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PAPER

Generating Mobile Virtual Tour Using UAV and 360 Degree Panorama for Geography-Environmental Learning in Higher Education

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ABSTRACT

Nowadays, the limitations of media in geo-environmental learning present a significant challenge, as media plays an indispensable role in fostering students' comprehensive understanding. Employing technology capable of delivering comprehensive landscape information is crucial for effective environmental education. Utilizing Unmanned Aerial Vehicles (UAVs) and 360-degree panoramic cameras represents a judicious technological choice, which can be seamlessly integrated into virtual tours. This research aims to develop a Mobile Virtual Tour (Movie-Tour) as a medium to support learning, especially for materials regarding environmental geography. The research and development (RnD) method is used in research with the ADDIE model (Analysis, Design, Development, Implementation and Evaluation). Data collection for the development of the product involved conducting a need assessment, performing validation tests and conducting trials with students. To gather field data for creating environmental geography materials for the Movie-Tour product, we utilized an Unmanned Aerial Vehicle (UAV) and a 360-degree stereoscopic camera. The results demonstrate that Movie-Tour is an educational medium capable of delivering an immersive learning experience and comprehensive materials, allowing for the virtual visualization of real-world conditions in the field. This capability enhances students' engagement in exploring physical geography conditions, fosters independent knowledge acquisition, and nurtures their innate curiosity. Movie-Tour stands as a potent and practical educational tool, offering an effective and secure learning experience for students, eliminating the need for direct field visits.

KEYWORDS

Movie-tour, geography environment learning, UAV, 360 degree-cameras

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1 INTRODUCTION

Currently, information technology is increasingly sophisticated, has a wide reach and is a tool capable of supporting educational improvement, especially for learning media [1], [2]. The integration of technology with education through the learning process greatly influences students' understanding, especially material related to geoscience. Geoscience studies, especially physical studies regarding geological and geomorphological features, are one of the interesting natural formations [3], [4]. Sometimes, exploring geological and geomorphological features in rough terrain can be quite challenging. However, recent technological developments such as Unmanned Aerial Vehicle (UAV), 360-degree cameras, virtual reality, augmented reality, and artificial intelligence have had a very significant impact on the ease of delivering material in the learning process that students can use for exploring geoscience, especially environmental geography [5].

Technology has not only simplified various aspects of human life but also introduced exciting experiences including learning [6]. One information technology that is able of providing direct experience and immersive learning is virtual tour (VT). VT is a technology currently being developed and capable of creating a 3D digital environment. Virtual tours are becoming increasingly interesting because they are able to provide in-depth and immersive experiences to students. Currently, virtual tours are widely needed in various fields of scientific study, one of which is learning to study physical and environmental geography [7], [8]. Virtual tour is a medium that is representative, comfortable and able to provide comprehensive information in the learning process. Apart from that, virtual tours have been proven to be a representative medium for visualizing geospatial data and producing 3D photos [9].

In recent years, VT has become one of the representative solutions that can be optimized for learning, especially in materials related to geoscience, one of which is the physical geography of the environment. Through the development of VT, it will indirectly provide information about the potential of the region, including information for understanding the interactions between humans and their physical environment [6], [10]. Virtual tours can represent physical data in a synthetic environment and provide users with an immersive experience. The VT system is one of the tools currently needed to visualize spatial data and produce high-quality products in various fields [11].

Within the field of geoscience, the learning process at tertiary institutions is expected to foster an understanding of environmental geography, a branch of geography that explores the Earth's surface and its processes. This is important because the study of environmental geography is one of the bases in the science of geography [12]–[14]. One of the breakthroughs that can be made to achieve this is the development of a virtual tour based on a mobile and web-based geographical environment. VT was built for understanding geographical environment and enable interaction in learning. It is interactive and provides immersive experiences to students in tertiary institutions as part of an effort to contextually visualize existing conditions regarding phenomena related to environmental geography without going directly to the field [15]–[17].

There have been many studies discussing the development of virtual tours in learning. Based on [18], research has been conducted on immersive virtual reality, which is related to student's cognitive and motivational abilities [18]. This research shows that having a virtual tour can improve students' cognitive abilities and the ease of accessibility of virtual nature-based sites [18]. The use of VT in learning

will also provide valuable information for students [5]. The application of VT in the learning process using 360-degree stereoscopic photos has now been widely developed because, through the 360-degree feature, students can explore the target site according to their wishes [5].

Several studies have stated that using 360-degree VT will encourage students' curiosity to explore the site [1]. The 360-degree VT provides an open digital window into the geographical environment of the physical world that allows users to "feel" real-world conditions through the simulation of geographic phenomena and collaborative experimentation. VR is an educational tool [19].

The use of 360-degree on VT in learning will be a more valuable learning process, providing comprehensive information and a real visualized experience if 360-degree is integrated with data obtained from Unmanned Aerial Vehicle (UAV) [20]. Although 360-degree in VR allows users to "feel" according to real conditions, 360-degree cannot provide comprehensive spatial information on geoscience studies, especially for environmental geography. This is because an understanding of environmental geography cannot be separated from landscape studies. In this study, visual understanding cannot be separated partially, so it requires 3D visuals according to the real conditions of the landscape in the field.

