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Exploring Tectonism: A Journey through Virtual Geotour in Geography Education for High School Students

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ABSTRACT

Based on a needs analysis in high school, geography learning in the independent curriculum emphasizes mastery of students' cognitive abilities. However, the complexity and abstraction of the material, especially tectonism, often pose challenges for students' understanding because the term verbalism is difficult to understand and limited field observations. This research aims to develop digital-based Virtual Tour learning media that can be accessed via the website. This media is equipped with relevant information to help students understand tectonic processes. Apart from that, it provides a more realistic interpretation of geographic material. The development method uses the Borg and Gall model through a modification stage by Sugiyono with 10 stages. The research results show that the Virtual Geotour Tectonism received high validation both in terms of media (92%) and material (75.71%), with positive responses from teachers (96%) and students (87%). This shows the great interest of both teachers and students regarding the importance of developing this learning media to improve students' understanding of geography material. Easy media accessibility helps students to study independently via laptop or cell phone.

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1. INTRODUCTION

In the implementation of learning, media plays a crucial role. The quality of education relies on the selection of media that aligns with students' characteristics and teaching methods (Suminar, 2019). The advancements in science and technology have substantially influenced how we utilize media for educational purposes (Wulandari et al., 2019). This indicates the necessity of integrating digital-based learning media in the educational context (Alrwele, 2017). Despite spatial and temporal constraints, the presence of various digitally connected learning media provides convenience to users (Saha et al., 2022). Teachers require media as tools to convey information to students (Hakim & Yulia, 2024). Hence, as educators, it is imperative to discern which media tools suit the educational needs (Yanto, 2019).

Based on the analysis of the independent curriculum implemented in schools, the utilization of digital technology is emphasized in the learning process (Ridwana et al, 2022). The aim is to ensure effective, efficient, and high-quality learning processes. Geography learning within the independent curriculum generally focuses on students' mastery of cognitive skills, yet the complexity and abstraction of the material often pose challenges to students' understanding (Seviana, 2022; Somantri, 2021). For instance, achievements in learning about lithospheric dynamics where students are expected to identify tectonism and analyze its effects on humans. There are verbalism terms that are challenging to comprehend due to limitations in direct field observations, influenced by considerations of distance, time, cost, and risks in field learning processes (Dharmayanthi, 2023). This indicates the need for learning media capable of providing real interpretations of geography materials.

Understanding students' characteristics is a pedagogical competency that teachers must possess (Dewantara & Harnida, 2020). To determine appropriate learning media, it is crucial to understand students' characteristics (Amala et al, 2019; Al Fauzi, 2022). Currently, students tend to rely on digital technology in their daily lives, including learning activities (Papanastasiou et al., 2019). The use of digital technology such as laptops and smartphones has become commonplace in seeking information during the learning process (Hakim & Yulia, 2024). Analysis of students' characteristics indicates a tendency for students to feel bored and have difficulty understanding geography materials verbally (Ghullam, 2011). Students prefer using digital media with audiovisual bases over print media. They find it easier to understand geography materials when presented in the form of images or videos (Hasri et al., 2021). Hence, there is a need for varied development of learning media capable of presenting and illustrating geography materials visually, particularly tectonism, in classroom learning processes (Ismail et al., 2023).

The objective of this research is to develop varied learning media through a Website platform integrated with Virtual Reality (VR), named Virtual Geotour Tectonism, to facilitate learning about tectonism material through a 360-degree field panorama model. Through this interactive teaching medium, it is hoped to stimulate students' critical and creative thinking abilities in the learning process. This media allows field simulation in the classroom and provides practical experience for teachers to convey information related to tectonism without the need for field trips (Pham et al., 2018). The development of VR-based technology has paved the way for innovation in geography learning (Putra et al., 2022). Furthermore, virtual field observations through smartphones or computers make it easier for students to enhance their knowledge without the need for risky field visits (Petersen et al., 2020). The application of virtual reality technology in learning media makes complex and abstract concepts in geography learning more concrete (Ihsan & Sugandi, 2019).

Although VR media development has been conducted before, there are differences in terms of content and functionality. Some research journals serve as references, such as those

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conducted by (Fathoni, 2021), aiming to develop VR media to depict the campus environment of the State Electronics Polytechnic (PENS) Surabaya. Whereas, in this study, the development of VR media aims to support classroom learning processes. Another research journal reference is from (Artawan et al., 2023), with the research goal of developing a web blog-based teaching media with biosphere material. In contrast, this study aims to develop learning media integrated with Virtual Reality (VR) technology for tectonism material.

Based on the aforementioned description, it is crucial to develop varied learning media based on digital technology integrated with Virtual Reality (VR). The aim is to create practical learning media for students to understand tectonism realistically in the field, overcoming constraints of distance, time, cost, and risk. Visualization of the field through the development of Virtual Geotour Tectonism is expected to enhance the effectiveness of classroom learning processes and students' critical and creative thinking abilities, even without direct field visits.

