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Utilization of Virtual Reality (VR) as A Tour of Buton Local Culture to Improve Understanding of Jelajah Nusantara Material in Elementary Schools

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ABSTRACT

This study aims to analyze students' understanding of the Jelajah Nusantara topic through Virtual Reality (VR)-based learning media featuring a Buton Local Culture Tour, describe the media development and validity, and examine its effectiveness in improving elementary school students' understanding. The study employed a Design-Based Research (DBR) approach involving needs analysis, design, development, validation, implementation, evaluation, reflection, and product refinement. The participants were 30 elementary school students. Data were collected through expert validation sheets, observations, pretest and posttest, student response questionnaires, interviews, and documentation. Data were analyzed using validation percentages, learning mastery, N-Gain, and a paired-samples t-test. The results showed that the media obtained validity scores of 87% from the material expert, 85% from the cultural expert, and 83% from the media expert, with an overall validity score of 85%. The mean score increased from 59.67 to 77.67, while learning mastery increased from 23.33% to 90%. The paired-samples t-test showed a significant difference, $t(29) = 17.897$, $p < .001$, while the N-Gain score of 0.45 was categorized as moderate. Student responses reached 83.00%, categorized as very good. These findings indicate that the media is feasible and effective in supporting Social Studies learning through visual, interactive, and contextual experiences.

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1. INTRODUCTION

In Social Studies (IPS) education at the elementary school level plays a strategic role in developing students' understanding of social life, cultural diversity, the environment, and community identity. Social Studies learning should not be limited to the acquisition of factual knowledge; rather, it should provide learning experiences that enable

students to connect knowledge with the social and cultural contexts of their surroundings. The integration of local wisdom into Social Studies learning has been shown to strengthen contextual understanding, cultural values, tolerance, and character development among elementary school students [1], [2], [3]. Other studies have also demonstrated that local wisdom-based Social Studies learning can provide learning experiences that are more closely connected to students' everyday lives while supporting the development of social attitudes and appreciation for cultural and national heritage [4], [5]. Within this context, the *Jelajah Nusantara* topic is particularly important because it provides students with opportunities to explore Indonesia's diverse regions, cultures, traditions, arts, and characteristics of community life. However, the breadth and diversity of cultural objects addressed in the topic may present challenges when students' learning experiences rely primarily on verbal explanations, textbooks, and two-dimensional images. This condition highlights the need for learning media capable of presenting cultural objects in a more concrete, visual, and contextual manner.

The development of educational technology provides an opportunity to broaden such learning experiences through Virtual Reality (VR). VR enables learners to enter three-dimensional virtual environments and interact with objects presented digitally. This characteristic creates opportunities to transform learning from merely receiving information into an experience involving observation, exploration, and interaction with the learning environment. Systematic reviews of *immersive virtual reality* have demonstrated the potential of VR to support learning processes and the development of knowledge and skills; however, its effectiveness is strongly influenced by the design of the learning environment and the extent to which the technology is aligned with instructional objectives [6], [7]. Therefore, VR should not be positioned merely as a visually appealing technology. Its pedagogical value depends on its capacity to connect virtual experiences with learning content, activities, and intended learning outcomes.

Research on VR in elementary education has also received increasing attention. A recent systematic review of VR use in elementary school learning indicates a growing number of publications, particularly during 2023 and 2024. The review found that VR remains predominantly applied in science education, although its use has expanded into other fields, including language, arts, religious education, physical education, and Social Studies. Overall, VR has been reported to have the potential to support conceptual understanding, learning motivation, student engagement, immersive experiences, and twenty-first-century skills [8]. Empirical findings involving elementary school students have also demonstrated improvements in learning outcomes following the use of VR media, as indicated by differences between *pretest* and *posttest* scores [9]. Other research on VR applications in elementary education has shown that the technology can provide visual and interactive experiences that help students understand learning materials more concretely (Rahmiati et al., 2024). Experimental research involving fourth-grade students has further demonstrated improvements in students' understanding and engagement following VR-based learning compared with conventional learning [10].

Despite this strong potential, the use of VR in elementary education still presents a conceptual challenge. Much of the existing research positions VR primarily as a means of

visualizing objects, providing simulations, or increasing student engagement, whereas its use as an environment for presenting local cultural experiences within Social Studies learning remains relatively open for further development. This issue is particularly important because Social Studies content requires more than the visualization of objects; it also requires attention to the social, historical, cultural, and identity-related meanings associated with those objects. In other words, the challenge of developing VR for Social Studies is not simply to create a three-dimensional environment, but to determine what cultural content should be presented, how the content should be represented accurately, how students should explore it, what contextual information should accompany the cultural objects, and how the virtual experience can help students understand their social and cultural meanings.