Understanding of environmental geography will be more comprehensive if learning includes the integration of VR with 360 degrees and information technology using UAVs. This integration is important because the use of UAVs as environmental geography learning media is able to provide spatial information, so that it is in accordance with the geography learning approach, which includes the environment, regionalism and spatiality. UAVs have been widely used for learning. The use of UAVs is able to provide spatial information, so it is very suitable for building artificial environments, especially for geo-environmental physical reality. Based on [9] they have integrated UAVs with virtual 3D using photogrammetry techniques, so that they are able to represent surface appearances in 3D. However, the use of UAVs is not able to provide comprehensive landscape information such as spatial information.

The integration of a 360-degree camera that is capable of providing complete spatial information and a UAV with 3D techniques will be very representative for use in virtual tour learning media, especially for environmental geography material. The development of VT that integrates 360-degree and UAV 3D data is still rare, especially for physical-environmental geography material. This research produces VR development products using 360-degree data and small format aerial photo 3D data from UAVs. VR developed in mobile and web-based Movie-Tour is very powerful and accessible in supporting the learning process.

2 METHOD

2.1 Site of research

Dilem Wilis Techno Science Park was chosen as a development site due to its location on the slopes of Wilis Volcano in Trenggalek Regency. Based on a geomorphological study of the Southern Mountain Zone of East Java, it can be identified that the southern part of Java Island is a mountainous zone where the relief is divided into two types, namely smooth relief and rough relief. Dilem Wilis is part of the southern mountainous zone formed by tertiary volcanic rocks that have been eroded for a very long time since the Middle Miocene. Based on the formation, Dilem Wilis

Science Techno Park (STP) is located in the Jaten (Tmj) formation with rock materials in the form of sandstone and tuff with volcanic breccia, carbonaceous siltstone, marl, and limestone intercalations. The weathering at Dilem Wilis was very intensive, causing Dilem Wilis STP to have the potential for landslides.

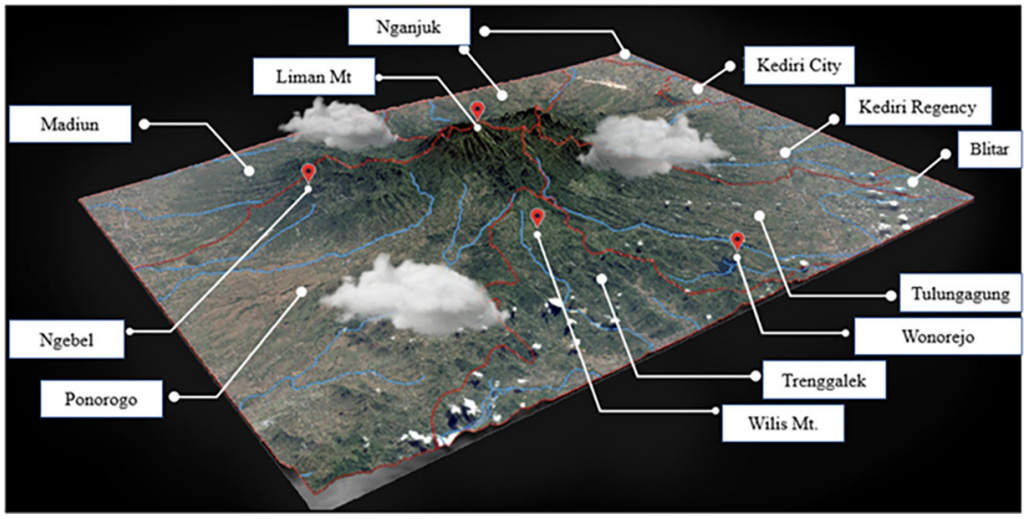


Fig. 1. Research area as the site for developing movie-tour content

2.2 Research design

This study is included in the type of research and development (RnD) using the ADDIE model. There are several stages in the ADDIE model, namely Analysis, Design, Development, Implementation, and Evaluation. At the development stage, it is carried out repeatedly because at the development stage, the resulting product is evaluated according to the validation results of experts, i.e., material experts, media experts and language experts. Figure 2 shows the Movie-Tour development procedure.