2. METHODS

This research adopts the Research and Development (R&D) approach, widely known as Research and Development. The context of this Research and Development (R&D) specifically focuses on product development and its application in empirically tested contexts (Saraswati et al., 2021). The R&D model in this research refers to the Borg and Gall model modified by (Sugiyono, 2013). In this development research, 10 Borg and Gall steps are used, starting from (1) potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) Product Trials, (7) product revision, (8) usage trials, (9) product revision, (10) mass production.

The subjects in this research are a part of the X grade students of SMAS Diponegoro Tumpang, totaling 40 individuals with 10 limited trial participants and 30 expanded trial participants. This research utilizes two types of data, namely quantitative and qualitative data. Quantitative data are obtained from assessment scores in validation test sheets and student and teacher response sheets to the developed media, while qualitative data are obtained from expert validator recommendations. Data collection methods applied in this research include interviews, observations, questionnaire filling, and documentation.

2.1 Analysis of Validation Sheets

The analysis of validation test results by expert validators is quantitative descriptive in nature, where all assessed aspects are presented in tabular form, covering assessment scores ranging from very feasible (5), feasible (4), quite feasible (3), less feasible (2), to very less feasible (1) (Sugiyono, 2013). The average score can be calculated using the following equation:

$$x = \frac{\Sigma x}{N}$$

Where:

X = Average score of validation assessment

Σ = Total score obtained from validation

N = Number of questions

The assessment of validation percentage results can be calculated using the following equation:

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$$SV = \frac{X}{5}\ x\ 100\ \%$$

The next step is to interpret the obtained values into percentage (%) units in the validation test assessment distribution table, where categories will be determined according to the presented table as follows:

Table 1. Validation Assessment.

Percentage	Explanation	Score
81<SV<100%	Very Feasible	5
61<SV<80%	Feasible	4
41<SV<60%	Quite Feasible	3
21<SV<40%	Less Feasible	2
0<SV<20%	Very Less Feasible	1

Source: Sugiyono(2013)

2.2 Analysis of Student and Teacher Responses

After completing the development of digital learning media based on website pages, an analysis of teacher responses is conducted. This analysis aims to determine how students and teachers respond to the created teaching media, using assessments on a scale from 1 to 5. The average score of the assessment can be calculated using the following formula:

$$x = \frac{\Sigma x}{N}$$

Where:

X = Average score of validation assessment

Σ = Total score obtained from validation

N = Number of questions

The assessment of teacher response percentage results can be calculated using the following equation:

$$SV = \frac{X}{5}\ x\ 100\ \%$$

The next step is to interpret the score values obtained in percentage (%) form into the teacher response assessment table, where categories will be determined according to the presented table as follows:

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Table 2. Teacher Response Assessment.

Percentage	Explanation	Score
81<SV<100%	Very Interested	5
61<SV<80%	Interested	4
41<SV<60%	Fairly Interested	3
21<SV<40%	Less Interested	2
0<SV<20%	Very Less Interested	1

Source: Arikunto (2004)

3. RESULTS AND DISCUSSION

This digital technology-based Virtual Reality learning media is designed to integrate field environment interpretation and visualization into classroom learning processes, with a focus on the study of tectonism material. To achieve the goal of producing a tested product, the development process follows a series of stages in line with the Borg and Gall research and development procedure. It begins with the first stage, analysis of potential and problems, which involves observation and questionnaire distribution to students and teachers. At this stage, the needs analysis to identify potential and problems includes curriculum needs analysis, student needs or characteristics, and evaluation of previously existing media. This research commenced with observations at SMAS Diponegoro Tumpang, specifically in classes X3 and X4. The analysis results indicate that the majority of students (79%) prefer digital audiovisual learning media over print media. They believe that learning with digital media would significantly aid in acquiring comprehensive information and interpreting the material effectively.

Furthermore, the analysis includes curriculum needs analysis. Based on the analysis of the independent curriculum implemented in schools, it is evident that geography learning emphasizes mastering students' cognitive abilities; however, complex and abstract materials often pose difficulties in understanding. The curriculum analysis is conducted by analyzing the characteristics of the material to serve as a basis for media development. One of the learning achievements, such as lithospheric dynamics, requires students to understand tectonism and its impacts on humans. Limitations in direct field observations lead to difficulties in verbal comprehension. Therefore, there is a need for varied digital learning media capable of providing a genuine interpretation of geography material, particularly in the study of tectonism.

Lastly, the analysis of learning media at SMAS Diponegoro Tumpang indicates that media usage is still limited to print media, such as books and worksheets, with insufficient emphasis on field visuals, especially in explaining tectonism processes. This makes it difficult for students to understand the processes of tectonism on Earth. Hence, the development of varied learning media such as Virtual Tours is necessary to accommodate students' imagination limitations in understanding tectonism processes. Previous studies indicate efforts to develop VR media have been conducted in other contexts, such as Fathoni's (2021) development of a virtual tour application for campus environment introduction. However, these studies are not specific in supporting geography learning, particularly tectonism. From the above discussion, it can be concluded that the potential of this school lies in the high interest of the learners. However, the problem lies in the scarcity of learning media that can engage and motivate students to learn. Therefore, to address this gap, this research and

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development aims to develop relevant and suitable VR media for classroom learning processes.

