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Innovation of Integrated Inquiry Project Learning Model for Ethnoscience and Socioscientific Issues with Virtual Reality (VR) Media on the Topic of Mangroves to Realize Sustainable Environmental Literacy

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Abstract

This research aims to produce an Integrated Inquiry Project Learning Model for Ethnoscience and Socioscientific Issues with Virtual Reality (IIPjLM Etho-SSI with VR) media to provide sustainable environmental literacy for students. This qualitative descriptive research uses data collection, verification, reduction, conceptualization, reconstruction, and scientific explanation activities. The results of the reconstruction of scientific knowledge are used as one of the contents of the virtual gallery on the Virtual Reality (VR) media, with the topic of Mangrove Forests. Data analysis was carried out descriptively and qualitatively to explore and reconstruct scientific knowledge regarding mangrove forests from community science. The results of the research and discussion can be concluded as follows: (1) an integrated Ethno-SSI Inquiry Project Learning Model has been produced along with valid, engaging and innovative Student worksheet learning tools, along with valid, engaging and innovative Ethno-VR media, (2) a valid and interesting Virtual Reality (VR) media has been produced with the topic of the Mangrove Forest Museum based on spatial and You Tube applications which consist of nine virtual galleries and content on Mangrove forest knowledge, technology, benefits of Mangroves, and pros and cons of Mangrove forests in the context of ecology, social, culture, science and technology, along with scientific reconstruction products, (3) a positive response has been produced by students regarding the presentation of the virtual gallery of the Mangrove forest and it is believed to be able to provide sustainable environmental literacy characters to students.

Keywords: Inquiry Project Learning Model, ethno-SSI, mangrove, environmental literacy

Introduction:

The background of this research refers to the Vision and Mission of Universitas Negeri Semarang (UNNES), namely to become a conservation-oriented university, a pioneer of educational excellence with an international reputation (1). This research focuses on Mangrove forests because Indonesia has the potential for vast Mangrove forests and serves as a factory of secondary metabolite compounds, beneficial for environmental ecology, economy, development of science and technology, and has the potential to withstand seawater abrasion, so that there is no erosion or flooding (2). Therefore, Indonesia's mangrove forests' natural potential must be preserved so future generations can benefit from them. A sense of concern for maintaining Mangrove forests and the surrounding natural environment needs to be instilled early, especially through education and learning for students majoring in science. Therefore, this research develops Ethno-VR media integrated with the Inquiry Project Learning Model (IPjLM) as an innovative learning model to instill the character of sustainable environmental literacy and Mangrove conservation in students. This research is related to Mangrove Forests, because currently Mangrove Forests in Indonesia as a

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northern coastal ecosystem are very important, even having a vital role in carbon absorption (up to 10 times more effective than mainland tropical forests), resistance to abrasion, protection from storms, and as a nursery area for various types of marine biota (3,4).

However, the existence of mangroves is currently very threatened by various anthropogenic activities such as land conversion for shrimp ponds, agriculture, coastal development, pollution, and deforestation. In Indonesia, from 1980 to 2019, there has been a loss of mangroves of around 182,091 ha, which has contributed significantly to CO_2 emissions, considering that the emission factor from mangrove deforestation is estimated at 136.9 $MgCO_2$-e per ha per year (5). In addition, due to climate change and rising sea levels, the rate of Mangrove land recovery is often lagging, limiting natural migration to land and sedimentation blocks, thus accelerating the decline in the health of its ecosystem, making it important to maintain the sustainability of Mangrove Forests through science learning. With this, researching to provide Mangrove forest literacy through an integrated Ethno-SSI Inquiry Project learning using VR media is important. In the early stages of the research, group work activities were carried out to design IPjLM Ethno-SSI using VRmedia as a form of innovative learning to instill sustainable environmental literacy (6). This research is on the target area of SDGs in the environmental sector, the UNNES 2024-2029 strategic plan (1, 6), and its benefits for life and the environment. The design of IPjLM Ethno SSI assisted by VR can provide an inquiry experience through a virtual gallery related to Mangroves, starting from the history and nature of Mangrove forests, benefits in terms of science, economy, and socio culture.

