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Development of Ethno-Virtual Reality Media in Biotechnology Project Learning to Realize Collaborative and Creative Skills

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Abstract

The development of Ethno-Virtual Reality (Ethno-VR) media in biotechnology project learning aims to analyze its development process, characteristics, validity, and practicality. This study uses a Research and Development (R&D) approach with the ADDIE model, covering five stages: Analysis, Design, Development, Implementation, and Evaluation. However, the implementation stage has not yet been carried out. The research subjects were Class X-4 students at SMA Negeri 1 Randudongkal. Data collection techniques included interviews, characteristic and validation questionnaires, and teacher and student response questionnaires. The findings show that Ethno-VR media received an excellent rating of 92.10% for its content and cultural feasibility, integration with ethnoscience, alignment with project-based learning, and potential to foster collaborative and creative skills. The media was deemed highly valid, with material validation scores of 96.66% and media validation scores of 94.60%. Its practicality was also rated very high, with teacher response scores at 93.75% and student responses at 86.48%. In conclusion, the developed Ethno-VR media demonstrates excellent characteristics, high validity, and strong practicality, making it highly suitable for implementation in high school biotechnology project learning.

How to Cite

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INTRODUCTION

The rapid development of science and technology in the 21st century requires strengthening the quality of superior human resources to face the dynamics and challenges of competition in the world of work in the era of globalization (Primadianningsih et al., 2023). The world of education must prepare itself to hone student skills that are relevant to facing the challenges of the modern world in the 21st century (Mardiyah et al., 2021). The main skills that must be emphasized in facing the challenges of the 21st century include critical thinking and problem solving, collaborative, communicative, and creative (Jannah & Atmojo, 2022). Collaborative and creative skills are needed in the world of work, especially those that prioritize teamwork and creative innovation to produce new products (Anggraeni et al., 2021). Students must be equipped with these skills as early as possible through the learning process at school (Qomaria & Wulandari, 2022). Teachers have a very important role in realizing a better future for students through 21st century learning (Qulsum & Hermanto, 2022). Teachers in the modern era must be proficient and adaptive to the use of technology and act as facilitators for students in creating interesting learning (Hadisaputra et al., 2018).

The results of interviews with biology teachers at SMA Negeri 1 Randudongkal in November 2024, collaborative and creative skills have not been optimally embedded in students. The teacher explained that in learning activities, he often encountered students who were picky about friends during group division and did not invite friends who were not liked to have discussions together. Research by Qomaria & Wulandari (2022) also states that collaborative problems that often arise include students' difficulties in dealing with differences of opinion between group members and the lack of motivation to solve problems together. This, if not resolved immediately, will have a negative impact on students' social relationships, such as triggering conflict and causing students to have an individualistic attitude and a fading attitude of caring for others (Oktarina & Ahmad, 2023). The teacher also explained the relationship with students' creative thinking skills, where the teacher felt that students were less responsive in answering questions from the teacher. Students need quite a long time to think about answering, and often the teacher has to give a stimulating sentence first. Students also tend to answer questions with very general answers and do it together. The teacher felt that students did not develop their ideas, because they only answered according to the explanation received from the teacher.

The biology learning process applied by the teacher still uses conventional methods through lectures using Power Point media and showing videos via Youtube, then students are invited to discuss related to the explanation given by the teacher and video shows. The use of technology in the learning process by teachers is limited to the use of internet access for Youtube, Google Form, Google Drive and Quiz. Teachers have also never developed their own learning media due to the limited ability of teachers in mastering existing technology. Research conducted by Aditama et al. (2019) also mentioned that the reason teachers have never developed their own learning media is because, teachers find it difficult to design technology-based learning media and teachers also have difficulty in operating technology-based learning media. Putra (2019) mentioned that teachers have several challenges in using technology including internal challenges and external challenges. Internal challenges faced by teachers such as lack of teacher creativity and lack of teacher ability in using technology. External challenges faced by teachers are related to the lack of availability of facilities and infrastructure in supporting the implementation of technology-based learning.

The biology learning process also needs to be associated with ethnoscience, especially on biotechnology material that needs to be taught contextually and applicatively (Muliadi et al., 2021). The ethnoscience approach facilitates students in exploring and reconstructing it in pure science learning (Atmojo et al., 2019). Integrating ethnoscience in learning can increase students' interest in learning, love local potential that lives in the community, and increase local wisdom values that can lead students to become individuals with character (Sudarmin et al., 2018). The results of the interview also explained that the learning process had not been integrated with local wisdom so that students did not understand the local potential of their region. Research conducted by Pangestika & Yansaputra (2021) argues that the lack of students' level of knowledge of the local potential of their region is feared to result in gradual extinction if not properly maintained and preserved. One of the local potential areas that can be developed is honey pineapple typical of Pemalang Regency (Munahefi & Melisawati, 2020). The honey pineapple produced has been partially processed into processed products such as jam, dodol, sweets, and pineapple chips. These

processed production activities produce pineapple peel waste up to 5.12 tons of total production and have not been properly processed, potentially causing new problems for the environment (Umami & Rahayu, 2024). One of the biotechnology innovations that can be developed is by integrating local wisdom through project activities to utilize honey pineapple peel waste into nata de pina. The importance of incorporating the value of local wisdom into the learning process at school through project-based activities is to maintain its sustainability (Nurfitriani et al., 2017). Students through project learning can design, solve problems, make decisions, conduct investigations, and train student character (Sudarmin et al., 2024).