At the same time, research on local culture demonstrates that cultural elements can serve as valuable learning resources when systematically integrated into instruction. Azahra et al. found that local wisdom can be utilized as a Social Studies learning resource to foster cultural values and tolerance among elementary and Islamic elementary school students [11]. Afriyadi et al. demonstrated that the integration of *Piil Pesenggiri* into Social Studies learning can serve as a foundation for strengthening character education among elementary school students In South Sulawesi [12]. Developed a Social Studies learning model based on *Pangngadakkang Tupanrita* by utilizing digital resources to support the development of students' prosocial behavior [13]. Other studies have shown that digital media based on local wisdom, including videos, digital comics, and interactive multimedia, can support learning outcomes while maintaining cultural elements in elementary education [14], [15]. These findings indicate that the direction of educational development is no longer simply a matter of choosing between technology and culture, but increasingly involves finding ways to integrate the two within meaningful learning experiences. integrating local culture into digital learning also raises the issue of cultural authenticity. Digital representation can potentially reduce cultural objects to visual elements if their historical, social, and cultural meanings are not adequately presented. Therefore, the development of culturally based digital learning media requires not only the selection of culturally relevant objects but also the use of reliable cultural references, expert clarification, and contextual explanations that help students understand the meanings associated with the objects being presented.

This development also reveals a research gap. Research on VR has provided evidence of the benefits of immersive learning experiences, while research on local wisdom has established the importance of culture as a source and context for learning. However, these two approaches have not yet been widely integrated into a virtual learning environment specifically designed for Social Studies and the *Jelajah Nusantara* topic. Moreover, the gap concerns not only the technological integration of VR and local culture but also how cultural content is selected, validated, contextualized, and transformed into an interactive learning experience. Furthermore, existing research on VR for cultural education has demonstrated that this technology can be used to introduce cultural heritage through virtual environments, but the cultural objects, educational context, and learning objectives differ from the needs of elementary school learning related to Buton culture

[16]. Therefore, there remains an opportunity to develop learning media that positions VR not merely as a visual medium, but as a virtual cultural tour through which students can explore representations of local culture as an integral part of Social Studies learning.

Based on this research gap, the present study contributes not only a Virtual Reality-based Buton Local Culture Tour but also a reference-based and expert-validated approach for integrating local cultural content into immersive Social Studies learning. The contribution is reflected in several interconnected design and pedagogical principles. First, cultural objects are selected based on their cultural relevance and their connection to the *Jelajah Nusantara* learning objectives. Second, the virtual environment is designed to provide accessible exploration for elementary school students. Third, cultural objects are presented not only as three-dimensional visual representations but also with contextual explanations that provide relevant historical, social, and cultural information. Fourth, teacher guidance is used to help students connect their virtual exploration with Social Studies concepts and learning objectives. The novelty of this study lies in the integration of three complementary components: Virtual Reality as an experiential learning environment, Buton local culture as the source and context of learning, and the *Jelajah Nusantara* topic as a curricular context for understanding Indonesia's cultural diversity. The virtual environment developed in this study presents representations of Buton local culture, including the Malige Traditional House, the Buton Sultanate Fortress, Buton traditional woven textiles, and traditional Buton performing arts. The cultural content presented in the virtual environment was developed from recognized and relevant historical and cultural references and was subsequently clarified by a cultural expert and a material expert. The cultural expert reviewed the accuracy and appropriateness of the cultural information and representation, while the material expert examined its relevance to the learning objectives and the characteristics of elementary school students. The content was revised based on the experts' suggestions before being incorporated into the VR environment. Importantly, the cultural representations in the VR environment were not limited to visual displays. Each selected cultural object was accompanied by explanatory information that students could access through the interactive features of the virtual environment. The explanations were designed to provide contextual information about the cultural and historical significance of the objects, allowing students to connect what they observed with the broader cultural context of the Buton community. Thus, the VR environment functions not only as a visual representation of cultural objects but also as a contextual learning environment.

