

Augmented Reality Learning Media on Geographic Symptoms to Increase University Students' Knowledge of Geographic Science: Pro-Environmental Behaviour

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ABSTRACT

In supporting difficult learning, innovative learning media are needed. One of the innovative learning media is augmented reality (AR). In this study, there is an AR design that is needed for the material of geographical phenomena. The method used is Research and Development (Borg & Gall, 2014). The results obtained in this study are AR designs for geographical phenomena (volcanoes, earthquakes, and tsunamis). It is hoped that the AR design for the material on geographical phenomena in this article can be useful in applying augmented reality material for geographical phenomena in social studies for lecturers who want to develop it as a learning medium for students.

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1. INTRODUCTION

Education is an effort that people make on purpose to change how they act. Article 3 of the Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional says that "National Education functions to develop capabilities and shape the character and civilization of a dignified nation in the context of educating the nation's life, aiming to develop the potential of students to become human beings who believe and fear God Almighty, have a noble character, and are healthy." For this educational goal to be met properly, the right learning strategies are needed. For example, it is important to figure out the different activities that will be done and the material that will be given, such as the instructional packages and learning media that will be used to teach both young children and adults.

In light of the foregoing, higher education institutions must plan ahead for the rapid technological developments that will characterise the era of the fourth industrial revolution. The economic and industrial climate is becoming more competitive, and as a result, curriculum and educational techniques must evolve to remain relevant. The Fourth Industrial Revolution and the Future of Work. The internet's incorporation into industrial production lines is a prime example of how information and technological expertise may be put to use. Digitization, production optimisation and customization, automation and adaptability, human-machine interaction, value-added services and enterprises, automatic data interchange and communication, and the usage of Internet technology are all hallmarks of the fourth industrial revolution (JPNN, 2017). In this age of fast scientific and technological advancement, often referred to as the "Industrial Revolution 4.0," global rivalry is fiercer than ever. Every nation is racing to be the next to invent something new by investing more resources into research and better universities. The key to success in this age of industrial revolution 4.0 is human resources that are highly competent and competitive.

This era will also disrupt various human activities, including the fields of science and technology (IPTEK) and higher education. In reality, the current lecture system is still mostly done conventionally, even though the learning model is no longer suitable to be applied to universities. The hope is that there will be the preparation of more innovative learning models that can improve student understanding in terms of data Information Technology (IT), Operational Technology (OT), Internet of Things (IoT), and Big Data Analytics, integrating physical, digital and human objects. To produce competitive and skilled university graduates, especially in the aspects of data literacy, technological literacy and human literacy (Dai et al., 2020).

In other words, the world of education demands the use of learning media from simple to sophisticated. This is because the learning media is not just a tool, but is seen as an important component in learning. The development of teaching materials/materials means that the role of lecturers in creating more effective learning methods is also increasing, all of which are related to the media. Lecturers are not the only source of learning, but there are still many learning resources that can help students gain knowledge, especially knowledge in the field of social studies education.

Augmented Reality (AR) is a technology that allows visual image information generated by gadgets to be in the real-world environment either directly or indirectly in real-time (Azuma, 1997; Zhou et al., 2008). While the material on geographical phenomena is difficult to understand by just reading without seeing the reality, with AR media on geographical phenomena, it is hoped that it can increase understanding of geography in social studies and environmental conservation (pro-environmental behaviour). Open University students are devoted to majors IPS. Previously, these were previous studies to get this research:

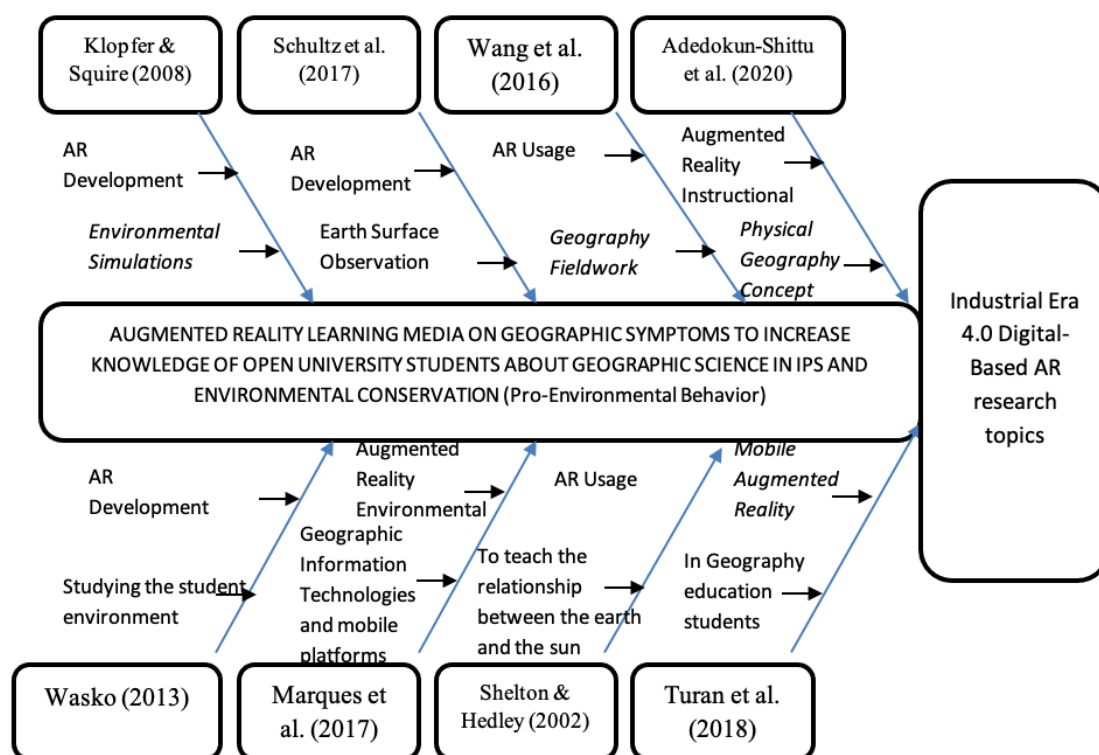


Figure 1. Roadmap from Previous Research.

Figure 1 shows that AR materials differ between this study and others. This study focused on geographic phenomena rather than geography teaching, which had been done before. In earlier studies, AR learning media improved students' understanding, but in this study, it improved students' pro-environmental behaviour, which will be validated in future research. Therefore, the application of learning media using augmented reality to Open University students can be said to be something new. Therefore, the state of the art in this research is contemporary issues related to the development of learning materials that are integrated into the industrial revolution 4.0 to encourage the development of learning technology in this era which demands progress in the field of education.

2. METHODS

The method and steps of R & D in this research refer to the research and development design developed by (Borg, 2014). Before that, a need assessment was carried out with measuring tools that had been developed. This development model consists of 10 implementation steps, namely:

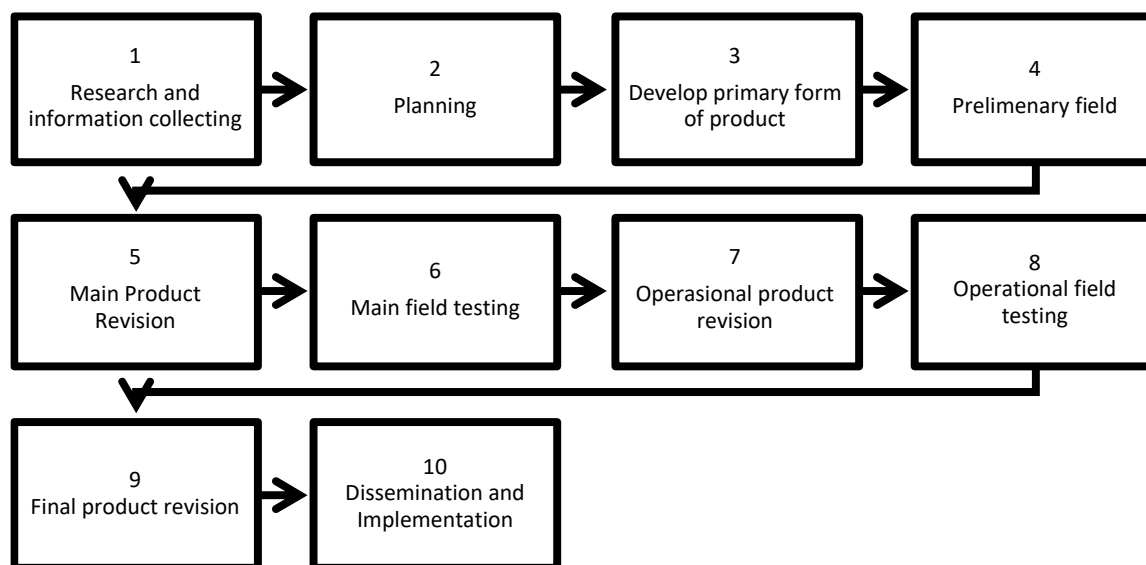


Figure 2. R&D Procedure (Borg, 2014).

Based on this scheme, the product resulting from this research was developed with the following steps:

1. Research and information gathering on the analysis of the needs of the Open University students for the material of geographical phenomena that will be used as a product.
2. Product planning, namely the planning of materials, measuring instruments, and designs.
3. Product development, which is starting to make products according to the plans that have been made.
4. Initial field testing, namely product testing.
5. Product revision.
6. Main field test. The main field test was carried out on 50 subjects, namely a pretest (before treatment) and then a posttest (after being given treatment) on student learning outcomes about geographical phenomena, and an initial questionnaire about pro-environmental behaviour was given.
7. Revision of operational products.
8. Operational field test. Operational field tests were conducted on 50 subjects, namely a pretest (before treatment) and then a posttest (after being given treatment) student learning outcomes about geographic phenomena, and an initial questionnaire about pro-environmental behavior was given.
9. Final product revision.
10. Dissemination and implementation.

3. FINDINGS AND DISCUSSION

3.1. Need Assessment Results

Of the ten lecturers, 5 lecturers from the geography education study program and 5 lecturers from the GIS UPI Bandung study program, 6 lecturers of geography education at UNJ, and 5 lecturers of geography education at UNY indicated that the most difficult material in geography for students was geographic phenomena, including mountains fire, earthquake, and tsunami. Of all the answers, all

lecturers explained the need for AR learning media to explain to students so that they were easy to understand. This is because AR media can make time to explain efficiently, clearly, and relevant to material that is difficult for students to understand, easy to access, and can reduce previously existing obstacles. Furthermore, written information is also needed from AR media to be made and not just 3D images of volcanoes, earthquakes, and tsunamis. This is to make it easier for Open University students to memorize them in terms of naming. In addition, other inputs are the need for concrete examples of volcanoes in Indonesia, earthquakes, and tsunami events that have occurred in Indonesia.

3.2. AR Dummy Results Geography on Earth's Surface

3.2.1 Volcanic Eruption

Volcanic eruptions are natural events in the form of magma coming out to reach the earth's surface. This event is related to the symptoms of volcanism, namely all processes of magma rising to the earth's surface. Some volcanic eruptions are explosive, and some are effusive. As the name implies, explosive means eruption, characterized by the release of magma accompanied by an eruption. Meanwhile, effusion is the process of weak magma coming out in the form of a melt.

Why are there volcanic eruptions that are explosive and effusive? The type of eruption is determined by the characteristics of the magma from the volcano itself. Acidic rhyolitic magma, with high silica and gas content, will be vicious and trigger explosive eruptions. On the other hand, alkaline basaltic magma, with low silica and gas content, will be liquid so that it does not trigger an explosive eruption but is effusive or melt. Volcanoes in areas where tectonic plates meet, such as Indonesia, the Philippines, and Japan, tend to erupt explosively. Meanwhile, in areas with divergent plate motions, such as Hawaii and Iceland, the eruptions tend to be effusive.