The second stage involves researchers collecting data and information related to research needs. Data collection methods include interviews and observations. Interviews are conducted not only with teachers for potential problem analysis but also with experts from the National Research and Innovation Agency (BRIN) Geopark Karangsambung Karangbolong, Kebumen, Central Java. These interviews aim to obtain information regarding the Geopark Karangsambung area, which is the result of tectonism processes. Subsequently, observations are conducted to gather media development materials and directly study the Geopark Karangsambung area. 360-degree panorama images are captured from designated geosite locations using a 360-degree camera. The 360 panorama location points can be viewed in the following figure:

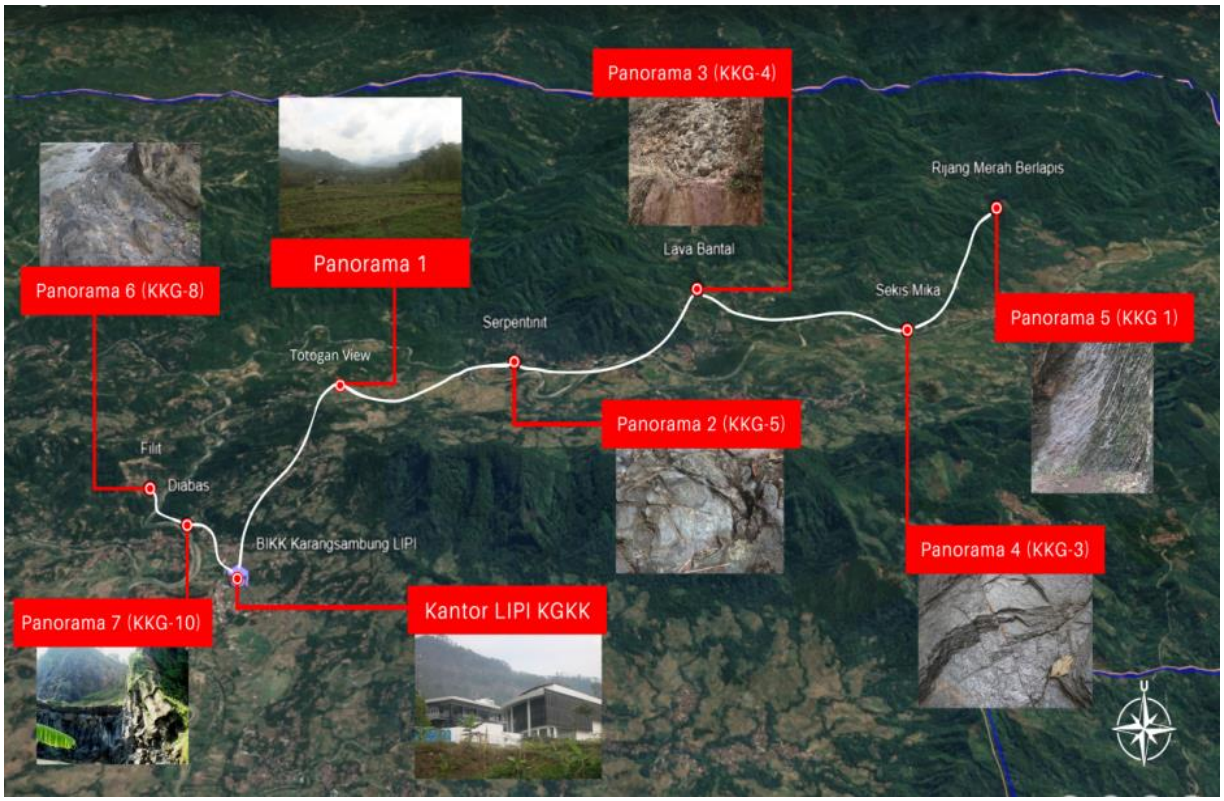

Figure 1. Geosite Points

The next stage is Product Design in this development process in the context of Virtual Geotour Tectonism, where users can engage in various activities, such as viewing the landing page, exploring the 360° view, running the virtual tour, accessing the menu panel, viewing geosite location panoramas, navigating the geopark location map, controlling the playback and stoppage of video, photo, audio, PDF materials, as well as information in textual form. Additionally, users can adjust the zoom in level, zoom out, and adjust the viewing direction (rotation) to the right, left, up, and down. Table 3, the Activity Diagram of Virtual Geotour Tectonism, illustrates the activities carried out by users in operating the features provided by the learning media website.