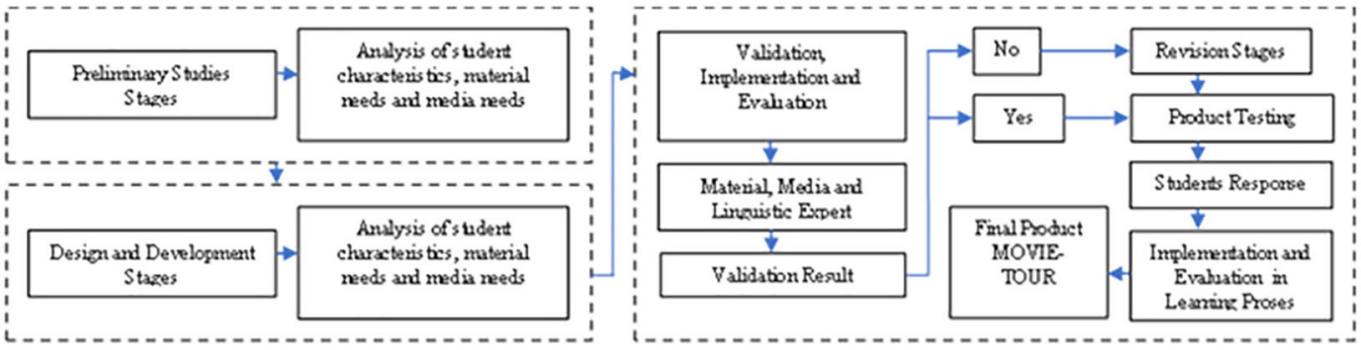


Fig. 2. Movie-tour development procedures

2.3 Framework of development

This section explains the theoretical concept of Movie-Tour development. Figure 3 illustrates that in the 21st-century learning, there has been a shift in the learning

process from conventional methods to technology-based learning. Despite this shift, the essence of learning objectives must be the most essential part. The development of Movie-Tour with 360 Degree and UAV as one of the technologies developed in learning will provide students with an immersive experience, a comprehensive understanding, evaluation, and assessment. Movie-Tour is equipped with instructions in a virtual roaming that will help students to reconstruct the knowledge of the geography of the environment in a virtual-contextual manner.

The development framework of Movie-Tour was carried out in accordance with the needs of environmental geography learning as well as 21st century learning methods that integrate technology with information and comprehensive student understanding [11], [21]. However, in this research, modifications were made by integrating UAV data and a 360-degree panorama.

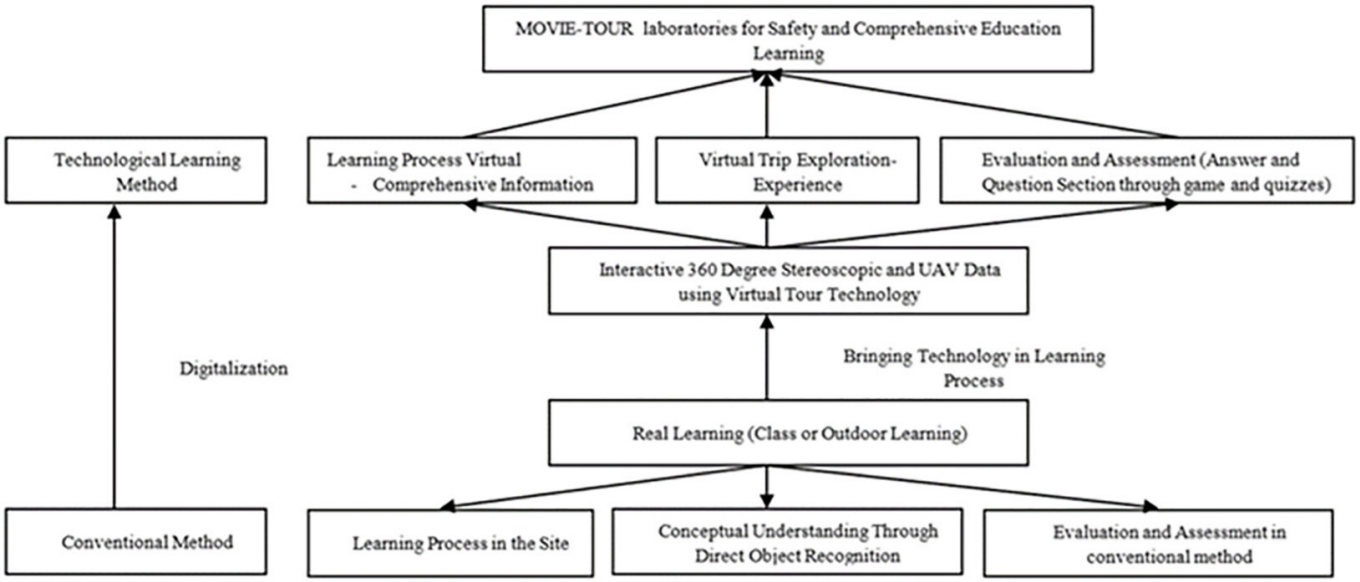


Fig. 3. Framework Movie-tour (Modified: (Pham et al., 2018))

2.4 Data collection

Data collection was carried out using a needs assessment for geography students using multiple choice of 20 questions and in-depth interviews with lecturers who taught environmental geography courses. Apart from that, in collecting data for product development, a validation test process is also carried out by validators based on the results of the products that have been developed. In this research, data was also collected for environmental geography material which was used as product development material content.

To collect data regarding environmental geography material, data was collected through surveys and field observations at several sites in the form of geomorphosite and technosite using the Unmanned Aerial Vehicle (UAV) with the DJI Mavic Pro type and a 360-degree stereoscopic camera. The UAV specifications are described in Table 1. The data collection did not apply the mapping method because the UAV was not used. It is only used as a medium in landscape capture. The results of the UAV data collection and the 360-degree stereoscopic camera were selected. This VT Movie-Tour was developed to make understanding the region's landscape easier, especially for tourism from geological, geomorphological and technosite features.