The need for innovative development in the form of digital learning media suitable for 21st century learning in overcoming problems and difficulties in the learning process of biotechnology material in high school. Ethno-Virtual Reality based media can be the right solution by presenting the environment in the form of simulated reality in real world events that make students have a sensation of presence in the virtual or virtual world (Ladjidji et al., 2024). The integration of Etno-VR media in learning the biotechnology project of making nata de pina presents a more interactive and immersive learning environment in accordance with the needs of Generation Z students and the demands of 21st century skills, one of which is to realize the collaborative and creative character of students (Ramadhan et al., 2024). Etno-VR media facilitates students in exploring biotechnology material comprehensively, contextually based on the real environment, and practically through experimental nata de pina project activities. Research related to virtual reality media has previously been conducted by Suleman et al. (2019) about the development of 3D media integrated with Virtual Reality in learning chemistry reaction rate material. The results of media validation obtained a percentage score of 78% in the good category and had an influence on student learning achievement. Similar research related to Virtual Reality media was also conducted by Monita & Ikhsan (2020) has developed application media on smartphones integrated VR-IPA for solar system material. The results of validity, practicality, and students' responses to the VR-IPA media that have been developed obtain a very good category.

Research related to the development of Ethno-Virtual Reality-based learning media on biotechnology learning is important to do as well as a means to introduce the potential of regional local wisdom presented in an attractive form. This study aims to analyze the process of developing Etno-Virtual Reality media, analyze the characteristics of Etno-Virtual Reality media, and analyze the validity and practicality of Etno-Virtual Reality media.

M ETHOD

The type of research used in this study is Research and Development (R&D). The product developed in this study is in the form of Etno-Virtual Reality (Etno-VR) based learning media on biotechnology project learning to realize collaborative and creative skills. Collaborative skills include indicators of actively contributing, working productively, showing flexibility and compromise, showing responsibility, and showing an attitude of respect (Mansur et al., 2022). Creative skills include indicators of fluency, flexibility, and originality (Hanifah et al., 2024). The research design used follows the model developed by Branch (2009) namely ADDIE. The ADDIE development model consists of five stages, namely Analysis, Design, Development, Implementation, and Evaluation.

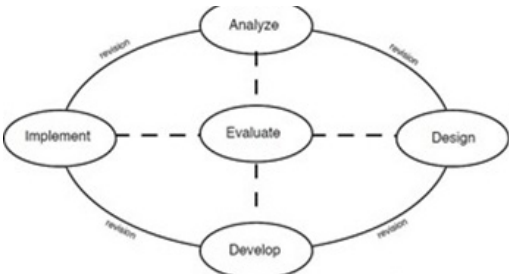


Figure 1. ADDIE Approach (Branch, 2009)

The development of Etno-VR media starts from the analysis stage which consists of media needs analysis, student analysis, and material concept analysis. The analysis stage by conducting interviews and observations with teachers and students at SMA Negeri 1 Randudongkal in November 2024 to obtain information related to problems that exist during the learning process that has been implemented, media needs, student characteristics, and material concept analysis. The design stage is carried out by compiling a storyboard design of the Etno-VR media to be developed and collecting material content from the media. At this stage, the instrument preparation of expert validation sheets, characteristic sheets, teacher response questionnaires and student responses was also carried out. The development stage is carried out by completing the manufacture of Etno-VR media which is then tested for media characteristics, expert validation tests, media

practicality tests, and making revisions based on input and suggestions from experts, teachers, and students. The implementation stage in this study has not been carried out for large-scale trials. The evaluation stage is carried out to produce a final product that is characterized, valid, and practical.

The targets in this study were expert lecturers to assess media characteristics, material validation, and media. Biology teachers totaling 2 people and students of class X-4 SMA Negeri 1 Randudongkal totaling 34 people to assess the practicality of the Etno-VR media developed. Data collection in this study was carried out using a media characteristics questionnaire, a media expert validation questionnaire and material expert validation, as well as a teacher response questionnaire and student responses. The data on characteristics, validity, and practicality that have been obtained are then analyzed descriptively quantitatively using the formula according to Sugiono in Noprinda & Soleh (2019) as follows.

$$P = \frac{f}{N} X\ 100\%$$

Description:
P = Percentage of feasibility
F = Number of scores obtained
N = Number of criteria scores

The result values obtained were interpreted in the assessment criteria in Table 1.

Table 1. Research Design

Percentage range (%)	Criteria
$0 \leq p \leq 25$	Less
$25 < p \leq 50$	Simply
$50 < p \leq 75$	Good
$75 < p \leq 100$	Very good

The assessment of Etno-VR media characteristics refers to five aspects, namely, 1) content and cultural feasibility; 2) integration with ethnoscience; 3) integration with project-based learning; 4) potential for realizing collaborative skills and; 5) potential for realizing creative skills. The material validation assessment refers to six aspects, namely, 1) content eligibility; 2) suitability to the curriculum; 3) clarity of presentation; 4) suitability to learning principles; 5) linkage to ethnoscience and; 6) development of collaborative and creative skills. Media practicality is assessed based on teacher assessments and student responses. Teacher assessments are reviewed from seven aspects: 1) ease of use; 2) suitability to curriculum and learning; 3) integration with ethnoscience; 4) student engagement in learning; 5) bringing out collaborative and creative skills; 6) display and audiovisual quality; and 7) media stability and security. Assessment of student responses is reviewed from five aspects, namely, 1) visual and audio display; 2) ease of navigation and interaction; 3) suitability for learning; 4) user comfort and safety; 5) usefulness and attractiveness.

