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Integrating Ethno-Vlog and Virtual Reality Media on Ecology and Biodiversity to Enhance Junior High School Students' Science Process Skills

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Abstract
Education in the 21st century requires innovative approaches that integrate technology and local wisdom to strengthen students' science process skills (SPS). This study aims to develop, validate, and evaluate the effectiveness of ethno-vlog and virtual reality (VR) media based on the cultural context of Oyol tea in enhancing junior high school students' SPS on ecology and biodiversity topics. Employing a research and development design with the 4D model (Define, Design, Develop, Disseminate), this study involved small-scale (n = 15) and large-scale (n = 32) trials with grade VII and VIII students at a junior high school in Indonesia. Data were collected through expert validation, student response questionnaires, observation sheets, and pre-post assessments of SPS. The results indicated that both media met the "very feasible" criteria from expert validators (average ≥ 87.5%) and received highly positive responses from students. Statistical analysis using N-gain (0.76, high category) and the Mann–Whitney test ($p < 0.05$) confirmed a significant improvement in students' SPS, particularly in observation, prediction, inference, classification, measurement, and communication skills. These findings demonstrate that the integration of ethnoscience-based vlog and VR provides a meaningful, interactive, and culturally relevant learning experience. The study contributes to digital pedagogy by bridging local knowledge and advanced technologies, offering a scalable model for science education in developing countries. Future research may extend this approach to other cultural contexts and subject areas to strengthen broader applicability.

Keywords: Digital Pedagogy; Ecology and Biodiversity; Ethno-vlog; Ethnoscience; Science Process Skills; Virtual Reality.

INTRODUCTION

The rapid advancement of science and technology in the 21st century has profoundly influenced education, demanding a paradigm shift toward fostering higher-order thinking, creativity, and adaptability in students. Science education, in particular, is expected not only to transmit conceptual knowledge but also to cultivate essential competencies such as critical thinking, problem-solving, and collaboration (Feyza & Seyda, 2023; Krishna & Chetry, 2024). Central to this transformation is the mastery of science process skills (SPS), which enable learners to observe, classify, measure, predict, infer, and communicate scientific phenomena systematically. SPS are regarded as fundamental for developing scientific literacy, preparing students to engage with complex global challenges, and equipping them with transferable skills for lifelong learning (Gizaw & Sota, 2023; Husna et al., 2022; Turiman et al., 2012).

Despite their importance, studies have consistently shown that students in many contexts, particularly in developing countries, exhibit low mastery of SPS. Several factors contribute to this problem, including teacher-centered pedagogies, limited use of experimental activities, and insufficient integration of innovative media (Gizaw & Sota, 2023; Mushani, 2021; Prayitno et al., 2017; Shana & Abulibdeh, 2020). In Indonesia, classroom observations and empirical findings indicate that students often struggle with applying SPS during practical activities due to inadequate exposure to inquiry-based approaches and a reliance on textbooks and traditional (Hasibuan et al., 2019; Mushani, 2021). This condition underscores the need for pedagogical innovations that can actively engage students

while contextualizing scientific content in ways that are meaningful and relevant.

One promising avenue is the integration of digital media with ethnoscience. Ethnoscience refers to the body of knowledge developed by local communities, encompassing cultural practices, indigenous technologies, and traditional wisdom related to nature and the environment (Dewi et al., 2020; Iskandar et al., 2022; Sutherland, 2014). When embedded in science learning, ethnoscience has been shown to enhance cultural relevance, motivation, and conceptual understanding, while bridging the gap between students' lived experiences and formal scientific concepts (Diwatin & Daza, 2025; F. P. Sari et al., 2023; Wirama et al., 2023). In this context, ethnoscience-based vlogs or ethno-vlogs represent a novel pedagogical tool that combines digital storytelling with local wisdom. Research has indicated that vlog media can enhance students' engagement, promote active participation, and improve science process skills by fostering inquiry and contextual learning (Gumilar et al., 2023; Hassan, 2023; E. Sari et al., 2024).