The development process employs a Design-Based Research (DBR) approach, enabling the development process to proceed iteratively through design, implementation, evaluation, reflection, and product refinement [17]. This approach strengthens the contribution of the study because the product is evaluated not only in terms of its technological features but also in terms of content suitability, cultural representation, usability, and students' learning experiences in an authentic classroom context. The iterative process also provides an opportunity to refine the relationship between cultural content, virtual exploration, contextual explanation, and Social Studies learning objectives, thereby generating design considerations that may be adapted to other local cultural contexts. The iterative process also provides an opportunity to refine the relationship

between cultural content, virtual exploration, contextual explanation, and Social Studies learning objectives, thereby generating design considerations that may be adapted to other local cultural contexts.

Based on the foregoing discussion, this study is directed toward answering three research questions: (1) What is the level of students' understanding of the *Jelajah Nusantara* topic through the use of Virtual Reality (VR)-based learning media featuring a Buton Local Culture Tour? (2) How are the design and development processes conducted, and what is the validity level of the Virtual Reality (VR)-based learning media featuring a Buton Local Culture Tour for Social Studies learning? (3) How effective is the Virtual Reality (VR)-based learning media in improving elementary school students' understanding of the *Jelajah Nusantara* topic?

2. METHOD

This This This study employed a Design-Based Research (DBR) approach to develop and evaluate Virtual Reality (VR)-based learning media in the form of a Buton Local Culture Tour for the *Jelajah Nusantara* topic in elementary school. The DBR approach was selected because it enables the development of educational solutions while generating knowledge through iterative processes of design, implementation, evaluation, reflection, and refinement in authentic learning contexts [18], [19]. This characteristic makes DBR appropriate for the present study, which not only aims to produce a learning media product but also to examine and refine the product based on empirical evidence obtained during implementation.

The research procedure consisted of six main stages: literature review and needs analysis, instructional design, learning media development, implementation of learning using VR media, data analysis, and reflection and evaluation, as presented in Figure 1.

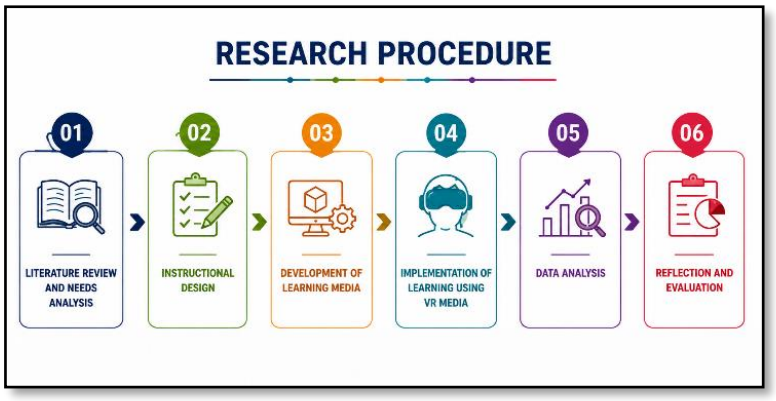


Figure 1. Research Procedure

These six stages were organized as a DBR process in which evidence obtained from needs analysis, expert validation, implementation, and evaluation informed subsequent design decisions and product refinement. Thus, the six stages should not be interpreted as a strictly linear procedure, but as an interconnected development process in which findings from evaluation and reflection were used to identify aspects requiring improvement and to establish the refined version of the VR learning media.

Table 1. Activities in Each DBR Stage

DBR Stage	Main Activities	Output
Literature Review and Needs Analysis	Reviewed literature and identified learning and media needs related to Exploring the Archipelago and Buton culture.	Learning needs and cultural content requirements.
Instructional Design	Designed learning objectives, content, learning flow, and VR interaction.	Instructional and VR design.
Learning Media Development	Developed VR using Unity and Millealab and conducted expert validation.	Validated VR learning media.
Implementation (Product Trial)	Implemented the VR media with 30 students and collected pretest, posttest, observation, and response data.	Implementation and empirical data.
Data Analysis and Evaluation	Analyzed learning outcomes, student responses, and implementation data.	Evidence of learning improvement and media use.
6. Reflection and Product Refinement (DBR Iteration)	Reflected on validation and implementation findings to determine aspects requiring refinement.	Refined final version of the VR learning media.

The study involved 30 elementary school students as research participants. Before classroom implementation, the developed media was validated by a material expert, a cultural expert, and a media expert. The validation was conducted to assess the suitability of the instructional content, the accuracy of the local cultural representations, and the technical quality of the media. Expert assessment was used as an initial evaluation stage before the product was implemented with students [20]. The developed media consisted of a virtual environment integrating the *Jelajah Nusantara* topic with representations of Buton local culture, including the Malige Traditional House, Buton Sultanate Fortress, traditional woven textiles, and traditional Buton dance. The media was developed using Unity and Millealab.

