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Development of Virtual Lab Integrating Ethnoscience in Project-Based Inquiry Learning Tools to Enhance Creative Thinking Skills

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Abstract: This study aims to develop and test the validity and practicality of a Project-Based Inquiry Virtual Lab learning tool integrated with ethnoscience to improve students' creative thinking skills. The study used the Research and Development (R&D) method with the ADDIE development model. Data were collected using expert validation sheets and practicality questionnaires for teachers and students, and analyzed using quantitative descriptive methods. The learning tool was rated very valid with an average score of 82.52%, covering aspects of content, construction, language, and display. The practicality test showed that the tool was very practical, with average scores of 86.9% from teachers and 85.5% from students. These findings indicate that the developed learning tool is feasible to use, easy to implement, and has the potential to be effective in improving students' creative thinking skills.

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Introduction

21st-century learning requires mastery of four key skills known as the 4Cs: communication, collaboration, critical thinking, and creative thinking (Luciana, 2020; Malik, 2018; Rusdin, 2018). These four skills are part of 21st-century intelligence, essential for facing evolving global challenges (Makhrus, 2018). One such challenge is the development of the digital era and global sustainability issues, which demand innovation in science learning, particularly to develop students' creative thinking skills and environmental awareness. Individuals with creative thinking skills tend to be wise in making decisions, considering both good and bad aspects (Amran et al., 2019), and are able to see the potential positive and negative impacts when faced with a problem (Sripongwiwat et al., 2016; Ulger, 2019). Therefore, developing creative thinking skills is an important focus in science education. In this context, the Ethnoscience Integration Virtual Lab with Project-Based Inquiry Learning Tools is a solution, as it is able to provide interactive and meaningful learning experiences that can stimulate students to think creatively and wisely in facing real-life problems.

The Project-Based Inquiry Learning Model allows students to explore science concepts through VR technology, overcome the limitations of physical laboratories, and connect modern science with local wisdom. The integration of local wisdom, traditions, or customs not only reflects the culture of the community but also strengthens unity and togetherness through the practice of mutual assistance and cooperation (Refisrul, 2019). This is in line with the findings of Agusti et al. (2019), emphasizing the urgency of developing innovative approaches that combine the advantages of various models with the integration of local wisdom and technological support, such as VR.

This is where technology plays a crucial role in supporting the learning process, as integrating technology into teaching and learning activities is currently a crucial aspect in achieving successful teaching (Irdalisa, 2022; Kusuma, 2020). One form of technology-based learning media that can be implemented is virtual reality (VR) simulation, which can provide interactive, immersive practical experiences that approximate real-world conditions, even without a physical laboratory. One technology-based learning media that can be implemented in learning is virtual reality (VR) simulation media. Virtual reality is evidence of current technological advances that can allow users to enter a virtual world and interact within it as if they were in the real world (Fitria, 2023).

Virtual laboratories can help students explore and visualize abstract concepts, especially in applying knowledge concepts and improving their scientific literacy (Aripin et al., 2020; Putri et al., 2021). They also improve student learning outcomes and collaboration skills (Junita et al., 2021; Verawati et al., 2022). Furthermore, virtual laboratories can be used by anyone at the same time and can be accessed anywhere and anytime (Harjono et al., 2017; Putra et al., 2020). Virtual laboratories also provide a simulated version of traditional laboratories that are related to student-centered learning (Asrizal et al., 2018; Faour et al., 2018).

Practical activities in virtual laboratories for biology learning must be aligned with core competencies and learning indicators so they can be used to achieve learning objectives and facilitate student understanding of the material being studied. As a solution, this research developed a virtual lab integrating ethnoscience with project-based inquiry learning tools to enhance creative thinking skills.

Research Method

This research uses the development research method, or Research and Development (R&D), and uses the ADDIE model. ADDIE model (Analysis, Design, Development, Implementation, Evaluation) (Widyastuti & Susiana, 2019). However, the development of this research is limited only to the development stage, which includes a review of practicality by student responses and teacher responses. The stages of this research can be illustrated in Figure 1 as follows.

