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Integrating Ethnopedagogy and Virtual Reality in Research-Based Learning for Regenerative Education

Mukhlis[1], Ariyatun[2*], Ika Septiana[3], Wijayanto[4], Ika Arifianti[5]

[1,3]*Faculty of Language and Arts Education, Universitas PGRI Semarang, Indonesia*
[2] *Department of Chemistry Education, Universitas Negeri Jakarta, Indonesia*
[4]*Faculty of Engineering and Informatics, Universitas PGRI Semarang, Indonesia*
[5]*Faculty of Language and Arts Education, Universitas Pekalongan, Pekalongan, Indonesia*

*__Corresponding Author:__ ariyatun@unj.ac.id

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ABSTRACT

This research aims to explore students' perspectives on the application of Ethnopedagogy-based Virtual Reality (Ethno-VR) in supporting regenerative education through a research-based learning approach. The research uses a quantitative approach with a comparative design, involving students from both science and non-science backgrounds. The data collection instrument was in the form of a questionnaire that measured learning engagement, understanding of local culture, ecological awareness, and perception of technological integration. Data were analyzed using ANOVA to see differences by field of study and gender. The results showed that science students had higher learning engagement (M = 21,100; SD = 2,654) compared to non-science (M = 18,615; SD = 3.709), with a significant tendency (F = 4.119; p = 0.052). Understanding of local culture was stronger in science students (M = 18,800) and women (M = 18,444), although the difference was not significant (F = 3,613; p = 0.067). Meanwhile, ecological awareness was significantly higher in science students (M = 17,860; F = 3.013; p = 0.047). On the other hand, the perception of technology integration was more appreciated by non-science students (M = 17,289) and women (M = 17,464), with ANOVA results being close to significant (F = 3,023; p = 0.052). In conclusion, Ethno-VR has the potential to strengthen the cognitive, affective, and ecological dimensions of students, although there are variations based on academic and gender backgrounds. The implications of this study emphasize the importance of integrating local wisdom-based technology in research-based learning to support the achievement of holistic regenerative education.

Keywords: Ethnopedagogy; Virtual reality; Research-based learning; Regenerative education

INTRODUCTION

The transformation of 21st-century education demands a learning approach that is not only oriented towards cognitive achievement, but also fosters ecological, cultural, and sustainability awareness (Ariyatun et al., 2025). In this context, regenerative education is present as a new paradigm that encourages students to think systemically, act reflectively, and play an active role in restoring and maintaining the balance of social and natural ecosystems (Armon, 2021; Beresford-Dey, 2025; Buckton et al., 2023). The application of the concept of regenerative education in the world of higher education in Indonesia still faces challenges, especially in terms of its approach and learning media. One of the learning approaches that is in line with the principles of regenerative education is research-based learning (RBL) (Lambert, 2009). In this approach, students are not only recipients of knowledge, but also active subjects in the process of knowledge construction through contextual and transformative research (Clement, 2000). RBL cultivates critical, collaborative, and reflective thinking skills that are essential in building

regenerative awareness (Susiani et al., 2019). The urgency of this research arises from the urgent need for a learning model that is able to bridge local values and global challenges through educational technology that is relevant to the times. However, the integration between Ethno-VR, the RBL approach, and the regenerative education framework is still rarely used as a comprehensive object of study, especially from the perspective of students as the main actors of learning.

Innovation opportunities lie in the use of immersive technologies such as Virtual Reality (VR) developed based on local or ethno-pedagogy values known as Ethno-VR (Leon-Paredes et al., 2022; Sudarmin et al., 2025). This technology not only provides a contextual and engaging learning experience, but also has the potential to revive local wisdom as a foundation for regenerative thinking (Hidayat et al., 2023). When Ethno-VR is applied within the framework of RBL, students not only learn from the culture, but also conduct research on the culture itself forming a bridge between technology, tradition, and ecological awareness (Chiu & Lien, 2025; Harris, 2010). By combining elements of local culture living in society with immersive technology, Ethno-VR is a medium that is able to bring students into a more authentic and transformative world of learning (Wahyudi et al., 2023). The learning experience is no longer one-way or theoretical, but is based on a real exploration of cultural values, practices, and narratives that have been marginalized in the modern education system (Zinchenko et al., 2021).