The use of VR in this study is based on its ability to provide learners with immersive and interactive learning experiences. The cognitive affective model of immersive learning explains that immersive virtual environments can influence learning through the interaction of presence, agency, motivation, and cognitive processing [21]. A meta-analysis of controlled studies in elementary education found that students who learned through virtual environments achieved higher learning scores than those who learned through traditional classroom instruction, supporting the potential of VR to improve learning outcomes in elementary education [22].

The research instruments consisted of expert validation sheets, a learning comprehension test, an observation sheet, a student response questionnaire, interviews, and documentation. The expert validation sheets were used to assess the feasibility of the media in terms of instructional content, cultural accuracy, and media quality. The learning comprehension test was administered as a pretest and posttest to measure changes in students' understanding of the *Jelajah Nusantara* topic. The observation sheet was used to record students' activities during the learning process. The student response questionnaire

consisted of 20 statements covering five aspects: interest in the media, ease of use, media quality, learning benefits, and learning motivation.

Comprehension Test Instrument. The learning comprehension test was developed to measure students' understanding of the *Jelajah Nusantara* topic, particularly the local cultural content presented through the VR media. The test consisted of 10 multiple-choice items with four response options for each assessment. The items covered cultural content including the Malige Traditional House, Banua Tada, Benteng Keraton Buton, Buton woven textiles, Mangaru, Lawati, Galangi, and cultural values of the Wolio community. The competency indicators included identifying cultural objects and their functions, recognizing characteristics of cultural objects, explaining cultural functions and meanings, identifying the context of cultural traditions, and recognizing values contained in local culture.

Two parallel forms of the test were used for the pretest and posttest. Both forms assessed the same learning content and competency indicators, but the wording and specific question contexts were varied. This arrangement was intended to reduce the possibility that students would answer the posttest based on recall of the pretest items. Each correct answer was assigned a score of 1, whereas an incorrect answer was assigned a score of 0. The total score was then converted to a scale of 0–100.

Table 2. Blueprint of the Learning Comprehension Test

No.	Competency Indicator	Learning Content	Item
1	Identify the function of Malige	Malige Traditional House	1
2	Identify characteristics of Malige	Malige Traditional House	2
3	Identify the function of Banua Tada Tare Pata Pale	Buton Traditional Houses	3
4	Identify the function of Benteng Keraton Buton	Buton Sultanate Heritage	4
5	Explain the function of Buton woven textiles	Buton Traditional Textiles	5
6	Identify the symbolic meaning of woven motifs	Buton Traditional Textiles	6
7	Identify the meaning/context of Mangaru	Buton Traditional Arts	7
8	Identify the meaning of Lawati	Buton Cultural Tradition	8
9	Identify the context of Galangi	Buton Traditional Arts	9
10	Identify cultural values of the Wolio community	Wolio Cultural Values	10

The content alignment of the test was examined by comparing the items with the learning objectives, competency indicators, and instructional content addressed in the VR learning media. The test items were also reviewed in relation to the instructional content before classroom implementation. In addition, empirical item analysis was conducted using the students' response data to examine item-level performance. Because the test items were scored dichotomously, internal consistency was assessed using the KR-20 coefficient.

The research implementation began with a literature review and needs analysis, followed by instructional design and learning media development. The developed product was subsequently validated by the material, cultural, and media experts. Evidence obtained from the needs analysis and expert review was used to identify aspects of the media requiring adjustment before classroom implementation. The product was then revised according to the identified needs and expert suggestions. The refined media was implemented in learning activities involving 30 students. Evidence obtained during

implementation, including student activities, learning outcomes, and student responses, was subsequently considered during the reflection and evaluation stage to determine the strengths and aspects of the media requiring further refinement.

During the implementation, the pretest was administered before the learning activity, after which students participated in learning using the VR media. Student activities were observed throughout the learning process. After the learning activity, the posttest and student response questionnaire were administered. Observation, interview, and documentation data were collected as supporting evidence to strengthen the interpretation of the implementation results. The testing and revision processes in design-based research enable educational products to be improved through iterative cycles of design, implementation, evaluation, and refinement based on evidence obtained from authentic learning contexts [23].