RESULT AND DISCUSSION

The results of the research and development process that has been carried out are in the form of Ethno-Virtual Reality (VR) based learning media that raises local wisdom in honey pineapple processing as a context for learning biotechnology projects. This Etno-VR media displays a real environment simulation based on a museum tour in the form of interactive 2D and 3D visuals, there are educational narratives, posters, songs, and videos that illustrate the concept of biotechnology, local wisdom from honey pineapple, and the traditional nata de pina fermentation process, and there are quizzes and assignments that can encourage students to bring up collaborative and creative skills. Etno-VR media is also equipped with navigation features, instructions for use, learning outcomes and objectives, material galleries that contain project-based learning syntax. Students when using Etno-VR media can explore thoroughly and interact by directing the navigation feature following the arrows on the media, students can press the selected gallery or scan QR to obtain information.

Characteristics of Ethno-Virtual Reality (VR) Media

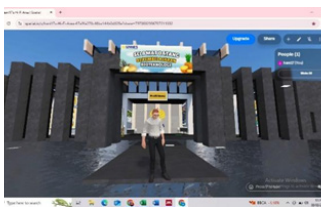
The process of making Etno-VR media goes through several stages including the analysis stage by analyzing media needs, learner characteristics, and analyzing material concepts through interviews and observations of teachers and students. The design stage is carried out by compiling a storyboard design of Etno-VR media and preparing the material content of the media. At this stage, the instrument preparation of characteristic sheets, expert validation sheets, teacher and student response questionnaires were also carried out. The development stage is done by completing the making of Etno-VR media using spatial software. This stage was also carried out a media characterization test which was assessed by three experts. Table 2 represents the results of the validation of Etno-VR media characteristics that have been developed.

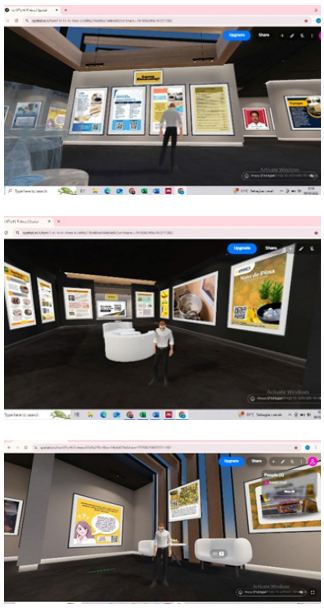
Table 2. Results of Validation of Etno-VR Media Characteristics

No	Aspects	Score			%
		V1	V2	V3	
1	Content and cultural appropriateness	15	15	15	93.75
2	Integration with ethnoscience	10	11	11	88.83
3	Integration with project-based learning	12	12	12	100
4	Potential to realize collaborative skills	22	21	21	88.87
5	Potential to realize creative skills	11	10	12	91.66
Total		**70**	**69**	**71**	
Average (%)		**92.10**			
Criteria		**Very Good**			

Based on Table 2, the developed Etno-VR media has characteristics that are categorized as very good with a total score of 92.10%. The assessment of Etno-VR media characteristics refers to five aspects, namely, content and cultural feasibility, integration with ethnoscience, integration with project-based learning, potential for realizing collaborative skills, and potential for realizing creative skills. All aspects have a very good category, the first aspect, namely content and cultural feasibility, obtained a score of 93.75%, in Etno-VR media contains complete, accurate, up-to-date information and supports the learning objectives of biotechnology which is presented in an attractive, immersive, and realistic manner according to the character of Generation Z era students. In line with research conducted by Maenah et al. (2024), good learning media must contain information in accordance with facts and correct concepts and in accordance with the learning objectives to be achieved. Fathoni et al. (2023) explained that learning media must be able to facilitate communication in learning and achieving goals through the presentation of complete, precise, and updated material, according to Sudaryono & Kartika (2022) also mentioned that the character of Generation Z who has a more visual and interesting learning preference. Etno-VR media also presents local cultural elements in the form of authentic honey pineapple and represents the honey pineapple-based biotechnology process in accordance with scientific principles. The second aspect, namely integration with ethnoscience, obtained a score of 88.83%, the Etno-VR media developed raised the local knowledge of the Pemalang Regency community about the processing and traditional cultivation of honey pineapple. Etno-VR media presents the process of processing honey pineapple skin waste into nata de pina products through traditional practices to foster awareness in students of the importance of preserving local wisdom. This is in line with the opinion of Mufrihah et al. (2024) ethnoscience-based learning can foster a sense of love for local potential that lives in the community. Research conducted by Syaifullah & Hidayah (2024) also stated that integrating local culture into the learning process can foster an environmentally conscious character in students.