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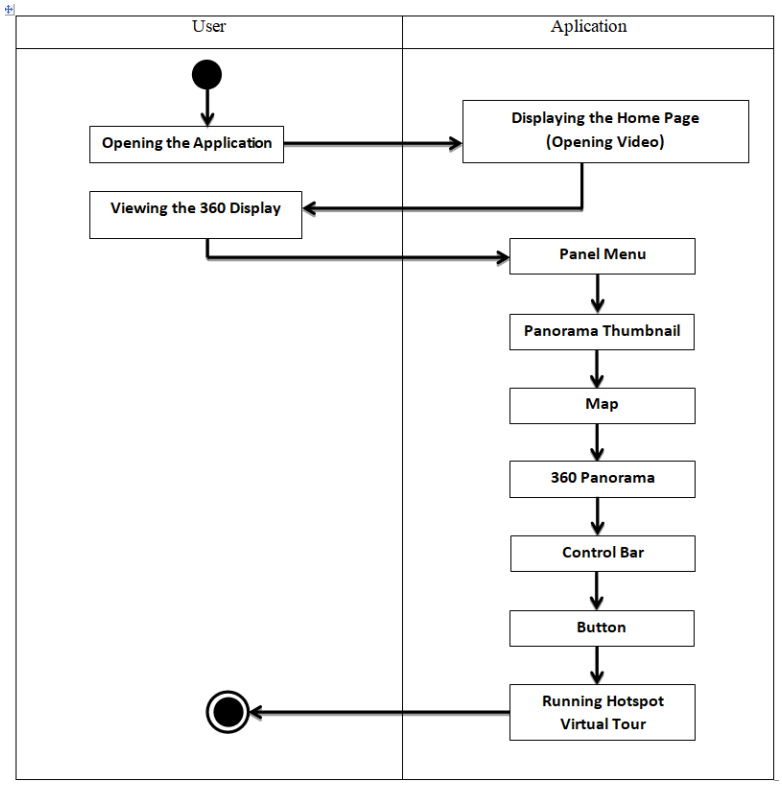
Table 3. Activity Diagram.



Before exploring the tectonism material, the initial display consists of an opening video providing a brief explanation of tectonism material within the real field environment of Geopark Karangsambung. Subsequently, the Virtual Geotour Tectonism website page features a 360-degree panorama image alongside a menu panel, thumbnail panorama, map, 360 panorama, control bar, buttons, and VR hotspots.

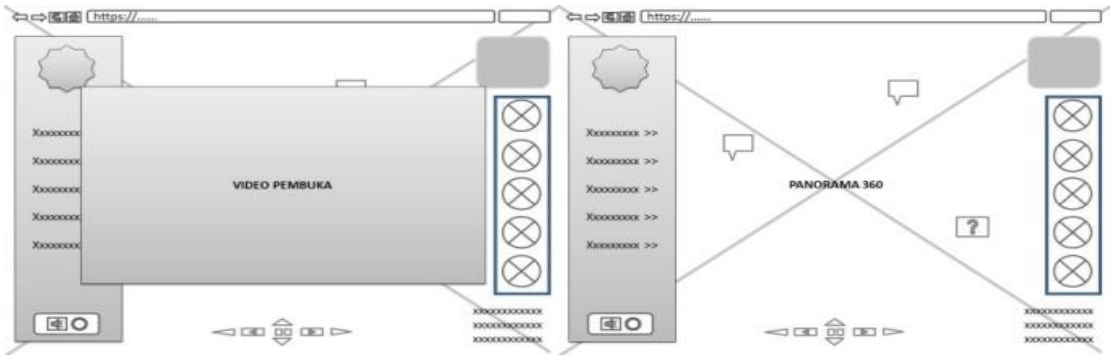


Figure 2. Storyboard Website

The Virtual Geotour Tectonism website page features a 360-degree panorama image alongside a menu panel, thumbnail panorama, map, 360 panorama, control bar, buttons, and VR hotspots. Thumbnails are provided for previewing geosite panoramas (Totogan View, Serpentinite, Rijang, Sekis, Lava basalt, filit, diabase) to expedite user access to geosite locations within the Virtual Tour. The floor plan map contains the geosite locations covered in the media, as well as geological information about the Geopark Karangsambung-Karangbolong. The menu panel includes sections for introduction, general information, site map, materials, location map, photo album, usage instructions, references, and control bar options (VR, fullscreen, visibility, sound, gyroscopic).

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Table 4. Contents of Virtual Geotour Tectonism

Site Name	Number of Panoramas	Location (Coordinate X-Y)	Main Features of Geographic Characteristics
Totogan View	2	Jl. Raya Sadang, Sawah Area, Totogan, Karangsambung, Kebumen Regency, Central Java 54353	Complex of Melange/Intermixture of rocks resulting from subduction, faults, and plate folding; Pre-Tertiary and Tertiary rock morphology
Serpentinite Geosite	1	Pucangan, Kebumen Regency (355647-9168428)	Oceanic crust rocks part of the melange complex
Lava Bantal and Red Rijang Geosite	2	Muncar River, Seboro (357419-9169655)	Ocean floor rocks, tectonic activity associated with submarine volcanic activity
Sekis Mica Geosite	1	Loning River, Sadang Wetan (359263-9168961)	Continental crust rocks exposed due to tectonism
Layered Red Rijang Geosite	1	Sadang Wetan (360979-9168966)	Sedimentary rocks from continental and oceanic plates, plate folding (Orogenesis)
Filit Geosite	1	Sipako Montain, Wonotirto (352771-9166637)	Metamorphic rocks, tectonic activity resulting in rock folding (upright folds, inclined folds to overturned folds)
Diabas Geosite	1	G. Parang, Karangsambung	Intrusive diabase rocks formed in the Oceanic Crust