At the same time, the use of VR in education has garnered increasing attention for its capacity to create immersive, interactive, and authentic learning environments. VR technologies allow students to explore complex or abstract phenomena that are otherwise difficult to access in traditional classrooms, thus supporting deeper conceptual understanding and problem-solving skills (Makransky & Mayer, 2022; Petersen et al., 2022; Radianti et al., 2020). In science education, VR has been reported to improve motivation, facilitate spatial reasoning, and strengthen SPS by simulating experiments and natural processes in safe, cost-effective environments (Campos et al., 2022; Gittinger & Wiesche, 2024; Purwanto et al., 2024; Yang et al., 2024). Moreover, VR fosters collaborative learning through features such as avatars, shared spaces, and interactive objects, thereby enhancing social and cognitive engagement (Huang & Macgilchrist, 2024; van der Meer et al., 2023; Wang et al., 2025)

The integration of VR with local cultural contexts further amplifies its educational potential. By situating scientific learning within ethnoscientific frameworks, VR applications can contextualize abstract concepts, reduce the cultural distance between learners and content, and foster a sense of identity and belonging (Verawati et al., 2024; Xing et al., 2024). However, while research on VR in science education is rapidly growing, there remains a paucity of studies that explicitly combine VR with ethnoscience to develop students' SPS, particularly in junior high school contexts in developing countries. Existing studies have either focused on the standalone use of vlogs or VR in teaching science or examined ethnoscience in conventional instructional formats (Yang et al., 2024; Zhang & Wang, 2021). Few, if any, have attempted to synergize these approaches into an integrated model of ethno-vlog and VR to promote a holistic enhancement of SPS.

Furthermore, previous research has highlighted that while VR enhances immersion and interactivity, it often lacks cultural relevance and authenticity, which are critical for student engagement in diverse contexts (Fink et al., 2023; Shadiev et al., 2021; Zhao et al., 2025). Conversely, ethnoscience-based approaches enrich cultural contextualization but may not fully exploit the affordances of digital technologies to engage learners in interactive and immersive experiences (Feng et al., 2022; Ilic, 2020). This disjunction highlights a gap in the literature: the absence of integrative approaches that combine the strengths of ethnoscience-based media and immersive VR technologies to comprehensively foster SPS.

To address this gap, the present study develops and evaluates ethno-vlog and VR media based on the cultural practice of Oyol tea, a traditional beverage from Limbangan, Indonesia, to enhance students' SPS in ecology and biodiversity topics. The research aims to (1) design and characterize the ethno-vlog and VR media, (2) determine their feasibility based on expert validation and student responses, and (3) examine their effectiveness in improving junior high school students' SPS. By merging local wisdom with cutting-edge digital technologies, this study seeks to contribute to the growing discourse on culturally relevant digital pedagogy and provide an innovative model for science education that can be scaled and adapted across diverse cultural contexts.

METHODS

This study applied a research and development (R&D) design that followed the 4D instructional development framework, which consists of four systematic stages: Define, Design, Develop, and Disseminate, to ensure that the learning media was rigorously designed, validated, and disseminated for educational use (Hariyanto et al., 2022). In the present study, the process was conducted up to the development stage, as the primary objective was to produce feasible and effective ethno-vlog and VR media for science learning. The Define stage consisted of needs analysis and curriculum mapping, identifying low levels of students' science process skills (SPS) and the limited use of technology-based learning media in science classrooms. The Design stage involved constructing the storyboard and framework of the ethno-vlog and VR media, integrating ethnoscience content derived from local knowledge of Oyol tea culture into ecology and biodiversity materials. The Develop stage included expert validation, small-scale trials, and large-scale implementation to evaluate feasibility, usability, and effectiveness. The Disseminate stage was planned for subsequent application in wider classroom contexts.

The study was conducted at SMP Negeri 1 Limbangan, Central Java, Indonesia, during the 2024/2025 academic year. The participants consisted of 15 eighth-grade students (small-scale trial) and 32 seventh-grade students (large-scale implementation) selected through purposive sampling. The small-scale trial aimed to collect preliminary feedback on the clarity, appeal, and usability of the media, whereas the large-scale implementation examined its impact on students' SPS. Ethical clearance was obtained from the school administration, and informed consent was provided by teachers and guardians. Anonymity of participants was ensured by coding their names in the datasets.

The instruments included expert validation sheets, student response questionnaires, observation rubrics, and pre- and post-tests of SPS. Expert validation was conducted by one science education lecturer and two science teachers, focusing on media quality, content accuracy, cultural integration, and instructional feasibility. Student responses were gathered through a Likert-scale questionnaire addressing usability, attractiveness, and relevance. SPS were assessed using observation rubrics adapted from Ongowo and Indoshi, (2013), covering six indicators: observation, prediction, inference, classification, measurement, and communication. Pre- and post-tests were also administered to strengthen the quantitative evidence of learning gains.