The third aspect is integration with project-based learning with a score of 100%, Etno-VR media facilitates students to design and implement projects, this media is equipped with project learning syntax to direct students in making nata de pina based on honey pineapple skin waste which can encourage students to produce a concrete product from biotechnology learning. Syakur et al. (2020) in their research argue that project learning can provide freedom for students to plan, collaborate and work together in producing a product. The fourth aspect, namely the potential to realize collaborative skills, obtained a score of 88.87%, Etno-VR media encourages student contributions in collaboration, provides motivation and support, problem solving & group management, and reflects together with the group in nata de pina making project activities. The fifth aspect of the potential to realize creative skills obtained a score of 91.66%, Etno-VR media presents quizzes and assignments that are able to stimulate fluency of thinking (fluency), flexibility of thinking (flexibility), and generate original ideas (originality). Research conducted by Riskayanti (2021) has proven that project-based learning is able to improve students' collaborative and creative skills, and make students more active in the learning process. Research conducted by Anggraeni & Syafira (2024) also stated that project-based learning can improve students' thinking skills, stimulate creativity, and encourage collaboration in groups.

Features	Description
	Main View of Etno-VR Media



Display of Biotechnology Content and Local Wisdom of Honey Pineapple

Nata de Pina Project Activity and PjBL Syntax

Quizzes and Assignments to Bring Out Collaborative and Creative Skills

Figure 1. The Ethno-Virtual Reality (Ethno-VR)

The Ethno-Virtual Reality (Ethno-VR) media developed in this research has unique characteristics that integrate local cultural elements with virtual reality-based learning technology. This media is designed to present biotechnology material contextually through immersive and interactive learning experiences. The galleries presented in the Ethno-VR media include 1) Introduction; 2) Local wisdom of honey pineapple and its products; 3) Concept of conventional biotechnology material and its products; 4) Nata de pina; 5) Myths and facts about pineapple; 6) Videos and songs about pineapple; 7) Creative products processed from pineapple skin; 8) Traditional cultivation of honey pineapple and; 9) Assignments and quizzes to train the character of mutual cooperation and creative thinking. Figure 1-4 presents the display of the developed Etno-VR media content.

Validity of Ethno-Virtual Reality (VR) Media

This development stage also tested the validity of the material and media aspects carried out by three material experts and three media experts. Table 3. Presents the results of the material expert validation of the developed Etno-VR media. Based on Table 3. we can know that Etno-VR media has material validation which is categorized as very valid with a total score of 96.66%. The material validation assessment refers to six aspects, namely, content eligibility, suitability to the curriculum, clarity of presentation, suitability to learning principles, linkage to ethnoscience, and development of collaborative and creative skills.

Table 5. Content Expert Validation Results

No	Aspects	Score			%
		V1	V2	V3	
1	Content eligibility	16	15	13	91.66
2	Suitability to the curriculum	12	12	12	100
3	Clarity of presentation	12	9	11	88.88
4	Conformity eith learning principles	12	12	12	100
5	Link to ethnoscience	11	10	12	91.66
6	Integration of collaborative and creative skills	16	16	16	100
Total		**80**	**76**	**76**	
Average (%)		**96.66**			
Criteria		**Very Valid**			

All aspects of the material expert assess ment obtained very valid criteria. The first aspect, namely content feasibility, obtained a score of 91.66%. This is because the developed Etno-VR media presents material that is in accordance with the learning objectives, in accordance with the correct, precise, and accurate concepts according to the facts, and the material presented is up-to-date according to the latest innovations. Research conducted by Dheadema et al. (2023) stated that good learning media must present material that is in accordance with the expected learning objectives and the material presented in complete and up-to-date media is in line with scientific developments. The second aspect, namely suitability for curriculum with a score of 100%, the material presented in the Etno-VR media supports the learning outcomes in Merdeka Curriculum, supports project-based learning, and is in accordance with the level of education of grade X students.

The third aspect, namely the clarity of presentation, obtained a score of 88.88%. The material in Etno-VR media is presented in detail and systematically, using language that is easy to understand, not multi-interpretive, and in accordance with the cognitive level of students, making it easier for students to understand biotechnology material. In line with the opinion of Rahmatih et al. (2017) that the presentation of consistent and systematic material content has a major influence on the development of student thinking so that it can make it easier to receive information. Apriliani et al. (2022) also argue that systematic presentation of material can avoid misconceptions in the learning process. The fourth aspect, namely suitability with learning principles, obtained a

score of 100%, Etno-VR media can increase student involvement in learning, provide meaningful learning experiences, and increase student motivation in learning biotechnology material. The fifth aspect, namely the connection with ethnoscience, obtained a score of 100%. The material presented reflects science based on local wisdom of honey pineapple that can increase appreciation and understand the value of local wisdom through learning biotechnology projects. The sixth aspect of integration with collaborative and creative skills scored 100%, the content of the material presented can encourage students to work together collaboratively and bring out creativity through learning biotechnology projects. The results of media expert validation assessed from five aspects, namely, visual and audio display, ease of navigation and interaction, suitability for learning, user comfort and safety, and usefulness and attractiveness are presented in Table 4.