Figure 1. Research and Development Stage of the ADDIE model

The results of the learning device validity analysis consist of the validator's assessment of the developed learning device, which is analyzed by considering the suggestions, input, and comments from the three validators to further revise the developed learning device. If the validator's score for each aspect is at least good, the learning device meets the validity criteria. Based on the validation assessment results obtained, the validity of the learning device can be determined based on the validity criteria in the following table:

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Table 1. Learning Device Validity Criteria

No	Average Percentage of Total	Validity Level
1	80% < P ≤ 100%	Very Valid
2	60% < P ≤ 80%	Valid
3	40% < P ≤ 60%	Fairly Valid
4	20% < P ≤ 40%	Less Valid
5	0% < P ≤ 20%	Not Valid

Source: (Pattimura et al., 2020)

The technique used to assess the practicality of the learning tools is quantitative descriptive analysis, which describes the syllabus, lesson plans, student worksheets, teaching materials, and assessment instruments. The data collected were the results of a student response questionnaire regarding the product developed by the researcher. Based on the practicality assessment results obtained, the practicality of the learning tools can be determined using the criteria in Table 2 below:

Table 2. Practicality Criteria for Learning Devices

No	Percentage Average Total	Practicality Level
1	80% < P ≤ 100%	Very Practical
2	60% < P ≤ 80%	Practical
3	40% < P ≤ 60%	Quite Practical
4	20% < P ≤ 40%	Less Practical
5	0% < P ≤ 20%	Not Practical

Source: (Pattimura et al., 2020)

Results and Discussion

The results of this development research are in the form of learning tools with a *Project-Based Inquiry model.* An integrated ethnoscience *virtual lab* designed to enhance students' creative thinking skills is feasible and practical. The research process begins with an analysis phase, which includes a literature review and field study. The literature review is conducted to review previous research and relevant studies, while the field study includes observations and direct interviews with teachers in charge of related subjects at the school. The next stage is the design of *the* learning tools to be developed, followed by the development phase. The products produced at this stage are validated by experts, and the validation results serve as the basis for determining the level of feasibility of the learning tools for implementation in the learning process.

Analyze

The research and development process begins with the *analysis stage*, which includes literature studies and field studies. The field study was conducted through direct observation and interviews with biology teachers at the school, as well as conducting an initial test to measure students' creative thinking skills. The observation results showed that the curriculum used was the 2013 Curriculum. Findings from the interviews indicated that teachers still applied conventional learning methods, such as lectures, discussions, and assignments. In addition, the initial test results showed that students' critical thinking skills were in the very low category. Based on the findings of the field study, it was concluded that more effective learning strategies and innovative learning tools were needed to support the achievement of quality learning outcomes. Well-designed and high-quality learning tools were expected to ensure the implementation of an effective, meaningful learning process that was in accordance with the expected objectives (Utami et al., 2019).

Design

The development of a project-based learning model to improve environmental awareness in early childhood includes components of syntax, social systems, teacher roles, and support systems. The implementation of this learning model is carried out through several stages, namely: (a) opening learning by asking a starting question (*start with the essential question*), (b) planning the project (*design a plan for the project*), (c) preparing a schedule of activities (*create a schedule*), (d) monitoring the implementation of the project and the progress of students (*monitor the students and the progress of the project*), (e) assessing the resulting product (*assess the outcome*), and (f) evaluating the entire learning process (*evaluate the experience*). evaluation of learning materials, initial planning of learning materials, and initial planning and learning (Cahyadi, 2019). Product designs include syllabuses, lesson plans, teaching materials or handouts, student worksheets (LKPD), and test instruments.

Development

Learning Device Validation Test Stage

In the development stage, researchers design learning tools according to a previously prepared plan and then validate them through assessment by expert validators. At this stage, the conceptual framework is implemented into a ready-to-use learning tool product that meets the stated objectives. A summary of the validation results by the expert validators is presented in Figure 2.