The implementation of Ethno-VR in research-based learning encourages students to study cultural and environmental phenomena holistically through the process of data collection, critical reflection, and presentation of findings in an interactive digital form (Rizki et al., 2025). This process not only strengthens academic skills such as research literacy and data analysis, but also builds empathy, love for the environment, and awareness of the importance of cultural preservation (Sari et al., 2024; Setiyaningsih et al., 2021). The virtual experiences presented allow students to explore cultural sites, listen to folklore directly from local narrators, or visualize traditional rituals in depth, which is conventionally difficult to reach in the classroom learning process (Verawati et al., 2025). More than that, the integration of Ethno-VR within the framework of RBL also opens up a cross-disciplinary collaborative space between students, lecturers, local communities, and technology developers. This collaboration is a meeting point between science, humanities, and technology, as well as creating a learning space that is inclusive, adaptive, and relevant to the challenges of the times (Degrave et al., 2017; Suryati et al., 2025). Therefore, the use of Ethno-VR is not only an innovation in terms of learning media, but also a pedagogical strategy that is rooted in local wisdom and oriented towards a regenerative future.

METHOD

This study uses a quantitative approach with a comparative design that aims to analyze differences in learning engagement, understanding of local culture, ecological awareness, and perceptions of technology integration between science and non-science students and based on gender. The research participants consisted of students of science and non-science study programs at the undergraduate level who were selected through purposive sampling techniques, with the consideration that they were involved in research-based learning that was integrated with Ethno-VR exploration.

Data collection was carried out using a structured questionnaire based on the Likert scale which included four main indicators, namely learning engagement, understanding of local culture, ecological awareness, and perception of technological integration. This instrument has gone through a content validity test by education experts as well as a reliability test with Cronbach's Alpha coefficient to ensure internal consistency. The research procedure was carried out through research-based learning sessions using Ethno-VR media, then students were asked to fill out questionnaires online and offline. The collected data was analyzed using Variance Analysis (ANOVA) to test the differences between student groups based on their field of study and gender. In addition, the mean value (M) and standard deviation (SD) are used to describe the trend of the data, while the value of F and p-value are used as the basis for determining the level of significance of the differences found.

The Ethno-VR media used in this study was designed to simulate the traditional process of natural batik making in an interactive virtual environment. Through this virtual experience, students were able to explore each stage of the batik production process from pattern selection, coloring, and dyeing, to the finishing stage. The following Figure 1., illustrate the visualization of the Ethno-VR environment used during the learning sessions.

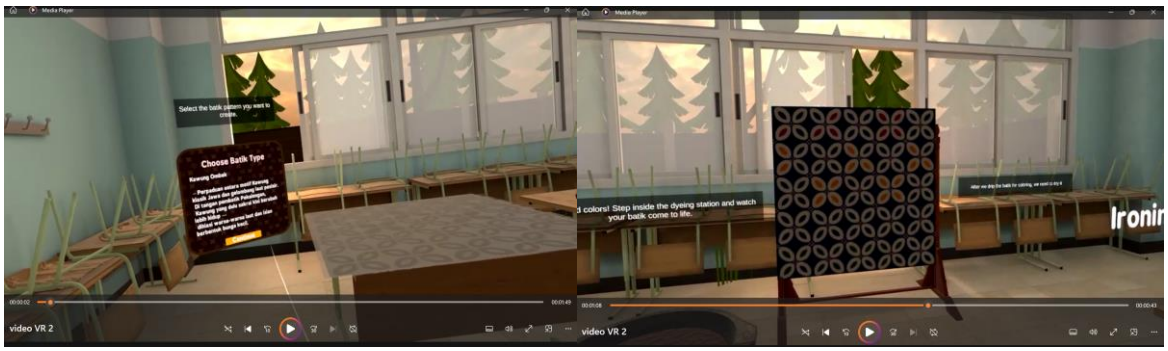

Figure 1. Visualization of the virtual batik pattern design process in Ethno-VR

RESULTS AND DISCUSSION

The survey was conducted on 72 students from education study programs who had participated in Ethno-VR-based learning within the framework of research-based learning. To ensure the quality of the questionnaire instruments used in this study, a series of validity and reliability tests were carried out on 16 statements developed based on four main indicators: learning engagement, understanding of the local cultural context, ecological awareness, and perception of technology integration in Research-Based Learning (RBL). The validity test consists of two stages, namely content validity and empirical validity (construct validity). The validity of the content was carried out through an expert judgment involving three lecturers in the fields of learning technology, cultural education, and evaluation. The results of the study show that all items are considered relevant, representative, and in accordance with the measured indicators. Meanwhile, the empirical validity was carried out through Pearson's correlation analysis between the score of each item and the total score of the questionnaire.