Table 4. Results of Validation by Media Experts

No	Aspects	Score			%
		V1	V2	V3	
1	Visual and audio display	23	20	23	91.66
2	Ease of navigation and interaction	16	14	15	93.75
3	Suitability learning	12	12	12	100
4	User safety and comfort	7	8	7	91.66
5	Usefulness and attractiveness	8	8	8	100
6	Integration of collaborative and creative skills	16	16	16	100
Total		**66**	**62**	**65**	
Average (%)		**94.60**			
Criteria		**Very Valid**			

Based on Table 4. we can know that Etno-VR media has media validation which is categorized as very valid with a total score of 94.60%. The assessment on the first aspect, namely visual and audio display, obtained a score of 91.66% with a very valid category. The Etno-VR media developed has a clear image, graphic, and video display quality, colors and elements do not disturb eye comfort, display visualization of honey pineapple local wisdom culture, display 3D and 2D objects that look real, and audio can be heard clearly and can be adjusted according to user desires. The second aspect related to ease of navigation and interaction obtained a score of 93.75% with a very valid category. Etno-VR media has navigation that is easy to understand, interaction and movement of objects like in the real world and does not experience delays or technical problems when used. The third aspect of suitability for learning obtained a score of 100%, this is because Etno-VR media can support interactive learning of biotechnology projects so as to increase student involvement in the learning process. The fourth aspect of safety and comfort of use obtained a score of 91.66% with a very valid category, Etno-VR media does not cause excessive side effects and does not cause discomfort such as dizziness or nausea. The fifth aspect of usefulness and attractiveness obtained a very good category with a score of 100%, this Etno-VR media is interesting and fun and can facilitate students in exploring and innovating in learning biotechnology. According to Muliadi et al. (2021) in their research stated that biotechnology learning must be taught contextually and applicatively. Through simulated reality can make students feel the sensation of presence in the virtual world so that it is in line with the character of Generation Z who likes interactive learning and can foster student learning motivation (Ramadhan et al., 2024).

Practicality of Ethno-Virtual Reality (VR)

The practicality test of Etno-VR media was also carried out at the development stage through teacher response assessments conducted by two biology teachers and student response assessments conducted by 34 X-4 class students. Table 5. presents the results of the teacher response test to the Etno-VR media developed.

Table 5. Teacher Response Test Results

No	Aspects	Score		%
		V1	V2	
1	Ease of use	14	15	90.62
2	Suitability to curriculum and learning	12	12	100
3	Integration with etnoscience	8	8	100
4	Student engagement in learning	7	8	93.75
5	Bring out collaborative and creative skills	8	8	100
6	Display and audio-visual quality	11	11	91.66
7	Media stability and security	6	7	81.25
Total		**66**	**69**	
Average (%)		**93.75**		
Criteria		**Very Practical**		

Based on Table 5. we can know that Etno-VR media obtained the results of teacher responses which were categorized as very practical with a total score of 93.75%. The teacher response assessment refers to seven aspects, namely, ease of use, suitability to curriculum and learning, integration with ethnoscience, student engagement in learning, bring out collaborative and creative skills, display and audio visual quality, and media stability and security. All aspects based on the teacher response assessment obtained very practical category results. The first aspect related to ease of use obtained a score of 90.62%. Etno-VR media can be used easily, navigation and instructions are clear and easy to understand, and the media runs smoothly without any significant interference. The second aspect of compatibility with the curriculum and learning scored 100%. Etno-VR media presents material that is in accordance with the Merdeka Curriculum, supporting biotechnology learning outcomes through a project-based approach. The third aspect related to integration with ethnoscience with a score of 100%, Etno-VR media integrates local wisdom of honey pineapple and nata de pina making which are relevant to biotechnology learning. The fourth aspect of student engagement in learning scored 93.75%, Etno-VR media can increase students' learning motivation and interest in exploring biotechnology material. The fifth aspect related to bringing up collaborative and creative skills obtained a score of 100%, Etno-VR media can encourage students to collaborate and develop creative ideas through project activities making nata de pina, research Ramadhan et al. (2024) also mentioned that learning using virtual reality media can bring out creative and collaborative skills in students during the learning process. The sixth aspect of display quality and audio visual with a score of 91.66%, Etno-VR media has a visual display in the form of clear and attractive images, animations, videos, 2D and 3D models, colors and designs are comfortable to use, and audio can support understanding of biotechnology material. According to Hanifah et al. (2020) visual presentation in the form of images, animations, and videos can increase interest in reading because it can help students in imagining so that it can strengthen their memories. The seventh aspect of media stability and security obtained a very good category with a score of 81.25%. Etno-VR media runs stably without errors and is safe to use without the risk of inappropriate content.

The results of student responses assessed from four aspects, namely, ease of use (usability), engagement and immersion (engagement and presence), learning effectiveness, and comfort and cognitive load are presented in Table 6.