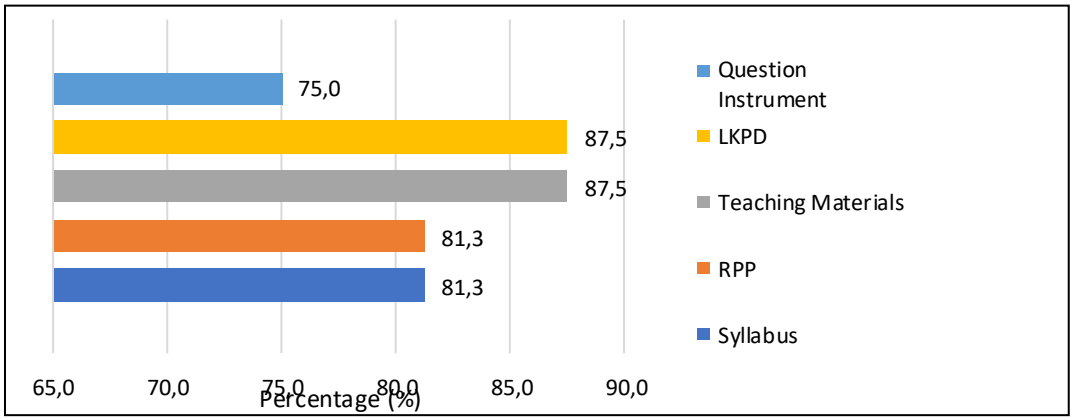

Figure 2. Results of Learning Device Validity

The development of the learning tools resulted in five main products: a syllabus, lesson plans, student worksheets (LKPD), teaching materials/handouts, and assessment instruments. All of the developed learning tools met the very valid criteria and were therefore deemed suitable for implementation and use after minor revisions. The following description provides a discussion of each of these learning tools.

Syllabus

A syllabus is a plan and agreement that outlines learning activities, classroom management, and assessment of learning outcomes (Aguss et al., 2021). Based on Figure 2, the syllabus's learning tool validity level is categorized as very good and is considered suitable for use after minor revisions, with an overall average percentage of 81.3%. Details of the syllabus validation results by experts for each aspect are presented in Table 3.

Table 3. Syllabus Validation Results

No	Validated Aspect	Average (%)	Criteria
1	Clarity of syllabus components	87.5	Very Valid

2	Syllabus developed with Physics content, ensuring relevance	87.5	Very Valid
3	Compliance of the syllabus with systematic principles	81.3	Very Valid
4	Consistency in syllabus structure, including Core Competencies (KD), main topics, indicators, learning activities, assessment, time allocation, and learning resources	75.0	Valid
5	Syllabus supports the achievement of Core Competencies (KD)	87.5	Very Valid
6	Statements align with the intended aspects	87.5	Very Valid
7	Syllabus development is based on actual and conceptual principles	81.3	Very Valid
8	Flexibility of the syllabus material	75.6	Valid
9	Syllabus development is based on a comprehensive approach	68.5	Valid
Average value Overall		**81.3**	**Very Valid**

Based on the data in the table, the validation results for the nine aspects of the syllabus assessment indicate that the overall syllabus is in the very valid category with an average of 81.3%. The aspect that received the highest score of 87.5% includes the clarity of the syllabus components, the relevance of the syllabus to the biology subject with the medicinal plant material, the syllabus's ability to support the achievement of basic competencies (KD), and the suitability of statements with the aspects to be achieved. This indicates that the syllabus has been prepared with a clear structure, is relevant to the material, and is able to support the achievement of learning objectives. Aspects that fulfill the systematic principles and the principles of actual and conceptual development also received high scores of 81.3% each, indicating that the syllabus preparation follows a coherent flow and considers the suitability of the content to the development of science. Meanwhile, the lowest score was obtained in the aspect of the principle of comprehensive syllabus development (68.5%), which indicates the need for improvements in the completeness of the material coverage and supporting components. Several other aspects, such as consistency in syllabus development (75.0%) and material flexibility (75.6%), although already in the very valid category, still require revision to achieve optimal quality. Overall, these results indicate that the syllabus is suitable for use in the learning process after minor revisions to certain aspects.

Lesson Implementation Plan (RPP)

The lesson plan product is based on the 2013 curriculum with relevant learning materials. The learning steps presented refer to the syntax of the project-based inquiry virtual lab integrated with ethnoscience to improve students' creative thinking skills. The lesson plan serves as an essential learning plan to direct all learning activities so that learning objectives are achieved and the expected skills can be mastered by students (Setiana, 2019). Details of the results of the lesson plan validation by experts on each aspect are presented in Table 4.