The results of data processing showed that all items had a calculated r value above the r of the table (0.232 for N = 72 at a significance level of 5%) and a significance value of < 0.05. Thus, all items are declared statistically valid and feasible for use in data collection. The reliability test is performed by calculating the Cronbach's Alpha coefficient to measure the internal consistency of the instrument. The results of the analysis showed that the four subscales had high reliability values, namely 0.812 for learning engagement, 0.844 for understanding local culture, 0.798 for ecological awareness, and 0.765 for perception of technology integration. The overall value of Cronbach's Alpha is 0.902, which indicates that this instrument is very reliable. Based on these results, it can be concluded that the questionnaire instrument used in this study has good quality, both in terms of validity and reliability, so that it can be used validly and consistently to measure students' perception of the application of Ethno-VR in research-based and regenerative-oriented learning.

Students' Perceptions of Learning Engagement

Findings from the perspective of students on their involvement in the learning process through the Ethno-VR-based RBL model were measured by four indicators. Results of the analysis Table 1. shows that there is a difference in the average score of learning engagement based on the background of the study program and gender.

Table 1. Descriptive Statistics of Student Learning Engagement

	Science Program Study	**Non-Science Program Study**	**Female**	**Male**
Valid	32	40	48	24
Missing	0	0	0	0
Mean	21.100	18.615	19.667	20.667
Std. Deviation	2.654	3.709	3.464	3.109
Shapiro-Wilk	0.852	0.853	0.834	0.850
P-value of Shapiro-Wilk	0.106	0.131	0.081	0.067

In terms of study programs, students from the science cluster recorded an average learning engagement score of 21,100 with a standard deviation of 2,654, while students from non-science had a lower average score, namely 18,615 with a standard deviation of 3,709. This difference indicates that students of science study programs tend to show higher learning engagement in the context of using Ethno-VR media. This can be attributed to the tendency of science students to be more familiar with the experiential approach and data exploration-based technology inherent in research-based learning. Judging from gender, male students had an average learning engagement score of 20,667 (elementary = 3,109), slightly higher than female students with an average of 19,667

(elementary = 3,464). Although this difference is not too large, it may reflect a variation in preferences or responses to Ethno-VR media based on gender, where male students tend to show more interest in visual and interactive technology-based learning media.

Table 2. ANOVA - Engagement

Cases	Sum of Squares	df	Mean Square	F	p
Gender	5.324	1	5.344	0.629	0.373
Study Program	40.630	1	31.630	4.119	0.052
Gender ✻ Study Program	1.358	1	1.408	0.124	0.607
Residuals	203.075	69	9.106		

Note. Type III Sum of Squares

The results of the ANOVA analysis in Table 2 were used to evaluate the influence of gender, study program, and interaction between the two on the level of student involvement in Research-Based Learning (RBL)-based learning using Ethno-VR media. ANOVA was conducted even though the distribution of data was not completely normal (based on the results of the previous Shapiro-Wilk test), noting that these results were exploratory and needed to be accompanied by caution in drawing conclusions. Based on the test results, the gender variables showed values of F = 0.629 and p = 0.373, which means that there was no significant difference in learning engagement between male and female students in the use of Ethno-VR. Similarly, the interaction between gender and the study program (F = 0.124, p = 0.607) did not show a significant effect on student engagement. This shows that differences in learning engagement are not affected by the two factors combined. However, the variables of the study program showed almost significant results with values of F = 4.119 and p = 0.052. Although the p-value is slightly above the conventional limit of significance (0.05), it indicates that there is a tendency for differences in learning engagement between students from science and non-science study programs. Students from science study programs tend to have higher levels of involvement in Ethno-VR-based learning compared to students from non-science study programs. These findings support previous interpretations of descriptive data, in which science students had higher average engagement scores.

Students' Perspectives on Understanding Local Cultural Context

The use of Ethno-VR media in RBL-based learning not only aims to increase students' active participation, but also to enrich their understanding of the local cultural context. Based on the results of a descriptive analysis of a number of statement items that focused on indicators of cultural understanding, the majority of students showed a positive response. Through virtual reality technology that displays elements of traditional culture, students are invited to experience visually and interactively local values that are often difficult to access in person. Based on the results of a descriptive analysis of indicators of local cultural understanding, data was obtained that showed differences in student perceptions based on study programs and gender.