Table 1. Specifications of the used UAV

Dji Mavic Pro 2	
Sensor	1″ CMOS; Effective Pixels: 20 million
Lens	FOV: about 77°; 35 mm Format Equivalent: 28 mm; Aperture: f/2.8–f/11;Shooting Range: 1 m t
ISO Range	Video: 100–6400; Photo: 100–3200 (auto)100–12800 (manual)
Shutter Speed	Electronic Shutter: 8–1/8000s
Video Resolution	4K: 3840 × 2160 24/25/30p; 2.7K: 2688 × 1512 24/25/30/48/50/60p; FHD: 1920 × 1080 24/25/30/48/50/60/120p
Dimension	214 × 91 × 84 mm (length × width × height)Unfolded:322 × 242 × 84 mm (length × width × height)
GNSS	GPS + GLONASS
Hovering Accuracy Range	Vertical: ± 0.1 m (when vision positioning is active); ± 0.5 m (with GPS positioning) Horizontal: ± 0.3 m (when vision positioning is active) ± 1.5 m (with GPS positioning)

2.5 Stages in product development

There are several stages carried out in the development of this virtual tour, namely 1) data collection which is carried out through on-site survey data and in-depth interviews; 2) data processing and development of virtual tours use 3D Vista virtual tour software. The 3D Vista Virtual Tour program can be used on all devices, whether Windows 10 and 11 or OS X. Recommended specifications are i7 processor, 16 Gb of RAM, and fast storage (Solid State Drive or SSD) whenever possible. The minimum specifications are i5 processor, 8 Gb of RAM, and Windows 7. There are three most essential parts in the virtual tour process and development, namely 1) compiling the information that will be conveyed in the virtual tour; 2) the image selection process resulting from photo rendering from the UAV and 3600 stereoscopic camera; 3) selection of animated hotspots, audio, floor, go to panorama, information, links, photos, and videos; 4) content editing, 5) virtual tour display layout (Figure 1).

This virtual tour is developed using 3D Vista virtual tour packages in the development framework. 3D Vista is used in virtual tour development because it doesn't require internet integration; all that's needed is the installation of packages. This VT-L development incorporates the JavaScript programming language, rendering UAV data and 360-photo. JavaScript is the basic coding system used in the development of VT-L. The use of VT-L in understanding the landscape of a region, including analysis of geosite, tourism and its carriers, is a representative medium. This VT-L development research has not been tested on students as a learning medium, so this research only emphasizes generating virtual tours using mobile.

In developing this Movie-Tour product, the aim was to provide students with an accurate depiction of environmental geography without the need for direct observation. The developed prototype design will give the impression of immersive learning. For the development of the prototype design, several stages were carried out, namely 1) data acquisition using UAV and 360-degree stereoscopic; 2) Photo rendering of the UAV and 360-degree stereoscopic; 3) Video rendering; 4) Setting skins and layouts; 5) Setting the placement of each content in the form of photos, videos taking

into account the characteristics of the physical environment, information and ease of understanding of students' knowledge. Figure 4 explains the stages in product development.