Table 4. Results of Validation of the Learning Implementation Plan (RPP)

No	Aspects that validated	Average (%)	Criteria
1	Identity Eye Lesson	87.5	Very Valid
2	Formulation Objective/ Indicator	87.5	Very Valid
3	Material	81.3	Very Valid
4	Method Learning	87.5	Very Valid
5	Activity Learning	87.5	Valid

6	Election Media/ Source Study	81.3	Very Valid
7	Evaluation Results Study	75.0	Valid
8	Linguistics	75.6	Very Valid
9	Development character	68.6	Very Valid
Average value Overall		**81.3**	**Very Valid**

Based on the data in Table 4, the validation results of the Lesson Implementation Plan (RPP) indicate that overall, it is in the very valid category with an average of 81.3%. The aspects that received the highest score of 87.5% were subject identity, formulation of objectives/indicators, learning methods, and learning activities. This indicates that the RPP has been designed in accordance with the learning identity, has clear objectives, uses appropriate methods, and contains systematic learning steps. The material aspect and selection of learning media/resources also received a high score of 81.3%, indicating that the learning content is in accordance with basic competencies and is supported by relevant media and learning resources. Meanwhile, the learning outcome assessment aspect received a score of 75.0% and the language aspect 75.6%, both of which are in the valid to very valid category, but still require improvement to make the assessment instrument more comprehensive and the use of language more effective. The aspect with the lowest score was character development at 68.6%, indicating that the integration of character values in the RPP still needs to be strengthened. Overall, the RPP that was developed can be declared suitable for use after minor revisions were made to aspects that still have weaknesses.

Student Worksheets (LKPD)

Student Worksheets (LKPD) are learning tools containing tasks to be completed by students, generally presented in the form of instructions and steps (Effendi et al., 2021). Based on Figure 2, the validity results of the LKPD learning tool are categorized as very valid and are declared suitable for use after minor revisions, with an overall average percentage of 87.5%. Details of the LKPD validation results by experts for each aspect are presented in Table 5.

Table 5. Validation Results of Student Worksheets (LKPD)

No	Aspects that validated	Average (%)	Criteria
1	Completeness identity LKPD	87.5	Very Valid
2	Clarity instruction Work	87.5	Very Valid
3	Objective learning in accordance with the Lesson Plan	93.8	Valid
4	Compliance material with the objective learning in LKPD	87.5	Valid
5	Convenience steps activity	87.5	Very Valid
6	Compliance allocation time	93.8	Very Valid
7	Use the order Language in accordance with EYD	87.5	Very Valid
8	A sentence that uses simple and easy-to-understand words	87.5	Very Valid
9	Illustration LKPD describes the material taught	87.5	Very Valid
10	Compliance letter	81.3	Very Valid
11	Harmony order location	81.3	Valid
12	The existence of indicators of creative thinking skills aspects	87.5	Very Valid
Average value Overall		87.5	Very Valid

Based on the data in the table, the validation results of the Student Worksheet (LKPD) show that overall, the LKPD is in the very valid category with an average of 87.5%. The aspects that received the highest scores were the suitability of time allocation and learning objectives according to the Lesson Plan, each with a percentage of 93.8%. This indicates that

the LKPD has been designed with attention to the achievement of learning objectives and proportional time management. Several other aspects, such as completeness of identity, clarity of work instructions, suitability of materials, ease of activity steps, and indicators of creative thinking skills, also received high scores, namely 87.5%, indicating that the LKPD has fulfilled its pedagogical function and is able to facilitate student learning activities.

In addition, aspects of language use in accordance with EYD, simplicity of sentences, illustrations that describe the teaching material, and the suitability of letters obtained scores between 81.3% to 87.5%, which means that visually and linguistically the LKPD is quite good and easy to understand. The aspect with the lowest score is the harmony of the layout, with a percentage of 81.3%, so it still needs improvement to make the LKPD display more attractive and proportional. Overall, the results of this validation indicate that the LKPD is suitable for use in learning after minor revisions are made to certain aspects, especially the layout and strengthening of indicators of creative thinking skills.

Handouts

Handouts are a form of simple teaching material compiled based on relevant literature (Prastowo, 2019). Based on Figure 2, the validity results of the learning tool in the form of handouts are categorized as very valid and are declared suitable for use after minor revisions, with an overall average percentage of 87.5%. Details of the handout validation results by experts for each aspect can be seen in Figure 6.