Table 6. Student Response Test Results

No	Aspects	Score		%
		S_1	S_{34}	
1	Ease of use	9	9	83.57
2	Engagement and immersion	11	10	87.74
3	Learning effectiveness	12	9	89.21
4	Comfort and cognitive load	13	12	85.66
Total		**45**	40	
Average (%)		**86.48**		
Criteria		**Very Practical**		

Based on Table 6. we can know that Etno-VR media obtained the results of student responses which were categorized as very practical with a total score of 86.48%. The assessment on the first aspect related to ease of use obtained a score of 83.57%. This is because Etno-VR media is easy to use in the learning process, navigation and instructions for use are easily understood by students. The second aspect related to engagement and immersion scored 87.74%. Etno-VR media is able to make students feel a real presence in a virtual environment and there are various illustrations such as pictures, videos, songs, and posters so that students are interested in exploring the material presented in the media and want to use this Etno-VR media in the future. This is in line with the opinion of Amalia et al. (2024) that a media that presents diverse illustrations will be more interesting than containing text narratives. Okiningrum & Handayani (2023) also mentioned that the presentation of illustrations in the form of pictures and videos can attract students' interest in learning the material well. The third aspect of learning effectiveness obtained a score of 89.21% with a very practical category. The biotechnology material presented in Etno-VR media is easy to understand, the display is more interesting so that it can motivate students in learning biotechnology. The fourth aspect of comfort and cognitive load obtained a very practical category with a score of 85.66%. Students after using Etno- VR media do not feel dizzy, nauseous, or excessive fatigue. Students also did not find it difficult to understand information and interact with Etno-VR media. The implementation stage in this study has not been carried out, the evaluation stage is carried out by making improvements based on suggestions and input from experts, te-

achers, and students to produce a final product of Etno-VR media that is characterized, valid, and practical so that it is feasible to be implemented in learning biotechnology projects in high school.

The limitation of the Etno-VR media developed is that it focuses only on conventional biotechnology materials, thus not covering other materials in the biology curriculum, such as modern biotechnology or other science topics. Therefore, it is recommended that future research expand the scope of Etno-VR media development to more diverse materials and test its effectiveness at various educational levels and learning contexts, in order to increase the media's usefulness and applicability more broadly.

CONCLUSION

Based on the results and discussion of research on the development of Ethno-Virtual Reality (VR) media has several stages of the process including the analysis stage by analyzing media needs, learner characteristics, and analyzing material concepts. The design stage is carried out by compiling a media storyboard design, preparing material content, and preparing instruments. The development stage is carried out by completing the making of Etno-VR media using spatial software, at this stage the characteristics test, validity test, and practicality test of Etno-VR media are also carried out. Media characteristics have a very good category with a score of 92.10%. The validity of Etno-VR media based on the assessment of material experts and media experts obtained a very valid category with a score of 96.66% and 94.60% respectively. The practicality of Etno-VR media based on the results of teacher responses and student responses obtained a very practical assessment with a score of 93.75% and 86.48% respectively. The implementation stage has not been carried out, and the evaluation stage is carried out by making improvements based on suggestions and input from experts, teachers, and students. It is hoped that future researchers can carry out the implementation stage of the Etno-VR media to assess the effectiveness of the media that has been developed.

REFERENCES

Aditama, P. W., Adnyana, I. N. W., & Ariningsih, K. A. (2019). Augmented Reality in Learning Multimedia. *Prosiding Seminar Nasional Desain Dan Arsitektur (SENADA)* 2, 176-182. https://eprosiding.idbbali.ac.id/index.php/senada/article/view/225

Amalia, R., Sumarni, W., & Widiyatmoko, A. (2024). Development of Augmented Reality on Molecule Geometry to Improve Mental Models of High School Students. *Unnes Science Educational Journal,* 13 (1), 12-19. https://doi.org/http://dx.doi.org/10.15294/usej.v13i1.359

Anggraeni, P., Imswatama, A., & Mulyanti, Y. (2021). Development of LKS with the RME Approach to Develop Students' Creative Thinking and Collaboration Skills. *De Fermat: Jurnal Pendidikan Matematika,,* 4 (1), 74-84. https://jurnal.pmat.uniba-bpn.ac.id/index.php/DEFERMAT/article/view/89

Anggraeni, R., & Syafira, H. (2024). Training Junior High School Students' Creative Thinking Skills through STEM Integrated Project-Based Differentiated Learning. *In Prosiding Seminar Nasional IPA XIV*, 555–563. https://proceeding.unnes.ac.id/snipa/article/view/3739

Apriliani, F., Erlina, Melati, H. A., Sartika, R. P., & Lestari, I. (2022). Development of Intermolecular Force Video Based on Multiple Representations to Overcome Misconceptions. *Jurnal Pendidikan Sains Indonesia*, 10(4), 790–802. https://doi.org/10.24815/jpsi.v10i4.25890

Atmojo, S. E., Kurniawati, W., & Muhtarom, T. (2019). Science Learning Integrated Ethnoscience to Increase Scientific Literacy and Scientific Character. *Journal of Physics: Conference Series,* 1254 (1), 1-6. https://doi.org/10.1088/1742-6596/1254/1/012033

Branch, R. M. (2009). *Instructional Design: The ADDIE Approach*. New York: Springer Science & Business Media.

Dheadema, S. A., Muharini, R., Rasmawan, R., Enawaty, E., & Lestari, I. (2023). Animated Videos as Learning Media on Hydrocarbon Material. *Jurnal Inovasi Pendidikan Kimia,* 17(2), 116–123. https://doi.org/10.15294/jipk.v17i2.40212

Fathoni, A., Prasodjo, B., Jhon, W., & Zulqadri, D. M. (2023). *Media and Learning Approaches in the Digital Age: The Nature, Development Model & Innovation of Digital Learning Media (1st Edition).* Purbalingga: Eureka Media Aksara.