This research also develops a research model assisted by virtual reality media for extraction, isolation, organoleptic testing, and phytochemical analysis activities. The research began with an ethnoscience study through the process of exploring various learning sources in various scientific articles, the internet, and interviews to find the essence of what Mangrove forests are, their role in the context of science, technology, economy, culture, and the advantages and disadvantages related to Mangrove forests [7]. This research was also continued with the process of explanation and reconstruction of scientific knowledge based on community knowledge related to Mangrove plants and their important role for the environment, continued with the discovery of the design of Ethno-VR media for Ethno-SSI teaching materials to scientifically explain Mangrove forests and provide sustainable environmental literacy. So. The application of VR-assisted Ethno SSI IPjLM on the topic of Mangrove Forests can foster a sense of concern for a sustainable environment and conservation character in students after being developed and implemented.

The objectives of this study are (1) to develop VR-assisted Ethno-SSI IPjLM on the topic of Mangroves to provide sustainable environmental literacy, (2) to reconstruct and scientifically explain community knowledge about the history, benefits, and issues of community science related to Mangrove Plants through content on VR media, (3) scientific explanation of Mangroves and their benefits for life. The urgency of this research is to realize the priority program of UNNES in 2023, namely, realizing a brilliant and leading field of Education, conservation, and world reputation in the field of education. Therefore, the expertise and findings of IPjLM Ethno-SSI assisted by VR will be one of the advantages.

Research Methods

Type and Focus of Research

This research is part of the development research at the design stage of the learning model for the ethno-SSI integrated inquiry project using Virtual Reality media. The research instruments are questionnaires and observation sheets. At the same time, data analysis is carried out descriptively and qualitatively related to the design results of the IPjLM Ethno-SSI using virtual reality media for the topic of mangroves to provide sustainable environmental literacy. The achievement of this research is an analysis related to the meaning of mangrove forests and the benefits of mangrove forests from the aspects of ecology, science, economy, and society.

Research Stages

The development stage of the Ethno-VR Mangrove Topic media is still developing, and the virtual gallery is being filled with the Ethno-VR media. It has not been carried out to collect research data. At this stage, several products were produced from the inquiry project related to (1) Student Modules and Worksheets for the learning device for the Ethno-SSI integrated inquiry project using Virtual Reality media, (2) products from Virtual Reality media related to the Mangrove museum as a medium to provide environmental literacy characters, and (3) student response products to the IPjLM Ethno-SSI using Virtual Reality media.

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Research Results and Discussion

Observation Results and Exploration of Forest Plants on the North Coast Indonesia is a country that has the most productive and largest Mangrove ecosystem in the world, with a variety of flora and fauna, namely around 157 Mangrove species located on large islands such as Java, Sumatra, Kalimantan, Sulawesi, and Papua [8]. In this research, several major Mangrove plants have been found on the North Coast of Java, namely the *Avicennia, Rhizophora, Bruguiera, Ceriops, Kandelia, Sonneratia, Lumnitzera, and Nypa species* [9]

Figure 1. Observation Results related to types of Mangroves on the North Coast

In this research, the observation results were documented in the learning resource of the Student Worksheet on the Mangrove Forest Topic to provide sustainable environmental literacy, as shown in Figure 2.

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Figure 2. Mangrove to integrate ini Student Worksheet Product Developed Link: https://drive.google.com/drive/folders/141NvbF960vhspfsJehV5G7gmS-jkFuOY

The Student Worksheet presents the Ethno-SSI Integrated Inquiry Project Learning Syntax, as follows (1) Ethno Socioscientific Problem Orientation Phase of Mangrove Plants: This section presents various Mangrove plant issues related to (a) Environmental issues, namely environmental damage to mangrove forests such as physical damage to habitats, excessive exploitation and conversion of mangrove forests, ineffective conservation and rehabilitation activities, and low community involvement in managing mangrove resources, (b) Social issues, related to social conflicts related to the use of mangrove forests, the increasing number of poor people in coastal areas, especially fishing communities, and the lack of well organized community groups in managing Mangroves which include planning, implementation and maintenance, (c) Economic issues, including: There are still many potential economic activities that have not been developed, various mangrove potentials that can generate sustainable income have not been utilized, and the low knowledge and skills of the community regarding the implementation of aquaculture techniques that can increase income. Phase 2: Problem Identification, in this section, exploration and identification activities are carried out regarding the problems (controversial issues) regarding mangrove plants in the context of Ethno SSI, namely related to "Utilization of Natural Mangrove Dyes as Ecoprint" in terms of health, culture, environment/sanitation, religion, and social. Mangrove leaves contain Tannin, so this tannin plays an essential role in making Ecoprint, and students are trained to make Ecoprint by referring to references [10-12].

