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Ethno-RSTEM Integrated E-Module Assisted by Virtual Reality to Provide Students with Chemical Literacy and Religious Values

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Abstract

This research aimed to describe the characteristics of the e-module containing Ethno-RSTEM assisted by virtual reality, and analyze the feasibility and effectiveness of the e-module to provide students with chemical literacy and religious values. This research method used a 4D model (define, design, develop, disseminate). The instruments in this research consisted of test and non-test instruments. The e-module possessed characteristics in the form of local wisdom content in the city of Kudus, STEM and religious values. The e-module also presented 360-degree videos and Ethno-VR local wisdom of the city of Kudus. The e-module was considered suitable for classroom implementation based on expert evaluations of its content, media, and ethno-virtual reality components. The results of student responses to the e-module in the implementation phase obtained an average score of 68.5 ("Very Good" category), and the teacher's practicality questionnaire achieved an average score of 70.1 ("Very Practical" category). Furthermore, the e-module was effective in providing students with chemical literacy, with 6% of students achieving the "Very Good" category, 69% in the "Good" category, and 25% in the "Fair" category. It also enhanced religious values as indicated by an average score of 59.91 ("Very Religious" category).

Keywords: chemical literacy, e-module, ethno-RSTEM, religious values, virtual reality

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1. Introduction

Learning in Indonesia is currently oriented towards 21st-century learning, so that students need to be prepared to have 21st-century skills in order to be able to compete and face the challenges of life in the era of globalization. One of the 21st-century skills needed by students is scientific literacy, including chemical literacy (Rahayu, 2017).

Chemical literacy refers to a person's ability to understand, perform, and apply chemistry accurately and efficiently in everyday life (Thummathong & Thathong, 2018). However, several studies show that students' chemical literacy still needs to be improved (Imansari & Sumarni, 2018; Yustin & Wiyarsi, 2019; Amtonis et al., 2022). Low chemical literacy can be caused by a learning process that is not optimal in providing chemical literacy. Low chemical literacy results require learning that adapts to the 21st-century, as well as to develop students' chemical literacy.

Ethnoscience integrated learning integrates culture into the learning process (Sudarmin & Sumarni, 2018). The application of learning models integrated with ethnoscience has a significant influence on students' chemical literacy (Imansari & Sumarni, 2018; Sanova et al., 2021; Khasanah & Sumarni, 2021; Sumarni et al., 2023). Ethnoscience learning to improve students' knowledge of local wisdom in society needs to be integrated with STEM so that it is relevant for application in 21st-century learning (Primadianningsih et al., 2023).

STEM is an educational paradigm that combines mathematics, science, technology, and engineering (Kulakoglu & Kondakci, 2023). STEM approaches integrated with ethnoscience are successful in improving 21st-century skills (Zakiyah & Sudarmin, 2022). In addition to 21st-century skills, the profile of Pancasila students is one of the important aspects that need to be developed in 21st-century learning, especially in learning with an independent curriculum. The profile of Pancasila students in the independent curriculum is an initiative in strengthening character education.

The profile of Pancasila students has six aspects of character that students must have, which are faith, devotion to God Almighty, noble morals, independence, collaboration, global diversity, critical thinking skills and creative thinking skills. One of the profiles of Pancasila students that must be integrated into learning is religious values. Religious values in society are declining both among children and adolescents (Khosiah et al., 2022). Religious values can be integrated with the Ethno-STEM approach into a new approach, which is Ethno-RSTEM.

The 21st-century is an era where the development of science and technology is very advanced; the delivery of learning materials to students is not enough by using the lecture method, so creative and innovative learning strategies are needed. The use of technology in learning increases the efficiency, effectiveness, and quality of learning and allows students to develop the skills they need to face future challenges (Alimuddin et al., 2023).

Technologies that can be utilized in 21st-century learning are 360-degree videos and virtual reality. A 360-degree video is a video that allows users to see every angle, and virtual reality can simulate processes, events, and conditions in the virtual world (Ratnaduhita et al., 2021). VR glasses, Android phones, and remote controls are tools used to help watch virtual reality media (Fitriya et al., 2022). The use of virtual reality in comprehensive chemistry learning can improve students' understanding of the chemistry material studied in class (Ramírez & Bueno, 2020).