Table 3. Descriptive Statistics of Understanding the Local Cultural Context

	Science Program Study	Non-Science Program Study	Female	Male
Valid	32	40	48	24
Missing	0	0	0	0
Mean	18.800	17.231	18.444	17.867
Std. Deviation	1.989	2.522	2.684	1.807
Shapiro-Wilk	0.937	0.768	0.832	0.822
P-value of Shapiro-Wilk	0.211	0.003	0.004	0.007

As shown in Table 3, students from science study programs have an average cultural comprehension score of 18,800 with a standard deviation of 1,989, slightly higher than non-science students who have an average of 17,231 with a standard deviation of 2,522. This difference indicates that science students show a higher openness in absorbing cultural information through technology-based approaches such as Ethno-VR. This may be influenced by the habits of science students in utilizing visual instruments and experiential media in their learning process. Viewed from a gender perspective, female students showed an average score of 18,444 (elementary = 2,684), while male students were slightly lower with an average of 17,867 (elementary = 1,807). Although the difference is not very significant, this data suggests that female college students tend to have slightly higher cultural sensitivities, which may correlate with levels of empathy or emotional engagement in responding to cultural content. The results of statistical analysis of the understanding of the local cultural context are presented in Table 4.

Table 4. ANOVA - Understanding the Local Cultural Context

Cases	Sum of Squares	df	Mean Square	F	p
Gender	1.905	1	1.905	0.401	0.531
Study Program	17.143	1	17.143	3.613	0.067
Gender ✻ Study Program	9.219	1	9.219	1.943	0.174
Residuals	137.600	69	4.745		

Note. Type III Sum of Squares

Variance analysis (ANOVA) was used to find out whether there was a significant difference in the level of understanding of students' local cultural context based on gender factors, study program, and interaction between the two in the context of Research-Based Learning and Ethno-VR media. Based on the results in Table 5, the gender variable yielded a value of $F = 0.401$ with $p = 0.531$, indicating that there was no significant difference between male and female students in terms of understanding the local cultural context. This indicates that the learning experience using Ethno-VR is able to have a relatively even impact across genders in terms of understanding local cultural values and practices.

Furthermore, the study program variable showed a value of $F = 3.613$ with $p = 0.067$. Although it has not reached the limit of conventional significance ($p < 0.05$), this value is close to the significant threshold, which indicates a tendency that the study program affects the level of understanding of the student's local cultural context. Students from science courses seem to have a higher tendency to understand than non-science students. This may be due to the systematic thinking approach and openness to new media that is more dominant in the field of science studies. Meanwhile, the interaction between gender and the study program resulted in a value of $F = 1.943$ with $p = 0.174$, which means that there was no significant interaction between the two variables on the understanding of the local cultural context. In other words, the combination of gender and the background of the study program does not have a significant influence on student learning outcomes in this aspect. Overall, although no statistically significant differences were found, these results still provide an early indication that the background of the study program may have an influence on the way students understand local cultural values through Ethno-VR media.

Perspectives on Ecological and Regenerative Awareness

The use of Ethno-VR in the framework of research-based learning not only focuses on cognitive aspects, but is also directed at fostering students' ecological awareness. Through virtual reality-based simulations featuring traditional practices, local wisdom, and representations of the natural environment, students are invited to see the relationship between culture, the environment, and sustainability (Seibert et al., 2023; Zhang et al., 2025). The results of the descriptive analysis are in Table 5. explaining the learning experience with Ethno-VR increased their sensitivity to environmental issues and the importance of ecosystem regeneration. The average score shows a positive trend on the ecological awareness dimension, where students assess that local culture-based content visualized in VR encourages them to connect scientific knowledge with sustainability practices.

Table 5. Descriptive Statistics of Ecological and Regenerative Awareness

	Science Program Study	Non-Science Program Study	Female	Male
Valid	32	40	48	24
Missing	0	0	0	0
Mean	17.860	16.256	16.454	14.886
Std. Deviation	1.809	2.596	2.786	1.908
Shapiro-Wilk	0.827	0.898	0.842	0.922
P-value of Shapiro-Wilk	0.111	0.002	0.003	0.001

The results of the descriptive analysis in Table 6 show that students from science study programs have an average ecological awareness score of 17,860 (SD = 1,809), higher than students from non-science study programs with an average of 16,256 (SD = 2,596). These findings indicate that science students are more sensitive to environmental sustainability and regeneration issues when studying with Ethno-VR media. This may be related to the orientation of the science curriculum which more often associates learning materials with ecological, conservation, and resource sustainability aspects. Viewed from a gender perspective, female students recorded an average score of 16,454 (SD = 2,786), slightly higher than male students who had an average score of 14,886 (SD = 1,908). This difference, although not particularly striking, indicates that female students tend to show greater empathy and emotional involvement in environmental issues. This is in line with several previous studies that have stated that gender factors can influence ecological orientation, although not always statistically significant.