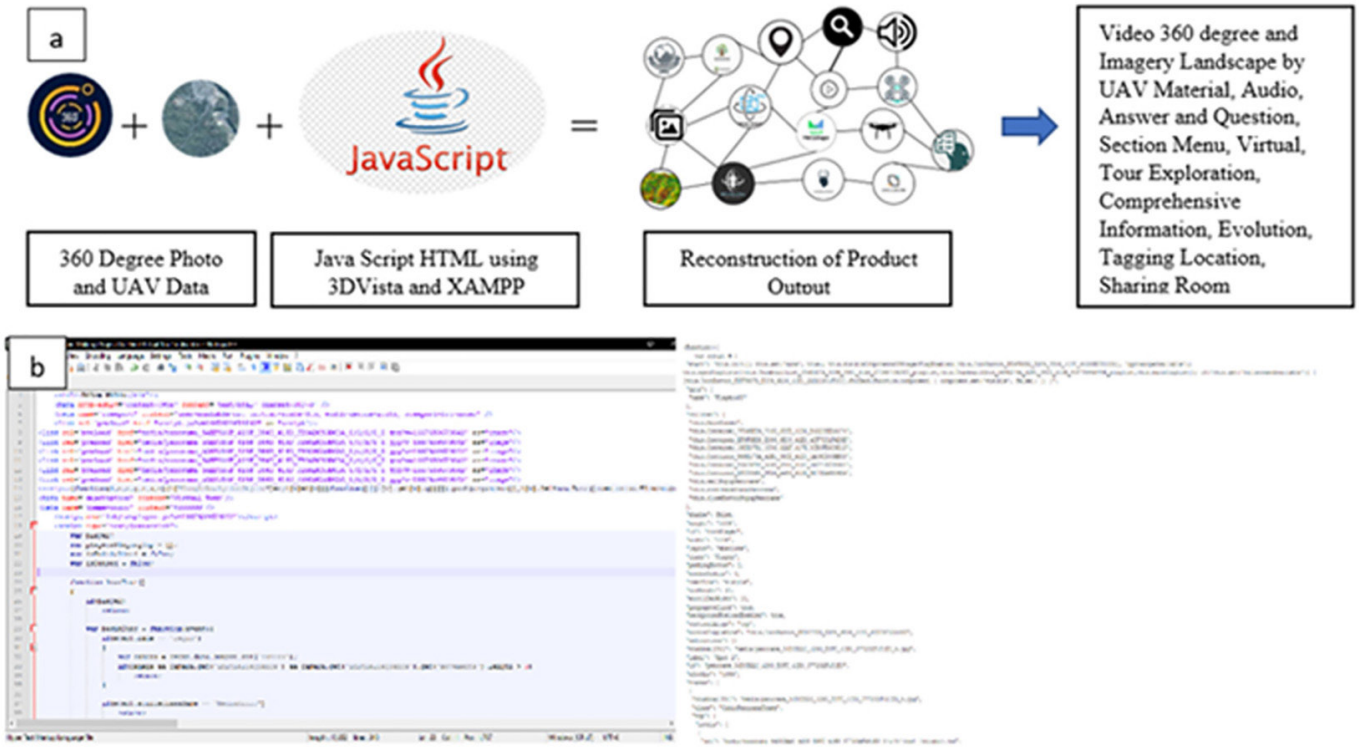


Fig. 4. Movie-Tour development construction a) acquisition process up to visualization; b) coding of 3D Vista and XAMPP

2.6 Implementation stages

Movie-Tour products are developed based on web applications that are integrated with mobile phones. This Movie-Tour was developed with convenience and effectiveness in mind, on the basis of ease of accessibility, network, media performance, and interfaces to achieve media with an interactive user platform. The implementation stage in a trial was carried out on fourth-semester students who took disaster geography and environmental courses. This is done because the study of disasters cannot be separated from the study of physical and environmental geography.

2.7 Data analysis

The data analysis technique uses quantitative descriptive analysis which aims to process test results from validators and also students who are taking disaster geography and environmental geography courses. There are four classes of criteria for testing validity tests, namely invalid with a percentage of <20% (product cannot be used), less valid with a percentage of 21%–40% (can be used with major revisions), quite valid with a percentage of 41%–60% (may be used with minor revisions), and is valid with a percentage of 61%–100% (good for use). The percentage is obtained by calculating the value obtained with the highest value and calculating the percentage.

3 RESULTS AND DISCUSSION

3.1 Movie-Tour as the virtual tour for geography environmental material

The Movie-Tour product was developed to analyze the needs of learning media in the Geography of Disaster course on physical and environmental geography in semester four of the Department of Geography, Faculty of Social Sciences, State University of Malang. The Movie-Tour can be used as a virtual media capable of providing comprehensive information, especially for physical and environmental geography studies. The features and interfaces developed in Movie-Tour have their purposes, namely 1) The Movie-Tour interface is equipped with a home menu which contains information as general menus regarding STP Dilem Wilis, geomorphosite as the physical and environmental geography, and information about natural hazards. The interface on this virtual tour was developed to provide comprehensive information to students so that students know that there is a link between physical geographic processes in the form of geomorphological and geological processes and existing environmental conditions.

Development of a home feature with several information menus providing comprehensive knowledge of physical and environmental geography; 2) Interactive menu equipped with detailed thematic information following material regarding environmental geography which is supplemented by details on 360-degree stereoscopic photos, videos, and panoramic photos of landscapes from Unmanned Aerial Vehicle (UAV) data. Acquisition of 360-degree stereoscopic data and UAV data allows students to independently explore physical and environmental geography phenomena, natural disasters, and physical conditions of the existing environment formed from past geomorphological processes [5], [9]. The Movie-Tour development is equipped with direction buttons that function for a more detailed exploration of the Dilem Wilis STP area; 3) The accessibility of using Movie-Tour as laboratory for technology learning regarding environmental geography is designed in two ways, which can be accessed via the website and also based on mobile phone, so that students are given the freedom to explore the material that has been prepared. Figure 4 shows the view from Movie-Tour.

Fig. 5. Movie-Tour interface

The development of Movie-Tour has integrated spatial aspects into learning which includes the data used in the form of small-format aerial photo data from shooting using UAVs and 360-degree photos. The purpose of using spatial data in this development is to provide a comprehensive picture of the landscape and physical and environmental geography processes in the STP Dilem Wilis area. The interface and system developed in Movie-Tour also prioritizes spatial aspects supported

through menus and Movie-Tour interfaces on mobile-phone and web-based displays. The 360-degree photos and UAV data used for this development provide opportunities for students to comprehensively explore the sites visited [20]. In addition, the display in this development provides spatial coordinate information that students can use to analyze the correlation of geomorphic processes if further analysis is carried out using a Geographic Information System (GIS).