The data were analyzed using descriptive quantitative and inferential techniques. Expert validation and student response data were analyzed using percentages. Learning outcomes were analyzed based on the mean scores and learning mastery using a minimum mastery criterion of 65. Improvements in students' understanding were analyzed using the N-Gain score. The normalized-gain approach was used to examine changes in students' scores between the pretest and posttest [24]. For the comprehension test, item-level analysis was conducted using the students' dichotomous response data to examine empirical item validity, while the KR-20 coefficient was used to estimate the internal consistency of the test.

Because the same participants were assessed before and after the learning intervention, differences between the pretest and posttest scores were analyzed using a paired-samples *t*-test at a significance level of 0.05 [25]. Observation, interview, and documentation data were used as supporting evidence to strengthen the interpretation of the implementation results. The findings were subsequently used in the reflection and evaluation stage to identify the strengths, limitations, and aspects of the media requiring further refinement.

3. RESULTS AND DISCUSSION

3.1. Needs Analysis Results

The needs analysis was conducted to identify the learning conditions, limitations of the existing learning media, and the needs of teachers and students related to the *Jelajah Nusantara* topic. The analysis involved classroom observation, interviews, and questionnaires with teachers and students. The findings indicated a need for learning experiences that could present local cultural objects more concretely and contextually, particularly because cultural diversity cannot always be directly presented within the classroom. These findings were used to determine the content and characteristics of the VR learning media. The needs analysis therefore focused on providing students with opportunities to explore local cultural objects through an interactive learning environment rather than relying solely on conventional representations.

Based on these needs, several design requirements were established. First, the media needed to provide concrete representations of Buton local cultural objects. Second,

students needed opportunities to explore cultural objects within a virtual environment. Third, cultural information needed to be presented together with the objects so that exploration remained connected to the learning content. Fourth, the learning environment needed to provide clear guidance for students when interacting with the VR media. These requirements informed the development of three-dimensional cultural objects, contextual information panels, guided navigation, tutorial features, and an interactive virtual tour environment.

Table 3. Needs Analysis Findings and Design Requirements

Temuan Analisis Kebutuhan	Kebutuhan Pembelajaran	Design Requirement	Fitur VR
Objek budaya lokal tidak selalu dapat dihadirkan secara langsung di kelas	Siswa membutuhkan representasi budaya yang lebih konkret	Menyediakan representasi objek budaya dalam lingkungan virtual	3D cultural objects
Pembelajaran budaya membutuhkan pengalaman eksplorasi	Siswa perlu kesempatan mengamati dan mengeksplorasi objek budaya	Menyediakan lingkungan virtual yang dapat dieksplorasi	Cultural tour environment
Informasi budaya perlu tetap terhubung dengan objek yang diamati	Siswa membutuhkan informasi kontekstual selama eksplorasi	Menempatkan informasi pendukung pada objek budaya	Information panels
Siswa membutuhkan arahan ketika menggunakan lingkungan VR	Siswa memerlukan orientasi sebelum eksplorasi	Menyediakan petunjuk penggunaan awal	Tutorial
Eksplorasi objek membutuhkan interaksi yang mudah dipahami	Siswa perlu mengakses dan mengamati objek secara lebih fleksibel	Menyediakan navigasi dan fitur zoom	Navigation and zoom

These design requirements directly informed the structure and content of the VR learning media. The resulting product integrated Buton cultural objects, including the Malige Traditional House, Buton Palace Fortress, traditional textiles, and traditional dances, into a virtual environment. The design combined three-dimensional representations with supporting information, navigation, and orientation features to connect cultural exploration with the learning objectives of the *Jelajah Nusantara* material.

3.2. Validity of the Virtual Reality Tour Budaya Lokal Buton Media

The Virtual Reality (VR) Tour Budaya Lokal Buton media was developed as a learning medium for the *Jelajah Nusantara* topic by integrating a virtual environment with representations of Buton local culture. The product was developed through a process of design, development, validation, implementation, evaluation, reflection, and refinement, consistent with the *Design-Based Research* approach employed in this study. The development was intended to enable students not only to obtain information about culture through texts and images but also to explore cultural objects within a virtual environment.

Before being implemented in the classroom, the media was evaluated by a material expert, a cultural expert, and a media expert. The validation results are presented in Table 4.