The results of observations conducted in the MGMP chemistry forum in Kudus district obtained information that in implementing the independent curriculum, teachers still face problems because the learning resources they use still come from textbooks. There is a discrepancy between the competencies set by the Ministry of Education and Culture and the content within the reference textbooks used in schools. Specifically, current textbooks often lack adequate integration of the Pancasila Student Profile (Profil Pelajar Pancasila) dimensions and fail to connect chemistry concepts with the practical local wisdom of students' surroundings, such as the Ethno-RSTEM contexts of Kudus City. Therefore, teachers need appropriate learning resources.

One of the learning resources that can be used in the independent curriculum is e-modules. Unlike traditional textbooks, online modules can effectively address varying levels of student proficiency because they are highly adaptable and easier to revise. E-Modules provide free navigation features, allowing students to browse through the learning materials at their own pace (self-paced learning) according to their individual needs. Furthermore, this interactive platform offers opportunities for students with diverse learning styles to explore chemistry concepts adaptively, ensuring that slower learners can revisit foundational topics while advanced learners can progress further (Jafnihirda et al., 2023). E-Modules have the advantage of being accessible anywhere and anytime, economical production budget, efficient to carry and not obsolete over time (Nisa et al., 2020).

The results of interviews with three chemistry teachers who teach at MA NU Ibtidaul Falah, MA NU Miftahul Falah, and MA NU Raden Umar Sa'id obtained information that the learning resources used by teachers in the chemistry learning process are LKS and textbooks purchased by the madrasah. The results of the interviews also obtained information that in chemistry learning, teachers have not implemented the Ethno-

RSTEM learning approach, teachers have not utilized virtual reality technology and teachers have not provided chemical literacy that is integrated with local wisdom optimally.

Although literature indicates that integration of Ethno-STEM and immersive virtual reality could significantly boost 21st-century skills and meaningful chemistry education (Zakiyah & Sudarmin, 2022; van Dinther et al., 2023), there is still a notable gap in literature and empirical evidence regarding their combined application with religious values into an integrated Ethno-RSTEM approach. Empirically, field interviews with chemistry teachers revealed that current learning practices still heavily rely on traditional textbooks and LKS that lack the integration of local wisdom, virtual reality tools, and the Pancasila Student Profile dimensions. Furthermore, prior studies rarely explore how flexible online modules can comprehensively bridge the discrepancy between rigid standard textbooks and the need for adaptive learning environments. This creates a critical need to bridge these pedagogical and empirical gaps by developing an innovative e-module containing Ethno-RSTEM assisted by virtual reality.

This study develops e-modules containing Ethno-RSTEM assisted by virtual reality. The development of e-modules containing Ethno-RSTEM assisted by virtual reality has not been widely developed. Learning using the Ethno-RSTEM approach is an approach that includes cultural contexts, scientific concepts, religion, technology, engineering and mathematics so that the development of e-modules is expected to provide chemical literacy and religious values to students. The use of virtual reality technology provides students with the experience of being virtually present and feeling real when seeing the observed local wisdom. The achievement of chemistry learning that is integrated with local wisdom is the concept of solution chemistry. The concept of solution chemistry is a topic related to the phenomenon of society in everyday life. Local wisdom integrated into chemistry material is three-flavored water, making Kudus soto and parijoto tea.

The e-module produced in this study is expected to be able to provide chemical literacy, religious values, increase cognitive abilities and strengthen the profile of Pancasila students. The importance of this study is to produce alternative learning resources in the form of e-modules containing Ethno-RSTEM assisted by virtual reality on the material of solution chemistry.

2. Research Method

This study uses a research and development method. The development model used in this study is the 4-D model from Thiagarajan et al. (1974) which are the define, design, development and disseminate stages. The product developed and tested in this study is an e-module containing Ethno-RSTEM assisted by virtual reality on chemical solution material implemented at MA NU Ibtidaul Falah and MA Tahfidh Putri Yanbu'ul Qur'an 2 Muria Dawe Kudus.