Data analysis combined quantitative and qualitative approaches. The feasibility of the media was determined from validation scores, with ≥ 62.50% considered valid. Student responses were analyzed descriptively to identify trends in engagement and satisfaction. The effectiveness of the ethno-vlog and VR media was evaluated using normalized gain (N-gain) to measure learning improvement between pre- and post-tests, with categories classified as low (< 0.3), medium (0.3–0.7), and high (> 0.7). To test statistical significance, a normality test was performed; as the data were not normally distributed, the Mann–Whitney U test was applied to compare pre- and post-test scores. Qualitative data from validator comments and student feedback were coded to complement the quantitative findings, providing richer insights into the usability and learning impact of the media. The overall design of the study is summarized in Table 1.

Table 1. Research and Development Design of Ethno-vlog and VR Media

Stage	Activities	Output
Define	Needs analysis, curriculum mapping, identification of students' SPS problems	Specification of learning objectives
Design	Storyboarding, selection of ethnoscience content (Oyol tea), VR environment creation	Prototype of ethno-vlog and VR media
Develop	Expert validation, small-scale trial (n = 15), large-scale implementation (n = 32)	Validated and revised media
Disseminate	Planned dissemination in broader contexts	Guidelines for classroom integration

This methodological design ensured rigor through multiple layers of validation, empirical trials, and mixed-methods analysis. By aligning the development process with 21st-century pedagogical demands, the study provides a comprehensive framework for evaluating the feasibility and effectiveness of integrating ethnoscience and VR-based learning media into science education.

RESULTS AND DISCUSSION

Development and Characteristics of Ethno-vlog and Virtual Reality Media

The ethno-vlog was developed as an innovative learning medium that integrates scientific content with values of local wisdom that deserve preservation, particularly cultural practices related to society, natural phenomena, and indigenous knowledge of local foods and beverages in Indonesia (Sudarmin et al., 2018). Each ethno-vlog video consisted of several structured components, namely: (1) an opening section introducing the ethnoscience context and local wisdom of the region; (2) interviews with key resource persons such as tea farmers and local artisans; (3) documentation of the product reconstruction process in the form of food, drinks, or cultural arts; and (4) a closing reflection (Gumilar et al., 2023). The inclusion of interviews provided not only factual information but also deeper socio-cultural insights into the traditions and practices behind Oyol tea production. As a result, students were able to access both scientific and cultural perspectives, enriching their learning experiences with contextual meaning (Awal et al., 2023). This is consistent with prior research showing that vlogs as learning media can offer interactive, enjoyable, and authentic experiences that support conceptual understanding (Hassan, 2023).

The development of the ethno-vlog followed a systematic and structured process aimed at producing informative and engaging educational content about Limbangan's specialty, Oyol tea. Previous studies have shown that students taught through ethnoscience-based video learning achieve higher levels of mastery compared to those taught using conventional methods (Sudarmin et al., 2018). The selection of "Teh Oyol Limbangan" as the main topic was therefore strategic, as it combined local cultural relevance with high educational value. The development process began with scripting interviews and collecting visual materials. A carefully designed interview script ensured that comprehensive information was collected from local informants, including details on tea cultivation, harvesting, processing, and its health-related benefits. This aligns with ethnoscience approaches in which cultural practices are reconstructed scientifically, such as ethnotechnology in tea-making and ethnomedicine concerning its health functions (Sudarmin et al., 2018). The script document served as a development guide to maintain coherence and structure in the final learning video (Seidel et al., 2022).

The video recordings were conducted in authentic settings, including the Medini tea plantation and the homes of farmers in Ngesrepbalong Village. To ensure quality, recordings employed high-resolution cameras or smartphones, supplemented with external microphones to optimize audio and visual clarity. Recording contextual scenes allowed students to connect scientific knowledge with their immediate environment (Hassan, 2023). Editing was performed using the CapCut application, which offers effective and user-friendly tools for both novice and experienced editors (Priandini et al., 2023). During this stage, interviews, tea-making processes, and scientific reconstructions were systematically organized into a coherent narrative. Additional elements such as background music characteristic of the Kendal region and subtitles were integrated to enhance accessibility and appeal. While music reinforced the cultural atmosphere, subtitles ensured inclusivity for students with different language proficiencies.