After collecting data in the form of 360-degree photos of geosite locations tailored to tectonism materials, the next step will be importing panoramas as shown in Figure 3. Subsequently, hotspot placement on the panorama will be carried out as indicated in Figure 4, while the assignment of action items to hotspots in the 3D Vista library will be adjusted according to needs, whether for video, photo, link, or text hotspots, as depicted in Figure 5. The subsequent stage involves adding skins (controllers) to the panoramic image that has been given hotspots and actions, as shown in Figure 6. The function of the skin itself is to control the movement of the virtual tour and the initial display with various control bars.

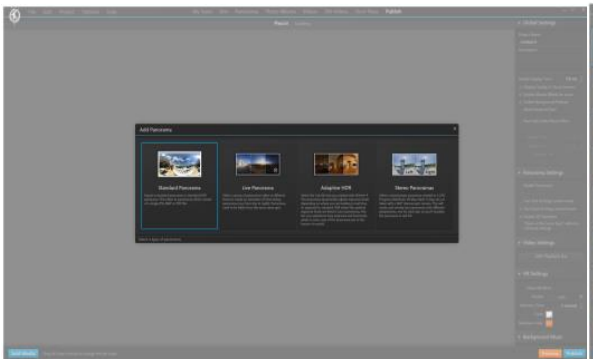

Figure 3. Panorama Import

Figure 4. Hotspot Placement

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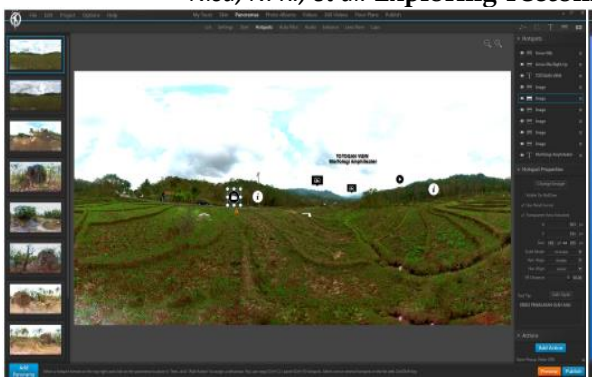

Figure 5. Action Addition

Figure 6. Skin Addition

The next stage involves Expert Validation and product revision based on input from experts. The assessment of instructional media feasibility is conducted by validating the media and material aspects of the product. The validation test for media expertise is conducted by Geography faculty members of the Faculty of Social Sciences, while the material expertise validation is performed by Special Education faculty members from the Faculty of Education. The assessment results of instructional media take the form of score data, which is then adjusted to five scoring criteria: highly feasible, feasible, moderately feasible, less feasible, and highly less feasible.

1) Expert Media Validation

The overall assessment result of Virtual Tour-based instructional media by media experts indicates a "highly feasible" criterion with a score of 92%, indicating that the instructional media meets the required standards for use in the student's learning process. The table below shows the calculation of the expert media validation assessment result:

Table 5. Media Validation Results

No.	Criteria	Score
1.	The media can be accessed and functions on both laptops and smartphones	5
2.	Features within the media run smoothly and responsively without technical hindrances	5
3.	Media navigation functions, allowing users to easily transition between panorama environments	5
4.	Hotspots within the media function effectively to display content	5
5.	Instructions or guidance are sufficient to assist users in using the instructional media	4
6.	The overall visual display of this instructional media is appealing	5
7.	The quality of visual effects in the media is excellent, including images, videos, animations, and infographics	4
8.	The quality of sound and narration in the media is clear	4
9.	The audio in the media supports explanations and does not distract attention	5

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10.	The quality of explanatory text included in the instructional media is clear, easy to read, and understand					5
11.	This explanatory text communicates concepts and information clearly and accurately				4	
12.	Does this instructional media maintain user engagement throughout its use?				4	
13.	This instructional media provides a deep and engaging learning experience for users					5
14.	This media can adapt to various student learning styles					5
	Σ Frequency	0	0	0	5	9
	Σ Score	0	0	0	20	45
	Total Σ Score			65		
	Average			4.6		
	Percentage			92%		
	Category			Very Feasible		

The assessment results above indicate that the instructional media possesses good accessibility and media functionality because it can be accessed and functions well on devices, including laptops and smartphones. Features within the media, such as hotspots, also operate smoothly and responsively without technical hindrances, indicating that the development has taken into account the media quality well so that relevant information can be easily accessed by students. Furthermore, from the assessment results by the validator, the overall visual appearance of the media is appealing, with good visual effects, sound, and narration in the media. This is crucial for enhancing students' attraction and understanding of the presented material. Additionally, it also sustains student engagement and provides a deep and captivating learning experience. Based on the last point of the media assessment results, this media can adapt to various learning styles of students, allowing them to learn according to their preferences and individual needs. Thus, the overall assessment of this media is feasible with revisions and highly recommended for enhancing the learning experience in geography education.