Furthermore, the results of the ANOVA test in Table 6. provides a more detailed picture of the influence of study program and gender factors. The study program variable resulted in a value of F = 3.013 with p = 0.047, which means that there is a significant difference between science and non-science students in terms of ecological and regenerative awareness. Science students showed higher ecological engagement, reinforcing the interpretation that academic background has an important role in shaping how students respond to environmental issues through Ethno-VR media.

Table 6. ANOVA - Ecological and Regenerative Awareness

Cases	Sum of Squares	df	Mean Square	F	p
Gender	1.805	1	1.795	0.561	0.421
Study Program	18.123	1	18.143	3.013	0.047
Gender ✻ Study Program	8.919	1	8.229	1.843	0.174
Residuals	147.600	69	4.945		

Note. Type III Sum of Squares

The gender variable yielded a value of F = 0.561 with p = 0.421, indicating that there was no significant difference between male and female students. Similar things are also seen in the gender interaction ✻ of the study program with a value of F = 1.843 and p = 0.174, which means that the combination of these two factors does not have a significant influence on the level of ecological awareness of students. Overall, these findings indicate that Ethno-VR plays an effective medium in fostering students' ecological awareness, with a more prominent impact on students from science study programs. This shows the potential of Ethno-VR as a regenerative learning instrument that is able to connect scientific knowledge with sustainability practices through immersive experiences based on local culture.

Perception of Technology Integration in RBL

The integration of technology through Ethno-VR is seen by students as a key element that enriches research-based learning experiences. The results of the descriptive analysis showed that most students felt more motivated and engaged when VR technology was used as a learning medium. Interactive visualization allows them to explore objects, cultures, and phenomena in a more in-depth way than conventional methods (Olshannikova et al., 2015), (Windhager et al., 2019). Students from science study programs appreciate this integration, especially in the methodological aspect, as Ethno-VR facilitates an experiential approach that supports data-driven exploration. Meanwhile, non-science students emphasized that the use of VR helps them understand abstract concepts in a more concrete way through visual representations. From a gender perspective, male students tend to highlight the technical and interactive aspects of technology, while female students emphasize more their contribution to understanding cultural context and social values. A descriptive analysis of students' perspectives on technology integration in RBL is presented in Table 7.

Table 7. Descriptive Statistics of Technology Integration in RBL

	Science Program Study	Non-Science Program Study	Female	Male
Valid	32	40	48	24
Missing	0	0	0	0
Mean	16.891	17.289	17.464	15.876
Std. Deviation	1.736	2.698	2.896	1.728
Shapiro-Wilk	0.827	0.998	0.742	0.922
P-value of Shapiro-Wilk	0.011	0.001	0.003	0.003

The results of the descriptive analysis in Table 7 show that students from non-science study programs have an average score of perception of technology integration in RBL of 17,289 (SD = 2,698), slightly higher than science students with an average score of 16,891 (SD = 1,736). This finding is interesting because it indicates that non-science students actually show a greater appreciation for the use of Ethno-VR in the context of research-based learning. This can be attributed to the need for non-science students to get concrete visualizations in understanding abstract concepts, so that VR technology is considered to be able to bridge the limitations of conventional methods. In terms of gender, female students recorded an average score of 17,464 (SD = 2,896), higher than male students who had an average score of 15,876 (SD = 1,728). This difference illustrates that female students tend to be more receptive to the integration of technology in the learning process, especially in the context of Ethno-VR which combines elements of local culture with immersive technology. This sensitivity can reflect women's openness to a learning approach that is contextual, interactive, and supports the understanding of socio-cultural values.