A review and refinement phase was then conducted, in which the research team and expert validators evaluated the videos to ensure clarity, cultural accuracy, and pedagogical quality. The incorporation of expert feedback further strengthened the scientific and educational validity of the product. Finally, the ethno-vlog was published on YouTube, providing broad accessibility for students and educators. This open-access dissemination ensured that the "Teh Oyol" ethno-vlog could be integrated into classroom learning and beyond, accessible anytime and anywhere on networked devices (Gumilar et al., 2023; Sudarmin et al., 2018). The structure of the Limbangan Oyol tea ethno-vlog, including the opening, interviews, production process, scientific reconstruction, and closing, is presented via the QR code in Figure 1.

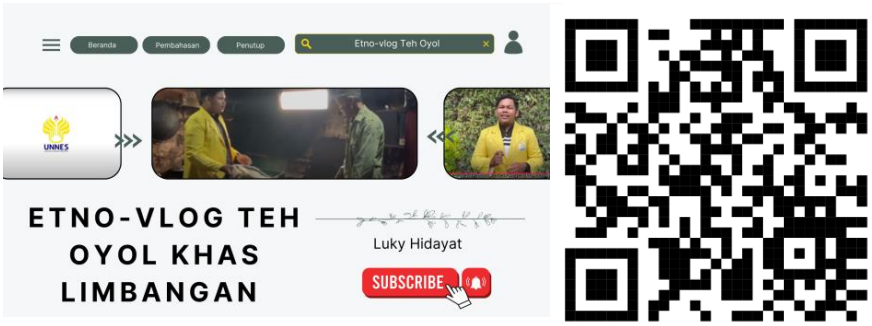

Figure 1. QR Code for Ethno-vlog of Limbangan's Oyol Tea

The use of VR technology in this study was intended to create an interactive and immersive learning experience that supports students' science process skills (SPS). The VR component developed falls into the non-immersive simulation category, also known as desktop VR, which is the least immersive implementation of virtual reality but remains widely accessible due to its reliance on standard devices such as computers and smartphones (Hamilton et al., 2021; Luo & Du, 2022). In this format, students enter the virtual world via a high-resolution monitor, with only partial stimulation of sensory modalities, yet sufficient to provide a meaningful sense of presence (Priandini et al., 2023)

The virtual world was constructed using the Spatial.io platform, which supports real-time rendering and interactive three-dimensional (3D) environments. In this study, a digital replica of the Medini tea plantation and the Ngesrepbalong Village cafeteria was created, enriched with local ecological and cultural details. Rendering technology in VR enables users to explore realistic environments, interact with objects, and develop a deeper understanding of spatial and contextual information. The 3D models, including representations of Mount Ungaran and traditional tea-making equipment, were developed to visualize shape, texture, and scale in a scientifically accurate manner (Rudi Susilana et al., 2024). These visualizations provided students with both ecological knowledge and cultural context, bridging abstract science content with lived cultural practices.

Immersion in the VR environment was achieved through detailed graphical displays and navigation using keyboard and mouse controls. Although categorized as low-immersion VR, such systems continue to evolve and have demonstrated pedagogical value in providing cost-effective access to interactive simulations (Luo & Du, 2022; Rudi Susilana et al., 2024). Sensory feedback was enhanced with audio components, including natural environmental sounds and traditional Kendal music, which created a supportive atmosphere and strengthened the cultural context. This integration of visual and auditory stimuli allowed students to feel present in the environment, thereby increasing their engagement with the learning process (Hariyanto et al., 2022; Vanitha & Alathur, 2021)

In terms of interactivity, students were able to navigate the virtual gallery, manipulate objects, and access multimedia elements such as images, embedded videos, and descriptive texts. This interactivity is crucial, as it provides students with real-time opportunities to explore, analyze, and communicate findings, thereby reinforcing the indicators of SPS (Lawhon, 1976; Luo & Du, 2022). The platform also supported limited social interaction through avatars, enabling peer discussion within the VR environment. While less sensorially rich than immersive VR headsets, desktop VR offers practical advantages in school settings because it does not require advanced or costly hardware

The VR media thus served as a complementary tool to the ethno-vlog, offering interactive simulations of cultural and ecological contexts that could not be fully captured through video alone. By combining cultural authenticity with interactive digital environments, the VR component enriched the students' learning experience and supported the contextualization of science concepts. The finalized VR product was published via Spatial.io and made accessible through a QR code for classroom use, as shown in Figure 2.