Table 4. Validation Results of the Virtual Reality Tour Budaya Lokal Buton Media

Validation Aspect	Percentage	Category
Material expert	87%	Very Valid
Cultural expert	85%	Very Valid
Media expert	83%	Very Valid
Average	**85%**	**Very Valid**

As shown in Table 4, the media obtained a validation score of 87% from the material expert, 85% from the cultural expert, and 83% from the media expert, resulting in an overall average of 85%. These findings indicate that the media met the feasibility criteria in terms of instructional content, cultural accuracy, and technical quality.

The material expert's score of 87% indicates that the content presented in the media was highly consistent with the *Jelajah Nusantara* topic and the intended learning objectives. Meanwhile, the cultural expert's score of 85% indicates that the representation of Buton local culture received a very positive evaluation. This aspect is particularly important because the media does not merely present cultural objects as visual illustrations but incorporates them as part of the students' exploration experience. The media expert's score of 83% further indicates that the technical aspects of the product met the required feasibility criteria.

These findings demonstrate that the quality of VR-based learning media is not determined solely by its ability to produce a three-dimensional environment, but also by the alignment among technology, content, and learning objectives. This finding is consistent with research on theory-based immersive VR learning design, which emphasizes the importance of instructional design principles, learner characteristics, cognitive load, and reflective activities in supporting effective learning experiences [26].

Previous research on virtual and augmented reality technologies in education has likewise shown that immersive experiences can provide opportunities to enhance learner engagement and learning experiences, although their benefits depend strongly on the pedagogical design and characteristics of learners [27]. Therefore, the overall validation score of 85% in the present study provides evidence that the integration of VR technology with local cultural content is feasible for learning purposes.

3.3. Media Design, Development, and Refinement

The VR learning media was developed as a virtual cultural tour that presents selected elements of Buton local culture within the *Jelajah Nusantara* topic. The media provides students with opportunities to explore cultural objects through a virtual environment supported by visual representations, information, navigation, and audio features.

Table 5. VR Media Features and Learning Functions

VR Feature	Learning Function
Start menu	Provides initial access to the learning environment
Tutorial	Provides orientation for students before exploration
3D cultural objects	Provides concrete visual representations of Buton culture
Information panels	Provides contextual explanations of cultural objects
Navigation and zoom	Allows students to explore cultural objects
Audio support	Supports students in accessing cultural information
Cultural tour environment	Connects local cultural objects with the *Jelajah Nusantara* topic

The features of the VR media were designed to connect technological affordances with the learning objectives of the *Jelajah Nusantara* topic. Rather than functioning only as a three-dimensional display, the media combined visual representation, guided navigation, contextual information, and interactive exploration to support students' learning experiences. The integration of these features positioned the VR environment as a learning space in which students could observe and explore Buton cultural objects while remaining connected to the instructional content.



Start Menu and Tutorial 3D Malige Traditional House Historical Information about Malige

Figure 2. Representative Views of the VR Learning Media

Figure 2 presents representative views of the VR learning media developed in this study. Panel (a) shows the start menu and tutorial used to introduce students to the virtual environment. Panel (b) presents the three-dimensional representation of the Malige Traditional House, which allows students to explore a cultural object in the virtual environment. Panel (c) shows historical information about the Malige Traditional House, including the zoom feature for accessing the displayed information. These views illustrate the integration of orientation, cultural object exploration, and contextual information within the VR learning environment.

The development of the media did not end with expert validation. Classroom implementation provided additional information regarding how the product functioned in an authentic learning environment. The observations indicated that several students still required guidance when they first used the media. This finding provided additional evidence regarding students' interaction with the VR learning environment and the need for appropriate assistance during initial use.

This finding is important because there may be a difference between product feasibility based on expert assessment and users' actual experiences. A learning medium may obtain a high validation score while students may still experience difficulties when interacting with it. In elementary education, navigation, information readability, usage

instructions, and interaction duration are particularly important because students require appropriate structure and guidance when encountering new technologies.

This condition highlights the strength of the DBR approach employed in this study. Expert validation provides information about product feasibility, whereas implementation provides evidence regarding product performance in an authentic learning context. These two forms of evidence can then be used as a basis for further product refinement.

Conceptually, this finding supports the view that design-based educational research should not focus exclusively on the final product, but should also consider the relationship among design, implementation, learning context, and reflection. Such an approach enables educational products to be continuously improved through iterative cycles informed by empirical evidence from users [28].

Thus, the contribution of the development process in this study extends beyond producing valid VR media. It demonstrates that immersive learning media for elementary school students should be developed iteratively and responsively according to users' actual learning experiences.