Table 8. ANOVA - Technology Integration in RBL

Cases	Sum of Squares	df	Mean Square	F	p
Gender	1.705	1	1.895	0.561	0.461
Study Program	17.123	1	17.184	3.023	0.052
Gender ✻ Study Program	8.817	1	8.229	1.963	0.184
Residuals	138.650	69	4.945		

Note. Type III Sum of Squares

The results of the ANOVA test in Table 8 confirm this finding. The variables of the study program produced a value of $F = 3.023$ with $p = 0.052$. This value is close to the significance limit ($p < 0.05$), so it can be interpreted that there is a tendency for differences in perception between science and non-science students towards technology integration, although it is not statistically significant. Meanwhile, the gender variable showed a value of $F = 0.561$ with $p = 0.461$, which means there was no significant difference between male and female students. Likewise, the gender interaction ✻ of the study program resulted in a value of $F = 1.963$ with $p = 0.184$, which indicates the absence of a significant combined influence of the two factors on the perception of technological integration.

The results showed that students' perception of the use of Ethno-VR in the context of RBL was generally positive, although there were variations based on the background of the study program and gender. From the dimension of learning engagement, students of the science study program showed a higher average score than non-science students. This indicates that science students are more likely to integrate Ethno-VR with experiential approaches and data exploration that are already part of their academic tradition. Meanwhile, from a gender perspective, the difference is not significant, although there is a tendency for male students to show greater interest in the technical and interactive aspects of VR, while female students are more responsive to the cultural aspects and social values displayed.

In terms of understanding the local cultural context, Ethno-VR has proven to be effective in providing an immersive learning experience, which allows students to internalize cultural values through visual and narrative interaction (Bekele & Champion, 2019; Calvert & Hume, 2022). Female college students show slightly higher average scores, which may reflect empathic sensitivity to cultural content. These results show that cultural integration through VR media is able to bridge the gap between theory and practice (Li et al., 2024; Singer, 2025), as well as fostering student awareness of the importance of cultural preservation in the framework of regenerative education (Zidny, 2021). In the aspects of ecological and regenerative awareness, science students again showed higher scores, showing a close connection between academic background and ecological perception (Giusti & Samuelsson, 2020). These findings are important because they show that Ethno-VR is not only a technological instrument, but also a reflective medium that is able to encourage students to connect scientific knowledge with the value of sustainability. Although gender variables are not significant, there are indications that female students are more prominent in terms of ecological empathy.

In the dimension of technology integration in RBL, non-science students and women showed higher appreciation. Non-science students assessed that VR helped them understand abstract concepts more concretely, while female students saw VR's contribution to cultural understanding and social values. However, some students also highlighted challenges in the form of limited access to devices, adaptation needs, and the importance of pedagogical support so that VR does not stop just as entertainment, but is truly integrated with the goals of RBL. Overall, student perceptions affirm that Ethno-VR has great potential in supporting regenerative education: strengthening learning engagement, enriching cultural understanding, fostering ecological awareness, and demonstrating how technology can be meaningfully integrated in educational research. However, the success of its implementation is still influenced by the student's academic background, individual preferences, and the readiness of the technological infrastructure.

CONCLUSION

This study shows that the application of ethnopedagogy-based Virtual Reality (Ethno-VR) in research-based learning has the potential to support regenerative education through improving the cognitive, affective, and ecological aspects of students. Science students tend to have higher learning engagement and ecological awareness, with significant differences in ecological aspects, while understanding local culture is stronger in science students and women although not significant. In contrast, appreciation for technology integration is more pronounced among non-science students and women with a tendency to be close to significant. These findings confirm that the integration of technology based on local wisdom not only encourages cultural understanding, but can also strengthen ecological concern and student learning engagement. However, the variation in responses based on field of study and gender shows that the strategy for implementing Ethno-VR needs to consider the characteristics

of students so that learning is more inclusive and has an optimal impact. Thus, Ethno-VR can be a relevant innovation to strengthen the concept of regenerative education oriented towards sustainability and local wisdom.

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Credit Authorship Contribution Statement

Ariyatun: Conceptualization, Methodology, Software, Visualization, & Writing original draft. **Mukhlis and Ika Septiana**: Formal analysis, Supervision and Resources. **Wijayanto & Ika Arifianti**: Writing review & editing, Project administration.

Consent for Publication

All authors of this study have consented to the publication of this article.

Informed Consent

The statement of willingness to participate in this study was included in the questionnaire, and respondents indicated their consent by ticking a box before answering the statements or items in the questionnaire. Thus, participation in this study was entirely voluntary.

Competing Interests

The authors declare no competing interests.

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