Hadisaputra, S., Hakim, A., Muntari, Hadiprayitno, G., & Muhlis. (2018). Training to Improve Science Teachers' Skills as 21st Century Role Models in Science Learning. *Jurnal Pendidikan Dan Pengabdian Masyarakat*, 1 (2), 274-277. https://doi.org/10.29303/jppm.v1i2.874

Hanifah, Triasianingrum, A., & Yani, I. (2020). Development of E-Booklet Teaching Media for Plantae Material to Improve Student Biology Learning Outcomes. *Journal of Biology Education Research (JBER)*, 1 (1), 10-16. https://doi.org/10.55215/jber.v1i1.2631

Hanifah, N. N., Sari, C. K., Kholid, M. N., & Faiziyah, N. (2024). Students' Mathematical Creative Thinking Ability in Solving Triangle and Quadrilateral Problems. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 8(1), 827-840. https://

doi.org/10.31004/cendekia.v8i1.2532

Jannah, D. R. N., & Atmojo, I. R. W. (2022). Digital Media in Empowering 21st Century Critical Thinking Skills in Science Learning in Elementary Schools. *Journal Basicedu,*6 (1), 1064-1074. https://doi.org/10.4018/jicte.2005070103

Ladjidji, D. A. P., Sudarmin, Kurniawan, C., Ramashani, D. G., Yulianto, A. A., Massora, K., & Widastra, H. (2024). Development of Virtual Reality-Based Ethno-SDGs Learning Media on Colloid Material to Improve Students' Chemical Literacy. *International Journal of Active Learning,* 9 (2), 91-103. http://journal.unnes.ac.id/nju/index.php/ijal

Maenah, Taufiqulloh, & Sudibyo, H. (2024). Development of Interactive Powerpoint Learning Media to Improve Teachers' Professional Competence. *Journal of Education Research,* 5(3), 3272–3282. https://doi.org/10.37985/jer.v5i3.1452

Mansur, N. R., Ratnasari, J., & Ramdhan, B. (2022). STEAM Model on Students' Collaboration and Creativity Skills. *Biodik: Jurnal Ilmiah Pendidikan Biologi,* 8(4), 185-196. https://doi.org/10.22437/bio.v8i4.19123

Mardiyah, R. H., Aldriani, S. N. F., Chitta, F., & Zulfikar, M. R. (2021). The Importance of Learning Skills in the 21st Century as a Demand in Human Resource Development. *Lectura: Jurnal Pendidikan*, 12 (1), 29-40. https://doi.org/https://doi.org/10.31849/lectura.v12i1.5813

Monita, F. A., & Ikhsan, J. (2020). Development of Virtual Reality IPA (VR-IPA) Learning Media for Science Learning. *Journal of Physics: Conference Series,* 1440 (1), 1-7. https://doi.org/10.1088/1742-6596/1440/1/012103

Mufrihah, F., Ellianawati, & Rusilowati, A. (2024). Effectiveness of Digital Teaching Materials with Content Ethnosci- ence in Increase Digital Literacy. *Unnes Science Educational Journal*, 13 (3), 196-204. https://doi.org/http://dx.doi.org/10.15294/usej.v13i1. 13886

Muliadi, A., Imran, A., & Sabrun. (2021). Bioentrepreneurship-Based Biotechnology: Perceptions of Biology Students. *Jurnal Ilmiah Mandala Education*, 7 (4), 321-327. https://doi.org/10.36312/jime.v7i4.2461

Munahefi, D. N., & Melisawati, D. I. (2020). Exploration of Ethnomathematics on Honey Pineapple Fruit in Beluk Village, Belik District, Pemalang Regency. *Delta: Jurnal Ilmiah Pendidikan Matematika*, 8 (2), 161-172. https://doi.org/10.31941/delta.v8i2.1011

Noprinda, C. T., & Soleh, S. M. (2019). Development of Learner Worksheets (LKPD) Based on Higher Order Thinking Skill (HOTS). *Indonesian Journal of Science and Mathematics Education*, 2 (2), 168-176. https://doi.org/10.24042/ijsme.v2i2.4342

Nurfitriani, W., Sumarmi, & Haryono. (2017). Thematic Teaching Materials Based on Local Wisdom for Grade IV Elementary School. *Prosiding Seminar Nasional Mahasiswa Kerjasama Direktorat Jenderal Guru Dan Tenaga Kependidikan Kemendikbud 2016 1-7*. http://journal.um.ac.id/index.php/jptpp/article/view/9760%0Ahttp://journal.um.ac.id/index.php/jptpp/article/download/9760/4612

Okiningrum, A. R., & Handayani, O. W. K. (2023). Effectiveness of Using Nutrition E-Booklet Media on the Level of Knowledge about Balanced Nutrition (Study at SMP Setiabudhi Semarang). *Nutrizone: Nutrition Research and Development Journal,* 03 (02), 22-29. https://doi.org/https://doi.org/10.15294/nutrizione.v3i2.64893