Figure 2. QR Recording of Virtual Reality (VR) of Limbangan's Oyol Tea

The development of the Oyol Tea VR environment followed a systematic procedure to ensure pedagogical feasibility and technological accuracy. The process combined content preparation, platform utilization, and iterative validation to create an interactive and culturally relevant simulation. The stages are summarized in Table 2.

Table 2. Oyol Tea Virtual Reality (VR) Development Procedure

Stage	Activities
Preparing content	1. Prepare video materials and 3D models to be included in the VR gallery. 2. Download 3D models from Sketchfab or create using Blender/Tinkercad.
Sign up for Spatial.io	1. Open Spatial.io and register using email. 2. Verify the account to access uploading and editing features.
Upload content	1. Log in to Spatial.io and select "Create a Space". 2. Upload images, 3D models, and video files. 3. Arrange elements according to the Oyol Tea VR design concept.
Custom space creation	Organize the virtual layout by positioning 3D objects within the environment.
VR experience settings	Enable keyboard and mouse-based navigation for user exploration.
Trial and adjustment	Test the VR space on PC and mobile devices. Gather feedback from expert validators for revisions.
Publish	Open access to the VR space on Spatial.io for use in classrooms and independent learning.

This structured process ensured that the VR gallery was both technically functional and pedagogically aligned with the learning objectives. The initial stage of content preparation guaranteed the accuracy of scientific and cultural representations, while the integration of Sketchfab and Blender/Tinkercad allowed flexibility in generating 3D models. The use of Spatial.io as the primary platform facilitated interactive navigation, enabling students to explore the virtual tea plantation and biodiversity context with ease. Importantly, the iterative validation phase, involving expert feedback, enhanced both the scientific accuracy and usability of the media before dissemination. The final stage of publication on Spatial.io provided open access for students and teachers, ensuring scalability and integration into broader educational settings.

Feasibility Test Results (Expert Validation)

The feasibility of the developed media was evaluated through expert validation conducted by one science education lecturer and two science teachers, focusing on both media and material aspects. The validation process assessed multiple criteria, including content accuracy, clarity of language, cultural integration, visual and audio quality, ease of use, and relevance to the curriculum. Results indicated that both the ethno-vlog and VR media achieved the "very feasible" category, surpassing the minimum threshold of 62.50% for feasibility standards. Specifically, the ethno-vlog obtained an average validation score of 91.6%, while the VR media achieved an average score of 89.6%.

Table 3. Expert Validation Results of Ethno-vlog and VR Media

Validator Type	Ethno-vlog (%)	VR (%)	Category
Media Experts	91.6	87.5	Very Feasible
Material Experts	91.6	89.6	Very Feasible

These results suggest that both media are highly appropriate for classroom use, demonstrating pedagogical soundness in terms of scientific accuracy, instructional design, and cultural contextualization. In particular, the ethno-vlog was praised for its integration of local

wisdom with scientific concepts, its clear narrative structure, and the use of authentic interviews with local tea farmers and artisans, which provided meaningful socio-cultural context for students. Meanwhile, the VR media was recognized for its interactive features, accurate 3D modeling of ecological and cultural environments, and the addition of audio elements such as local music, which enhanced immersion and strengthened cultural identity.

The strong feasibility ratings obtained in this study are consistent with prior research showing that digital ethnoscience-based learning media can effectively bridge local wisdom with modern pedagogy. Sudarmin et al. (2018) emphasized that combining cultural practices with scientific content promotes student engagement and contextual understanding. Similarly, Awal et al. (2023) reported that local wisdom-based teaching materials achieved high validation scores when evaluated for clarity, content relevance, and student engagement potential.

Importantly, the validation findings confirm that the integration of cultural authenticity with technological innovation can produce learning media that is both scientifically rigorous and culturally meaningful. The expert endorsement underscores the readiness of the ethno-vlog and VR media for classroom implementation, ensuring that students are not only exposed to scientific knowledge but also encouraged to value and preserve local traditions. This dual emphasis positions the developed media as an innovative contribution to culturally relevant digital pedagogy.