2) Expert Material Validation

The assessment results of Virtual Tour-based instructional media by material experts overall indicate a feasibility criterion of 75.71%, indicating that the instructional media meets the required standards for use in the students' learning process. The table below presents the calculation of the score assessment validation by material experts.

Table 6. Material Validation Results

No.	**Criteria**	**Skor Penilaian**
1.	The material presented in the media accurately depicts tectonism concepts in the real world	4
2.	The instructional media includes relevant information and explanations about the places visited	4

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3	Illustrations and animations help explain geological events related to tectonism			3		
4.	The media can integrate tectonism concepts with real-world contexts				4	
5.	The media elaborates on tectonism concepts in-depth and relevant to high school student users				4	
6.	The presented material can explain the basic concepts of lithosphere in tectonism processes clearly and comprehensively				4	
7.	The presented material can provide adequate analysis of tectonic plate movement			3		
8.	The presented material can analyze the impact of tectonism on Earth's surface topography accurately				4	
9.	The presented material can analyze the impact of tectonic plate movement on human life			3		
10.	The narration and text used in the media are clear and easily understandable by users				4	
11.	Images, maps, infographics in the instructional media are clear and relevant to tectonism material				4	
12.	Audio and video in the media are clear in presenting tectonism content				4	
13.	The use of standard and easily understood Indonesian language				4	
14.	Accuracy of writing/editing				4	
	Σ Frequency	0	0	3	11	0
	Σ Score	0	0	9	44	0
	Total Σ Score			53		
	Average			3.7		
	Percentage			75.71%		
	Category			Feasible		

Based on the feedback provided in the validation questionnaires by media and material experts, the media product has been revised according to the recommendations and inputs provided. The percentage of the media expert validation test results is 92% with the criterion "very feasible," and the material expert validation test is 75.71% with the criterion "feasible." Evaluation of each item point indicates that the material presented in the media effectively portrays the concept of tectonism well and in line with the actual conditions in the real world. This assessment also indicates that the instructional media provides relevant information and explanations about places related to tectonism visited in the Virtual Geotour Tectonism media. Although the score on point 3 was not maximal, illustrations and animations still make a significant contribution to explaining geological events related to tectonism and elucidating the concept of tectonism in depth and relevance, commensurate with the understanding level of high school students. The narration and text in the instructional media are considered clear and understandable. Audio, video, maps, and infographics features are also clear and helpful

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in explaining the content. Finally, the writing and editing in the media are deemed appropriate and fitting. Therefore, based on the conclusion drawn from the assessment results, the Virtual Geotour Tectonism instructional media is suitable for testing with teachers and students in schools with revisions.

After going through the validation process by media and material experts and revising the product based on the inputs from the experts, it will be tested with Geography subject teachers and trailed by students. This is done to evaluate the interest response from teachers and students through questionnaire responses. Additionally, the aim is to analyze these response results to improve or make further revisions if necessary to the developed instructional media product.

3) Data on Geography Teacher' Response Results

The response results from Geography subject teachers at SMAS Diponegoro Tumpang regarding the Virtual Geotour Tectonism instructional media show a score of 96%, with the criterion "very interested," obtained from the percentage of 10 question items. This indicates that the developed instructional media is highly engaging and very suitable for use. Below is the data on the response results from Geography subject teachers at SMAS Diponegoro Tumpang regarding instructional media development.

Table 7. Teacher Response Results

No.	**Kriteria**	**Skor Penilaian**				
1.	The material in the media is relevant to the curriculum or tectonism learning objectives					5
2.	The overall appearance of the media is attractive and innovative					5
3.	Features in the media support different student learning styles				4	
4.	Images, Videos, Maps, Infographics in the media are informative and communicative					5
5.	The information text is clear and easily understood				4	
6.	Navigation and Hotspots are easy to understand and use					5
7.	Digital instructional media is easily accessible on laptops and smartphones					5
8.	Language usage conforms to standard Indonesian language rules					5
9.	Digital-based instructional media facilitates teachers in explaining the material					5
10.	Digital-based instructional media facilitates students in understanding the material					5
	Σ Frequency	0	0	0	2	8
	Σ Score	0	0	0	8	40
	Total Σ Score			48		
	Average			4.8		
	Percentage			96%		
	Category			Very Interested		

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Several crucial aspects were well-assessed in this evaluation, including the relevance of the material to the curriculum or the objectives of tectonism learning, the overall appealing and innovative presentation of the media, and features supporting different learning styles of students. Additionally, images, videos, maps, and infographics in the media were considered informative and communicative, while informational texts were deemed clear and easily understood. Navigation and hotspots in the media were also found easy to comprehend and use. This digital learning media is accessible on various devices such as laptops and mobile phones, and the use of language adheres to Indonesian language norms. This digital-based learning media was also evaluated as facilitating both teachers in explaining the material and students in understanding it. Thus, the overall assessment indicates that Virtual Geotour Tectonism has successfully created highly engaging and beneficial learning media to enhance students' understanding of tectonism material.