Movie-Tour product development has several advantages and disadvantages. Some of the benefits that make it different from other virtual tour developments are 1) This product was developed with material obtained from the acquisition of UAV aerial photographs and 360 degrees for photos and videos; 2) this product was developed by integrating geospatial technology so that with landscape visualization, interactive digital maps and geographic coordinate information, it will encourage students to think spatially and analytically; 3) material regarding Movie-Tour is developed with an exploration button at each spot so that it encourages students to increase their sense of curiosity; 4) Movie-Tour is equipped with a menu for evaluating and assessing students which focus on the results of assessing students' abilities. However, the development of this Movie-Tour also has several weaknesses, namely 1) to make Movie-Tour accessibility requires an internet network, so this product cannot be used when there is no internet network; 2) The material used in this development still focuses on material regarding physical and environmental geography and disasters; 3) Movie-Tour development cannot be used to measure how much curiosity students have because this development is not equipped with historical records of students' activities in exploring Movie-Tours. For further development, additional assessment and evaluation is needed for the analysis of the curiosity and motivation of students through the use of Movie-Tour.

The material described in this product emphasizes being contextual following the existing conditions of STP Dilem Wilis, which geographically has the potential to be used as teaching material for students, especially for students in semester three and semester four, who take environmental geography and disaster geography courses. These two courses are interrelated. Table 2 shows the materials developed in Movie-Tour products based on the existing conditions at STP Dilem Wilis.

Table 2. STP Dilem Wilis environmental geography material for Movie-Tour content

Material	Sub Material	Detail Description
Physical Material	Geomorphosite (Andesitic Intrusion site)	Material regarding andesite rock intrusion
	Introducing of Landscape	Material regarding the division of landscapes and landforms based on morphology
	Physical Environment	Soil condition, slope, and hydrology
	Hydrometeorology Disaster	Landslides and floods
Human, Social, and Economic Material	Local Wisdom	Material on local wisdom in Dilem Wilis
	Human Interaction	Explain human interaction in disaster-prone areas
	Community Work	Describe the physical conditions of the environment that affect work.
	Land Utilization	Land Management in volcanic areas for a sustainable environment
	Waste Management	Explain waste management for a sustainable environment

3.2 Exploration of the physical geography and environment of STP Dilem Wilis in Movie-Tour media

Several spots in the STP Dilem Wilis area are used as materials that represent physical and environmental geography studies. Some spots include spots for physical geography studies in the form of andesite rock intrusions, natural disasters in the form of landslides, landscapes, existing socio-economic conditions, and hydrological conditions. The physical condition of the geographic environment will affect the socio-economic conditions of the community so that most of the people in the study area have jobs in agriculture to animal husbandry. Each spot is explained in the material described in Table 3.

Table 3. Geographical position on environmental geographical spots

No	Spot Site	Number of Sites	Geographic Position	Description
1	Andesite Intrusive Rocks	1	7055'41"S111042'59"E	A site that shows intrusion of andesite rocks resulting from volcanic processes
2	Landscape	3	7055'45"S111043'06"E	Landscape showing the division of morphological units in the volcanic system
3	Natural Hazard	4	7055'43"S111042'59"E	Elaborating natural disasters, landslides and floods
4	Hydrology	1	7055'49"S111043'11"E	Describe the hydrological characteristics

3.3 Description of the physical-environmental geography site STP Dilem Wilis in Movie-Tour media

The development of Movie-Tour as one of the media used in environmental geography courses has a significant role in students' understanding, especially regarding physical-environmental geography material. The use of Movie-Tour is one of the tools that can facilitate students to find out about the existing conditions in the field virtually, with an attractive display, making it interactive, and using data.

3.4 Spot 1 Landscape of STP Dilem Wilis (geographic coordinate 7055'45"S111043'06"E)

Dilem Wilis Techno Science Park is located on the slopes of Mount Wilis, Trenggalek Regency. Based on a geomorphological study of the Southern Mountain Zone of East Java, it can be identified that the southern part of Java Island is a mountainous zone whose relief is divided into two types, namely smooth relief and rough relief [22]. Dilem Wilis is part of the southern mountainous zone formed by tertiary volcanic rocks that have been eroded for a very long time since the Middle Miocene [23]. Based on the formation, Dilem Wilis Science Techno Park (STP) is located in the Jaten (Tmj) formation with rock materials in the form of sandstone and tuff with volcanic breccia, carbonaceous siltstone, marl and limestone intercalations. The weathering that occurred at Dilem Wilis was very intensive. The landform of the Dilem

Wilis area is divided into mountain tops high ridge, midslope, local ridge, upper slope, open slopes, plains, upland drainages, midslope drainage, shallow valley, and canyon. The division of the landform is based on Topographic Position Index (TPI) analysis using the Arc GIS 10.2 algorithm (Figure 2). But on the other hand, Dilem Wilis Techno Science Park has a variety of plants that are used by the local community for medicinal plants. In addition, the potential for plant diversity makes Dilem Wilis to be developed as a site in education such as greenhouse models, essential nurseries, coffee cultivation, and several other medicinal plants.

3.5 Spot 2 Andesite Intrusive Rocks (geographic coordinate 7055'41"S111042'59"E)

The Dilem Wilis area is located on the geological map sheet Madiun 1508-2 with a scale of 1:100,000, which is located in the Jaten (Tmj) formation with lithology in the form of sandstone and tuff with volcanic breccia, carbonaceous siltstone, marl and limestone intercalation. The Tmj Formation, which shows a tertiary age, represents that the research area was formed 66 million years ago. A rough morphological formation on the southern mountain route in the Dilem Wilis region is caused by a geomorphological process in the form of erosion over a long period of time since the middle Mieocene. In this area, there is the influence of boulder faulting, which is partly a tertiary volcanic complex that has decreased and is covered by limestone [24]. The slope of the Dilem Wilis area measures 320, indicating a rugged hilly terrain.