Phase (3) is the Exploration phase, in which interviews, observations, and documentation related to the IPjLM Ethno SSI Inquiry Project using Virtual Reality media related to the Mangrove museum project to improve the environment are carried out. In the virtual reality content, there are interview activities, and this documentation is carried out to obtain data on the community's original knowledge related to the manufacturing procedure, benefits of the ecoprint products made, and controversial issues. In this section, students are encouraged to make ecoprint products in groups, and tutorials are presented in the following link.

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Figure 3. Tutorial on Making Ecoprint from Mangrove Leaf Waste to Develop Environmental Literacy Character
Link. https://www.youtube.com/watch?v=jcboU0wdM-s

are presented, starting from photographic documents of observation activities, interviews, and various types of Mangrove

In the fourth phase, the Publication and Communication Phase, in which this activity is carried out, exploration activities forest tourist attractions in Indonesia, as presented in Figure 3.

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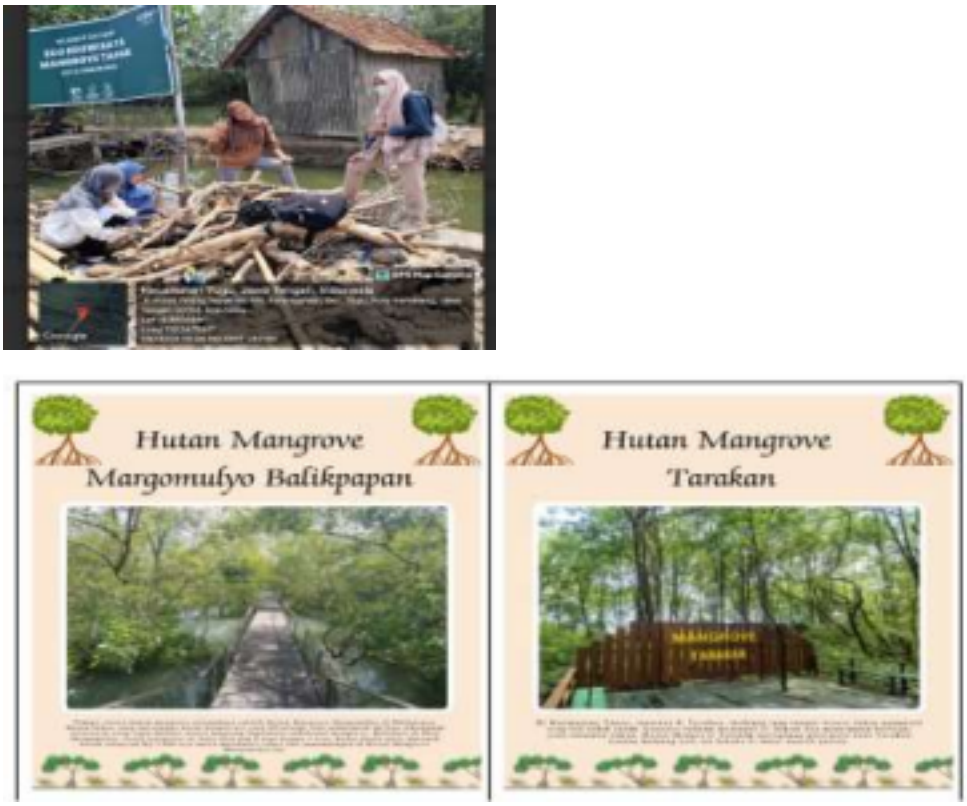

Figure 3. Publication and communication stage of documentation activities in the Mangrove Forest Ethno-SSI Inquiry Project

Results of Ethno-VR Ecoprint Media from Mangrove Leaf Waste to Provide Environmental Literacy for Students

In this research, a product from Ethno-VR media was also produced to make Ecoprint from Mangrove leaf waste to equip environmental literacy for students. This project was carried out in groups to deliver the product "Batik Ecoprint from Mangrove leaf waste"; the process and results are presented in Figure 4.

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Figure 4. Video of making Ecoprint with 360 video from Mangrove leaf waste to equip environmental literacy characters,
Link and scan Qris: https://me-qr.com/9zanUofr

The results of making the Ethno-VR Ecoprint Mangrove media product with 360 video from Mangrove leaf waste received a very good response, where the Ecoprint video product was interesting, innovative, and creative, based on the assessment of lecturers and fellow students.