3.4. Improvement in Students' Understanding of the Jelajah Nusantara Topic

The media was implemented with 30 elementary school students. Students' understanding was measured through a pretest administered before the learning activity and a posttest administered after learning using the VR media.

Table 6. Comparison of Pretest and Posttest Results

Indicator	Pretest	Posttest
Number of students	30	30
Minimum score	50	60
Maximum score	80	100
Mean score	59.67	77.67
Students achieving KKTP	7	27
Learning mastery	**23.33%**	**90.00%**

As presented in Table 6, the students' mean score increased from 59.67 on the pretest to 77.67 on the posttest, representing an increase of 18 points. Before the intervention, only 7 students, or 23.33%, achieved the KKTP score of 65. After learning with the VR media, the number of students achieving mastery increased to 27 students, or 90%. Thus, learning mastery increased by 66.67 percentage points.

This change indicates an improvement in students' understanding following the implementation of the Virtual Reality Tour Budaya Lokal Buton. The improvement was evident not only in the mean score but also in the number of students who achieved the predetermined mastery criterion.

From a pedagogical perspective, this improvement may be associated with the characteristics of the media, which provide students with visual and exploratory learning experiences. In the *Jelajah Nusantara* topic, cultural objects that might otherwise be studied primarily through textbooks or two-dimensional images can be represented within

a virtual environment, allowing students to observe and explore them in a more concrete manner.

This finding is consistent with previous research on the use of VR in elementary education, which indicates that virtual learning media can provide more interactive learning experiences and support students' understanding of instructional content [29], Other research has also reported that VR experiences can enhance learners' experiences and engagement, although their cognitive effectiveness remains dependent on the instructional design in which the technology is embedded [30].

In the present study, the virtual experience is particularly contextual because the objects presented are not merely three-dimensional objects but representations of Buton local culture. Therefore, the improvement in students' understanding cannot be viewed solely as a consequence of VR visualization. It may also reflect the capacity of the media to connect cultural objects with the content of the *Jelajah Nusantara* topic.

3.5. Effectiveness of the Media Based on Statistical Analysis

To examine differences in students' learning outcomes before and after implementation, a *paired-samples t-test* was conducted. The results showed $t(29) = 17.897$, $p < .001$, indicating a statistically significant difference between the pretest and posttest scores. The N-Gain score was 0.45, which falls within the moderate category.

These findings strengthen the descriptive results presented in Table 2. The increase in the mean score from 59.67 to 77.67 represents not only a numerical improvement but also a statistically significant difference. Meanwhile, the N-Gain score of 0.45 indicates that the magnitude of students' improvement was moderate.

The two analyses therefore provide complementary information. The *t*-test indicates the statistical significance of the difference, whereas the N-Gain indicates the level of improvement. Accordingly, the findings should not be interpreted as demonstrating a large effect of VR, because the N-Gain score indicates a moderate level of improvement.

This finding is consistent with previous research on VR use in elementary education, which has reported improved learning outcomes following VR-based learning experiences [31]. Nevertheless, the present study provides a different context because VR was used specifically to introduce local cultural experiences within Social Studies learning.

3.6. Student Responses to the Virtual Reality Media

Students' responses to the media were measured using a questionnaire consisting of 20 statements. The results indicated that all assessed aspects achieved the minimum target of 80%.

Table 7. Student Responses to the Virtual Reality Media

Aspect	Percentage	Category	Target	Achievement
Media interest	86%	Very Good	80%	Achieved
Ease of use	80%	Good	80%	Achieved
Media quality	82%	Very Good	80%	Achieved
Learning benefits	83%	Very Good	80%	Achieved
Learning motivation	84%	Very Good	80%	Achieved
Overall	**83%**	**Very Good**	**80%**	**Achieved**

As shown in Table 7, the overall student response reached 83%, exceeding the research target of 80%. All assessed aspects also met the target, with scores ranging from 80% to 86%. The highest score was obtained for media interest (86%), while the lowest was recorded for ease of use (80%).

The high score for media interest indicates that the virtual environment and cultural objects presented in the media were able to provide an engaging learning experience. Meanwhile, the scores of 84% for learning motivation and 83% for learning benefits suggest that students were not merely attracted to the technology itself but also perceived the media as beneficial for their learning activities.

This finding is consistent with research on elementary school students' experiences with immersive VR, which indicates that virtual experiences can provide positive and engaging learning experiences for students [32]. However, the ease-of-use score, which was exactly at the predetermined target, suggests that the attractiveness of immersive technology needs to be accompanied by interface and navigation designs appropriate to elementary school students' abilities [33].