Student Responses to Ethno-vlog and VR Media

The results of student responses to the ethno-vlog media are illustrated in Figure 3. The data show overwhelmingly positive perceptions. More than two-thirds of students (66.67%–73.33%) agreed across the indicators, with the highest rating in Category 3 (73.33%), which evaluated the clarity of videos and images. This finding highlights that students found the ethno-vlog visually effective in conveying concepts. Meanwhile, Category 1 (66.67%), which assessed the attractiveness of the overall display, also received a high level of agreement. A substantial proportion of students (26.67%–46.67%) selected "strongly agree," reflecting their enthusiasm toward the integration of cultural elements in science content. Negative responses were negligible (≤ 13.33%), suggesting that the ethno-vlog was widely acceptable and pedagogically sound.

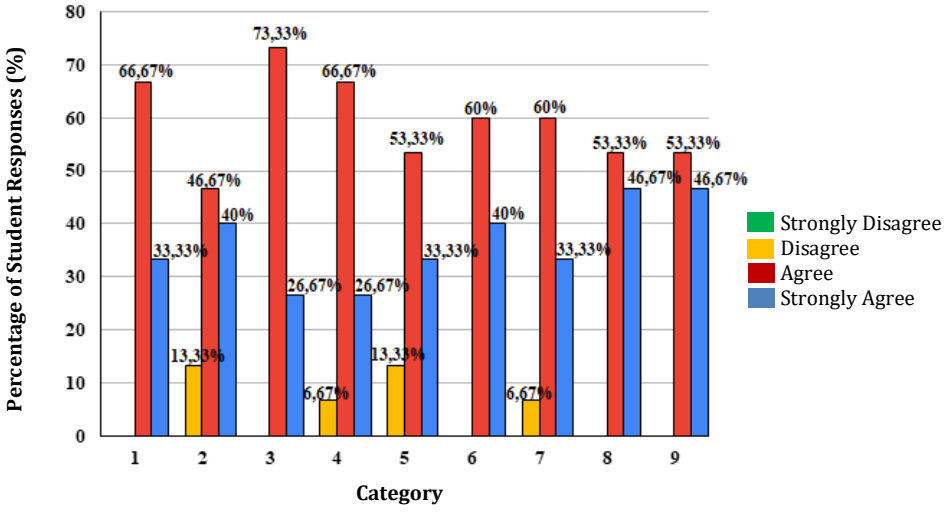

Figure 3. Student Responses to Ethno-vlog Media

The high acceptance of ethno-vlog media demonstrates its ability to contextualize science content within students' cultural environment. The use of interviews with tea farmers and artisans offered authentic narratives, which helped students not only access scientific concepts but also understand their social and cultural relevance. These results are consistent with research by (Awal et al., 2023), who reported that ethno-vlogs effectively enhanced students' motivation by situating science within familiar cultural practices. Similarly, Vanitha and Alathur (2021) found that ethnoscience vlogs fostered inquiry and critical thinking. Together, these findings reinforce the notion that ethnoscience-based vlogs contribute to culturally relevant pedagogy and the development of science process skills.

The results of student responses to the VR media are shown in Figure 4. The data indicate even stronger levels of enthusiasm compared to the ethno-vlog. Notably, 80% of students strongly agreed with Category 3 (ease of operation) and Category 8 (effectiveness in supporting learning), while 73.33% strongly agreed in Category 1 (attractiveness of the display). Agreement levels were also consistently high across other categories (40%–66.67%), demonstrating the practicality and appeal of VR in classroom contexts. Negative responses remained very low (≤ 20%), underscoring the accessibility and usability of the VR platform.