2.1. Research Procedure

Research and development procedure of e-module containing Ethno-RSTEM assisted by virtual reality using 4-D model. In the define stage, a needs analysis is carried out by conducting interviews and looking for information about learning resources, media and chemistry learning techniques. The design stage was carried out by preparing an e-module design, preparing a 360-degree video innovative media design, preparing an Ethno-Virtual Reality Design for Local Wisdom in Kudus City and preparing research instruments.

In the development stage, e-module validation is carried out which consists of media and material expert validation, ethno-virtual reality validation, draft revision, small-scale trials, product revisions, large-scale trials, product revisions and implementation tests. The disseminate stage is done by distributing the e-module through MGMP and journal publications.

The implementation of the developed e-module was conducted as a structured classroom treatment over four consecutive meetings (each lasting 2 x 45 minutes). The intervention was divided into two core learning units. Before interacting with the e-module, students perform a virtual exploration using their individual spatial accounts to immerse themselves in the local wisdom of Kudus.

The learning units consist of several key components: the learning objectives to be achieved, local wisdom insights, a virtual field trip, comprehensive content explanation, deep dive into religious values, a project-based learning activity utilizing the 'NURUL' syntax, a summary, and an exercise section. Learning Unit one presents electrolyte and non-electrolyte solution concepts, whereas learning unit two addresses acid-base solution topics.

The 'NURUL' syntax-based learning framework refers to five major activities: State the problem, performance through exploration and elaboration, design the project, express the experimental results, and report in video format. The learning process is carried out through an Ethno-RSTEM approach, which initiates with stating a problem regarding the local wisdom of Kudus, followed by a virtual field trip to observe ethno-vlog and 360-degree videos accessible via VR-boxes. The learning activities then proceed to in-depth material discussion, project designing according to the project guidelines, executing an electrolyte and non-electrolyte test project in Learning Unit one, and conducting an acid-base test project in learning unit two. Finally, students report their projects in the form of written reports and also create an ethno-vlog video of the completed project.

2.2. Data Collection Techniques

Data collection techniques to obtain information about needs analysis using interviews. The results of the interview are presented in Appendix three. The questionnaire technique is used to test the feasibility of the product, practicality, student responses to the e-module product and information about students' religious values. In addition, data on students' chemical literacy is also collected through test techniques.

2.3. Data Analysis Techniques

2.3.1. E-Module Feasibility Analysis

The feasibility of the e-module is analyzed based on the results of the validation from material experts, media experts, and Ethno-VR experts. The analysis was carried out by calculating the total scores obtained through the validation Google Forms. The eligibility criteria for the material validation results are presented in Table 1. Furthermore, the eligibility criteria for both the media expert validation and the Ethno-VR expert validation follow the exact same converted scale category as the material expert criteria in Table 1.

Table 1. Eligibility Criteria for Experts Validation

Interval	Category
$48.75 < x \leq 60$	Highly Feasible
$37.5 < x \leq 48.75$	Feasible
$26.25 < x \leq 37.5$	Moderately Feasible
$15 < x \leq 26.25$	Not Feasible

(Sudaryono et al., 2013)

2.3.2. Analysis of Chemical Literacy

The chemical literacy data of students were obtained from the test results using a multiple-choice reasoned test instrument. Multiple-choice questions with correct answers received a score of two and correct reasons received a score of three. The criteria for students' chemical literacy mastery are presented in Table 2.

Table 2. Criteria for Students' Chemical Literacy Mastery

Score	Criteria
86-100	Very Good
71-85	Good
61-70	Fair
51-60	Less
≤ 50	Very Less

(Sumarni, 2018)

2.3.3. Analysis of Students' Religious Values

The analysis of students' religious values was carried out by calculating the average score obtained through the Google form of the student religious values questionnaire, which had calculated the total score of each student. The criteria for students' religious values are presented in Table 3.