Figure 6. Results of Teaching Material Validation

No	Assessment Aspects	Indicators/Assessment Items	Average (%)	Criteria
1	Content Eligibility	Suitability of material to learning objectives	87.5	Very Valid
		Accuracy and precision of the material	93.1	Very Valid
		Up-to-date information and references	87.4	Very Valid
		Suitability of material to the level of student development	92.0	Very Valid
Average Amount			**90.0**	**Very Valid**
2	Linguistics	Clarity of use Language	87.5	Very Valid
		Accuracy of use of terms and symbols	81.5	Very Valid
		Text readability	81.6	Very Valid
Average Amount			**83.5**	**Very Valid**
3	Presentation	Systematization of material presentation	93.1	Very Valid
		Clarity of presentation of illustrations/images	87.0	Very Valid
		Matching examples and exercises	87.1	Very Valid
Average Amount			**89.0**	**Very Valid**
4	Graphics	Attractive layout and typography design	87.5	Very Valid
		Color combination suitability and appearance cohesion	87.5	Very Valid
Average Value Per Aspect			**87.5**	**Very Valid**
Overall Average Value			**87.5**	**Very Valid**

Based on the results of the data analysis in the table, it can be seen that the developed learning device meets the criteria of very valid with an overall average of 87.5%. In the aspect of content feasibility, an average of 90.0% was obtained with a very valid category. This indicates that the material in the learning device is in accordance with the objectives, accurate, up-to-date, and relevant to the level of development of students. Furthermore, the linguistic aspect obtained an average of 83.5% with a very valid category, which means the use of language, terms, symbols, and readability of the text are quite clear and easy to understand by students, although they still need some improvement. In the presentation aspect, the average obtained was 89.0% with a very valid category, indicating that the presentation of the material is systematic, supported by relevant illustrations, as well as appropriate examples and exercises. Meanwhile, the graphic aspect obtained an average of 87.5% with a very valid category, which indicates that the layout, typography, and color combinations have been designed attractively and harmoniously. Overall, these results prove that the learning device validated by experts is suitable for use in the learning process after going through minor improvements.

Assessment Instruments

The assessment instrument consisted of questions that referred to indicators of creative thinking skills. The questions developed were nine descriptive questions. Figure 2 shows that the validity level of the learning tool, in the form of an assessment instrument, was valid and suitable for use after minor revisions, with an overall average percentage of 75.0%. The results of the assessment instrument validation by experts for each aspect can be seen in Figure 7.

Figure 7. Assessment Instrument Validation Results

No	Aspects that validated	Average (%)	Criteria
1	Fluency in generating ideas	78.0	Valid
2	Flexibility in seeing various points of view	77.0	Valid
3	The novelty (originality) of the proposed idea	75.0	Valid
4	Detail (elaboration) in developing ideas	74.0	Valid
5	The ability to combine ideas into new concepts	76.0	Valid
6	Clarity of delivery of ideas	75.0	Very Valid
7	Ability to relate ideas to local/real context	74.0	Valid
8	Courage to take risks on new ideas	72.0	Valid
9	Ability to reflect and improve ideas	74.0	Valid
Average value Overall		**75.0**	**Valid**

Based on the data in the table, students' creative thinking skills showed an overall average of 75.0%, categorized as valid. This indicates that students have been able to demonstrate creative thinking skills in various aspects, although there is still room for improvement. In the fluency aspect, students obtained a score of 78.0%, categorized as valid, which means they are quite capable of generating many ideas. The flexibility aspect obtained a score of 77.0%, indicating the ability to see problems from various perspectives. Furthermore, the originality aspect was at 75.0%, indicating that the new ideas that emerged were valid, but not yet very prominent.

Practicality Testing Stage of Learning Devices

The practical value of the project-based inquiry virtual learning tool, the Ethnoscience Integrated Lab, for enhancing creative thinking skills is evident from the analysis of questionnaires completed by teachers and students as users during the field test. The following describes the results of the analysis of each instrument.\

1) Teacher Response Questionnaire Results

The practicality questionnaire completed by teachers aims to obtain information regarding the practicality of learning devices based on teachers' predictions and considerations after using the devices during the learning process. In general, the results of the practicality questionnaire completed by teachers can be seen in Table 8.

Table 8. Teacher Response Questionnaire Results Data

No	Practical Aspects	Teacher 1 (%)	Teacher 2 (%)	Teacher 3 (%)	Teacher 4 (%)	Average (%)	Criteria
1	Ease of use	88	90	85	87	87.5	Very Practical
2	Clarity of instructions	90	92	88	89	89.8	Very Practical
3	Timeliness	84	86	85	83	84.5	Practical
4	Attraction	87	88	86	85	86.5	Very Practical
5	Usefulness	89	90	88	87	88.5	Very Practical
6	Suitability to school conditions	85	84	82	83	83.5	Practical
7	Efficiency	86	87	85	84	85.5	Very Practical
8	Student involvement	88	90	87	86	87.8	Very Practical
9	Support for learning objectives	90	92	89	88	89.8	Very Practical
10	Flexibility	85	87	84	83	84.8	Practical
Average value Overall						**86.9**	**Very Practical**