Oktarina, S., & Ahmad, F. (2023). Implementation of Pancasila Values as a Moral Foundation in Building the Character of the Young Generation of Indonesia in the Era of Globalization. *The Indonesian Journal of Politics and Policy (Ijpp),* 5(1), 182–191. https://doi.org/10.35706/ijpp.v5i1.9324

Pangestika, R. R., & Yansaputra, G. (2021). Development of Interactive Multimedia Integrated with Purworejo Local Culture on the Subtheme of the Diversity of My Nation's Culture. *Jurnal Cakrawala Pendas*, 7 (1), 99-109. https://doi.org/http://dx.doi.org/10.31949/jcp.v6i1.2465

Primadianningsih, C., Sumarni, W., & Sudarmin, S. (2023). Systematic Literature Review: Analysis of Ethno-STEM and Student's Chemistry Literacy Profile in 21st Century. *Jurnal Penelitian Pendidikan IPA,* 9 (2), 650-659. https://doi.org/10.29303/jppipa.v9i2.2559

Putra, Z. H. (2019). Challenges and Opportunities for Elementary Teachers in Digital Technology-Based Mathematics Learning in the Era of the Industrial Revolution 4.0. *Prosiding Seminar Nasional Pendidikan Guru Sekolah Dasar Fakultas Keguruan Dan Ilmu Pendidikan Universitas Riau,* 1, 7-19. https://doi.org/10.33578/psn.v1i1.7766

Qomaria, N., & Wulandari, A. Y. R. (2022). Development of Students' Collaborative Skills through Learning with Ethno-Steam Project Approach in Pesapean Context. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 11 (2), 1306-1318. https://doi.org/10.24127/ajpm.v11i2.4586

Qulsum, D. U., & Hermanto. (2022). The Role of Leading Teachers in Strengthening the Profile of Pancasila Students as the Resilience of 21st Century Character Education. *Jurnal Ketahanan Nasional*. 28(3), 315-330. https://doi.org/10.22146/jkn.71741

Rahmatih, A. N., Yuniastuti, A., & Susanti, R. (2017). Booklet Development Based on the Study of Potential and Local Problems as a Supplement to Teaching Materials for Agricultural Vocational Schools. *Journal of Innovative Science Education*, 6 (2), 162-168. https://doi.org/https://doi.org/10.15294/jise.v6i2.14224

Ramadhan, M. N., Samadi, & Hardi, O. S. (2024). Development of PBL-based Virtual Reality

Media to Improve Creative and Collaborative Competencies in Learning Geospheric Phenomena. *Didaktika: Jurnal Kependidikan*, 13 (001), 1017-1032. https://doi.org/https://doi.org/10.58230/27454312.1277

Riskayanti, Y. (2021). Improving Critical Thinking Skills, Communication, Collaboration and Creativity through Project Based Learning Model at SMA Negeri 1 Seteluk. *SECONDARY: Jurnal Inovasi Pendidikan Menengah*, 1 (2), 19-26. https://doi.org/10.51878/secondary.v1i2.117

Sudarmin, Prasetya, A. T., Kusuma, A. H., Setiawan, B., Pujiastut, R. S. E., Zain, H. H. B. M., & Winarto. (2024). How to Increase Students' Global Diversity Character: Study of the Influence of Ethno-STEM-Integrated Project Learning Model on Indonesian Tea Aroma Volatile Compounds. *Pakistan Journal of Life and Social Sciences (PJLSS)*, 22 (1), 4707-4722. https://doi.org/10.57239/pjlss-2024-22.1.00347

Sudarmin, Selia, E., & Taufiq, M. (2018). The Influence of Inquiry Learning Model on Additives Theme with Ethnoscience Content to Cultural Awareness of Students. *Journal of Physics: Conference Series*, 983 (1), 1-6. https://doi.org/10.1088/1742-6596/983/1/012170

Sudaryono, H. N. B., & Kartika, L. (2022). Education-based Green Behavior Internalization Strategy for Generation Z for the Realization of Healthy Environment for Golden Indonesia 2045. *Among Makarti*, 15 (1), 38-51. https://doi.org/10.52353/ama.v15i1.228

Suleman, M., Sugiyarto, K. H., & Ikhsan, J. (2019). Development of Three-dimensional (3D) Visualization Media using Virtual Reality on Chemistry Education. *Journal of Physics: Conference Series*, 1397 (1), 1-8. https://doi.org/10.1088/1742-6596/1397/1/012034

Syaifullah, R., & Hidayah, R. (2024). Ethnoscience Study on the Tradition of Bilih Fishing in Lake Singkarak in Learning as Strengthening Students' Environmental Awareness. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, 10(4), 231–242. https://doi.org/10.36989/didactic.v10i04.4972

Syakur, A., Musyarofah, L., Sulistiyaningsih, & Wike. (2020). The Effect of Project Based Learning (PjBL) Continuing Learning Innovation on Learning Outcomes of English in Higher Education. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal,* 3(1), 625–630. https://doi.org/10.33258/birle.v3i1.860

Umami, H., & Rahayu, E. S. (2024). Development of E-Booklets Making Nata de Pina as a Learning Resource for Biology Technology Innovation Material in the Merdeka Phase E Curriculum in High School. *Jurnal Penelitian Pendidikan IPA*, 10 (10), 7209-7219. https://doi.org/10.29303/jppipa.v10i10.9476.