In volcanic eruptions, various types of material are produced, namely lava, pyroclastic, and gases. Lava material in the form of hot melt and incandescent. In Indonesia, lava tends to be thick so that it only reaches areas close to the centre of the eruption. At night, lava flows often appear fiery red in the volcanic cone region. Pyroclastic material comes from the word pyro, which means fire and clastic, which means lump. This material is in the form of hot rocks. When an explosive eruption occurs, there is often a scattering of various types of pyroclastic material in the form of volcanic ash, sand, gravel, and pumice, to larger chunks of rock. All this scattered material is known as tephra. In addition to falling pyroclastic, there is also flow pyroclastic. Piles of lava around the center of the eruption, which are unstable and exposed to pressure and volcanic earthquakes, will fall down the slope. The rock material falls down the slope at high speed and is still hot, releasing gases that look like plumes of smoke. This material is often known as hot clouds or *nuee ardente*.

The type of eruption hazard does not only occur during the eruption but also after the eruption. The type of hazard posed during the eruption is called the primary hazard, while the post-eruption hazard is a secondary hazard. Lava is an example of a secondary hazard. Lahar is a high-speed mud flow that occurs because the impermeable material resulting from the eruption is dismantled and mixed with rainwater. Lahars have a wide range and the following are examples of volcanoes in Indonesia, namely *Tangkuban Perahu* mountain:

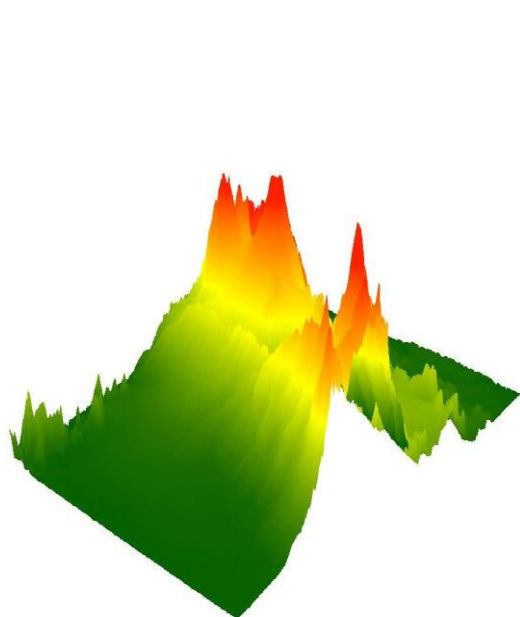


Figure 3. Map of *Tangkuban Parahu* Mountain in Side View

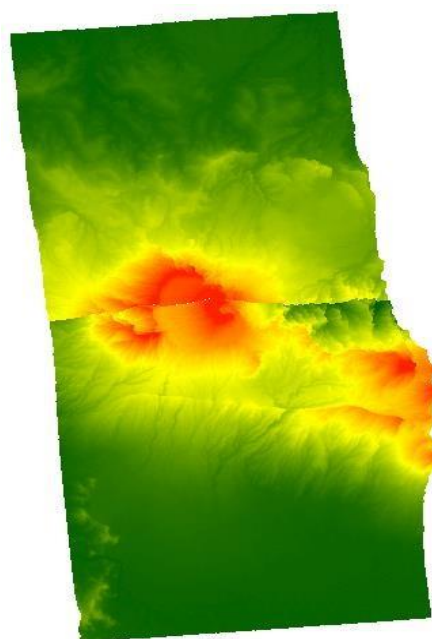


Figure 4. Map of *Tangkuban Parahu* Mountain in Top View

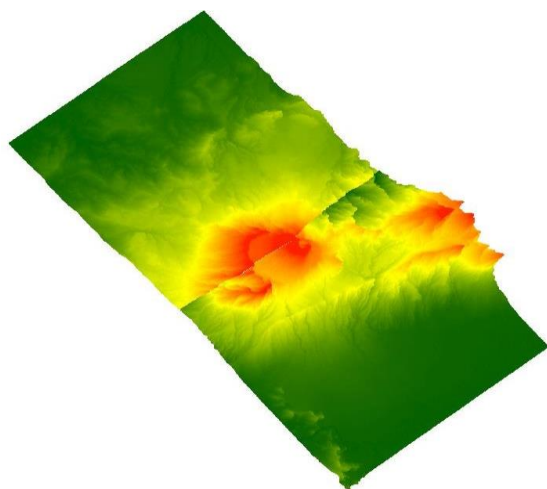


Figure 5. Map of *Tangkuban Parahu* Mountain on Top View Slightly Slanted

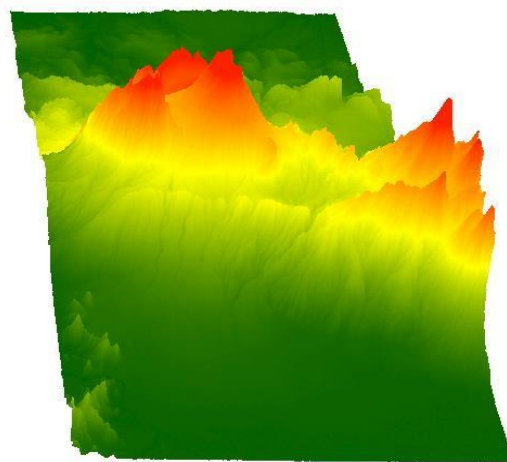


Figure 6. Map of *Tangkuban Parahu* Mountain on Top View Slanted

3.2.2 Earthquake

Earthquakes are natural vibrations that occur on the earth's surface. These vibrations occur due to the rapid release of energy. Based on the source of energy, earthquakes can be divided into tectonic earthquakes, volcanic earthquakes, collapse earthquakes, and meteoric earthquakes. Tectonic and volcanic earthquakes are the most common types. Tectonic earthquakes occur due to the release of energy in the collision zone of tectonic plates. Volcanic earthquakes are vibrations that accompany the process of magma rising to the earth's surface. Collapse earthquakes occur due to the collapse of rock masses, while meteoric earthquakes are vibrations that occur due to extraterrestrial objects hitting the earth's surface.

Tectonic earthquakes are the types of earthquakes that have the greatest energy and have the widest impact. Meanwhile, volcanic earthquakes produce weaker energy and are limited in the area around the body of an erupting volcano. Tectonic earthquakes have strong vibrations because they get a large accumulation of energy from collisions between tectonic plates. Plate collision areas such as Indonesia and Japan experience many earthquakes every year. Large earthquakes often repeat within a certain period. Why can this happen? According to the elastic rebound theory, various types of rock in the tectonic plate collision area have elasticity. Therefore, when a collision occurs, there is no immediate release of energy. The rock can still maintain elasticity while accumulating energy. In the event of a tectonic earthquake, the centre of the earthquake is in the earth's crust which is called the focus or hypocenter. A point on the Earth's surface that is perpendicular to the focus is called the epicenter or epicenter. This term comes from the word epi which means surface and center which means center. From the focus, the earthquake energy spreads as earthquake waves. There are three types of earthquake waves, namely primary, secondary, and surface. Primary waves move straight ahead so they are the fastest. Secondary waves move like swings with peaks and valleys. Meanwhile, surface waves move first to the surface and then spread. Due to the nature of this kind of propagation, surface waves are the slowest but have a very large impact in causing damage. The following are the types of faults and faults that can cause earthquakes (ESDM, 2012):

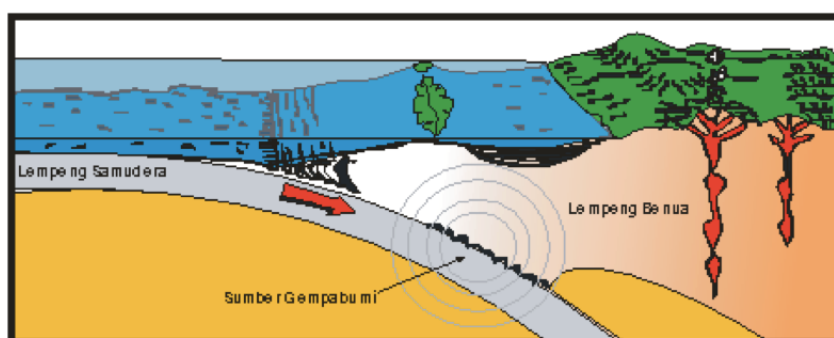


Figure 7. Earthquake Process.