Table 3. Criteria for Students' Religious Values

Interval	Criteria
X > 57.8	Very Religious
47.6< X ≤ 57.8	Religious
37.4< X ≤47.6	Quite Religious
27.2< X ≤ 37.4	Less Religious
X ≤ 27.2	Not Religious

(Widyoko, 2010)

3. Result and Discussion

The product produced in this study is an e-module containing Ethno-RSTEM assisted by virtual reality on the material of chemical solutions to equip students with chemical literacy and religious values. The e-module was developed using the Project-Based Learning approach with the NURUL syntax. MA NU Ibtidaul Falah and MA Tahfidh Putri Yanbu'ul Qur'an 2 Muria were chosen as the places to conduct research with subjects of class XI MIPA students. This study aims to describe the characteristics of the e-module containing Ethno-RSTEM assisted by virtual reality on the material of chemical solutions, analyze the feasibility of the e-module, analyze student responses and the practicality of chemistry teachers towards the use of the e-module containing Ethno-RSTEM assisted by virtual reality which was developed, and analyze the effectiveness of the e-module.

The e-module containing Ethno-RSTEM assisted by virtual reality has characteristics containing ethnoscience, religious values, and STEM (Ethno-RSTEM). The e-module also presents 360-degree videos that can be observed using VR-box and Ethno-VR local wisdom of Kudus City which can be accessed online via YouTube and spatial links. 360-degree videos are taken using a 360 camera and then uploaded to YouTube and can be watched with a VR-box. An example of a 360 video presented in the e-module is shown in Figure 1.

Figure 1. 360-Degree Video Display

Ethno-Virtual reality (Ethno-VR) of Kudus City's local wisdom is also presented in the e-module containing Ethno-RSTEM assisted by virtual reality. Ethno-VR was developed through the spatial.io web. The ethno-virtual reality developed contains 3D assets of Kudus City's local wisdom, posters, ethno-vlog videos, 360-degree videos, Kudus City songs, Walisongo songs, Parijoto tea songs, and Asam Basa songs developed through the Suno web, as well as supporting 3D assets in accordance with Kudus City's local wisdom. The ethno-virtual reality of Kudus City's local wisdom has three main galleries, which are the Kudus City gallery, the Parijoto tea gallery, and the three-flavored water gallery. The Ethno-VR display is presented in Figure 2.

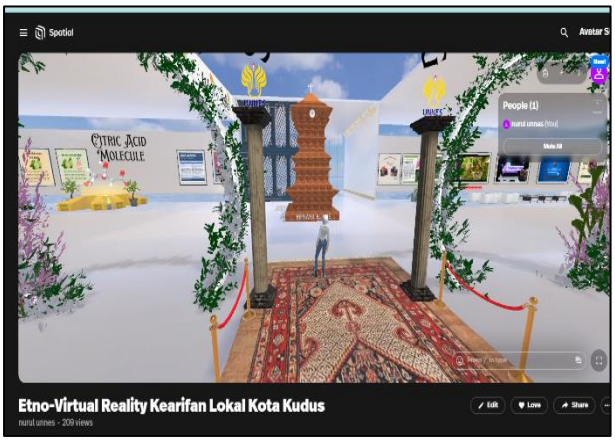

Figure 2. Ethno-Virtual Reality Display of Local Wisdom in Kudus City

Ethno-virtual reality of Kudus City's local wisdom can be accessed via spatial and

YouTube. The following is the spatial link and Ethno-VR YouTube link:
https://bit.ly/Video_Youtube_Etno_vr
https://bit.ly/Etno_VR_kearifanlokalkotakudus

Ethnoscience material developed in e-module is able to improve 21st-century skills (Zakiyah & Sudarmin, 2022). Learning using the STEM approach can create students who are able to face the increasingly complex challenges of life in the 21st-century by developing problem-solving, critical thinking, creativity and innovation, systematic and logical skills (Nurhasnah et al., 2022).

The use of STEM and ethnoscience encourages teachers and students to be able to utilize learning resources in the surrounding environment and technology so that the learning process and learning products produce quality, which are problem-solving skills, critical thinking, creativity and innovation, systematic, and logical (Ahmad et al., 2023). Religious values also need to be integrated into learning because religious values are one of the most important character education values because they are a guideline for every individual in life (Fatimah et al., 2022). The use of Immersive Virtual Reality (IVR) in chemistry learning can support meaningful learning for students (van Dinther et al., 2023).