3.6 Spot 3 Hydrology characteristic site (geographic coordinate 7055'49"S111043'11"E)

Hydrological characteristics in the study area show that the water discharge is not too fast. However, the water stream has a brownish tint. This indicates that the flow of water on the slopes of Mount Wilis carries sedimentary material due to very intensive geomorphological processes, namely in the form of landslides and erosion. Students are given information about lateral erosion and intrusive rocks along the river body at this site. The color of the intruded rocks in this section is reddish, indicating that the material in the study area is affected by volcanism.

3.7 Spot 4 natural hazard (geographic coordinate 7055'43"S111042'59"E)

Landslide is the movement of rock and soil masses on the ground surface which contributes significantly to erosion, sediment, release, transportation and deposition on hillsides [25], [26]. Landslide occurrence depends on different factors related to topography, geology, climate, land cover, people and the environment [27], [28] Landslides hold significant geomorphological importance as they provide insights into landscape evolution. They constitute a component of the landscape that can be explored as a geomorphosite, offering educational insights into geological and geomorphological processes (Pelfini & Bollati, 2014). The landslide geomorphosite can be used as a site to study the relationship between slope geomorphology and parts of the landslide, such as the landslide perimeter, the landslide head, the scarp, the landslide body, and the landslide toe (Figure 5). This site can explain that the landslide

occurred on a minor slope in the cut-slope system. Hydrological characteristics in the study area show that the water discharge is not too fast. However, the water stream has a brownish tint. This indicates that the flow of water on the slopes of Mount Wilis carries sedimentary material due to very intensive geomorphological processes, namely in the form of landslides and erosion. Students are given information about lateral erosion and intrusive rocks along the river body at this site. The color of the intruded rocks in this section is reddish, indicating that the material in the study area is affected by volcanism.