3.3.3 Tsunami

A tsunami is a Japanese term used to describe a type of strong and destructive ocean wave in coastal areas. Tsunami comes from the words tsu and nami which means harbor waves. This tsunami is a sea wave, but the process of occurrence is different from the ocean waves that are encountered every day. Ocean waves that are encountered every day are formed due to wind blows, while tsunamis are formed due to the release of large amounts of energy on the seabed which disturbs the balance of seawater. This energy can be caused by the occurrence of faults or faults on the seabed (Mareta, 2018):

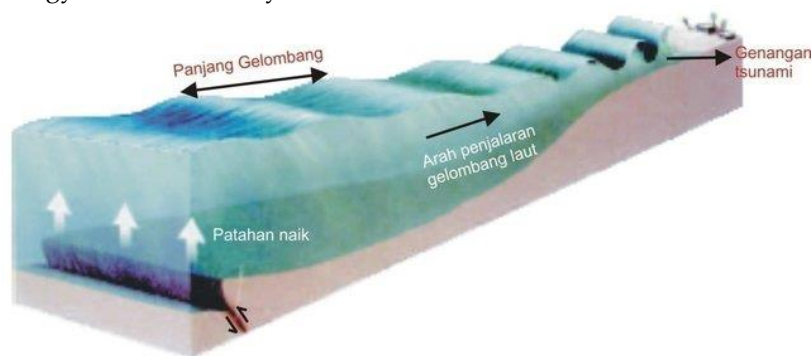


Figure 8. Faults that can create a Tsunami

The most common cause of tsunamis is earthquakes. However, not all earthquakes can generate tsunamis. An earthquake can trigger a tsunami if it occurs on the seabed with a large magnitude and shallow depth. Earthquakes that occur on the seabed will cause disturbances to the balance of seawater. In the process of achieving balance again, ocean waves will form that move quickly in various directions. This high speed will be very dangerous if it enters shallow water. Waves with high speed will experience sudden braking in shallow water to form high and strong wave sweeps towards the mainland. In addition to earthquakes, tsunamis can also be caused by volcanic eruptions on the seabed, as happened in the eruption of Mount Krakatau in 1883.

Research into Augmented Reality, as explained by (Lee, 2012), seeks to create technologies that enable the seamless insertion of computer-generated digital content into the physical world in real time. Users of Augmented Reality systems can superimpose two- or three-dimensional digital content onto their physical surroundings. (Augmented Reality Interface Design & Development). Webcams, PCs, Android phones, and specialised glasses are just some of the devices that can be used to experience this augmented reality. Users in the actual world cannot see virtual items directly; instead, computers and cameras must act as mediators to integrate the objects into the real environment so that they may be identified.

Data displayed by virtual objects is outside the range of human senses. Because of this, augmented reality can be used to improve how its user perceives and engages with the physical world around them. Users are aided in their real-world endeavours by the data shown by virtual items. According to Azuma (1997), augmented reality is the merging of the virtual and physical worlds through the use of computer-generated imagery and other sensory input to create a fully immersive, interactive experience. With the right display technologies and input devices, it is possible to blend actual and virtual things, but for seamless integration, tracking is essential. According to research by Wu et al. (2013), augmented reality allows users to superimpose computer-generated imagery over a live video feed of their surroundings.

Augmented reality, in contrast to virtual reality, just adds virtual things to the real environment, rather than replacing it (Huang et al., 2019). Seems like a breeze. But augmented reality is so much more than merely superimposing computer-generated imagery on the real world. To integrate and run interactively in a real-time context, augmented reality is a technology that integrates virtual things (both dimension 2 and/or dimension 3) with actual objects in a real environment with dimension 3, then displays these virtual objects in real time. in actuality (Lee, 2012). Similarly, the purpose of this research is to make Open University students' geographies classes more engaging by projecting natural disasters like earthquakes, tsunamis, and volcanoes.

4. CONCLUSION

Based on the results that have been obtained, it is necessary to use augmented reality learning media to improve understanding and environmental preservation for Open University students. This can also be applied to students at other universities. In addition, this article also discusses the AR design needed to create AR for geographic phenomena. It is hoped that the AR design for geographic phenomena in this article can be useful in applying augmented reality material for geography in social studies for lecturers who want to develop it as a learning medium for students.

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Conflicts of Interest: No conflict of interest.

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