The data from the student trial at SMAS Diponegoro Tumpang regarding the Virtual Geotour Tectonism learning media are as follows:

Table 8. Student Trial Response Results (Limited Group)

Student Response	Class	Assessment of Each Question Item											
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
R-1	X-B	5	4	4	4	5	5	4	4	4	5	5	4
R-2	X-B	5	4	5	4	3	5	5	5	5	5	5	4
R-3	X-B	5	4	5	4	4	4	5	5	5	4	5	4
R-4	X-B	4	5	5	4	4	5	4	5	4	5	5	4
R-5	X-B	5	5	4	5	5	4	5	5	4	4	4	5
R-6	X-B	5	5	5	5	4	4	4	5	4	5	5	4
R-7	X-B	4	4	4	5	4	4	3	5	4	4	3	3
R-8	X-B	5	4	5	5	3	5	4	5	3	3	4	4
R-9	X-B	5	4	5	5	5	4	5	5	4	4	4	3
R-10	X-B	5	5	4	5	5	4	4	4	5	5	4	5
Σ Frequency		48	44	46	46	42	44	43	48	42	44	44	40
Average		4.8	4.4	4.6	4.6	4.2	4.4	4.3	4.8	4.2	4.4	4.4	4.0
Percentage		96 %	88 %	92 %	92 %	84 %	88 %	86 %	96 %	84 %	88 %	88 %	80%
Σ Average percentage		89%											
Category		Very Interested											

Table 9. Student Trial Response Results (Expanded Group)

Student Response	Class	Assessment of Each Question Item											
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
R-1	X-B	5	5	5	5	5	4	4	4	5	5	5	4
R-2	X-B	5	2	4	5	5	4	5	3	5	5	4	5
R-3	X-B	5	4	5	5	4	5	5	4	4	5	5	4
R-4	X-B	4	4	4	5	3	4	4	4	5	4	4	4
R-5	X-B	5	4	5	5	4	5	5	5	5	5	5	4
R-6	X-B	4	3	5	4	4	3	5	4	5	5	4	3
R-7	X-B	5	4	4	4	4	3	5	5	5	5	5	4
R-8	X-B	5	4	4	5	5	5	4	5	5	4	5	4
R-9	X-B	5	4	4	5	5	5	4	5	5	4	5	4

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R-10	X-B	**5**	**5**	**5**	**4**	**4**	**3**	**3**	**4**	**4**	**4**	**5**	**3**
R-11	X-B	4	3	5	5	5	3	5	4	4	3	4	3
R-12	X-B	5	4	5	5	5	5	5	5	5	4	4	4
R-13	X-B	5	5	5	5	5	5	5	5	5	5	5	5
R-14	X-B	4	4	5	5	5	3	4	4	5	4	5	4
R-15	X-B	5	4	5	5	5	4	5	5	5	4	5	4
R-16	X-B	5	5	5	5	5	4	5	4	5	4	5	4
R-17	X-B	4	3	5	4	4	4	3	4	4	3	4	3
R-18	X-B	3	3	5	4	5	3	4	4	4	4	5	3
R-19	X-B	5	5	5	5	5	5	5	5	5	5	5	5
R-20	X-A	5	4	5	5	5	5	5	5	5	3	4	4
R-21	X-A	4	2	4	5	3	3	3	2	3	2	3	2
R-22	X-A	5	4	5	5	5	5	5	5	5	3	4	4
R-23	X-A	4	4	5	5	5	4	5	3	4	3	4	3
R-24	X-A	4	4	5	5	5	4	5	3	4	3	4	3
R-25	X-A	5	4	5	5	5	5	5	5	4	5	5	4
R-26	X-A	5	4	4	4	4	4	4	5	4	4	5	4
R-27	X-A	5	4	4	5	4	5	4	5	3	4	4	2
R-28	X-A	4	5	4	5	4	5	4	5	5	5	4	5
R-29	X-A	5	4	3	3	3	3	3	4	4	4	4	5
R-30	X-A	5	5	4	5	5	4	5	4	4	5	4	5
Σ Frequency		**139**	**119**	**138**	**142**	**135**	**124**	**133**	**129**	**135**	**123**	**134**	**115**
Average		**4.6**	**4.0**	**4.6**	**4.7**	**4.5**	**4.1**	**4.4**	**4.3**	**4.5**	**4.1**	**4.5**	**3.8**
Percentage		**93 %**	**79 %**	**92 %**	**95 %**	**90 %**	**83 %**	**89 %**	**86 %**	**90 %**	**82 %**	**89 %**	**77%**
Σ Average percentage		**87%**											
Category		**Very Interested**											

