers have examined: • display and format on digital media. • the effectiveness of the sentences used. • use of punctuation marks for any text on digital media.	Researchers have adjusted the format and appearance according to the needs of students. In addition, sentences and punctuation marks have been adjusted.
graphics	Researchers have examined: • Accuracy in the use of fonts. • Conformity of color selection • Integration of image illustrations • Alignment of each part	The researcher has set the graphics as needed.

After carrying out a self-evaluation, prototype 1 was obtained. Furthermore, this prototype will be reviewed by experts.

b. Expert Reviews

After completing the self-evaluation stage, digital media was validated by 5 experts. This validation aims to obtain their suggestions for improvement regarding the quality of digital media based on constructivist and cognitive multimedia theories with a cultural context. The suggestions of experts were used by researchers as a basis for improving digital media. In this study, the validation process applied the Aiken Validation Test, where the researcher divides the Eiken validation index for each aspect, namely content, construct, and language. The results of the validity are shown in Table 5.

Table 5. Instrument validation test results

Validation Aspect	Vi (Average Aiken Validation Index)	Category
content	4.55	Very Valid
Construct	4.46	Very Valid
Language	4.32	Very Valid

Based on the data in Table 5, validation in the content, construct and language aspects is included in the very valid category. However, there are still slight revisions to the writing of terms and words. After revising based on suggestions from the five validators, constructivist-based digital media and cognitive multimedia were named prototype 2.

c. One to one

In the One to One Evaluation phase, a closed interview technique was applied to 3 students. The researcher prepared several questions to gather the necessary information. The outline of the questions and statements used are related to: (1) appeal and cultural context; (2) readability; (3) ease of use; and (4) duration of time. The results of the revision at this stage produced prototype 3. The results are described in Table 6.

Table 6. Conclusions and interview results for the one to one evaluation stage

Aspect	Conclusion of interview results
Attraction and cultural context	Students expressed interest in digital media based on constructivist and cognitive multimedia theories with a cultural context. They feel happy using it in the learning process because it can help them to visualize abstract material to be more real. In addition, they are very interested in Malay songket motifs on the digital media.
Readability	Students admitted that the information contained in digital media based on constructivist and cognitive multimedia theories with a cultural context can be understood by students.
Ease of use	Students explained digital media based on constructivist and cognitive multimedia theories with cultural contexts that can be accessed online and offline. Then, this media is very easy to use anytime and anywhere.
Duration of time	Students stated that constructivist theory-based media and multimedia cognitive with cultural contexts could shorten the duration of time to be able to achieve learning objectives.

Based on the interview results shown in Table 6, it can be concluded that: (1) The media content is interesting, (2) the sentences in the media can be understood well, (3) it can be used easily, (4) and the use of the media is relevant to the time available.

d. Small Group

The small group evaluation (micro-evaluation) aims to measure the actual practicality of prototype 3. There are five multimedia experts, a teacher, and 9 students involved in this evaluation stage, where there are 3 students each with abilities in the high, medium and low categories. The purposive technique was used to determine the sampling based on the math scores in the report books. The practicality level of the product is given in Table 7.

Table 7. Product practicality results in small group trials

Respondents	Practicality average score (Vp)	Category
five Experts	89 %	Very Practical
Teacher	90 %	Very Practical
29 Students	92 %	Very Practical

Based on the results of interviews with 9 students which are concluded in Tabel 7, they stated that digital media could make it easier for them to achieve the specified learning objectives, because media components such as images, videos, animations, etc. can help them to understand complex concepts. In addition, it's can help them to solve complex and abstract problems. The suggestions for improvement that they conveyed were to make the back sound smaller so that the main sounds could be heard clearly. Thus, revisions were made to several videos to gain prototype 4.

3. Assessment Phase

After the small group phase, a summative evaluation was carried out by conducting an experiment in the classroom (Field Test). This evaluation aims to measure the actual practicality and effectiveness of digital media based on constructivist and cognitive multimedia theories with a cultural context. The instruments used are actual practicality questionnaires and student response questionnaires to measure effectiveness, as shown in Table 8.

Table 8. Practical results in field trials

Respondents	Practicality average score (Vp)	Category
Teacher	90%	Very Practical
Student	93%	Very Practical

The data in Table 8 explains that the media meets the practicality criteria. This means that teachers and students state that the product can be used to improve students' high-level thinking abilities. Apart from that, this media is easy to access online and offline. The conclusions from the results of student responses after using digital media based on constructivist and cognitive multimedia theories with a cultural context are shown in the Table 9.

Table 9. The results of student responses to digital media.