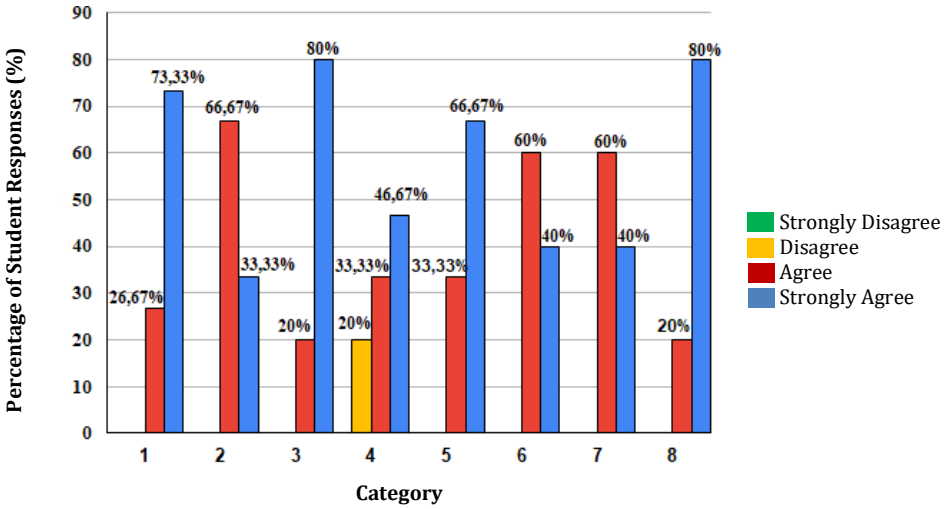

Figure 4. Student Responses to Virtual Reality (VR) Media

Students valued VR for its interactivity, which allowed them to explore and manipulate objects in a three-dimensional cultural and ecological environment. The addition of audio elements, such as local music, further enhanced immersion and strengthened their connection to cultural identity. These results resonate with earlier studies demonstrating the capacity of VR to improve student engagement, motivation, and conceptual understanding (Radianti et al., 2020). Importantly, the findings of this study extend those of previous research by showing that even non-immersive desktop VR can provide highly engaging experiences when enriched with cultural authenticity and multimedia elements.

When comparing the two media, it is evident that both ethno-vlog and VR received high levels of positive responses, with VR slightly outperforming the ethno-vlog in terms of "strongly agree" percentages. This pattern suggests that while ethno-vlogs excel in delivering cultural narratives and fostering contextual understanding, VR provides additional value through interactivity and sensory engagement. Together, these media create a complementary learning experience: the ethno-vlog engages students affectively and culturally, while VR immerses them in exploratory and interactive simulations.

This integration represents a novel pedagogical approach. Previous studies have often investigated vlogs or VR (E. Sari et al., 2024) in isolation. However, the present study demonstrates that the combined use of ethno-vlog and VR media produces a synergistic effect, yielding stronger engagement, motivation, and acceptance than either medium alone. This provides empirical support for the design of culturally relevant digital pedagogy in developing country contexts, where both cultural preservation and technological innovation are educational priorities.

Results of the Effect of Ethno-vlog and VR Media on Science Process Skills

The effectiveness of the ethno-vlog and VR media in improving students' science process skills (SPS) was examined through four consecutive learning sessions. Data were collected using validated SPS rubrics and analyzed through pre- and post-test comparisons, with statistical testing confirming significant improvements. The average pre-test score of 23.18 increased substantially to 48.28 after the intervention, yielding an N-gain value of 0.7651, which falls into the "high" category. As the normality assumption was not satisfied, the Mann–Whitney U test was applied, producing a significance value of 0.000 ($p < 0.05$), thereby confirming that the improvement was statistically significant. These findings validate that the integration of ethno-vlog and VR media was effective in

enhancing students' SPS, consistent with earlier reports by Mudana (2023) on the effectiveness of technology- and ethnoscience-based pedagogies.

The mastery of each SPS indicator across the four sessions is illustrated in Figure 5. The results reveal progressive improvements in all six indicators, though with varying degrees of achievement. Observation skills increased from 60.94% in the first session to 86.17% in the fourth, showing that repeated engagement with culturally contextualized visual and virtual environments enhanced students' ability to focus on detail and accuracy during scientific inquiry. Prediction skills also demonstrated steady improvement, rising from 50% to 81.25%, indicating that students became more adept at anticipating outcomes based on empirical evidence.

Inference emerged as the indicator with the most dramatic improvement, jumping from 32.03% in the first session to 94.27% in the third and remaining stable thereafter. This finding suggests that the integration of video-based cultural narratives and immersive VR effectively trained students to interpret data and draw logical conclusions, corroborating the work of Asy'ari et al. (2019), who emphasized inference as central to scientific reasoning. Classification skills followed a similar upward trajectory, increasing from 60.94% to 87.5%, reflecting students' improved ability to identify similarities, differences, and categorical relationships when exposed to structured visual and interactive materials.

Measurement, which initially recorded the lowest mastery level at 25%, increased sharply to 90.63% by the third session and remained constant in the fourth. This remarkable growth underscores the role of VR in simulating measurement tasks and providing hands-on experiences in virtual ecological contexts, confirming earlier findings by Turiman et al. (2012) regarding the value of interactive digital environments in supporting procedural learning. Communication skills also showed substantial gains, improving from 26.56% to 76.04%. Although this indicator remained the lowest compared to others, the improvement reflects students' growing ability to articulate observations and share scientific information, consistent with prior research by Angganing et al. (2023).