The developed e-module was validated by media experts, material experts, and Ethno-virtual reality experts as well as chemistry subject teachers. After the validation of the e-module, a trial was carried out on a small and large scale, and then an implementation test was carried out. An analysis of the feasibility of the e-module containing Ethno-RSTEM assisted by virtual reality needs to be carried out to determine the feasibility and validity of the e-module product before it is used in learning.

The assessment of material experts consists of five assessment aspects, which are content quality, presentation quality, Ethno-RSTEM, chemical literacy, and religious values. The results of the validation of material experts on the e-module containing Ethno-RSTEM assisted by virtual reality are presented in Figure 3.

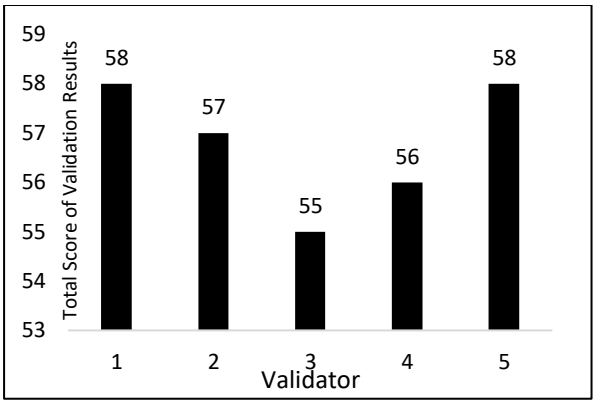

Figure 3. Results of Material Expert Validation

The results of the validation of material experts based on Figure 3 show that the validator of material expert one obtained a score of 58, validator of material expert two obtained a score of 57, validator of material expert three obtained a score of 56, validator of material expert four obtained a score of 56, and validator of material expert five obtained a score of 58. The five scores from the validators meet the criteria of highly feasible. The results of the validation of material experts obtained an average score of 56.8 with the category of highly feasible.

The media expert assessment consists of four assessment aspects, which are the size of the e-module, the design of the e-module cover, the illustration of the e-module, and the design of the e-module content. The results of the media expert validation of the e-module containing Ethno-RSTEM are presented in Figure 4.

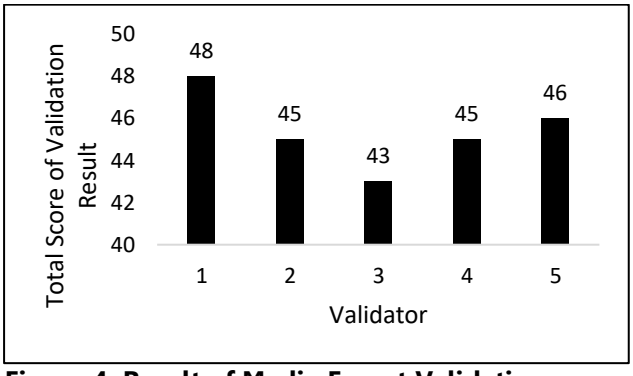

Figure 4. Result of Media Expert Validation

The results of media expert validation based on Figure 4 show that validator one obtained a score of 48, validator two obtained a score of 45, validator three obtained a score of 43, validator four obtained a score of 45, and validator five obtained a score of 46. The five scores from the validators meet the criteria of being very feasible. The results of media expert validation obtained an average score of 45.4. Based on the converted equivalence of the expert validation criteria (Table 1), this score falls into the highly feasible category.

The expert assessment of Ethno-VR consists of seven assessment aspects, which are visual quality, audio quality, immersion and user experience, user friendliness, content quality, chemical literacy, and religious values. The results of the expert validation of Ethno-VR in the e-module containing Ethno-RSTEM assisted by virtual reality are presented in Figure 5.