Based on the practicality assessment by four biology teachers, the learning device received an overall average score of 86.9%, categorized as Very Practical. The highest-scoring aspects were clarity of instructions (89.8%) and support for learning objectives (89.8%), while the lowest-scoring aspect was suitability to school conditions (83.5%). This indicates that the learning device is very easy to use, clear, useful, and able to engage students, although it still needs some adjustments to better suit the school's infrastructure.

2) Results of Student Response Questionnaire

This practicality questionnaire was administered to students after participating in the learning process using the syllabus, lesson plans, student worksheets, teaching materials, and creative thinking skills instruments based on guided discovery. The overall results of the practicality questionnaire completed by students can be seen in Table 9 below.

Table 9. Student Response Questionnaire Results Data

No	Aspects that validated	Average (%)	Criteria
1	Ease of use	85.0	Very Practical
2	Clarity of instructions	87.0	Very Practical
3	Timeliness	82.5	Practical
4	Attraction	86.0	Very Practical
5	Usefulness	88.0	Very Practical
6	Suitability to school conditions	83.0	Practical
7	Efficiency	84.5	Practical
8	Student involvement	87.5	Very Practical
9	Support for learning objectives	89.0	Very Practical
10	Flexibility	82.0	Practical
Average value Overall		**85.5**	**Very Practical**

Based on assessments from 20 students, the learning tool received an overall average score of 85.5%, categorized as Very Practical. This indicates that the learning tool is easy to use, clear, useful, and able to support learning objectives. The highest-scoring aspects were support for learning objectives (89.0%) and usefulness (88.0%), indicating students felt the device truly aided their learning process. Meanwhile, the lowest-scoring aspects were flexibility (82.0%) and timeliness (82.5%), indicating a need for adjustments in time allocation and flexibility in device use across various settings.

Based on the validation results in the graph, the Project-Based Inquiry Virtual Lab learning tool, integrated with ethnoscience, was categorized as valid to very valid. The test instrument received a score of 75.0% (valid), thus still requiring minor revisions. The Student Worksheet (LKPD) and teaching materials components received the highest score of 87.5% (very valid), indicating the quality of the content and presentation is suitable for use. Meanwhile, the Lesson Plan (RPP) and syllabus received a score of 81.3% (very valid), indicating a sound planning structure, although still requiring minor improvements. This is reinforced by research by Aulianingsih (2021), which states that validation aims to determine the quality of the developed product, where the validation process is carried out by validators in their respective fields. Similarly, based on the analysis of the articles obtained, several studies also concluded that the use of virtual laboratories or virtual reality cannot completely replace traditional laboratories. This conclusion is based on the responses of most students who disagreed with the idea that virtual laboratories (VL) should replace conventional biology laboratories (Byukusenge et al., 2023; Coan et al., 2020).

Several other studies have shown a different perspective, stating that virtual microscopy with digital slides can gradually replace light microscopes with glass slides due to higher acceptance and improved diagnostic capabilities (Chang et al., 2021). However, virtual laboratories cannot replace conventional laboratories, but they can address existing challenges, optimize the learning process, and be used to support and complement the shortage of laboratory equipment in schools (Lestari et al., 2023).

Conclusion

The results of the study indicate that the *Project-Based Inquiry Virtual Lab learning device* integrated with ethnoscience, is declared very valid, with an average validation score of 82.52%. All learning device products developed have obtained validity criteria with a very valid category, so that they are suitable for use without major revisions. In addition, the practicality test involving 4 biology teachers obtained an average score of 86.9% (very practical), and the practicality test by 20 students obtained an average score of 85.5% (very practical). This shows that the device is easy to use, understand, and supports the implementation of learning. Thus, this device has the potential to be effective in improving students' creative thinking skills.

Recommendation

Based on the research results, the *Project-Based Inquiry Virtual Lab learning tool,* integrated with ethnoscience, was declared highly valid and very practical, so it is recommended for use in the biology learning process to improve students' creative thinking skills. Teachers can utilize this tool as an innovative learning alternative that integrates virtual technology with local wisdom values, so that learning becomes more contextual, interesting, and meaningful.

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