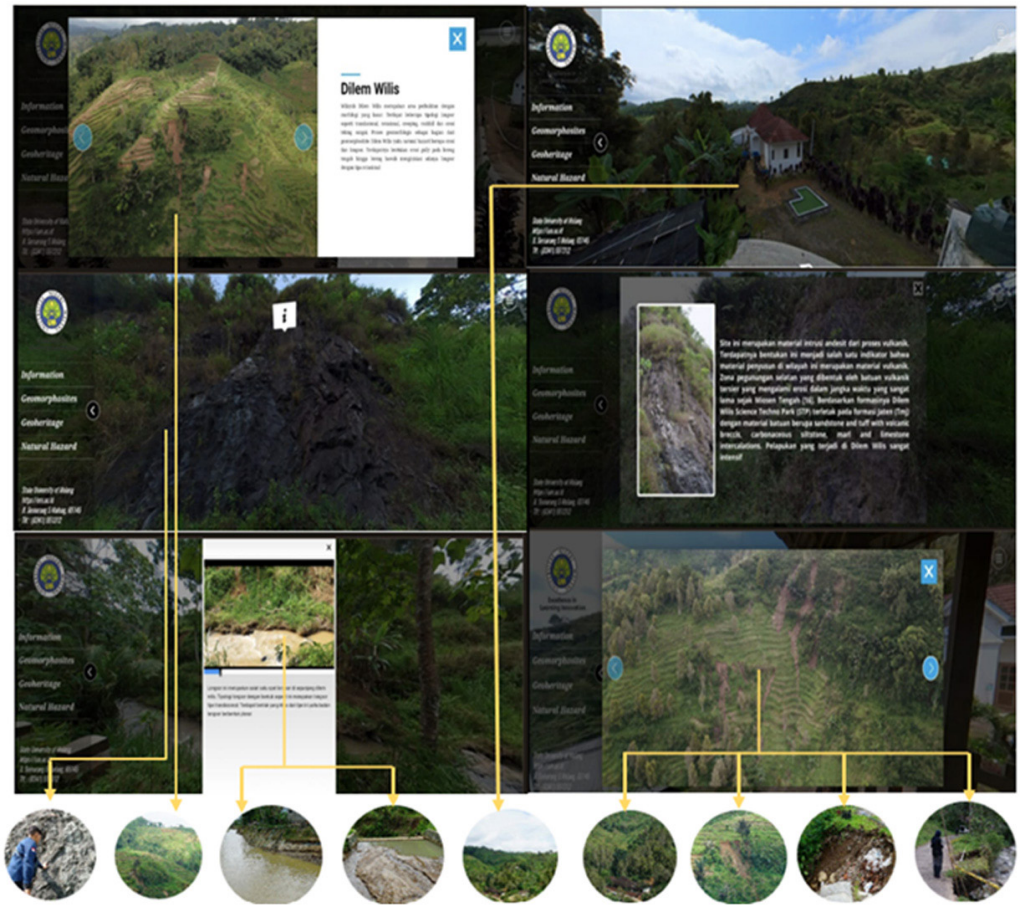


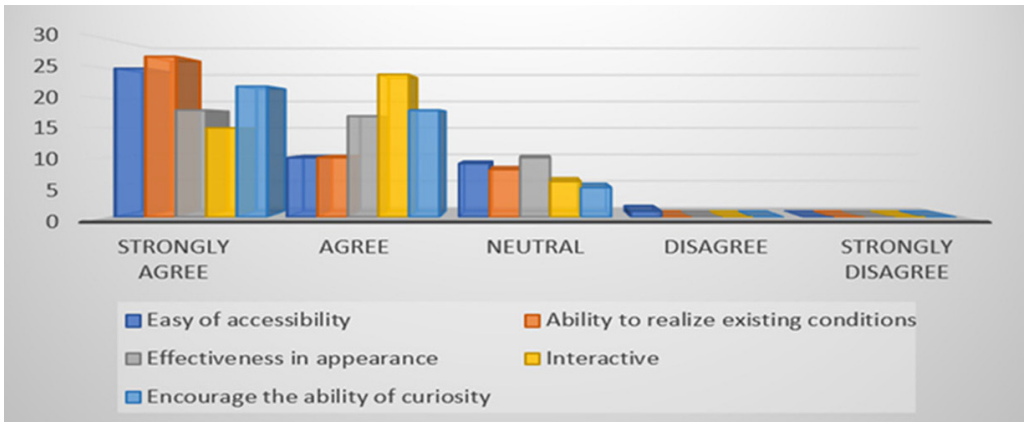
Fig. 6. Appearance of existing conditions a) Translational and rotational landslides; b) Landscapes; c) Andesite Intrusion; d) Hydrological conditions; e) Multi-hazards

3.8 Assessment and evaluation Movie-Tour

Validation tests are carried out to assess product reliability, namely material, media and language experts. Based on the validation results, the average rating is 88% with valid criteria. Based on these values, it shows that the development of Movie-Tour is suitable for use in the learning process both in terms of material and language as well as for teenagers in terms of its accessibility. Validation testing in development research is an essential part [29].

Another evaluation carried out in the development of the Movie Tour was also carried out based on distributing questionnaires to students, especially fourth semester students who taught the Disaster Geography course. Test this product in a

disaster geography course because understanding environmental geography is one of the prerequisite materials that students must take in a disaster geography course. In general, it shows that mobile and web-based Movie-Tour is easy to use and provides convenience for students. Based on research [30], it is explained that studies regarding environmental science really need field observation activities as support, one of which that can be utilized is laboratory exercises using virtual tours. The use of media in learning really has an impact on understanding and learning outcomes. Based on [31], the use of virtual media applied in Hong Kong Universities resulted in virtual media being very effective [6]. To find out the results of the implementation of Movie-Tour on learning, a product comfort test was carried out for effectiveness using a Likert scale modified from research [5] which uses activity learning parameters with four indicators, namely ease of accessibility, interactivity, effectiveness in appearance, ability to realize existing conditions and encouraging the ability of curiosity. [5] uses four indicators to test media products developed with geosite objects using 360 degrees panoramic. Figure 7 shows a graph of the convenience of using Movie-Tour implemented for students taking disaster geography and environmental geography courses.



Learning Activity	Learning Outcomes
Easy of accessibility	Curiosity
Interactive	
Effectiveness in appearance	
Ability to realize existing conditions	Explore Creativity, Discovery, and Exploring
Encourage the ability of curiosity	

Fig. 7. Graph of the convenience of using Movie-Tour

The graphic information in Figure 7 was assessed using the Likert scale method with a range from strongly disagree to strongly agree. Most students answered strongly agree to agree on each comfort indicator. Evaluation of the use of Movie-Tour for learning is also measured based on student learning outcomes in the form of curiosity, creativity, discovery and exploration. Figure 6 shows the number of students' ease in using Movie-Tour. The indicators used in analyzing the use of Movie Tour are based on the output of learning outcomes. Measuring learning outcomes as part of product development assessment and evaluation is an essential part [32], [33].

4 CONCLUSION

Movie-Tour provides an immersive learning experience, comprehensive material and is able to visualize existing conditions in the field virtually. Through data integration using 360 degrees and 3D rendering, UAV is able to provide understanding and knowledge independently and supports and encourages the ability of curiosity of students. The validation results from media experts and linguists are an average of 88%, indicating that the media is valid and feasible to use. Evaluation of comfort in using Movie-Tour shows that on average, students respond strongly agree to agree regarding learning activity, easy accessibility, interactivity, effectiveness in appearance, ability to realize existing conditions, and encouraging the power of curiosity. Movie-Tour is very powerful to be used as an effective learning media for students for environmental geography material in the STP Dilem Wilis area without going directly to the field. On the other hand, there are limitations to the Movie-Tour product, namely 1) running Movie-Tour for learning media requires a strong internet network because the data uses high resolution; 2) some students may not be familiar with the use of Movie-Tour. Therefore, a recommendation for further research is to develop a more user-friendly version of Movie-Tour that includes data compression to improve its usability; 2) complete material regarding case examples related to environmental geography and 3) add additional instruments to measure learning outcomes related to learning outcomes.

5 ACKNOWLEDGEMENT

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