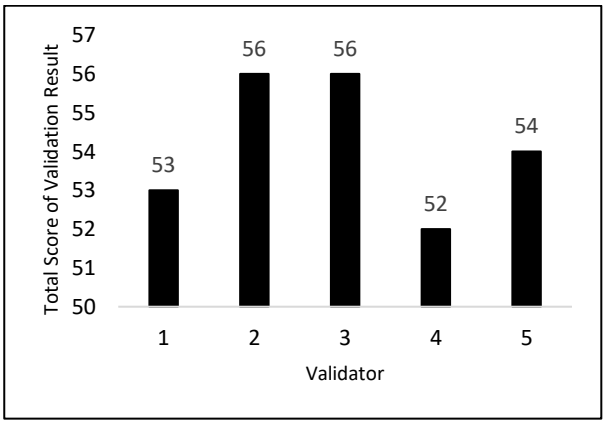

Figure 5. Expert Validation Results of Ethno-VR

The results of the Ethno-VR expert validation based on Figure 5 show that validator one obtained a score of 53, validator two obtained a score of 56, validator three obtained a score of 56, validator four obtained a score of 52, and validator five obtained a score of 54. The five scores from the validators met the criteria of being highly feasible. The results of the Ethno-VR expert validation obtained an average score of 54.2. Based on the converted equivalence of the expert validation criteria (Table 1), this score falls into the highly feasible category.

The student response questionnaire aims to determine the student's response to the use of e-modules containing Ethno-RSTEM assisted by virtual reality. The student response questionnaire was given to 10 students in a small-scale trial, 25 students in a large-scale trial and 32 students in an implementation test. The student response questionnaire consists of 20 questions. The results of student responses in small-scale trials obtained an average score of 70.1, large-scale trials obtained an average score of 68.28, and the implementation test obtained a score of 68.5. Based on the converted equivalence of Widyoko's evaluation criteria (2010), these three scores consistently fall into the very good category.

The practicality of the e-module can be seen from the results of filling out the practicality questionnaire by chemistry teachers. The results of the practicality questionnaire filled out by chemistry teachers obtained an average score of 70.1. Based on the converted equivalence of Widyoko's evaluation criteria (2010), this score falls into the very practical category.

The effectiveness of the e-module containing Ethno-RSTEM assisted by virtual reality is reviewed from two aspects, which are the chemical literacy aspect and the religious values aspect of students.

The assessment of students' chemical literacy was carried out through a chemical literacy test consisting of 20 multiple-choice questions with reasoning. The assessment of students' chemical literacy includes aspects of competence, attitude, knowledge and context. Chemical literacy questions that have been analyzed and declared feasible through large class trials can be used to measure chemical literacy at the implementation test stage. After learning using the e-module containing Ethno-RSTEM assisted by virtual reality, students took a chemical literacy test with a time of 90 minutes. The results of the analysis of chemical literacy of 32 students showed that 2 (6%) students had chemical literacy with the criteria of "Very Good", 22 (69%) students had chemical literacy with the criteria of

"Good" and eight (25%) students had chemical literacy with the criteria of "Fair". The mastery of student chemical literacy is presented in Figure 6.

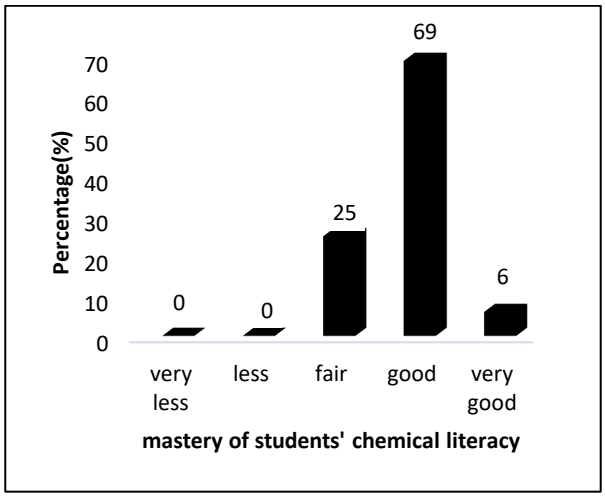

Figure 6. Mastery of Students' Chemical Literacy

The results of the analysis of chemical literacy mastery showed that most students showed a significant increase in chemical literacy after using the e-modules containing Ethno-RSTEM assisted by virtual reality. A total of 22 students (69%) were in the "Good" category, while two students (6%) were in the "Very Good" category. These results indicate that the e-modules is effective in helping students understand chemical concepts through the context of culture, STEM, religious values and virtual reality. Eight students (25%) who were in the "Enough" category showed that there is still an opportunity to improve students' chemical literacy, both in terms of material presentation and the approach used in the e-module.