Based on the survey responses from students, the trial test yielded a percentage of 87% with the criteria "very interested". This trial highlights key aspects influencing students' experience with the learning media in the context of geography education. The majority of students (93%) showed high interest in learning media that are easily accessible and functional across various devices, such as laptops and mobile phones. However, there is room for improvement in hotspot features and navigation to make them more responsive for students (79%). Additionally, clear and easily accessible instructions are considered important by students (92%), emphasizing the importance of providing good guidance in learning media. Students also highly appreciate the visual and audio quality of the learning media, including images, videos, animations, and overall visual design. This indicates that visually appealing elements can significantly contribute to the understanding of geography concepts. In terms of language use, clarity and ease of understanding in narration are also considered important in enhancing concept comprehension (86%). Furthermore, the learning media has proven to provide an engaging and enjoyable learning experience for students (89%), although there is room for improvement in boosting students' confidence in understanding concepts after using the learning media (77%). Therefore, based on the student response data above, it can be concluded that the learning media has successfully captured the interest of both students and teachers and has aided in the understanding of geography concepts. Hence, this virtual

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tour-based digital teaching media can be used as one of the main geographies learning support media, particularly in the Lithosphere Dynamics chapter on Tectonism.

Once all the steps have been completed, the next step is to publish the project, as illustrated in Figures 7 and 8. After going through the design stage, product design validation, testing, and revision, the next stage is mass production. This stage is carried out by publishing through the use of a website, where the application automatically generates website files using JavaScript and HTML programming languages. These files can be uploaded to a server and accessed online at https://vgt.mohammath.com/. The results of the Virtual Geotour Tectonism development can be seen in Figures 9 and 10.

Figure 7. Publishing

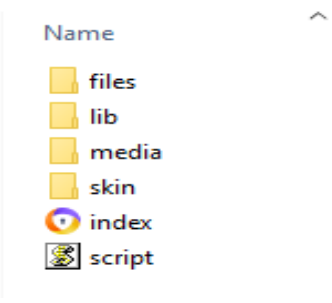

Figure 8. Published File

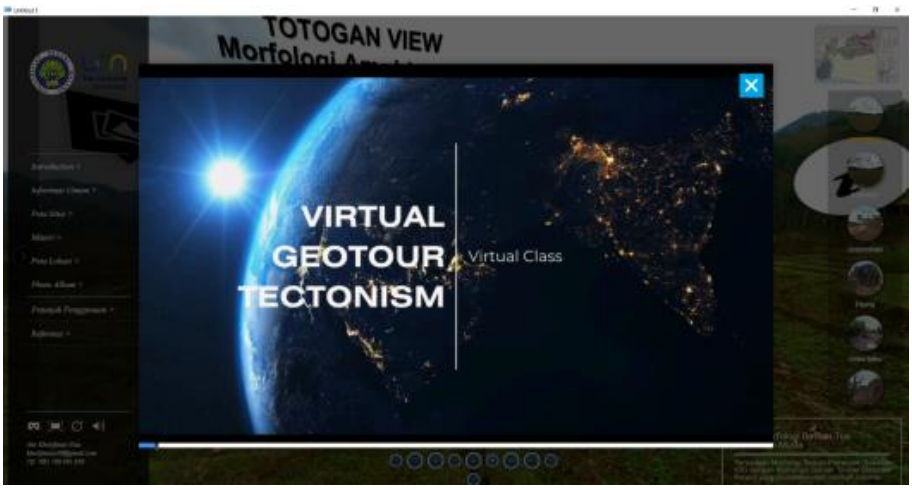

Figure 9. Virtual Geotour Tectonism Creation Result

Figure 10. Virtual Geotour Tectonism Creation Result

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4. CONCLUSIONS

This study aims to develop Virtual Reality (VR)-based digital technology learning media that are relevant and suitable for enhancing the learning process in the classroom, particularly in the context of teaching tectonism material. The development of this media follows the research and development procedures of Borg and Gall, starting with the analysis of potential and problems through observation and distribution of questionnaires to students and teachers. The analysis results indicate high student interest in audio-visual digital technology-based learning media. Additionally, curriculum needs analysis also reveals challenges in understanding complex materials such as tectonism. Considering the limitations of existing learning media at SMAS Diponegoro Tumpang, especially in explaining the tectonism process, VR media development becomes a relevant solution. The development stage involves data collection through interviews and observations, as well as the design of a product in the form of Virtual Geotour Tectonism, which features various learning support features such as 360° navigation, maps, hotspots, and clear explanatory texts. The results of validation tests by media and subject matter experts indicate that this media is appropriate and highly engaging for use in learning. Positive responses are also obtained from teachers and students, indicating that Virtual Geotour Tectonism has successfully created a deep and engaging learning experience for students. Thus, the development of this VR learning media is expected to make a positive contribution to improving students' understanding of tectonism material in schools.

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