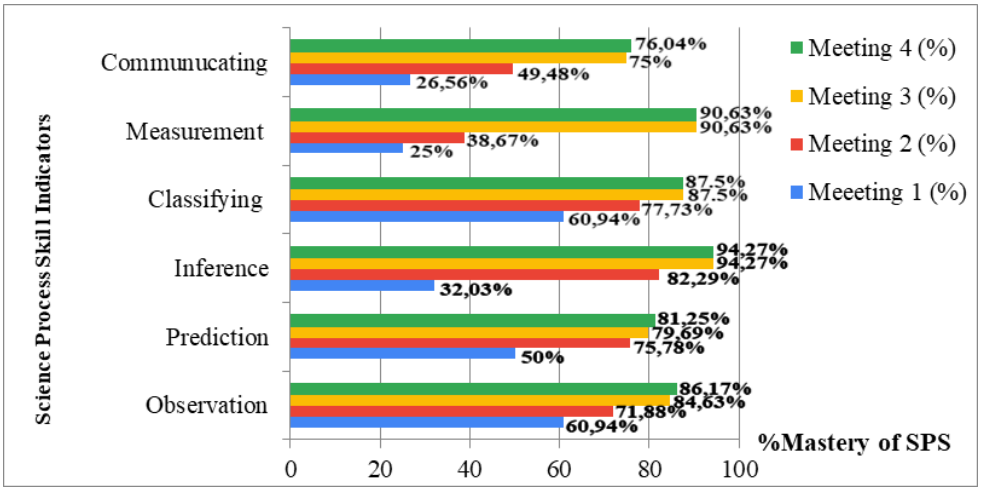

Figure 5. Mastery of Each Science Process Skills Indicator Across Four Sessions

Taken together, these results demonstrate that the ethno-vlog and VR media not only enhanced overall SPS but also addressed specific skill domains. Inference and measurement benefitted most strongly from the intervention, while communication, although improved, remains an area requiring further reinforcement. The integration of cultural authenticity through ethno-vlogs with interactivity and immersion offered by VR provides a complementary effect, producing a more holistic and culturally relevant digital pedagogy than previously documented in studies using either approach alone.

To further illustrate these findings, the following figures present the outcomes of both the small-scale and large-scale trials of the ethno-vlog and VR media on the topic of Oyol Tea. Figure 6 highlights the results obtained from the small-scale trial, reflecting students' initial responses and skill development when first introduced to the media. Figure 7 depicts the large-scale implementation, which provides a broader validation of the media's feasibility and effectiveness in enhancing science

process skills across a wider group of learners.

Figure 6. Small Scale Trial of Etnovlog Media and VR of Oyol Tea

Figure 7. Large Scale Trial of Etnovlog Media and VR of Oyol Tea

Taken together, the visual evidence from Figures 6 and 7 reinforces the statistical and qualitative analyses presented earlier, demonstrating that the integration of ethno-vlog and VR media not only improved students' overall science process skills but also provided a culturally relevant and engaging learning experience. These outcomes establish a strong foundation for drawing the study's final conclusions.

CONCLUSION

This study concludes that the integration of ethno-vlog and VR media based on the cultural context of Oyol tea is highly feasible, well-received by students, and significantly effective in enhancing junior high school students' SPS. Expert validation confirmed that both media achieved the "very feasible" category, while student responses in both small- and large-scale trials indicated high levels of attractiveness, usability, and cultural relevance. Statistical analyses revealed significant improvements in students' SPS, with an N-gain of 0.7651 in the high category and Mann–Whitney results confirming meaningful differences between pre- and post-tests. Mastery increased across all SPS indicators, with inference and measurement showing the most substantial growth, while communication skills, although improved, remained relatively lower. These findings highlight the novelty of combining ethnoscience-based vlogs with interactive VR environments, providing a culturally relevant digital pedagogy that bridges local wisdom with modern technological innovation. The study offers practical implications for developing nations by demonstrating that meaningful science learning can be achieved through accessible technologies enriched with local culture, though further research with larger and more diverse populations is needed to strengthen generalizability and to address remaining challenges in communication skills.

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