Category	Number of students	Percentage	Number of Teachers	Percentage
Positive Response	29	97%	1	97%
Negative Response	0	0%	0	0%
Not present	1	3%	0	0%
Total	30	100%	1	100%

Based on the Table 9, all students responded positively to constructivist-based digital media and cognitive multimedia with cultural contexts. Based on the results of the interviews, they felt interested, happy, and wanted to return to using similar media in the next lesson. Classical completeness is how many students in a class are able to achieve the minimum completeness criteria targeted by the school. The number and percentage of students who achieved it are described in Table 10.

Table 10. Classical Learning Mastery

Information	*Pretest*		*Posttest*	
	Number of Students	Percentage	Number of Students	Percentage
Complete	6	20%	29	97%
Not Completed	24	80%	1	3%
Total	30	100%	30	100%

Data in Table 10 shows that 24 students (80%) have not been able to achieve the minimum completeness criteria (MCC), on the other hand there are only 6 students (20%) who have been able to achieve the minimum completeness criteria. Then the results of the achievement of each indicator or learning objectives are presented in Table 11.

Table 11. Achievement of Learning Indicators

No	Indicator	Pretest		Posttest	
		Percentage	Description	Percentage	Description
1	Analyze	20%	Achieved	97%	Achieved
2	Evaluate	17%	Achieved	97%	Achieved
3	create	3%	Achieved	93%	Achieved

The Table 11 shows, the percentage of students who are able to analyze, evaluate, and create is 20%, 17%, and 3%, respectively. Then there was an increase after using digital media based on constructivist and cognitive multimedia theories with cultural contexts to 97%, 97%, and 93%, respectively.

Table 12. Learning outcome based on the N-gain score

N-Gain	Category	Number of Learner	Percentage	Average of gain
g > 0,7	high	21	70,00%	0.791
0,3 ≤ g ≤ 0,7	moderate	8	26,67%	
g < 0,3	low	1	3,33%	
Total		30	100%	

Based on the Table 12, there are 70% of students achieving learning outcomes in the high category, 26.67% in the medium category, and 3.33% in the low category. The average N-gain is 0.791, this means that the gain of learning outcomes is in the high category. Digital media based on constructivist and cognitive multimedia theories have met Nieeven's product quality standards. Where this product has been declared valid by five validators on the aspects of content, construct and language, with an average score of 4.55, 4.46, 4.32 with each category being very valid. This means that digital media has been developed based on the principles of constructivist and cognitive multimedia theories, culture context and higher order thinking skills principles.

The practicality of digital media based on constructivist and cognitive multimedia theories with a cultural context was obtained through the assessment of media experts, teachers and students. Based on a practicality questionnaire filled out by five media experts, a math teacher and 9 students, the product practicality scores were 89% and 90% and 92% respectively, thus the digital media can be categorized as very practical. In that case, the products developed are usable and easy to use to improve students' higher-order thinking skills. This shows that this media can be used by teachers and students to achieve learning goals. Apart from that, teachers and students as product users stated that this media was easy to implement in the learning process.

Indicators of the effectiveness of digital media based on constructivist theory and multimedia cognitive theory with a cultural context have been well fulfilled, where: (1) a teacher and 97% of students respond positively to digital media; (2) the increase in students' higher-order thinking skills is in the high category with an N-gain score of 7.91; (3) classical student learning achievement reaches 97%; and (4) the achievement of indicators of analyzing, evaluating, creating respectively is 97%, 97% and 93%.

The results of this research are in line with supporting research, where media developed based on multimedian theory can improve high-level thinking abilities (Ali, W., & Yahaya, W., 2022). Apart from that, other supporting research shows an increase in high-level thinking abilities after implementing media based on constructivist theory. Meanwhile, in this research, integration was carried out between multimedia cognitive theory and constructivist theory with cultural context to build digital learning media. The results show a significant increase in students' high-level thinking abilities.

D. CONCLUSION AND SUGGESTIONS

The quality of digital media based on constructivist theory and multimedia cognitive with a cultural context that was created to improve students' high-level thinking skills has met Nieveen's quality standards consisting of validity, practicality, and effectiveness. The intervention product was declared very valid by the five experts. The product of this intervention was also stated to be very practical by media experts, teachers and students in terms of content, construct and language. That being the case, the digital media is useful and easy to use by teachers and students to improve students' higher order thinking skills. Furthermore, there was an increase in students' high-level thinking skills in the high category, then teachers and students responded positively to the intervention product. Thus, the researcher suggests to mathematics teachers, practitioners, or researchers to develop constructivist-based digital media and cognitive multimedia with local cultural contexts, so that they can be used to improve students' higher-order mathematical thinking skills. Then the researcher recommends continuing this research by considering aspects of learning modalities, spatial abilities and local culture simultaneously in order to meet the learning needs of students with their own uniqueness. Apart from using digital media, researchers recommend using visual aids to meet the needs of students with kinesthetic learning styles.

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