Therefore, the overall student response of 83% provides additional support for the feasibility of the media from the users' perspective. This finding also complements the expert validation result of 85%, indicating that the feasibility of the media was supported not only by professional evaluation but also by its acceptance among students as direct users.

3.7. Learning Activities During Implementation

The observation results showed that researcher activity reached 85%, student activity reached 80%, and overall learning activity reached 82.50%.

Table 8. Learning Activities during Implementation

Component	Percentage
Researcher activity	85%
Student activity	80%
Overall	**82.50%**

These findings indicate that the implementation of the media proceeded well. Student activity reached 80%, indicating that students were actively involved in the learning process while using the VR media. Such involvement is important because

immersive experiences may have limited pedagogical value if students merely act as passive users.

In this study, student activities included observing, exploring, receiving information, and responding to instructional guidance while using the media. Thus, VR functioned as an experiential learning environment, while the teacher or researcher continued to play an essential role in guiding students' experiences toward the intended learning objectives.

This finding reinforces the view that immersive technologies should be embedded within a structured pedagogical design. VR should not replace the teacher; rather, it should function as a tool for extending students' learning experiences. Previous research on VR-based learning likewise indicates that the educational value of immersive technology depends substantially on how it is integrated with learning activities and instructional objectives [34].

3.8. Design Principles Derived from the DBR Process

The findings from the needs analysis, media implementation, and student learning activities were further synthesized to identify design principles emerging from the DBR process. These principles connect the empirical evidence obtained during implementation with practical implications for the design of VR-based local culture learning for elementary school students. The resulting design principles are presented in Table 9.

Table 9. Design Principles Derived from the DBR Process

Design Principle	Evidence from the Study	Design Implication
Guided exploration	Several students required guidance during initial VR use	Provide guidance during students' initial exploration
Orientation before exploration	Students required assistance when first interacting with the VR environment	Provide tutorial and orientation before exploration
Contextual cultural representation	Cultural objects were integrated with supporting information	Present cultural objects together with contextual learning information
Teacher-supported VR learning	Students' activities involved responding to instructional guidance	Position VR as a learning support rather than a replacement for the teacher

The DBR process generated several design principles that extend beyond the specific VR product developed in this study. First, VR-based learning for elementary students should employ guided exploration because students may require assistance when first interacting with an unfamiliar immersive environment. Second, orientation should precede exploration so that students understand how to interact with the virtual environment before engaging with cultural objects. Third, local cultural objects should be presented together with contextual information so that immersive exploration remains connected to the intended learning content. Fourth, VR should be implemented as a teacher-supported learning environment rather than as a replacement for teacher guidance.

4. CONCLUSION

This study demonstrates that the Virtual Reality (VR) Tour Budaya Lokal Buton media is feasible for use in Social Studies learning on the *Jelajah Nusantara* topic in elementary school. The media obtained an overall validity score of 85%, consisting of 87% from the material expert, 85% from the cultural expert, and 83% from the media expert, indicating a very valid level of feasibility. The implementation involving 30 elementary school students showed an improvement in students' understanding, with the mean score increasing from 59.67 to 77.67 and learning mastery increasing from 23.33% to 90%. The paired-samples *t*-test confirmed a statistically significant difference between the pretest and posttest scores, $t(29) = 17.897$, $p < .001$, while the N-Gain score of 0.45 indicated a moderate level of improvement. Student responses reached 83%, indicating a very good level of acceptance and exceeding the predetermined target of 80%.

The findings may be influenced by the characteristics of the school, students, and cultural context. Fourth, the involvement of the teacher and researcher in guiding students during VR use may also have contributed to students' learning experiences and outcomes. Fifth, the participants included students from Grades IV and V, whose prior knowledge and developmental characteristics may differ. Sixth, the use of pretest and posttest may have introduced a testing effect because students were exposed to the assessment content before the learning intervention. Finally, the study did not include a delayed posttest, so the extent to which students retained their understanding over time remains unknown. Accordingly, the findings should not be generalized to all elementary school students or to other local cultural topics without further investigation. Future studies should involve larger and more diverse samples across multiple schools and cultural contexts, include control or comparison groups, examine possible novelty and teacher effects, and incorporate delayed posttests to assess learning retention. Further refinement of navigation, interactivity, and cultural content is also recommended to optimize students' learning experiences

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