While the development of the VR-assisted Ethno-RSTEM e-module represents a significant technical effort in this study, it is fundamentally positioned as a pedagogical tool rather than the ultimate objective. The true core contribution of this learning resource lies in how its integrated structural features actively drive the improvement of students' chemical literacy. By transitioning from abstract chemical representations to immersive visual and cultural contexts, the product serves as a cognitive bridge. For instance, when students engage with the 360-degree videos of Kudus soto making or parijoto tea preparation, the abstract concepts of solution chemistry (such as concentration and chemical properties) become concrete. This immersive experience, facilitated by virtual reality, reduces the cognitive load traditionally associated with text-heavy curriculum materials. Consequently, the high proficiency in chemical literacy achieved by students (with 75% scoring in the Good and Very Good categories) demonstrates that the product successfully fulfills its purpose as a catalyst for deeper conceptual understanding and scientific literacy, rather than just a standalone technological innovation.

The measurement of students' religious values was carried out through a questionnaire of students' religious values consisting of 17 questions. The average score obtained was 59.91, which showed that students in the implementation test had religious values with the criteria of "Very Religious" after implementing learning with e-modules containing Ethno-RSTEM assisted by virtual reality.

These findings are consistent with prior research regarding the impact of technology-integrated ethnoscience on learning outcomes. Specifically, the significant increase in students' chemical literacy aligns with the studies by Sumarni et al. (2023) and Sanova et al. (2021), which demonstrated that integrating local wisdom into chemistry concepts enhances contextual understanding and scientific literacy. Furthermore, the successful implementation of the VR-assisted system in this study reflects the findings of van Dinther et al. (2023) and Ramírez & Bueno (2020), who noted that immersive virtual reality provides a meaningful, real-world simulation that bridges abstract chemistry concepts with concrete visual experiences. By comparing these results, it is evident that the combination of the Ethno-RSTEM approach and VR technology in an e-module offers a more powerful, dual-impact solution—not only in boosting cognitive chemical literacy but also in significantly reinforcing students'

religious values compared to traditional, single-approach learning resources.

4. Conclusion

The e-module containing Ethno-RSTEM assisted by virtual reality has unique characteristics, integrating the local wisdom of Kudus City, STEM, and religious values. It also presents 360-degree videos observable via VR-box and Ethno-VR local wisdom of Kudus City, accessible online through YouTube and Spatial links. Based on the validation results from media, material, and Ethno-VR experts, as well as highly positive student responses and teacher practicality assessments, this e-module is highly feasible and practical for chemistry learning. Furthermore, the e-module is proven effective in providing chemical literacy and reinforcing religious values among students. The effectiveness is backed by empirical data from 32 participants, where 6% of students achieved the "Very Good" category, 69% achieved the "Good" category, and 25% achieved the "Fair" category in chemical literacy proficiency. Additionally, students' religious values significantly improved, reaching an average score of 59.91, which falls into the "Very Religious" category after implementing this learning resource.

In a wider context, these findings contribute significantly to the field of chemistry education by demonstrating how immersive technology and culture-based learning can be harmonized to overcome the rigidity of traditional learning resources. This study provides an empirical benchmark for educational designers and policy makers in integrating modern 21st-century technology with character-building frameworks, such as the Pancasila Student Profile, within modern curricula.

Based on the research findings, teachers who intend to implement this e-module are advised to carefully allocate and manage classroom time so that all integrated Ethno-RSTEM activities can be fully optimized. For future researchers, it is highly recommended to develop similar Ethno-RSTEM e-module assisted by virtual reality for other chemistry topics to further enrich innovative learning resources.

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