Mangrove Museum's Ethno-VR Media Products to Equip Sustainable Envi-ronmental Literacy Characters

In this research, the results of the group's work produced Ethno-VR media for the Mangrove forest museum to equip sustainable environmental literacy characters with spatial applications. This inquiry project was carried out during six meetings starting from meetings (1) project preparation, training in making Virtual Reality based on spatial applications, (2) preparing assets such as videos, images, YouTube, posters, and recordings of practicums for virtual gallery content, (3) creating a student team account for making the Ethno-VR Mangrove Museum on the spatial application, (4) entering all available assets and prepared in virtual gallery content in several virtual gallery rooms on the spatial application, (5) testing the Ethno-VR media product for the Mangrove museum, followed by improvements, so that it is engaging and adaptive, and stage (6) recording the Ethno-VR product for the Mangrove museum to be used in the downstreaming of this expert research in the mini research course.

The Ethno-VR media product for the Mangrove museum to equip sustainable environmental literacy for students with applications is presented in the following link https://www.spatial.io/s/vrp_2024s-Digital-Area 66b9a4ab7e254af5873c2d6b. Meanwhile, the summary results of the Ethno VR Mangrove Museum in the form of YouTube are presented at the following link https://www.youtube.com/watch?v=dl2feHwvdhc, which YouTube has a virtual gallery context, as presented in Table 1.

Table 1. Results of the Mangrove Forest Museum's Ethno-VR Media Products to Provide Sustainable Environmental Literacy

	No Virtual Reality Gallery Components and Sequence	Visual Content Gallery View presented

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01	Introduction to opening VR media: The introduction is preceded by the UNNES Conservation March, followed by a gallery space showing the benefits of mangroves in the context of daily life from a scientific, economic, social and ecological perspective	
03.	Cinema Room: Mini cinema room: Contains interesting documentary films about Mangrove plants.	
04.	Virtual Gallery Space Technology related to various efforts for conservation, cultural power and preserving Mangrove plants, both physically, biotechnologically, and traditionally.	
05.	Gallery space that presents posters or news related to pros (agree) and cons (disagree) regarding the issue of forests and mangrove plants on the North Coast of Java and its communities, as well as their impact on the environment,	
	economy, flooding, tidal flooding, socio-culture.	
06.	Virtual gallery space of history and scientists related to Mangrove conservation, community figures who saved Mangroves both in Indonesia and the world, along with several documentaries related to Mangroves.	

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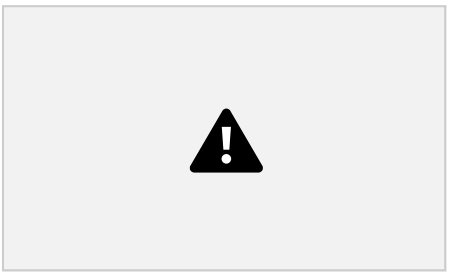
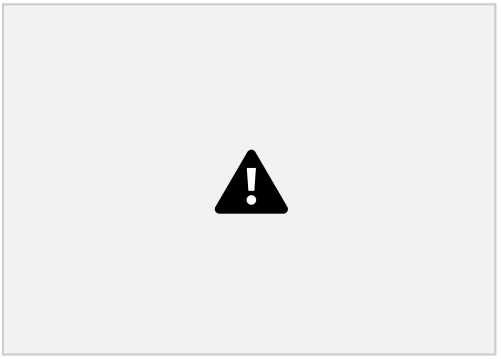
07	Virtual gallery related to the observation and interview project activities on mangrove plants in the Tapak and Tirang Coastal Mangrove Forests, Semarang Central Java	
08	Virtual tour room about various Mangrove Tourism places in Indonesia, starting from the North Coast of Jakarta to the North Coast of East Java.	
09	The Closing Virtual Gallery Room contains photos of the components of the virtual reality mangrove museum, and Farewell to the Virtual Mangrove Gallery Museum	 

The results of the development of the Etno-VR media received a positive response from students after implementation. Students believe that the Etno-SSI inquiry project learning model using VR media can provide sustainable environmental literacy characteristics.

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Conclusion

The results of the research and discussion can be concluded as follows: (1) an integrated Ethno-SSI Inquiry Project Learning Model has been produced along with valid, engaging, and innovative Student worksheet learning tools, along with valid, interesting, and innovative Ethno-VR media, (2) a valid and interesting Virtual Reality (VR) media has been produced with the topic of the Mangrove Forest Museum based on spatial and YouTube applications consisting of nine Virtual galleries and content on Mangrove forest knowledge, technology, benefits of Mangroves, and pros and cons of Mangrove forests in the context of ecology, social, culture, science and technology, along with scientific reconstruction products, (3) a positive response has been

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