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Development of VR-Based Virtual Tours for South Sorong Regency Using the Analysis, Design, Development, Implementation, and Evaluation Model

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Abstract.
Purpose: The limited availability of digital documentation and interactive promotional media has reduced public awareness of tourism destinations in South Sorong Regency. This study aims to develop and evaluate a Virtual Reality (VR)-based virtual tour as a solution to enhance user understanding, engagement, and visitation intention.
Methods: This study employed a Research and Development approach using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model. Three tourism destinations were captured using 360° panoramic video and integrated into an interactive VR-based virtual tour. The virtual tour was evaluated with 97 respondents. Respondents completed a pre-test before using the virtual tour and a post-test after the experience to measure changes in understanding and interest, analyzed using the N-Gain method. Usability and acceptance were assessed through Likert-scale user questionnaires and percentage-based feasibility analysis. Media and material experts evaluated technical quality and content accuracy; their feedback was used for virtual tour media revision before final validation.
Results: The results show improved user understanding and engagement, indicated by an N-Gain score of 0.64, categorized as moderate to high effectiveness. User evaluation yielded a feasibility score of 93%. Expert validation confirmed readiness, with feasibility scores of 89% from media experts and 94% from material experts.
Novelty: This study introduces a systematic ADDIE-based engineering framework for multi-destination VR virtual tour development, integrating effectiveness analysis, usability evaluation, and expert validation as a scalable informatics solution for digital tourism promotion in underdeveloped regions.

Keywords: ADDIE, Digital tourism, South Sorong, Virtual reality, Virtual tour
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INTRODUCTION

The transformation of tourism information into digital is a part of national development agenda as stated in the Asta Cita which mentions strengthening economic resilience, achieving an equal regional development and technology- based public services [1], [2]. In addition to these priorities, the need for digital promotional media that are creative and innovative has become greater as contemporary travellers increasingly rely on visual and interactive depictions of destinations before making travel choices [3], [4], [5]. Comparable issues are faced in parts of Eastern Indonesia (such as West Papua) where the tourism potential of certain areas is still highly under-promoted, due to lack of digital information and unequal accessibility to information [6]. The introduction of Virtual Reality (VR) as a means of promoting tourism supports Asta Cita point 2 that is regional development, and point 5 technology-based public services [7], [8], [9].

Meanwhile in the local context, South Sorong Regency has faced similar problems since this region still lacks representative and immersive digital documentation of its tourism objects. This combined with geographic distance limits the effectiveness of online promotion and doesn't let potential tourists get a full impact of local destinations [10], [11]. Therefore, there is a great demand for digital methods in this field, since they can close the gap by providing an immersive way of visualizing tourism offer and a structured way of depicting tourism assets [12].

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Several previous researchers have developed VR-based virtual tours as digital tourism promotion material. Idris et al. demonstrated that VR applications following the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model facilitate both immersion and destination exposure [13], [14], [15]; however, assessment was largely concerned with application feasibility and overall user perception, and there was no quantitative proof of changes in user learning to multiple destinations. Other studies such as Amali et al. worked on 360 degree virtual tours with interactive maps (Leaflet JS) to improve spatial visualization and usability especially for campus, however they didn't apply a structured instructional development framework, learning effect measurement or expert-based content validation [16]. In general, available studies show that VR virtual tour has been proved to work very well for visualisation and promotion but they either focus on single-attraction application, or on the usability of the virtual tour media, or on technical implementation only.

In the field of VR tourism promotion, the majority of current research emphasizes its descriptive aspects, such as user satisfaction, visualization quality, or case studies focusing on one destination [17], [18]. Even though some studies use systematic development approaches like the ADDIE model, most of them do not provide sufficiently empirical-supported and reproducible studies [19], [20]. Research integrating thorough evaluations—effectiveness, usability, and expert assessments—remains scarce, especially in the context of underdeveloped multi-destination tourism regions. This gap suggests the need to reconceptualize VR-based virtual tours purely as visual marketing tools and as structurally sound, built, and assessed applied information systems. Despite the ADDIE model being used as a primary framework in many VR-based educational media [21], [22]. This study contributes to the tourism field by designing and testing a VR virtual tour with multiple destinations for South Sorong Regency. This research is unique in that it combines a systematic development process grounded in ADDIE with a multi-faceted evaluation approach that includes learning-outcome evaluation, user feedback evaluation, and expert evaluation [23], [24].

METHODS

This study employed a structured research and development (R&D) workflow based on the ADDIE model. Each ADDIE phase was operationalized into specific activities following an input–process–output scheme. Development of the virtual tour will be based on ADDIE model to guarantee it is appropriate, organized, and suitable to users [25], [26]. As illustrated in Figure 1, the workflow systematically integrates virtual tour media requirement, VR design and development, implementation, and multi-stage evaluation to ensure a coherent, reproducible, and technically grounded development process for a 360° video-based virtual tour as a digital tourism promotion medium [27], [28].

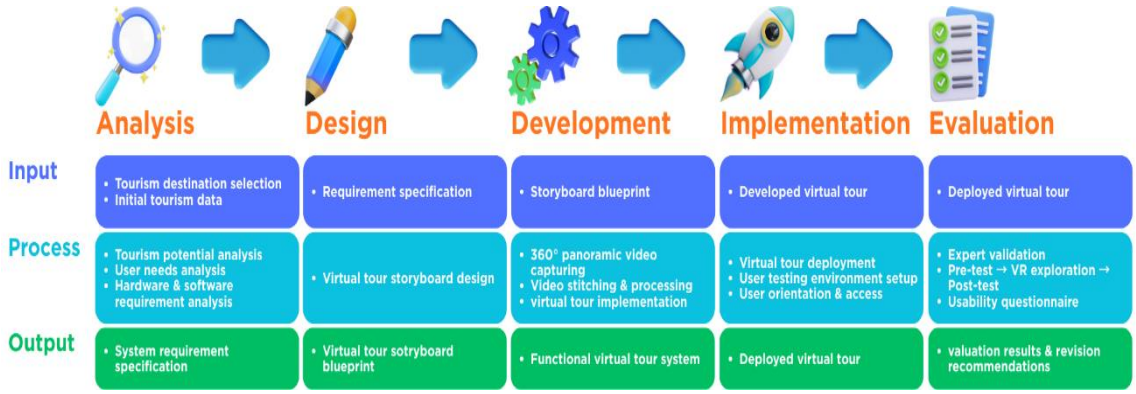

Figure 1. Research Method

Figure 1 shows the ADDIE-based research workflow for developing a 360° VR virtual tour, illustrating the input–process–output structure, system development stages, and iterative evaluation process.

Research Workflow

This study followed a structured research workflow based on the ADDIE model to develop and assess a Virtual Reality (VR)-based virtual tour. The analysis phase identified tourism promotion needs, user requirements, and technical constraints. These requirements were translated in the design phase into a virtual tour storyboard. The development phase implemented the VR through 360° panoramic video and video processing. The implementation phase deployed for user access and testing. Finally, the evaluation

phase applied pre-test and post-test measurements, usability questionnaires, and expert validation. Feedback from users and experts was used to refine the prior to final evaluation.

Analysis

The analysis stage identified the need for a 360° VR-based virtual tour as a digital tourism promotion medium for South Sorong Regency through observations, interviews, literature review, and assessment of existing visual documentation, user needs, and destination characteristics [29]. The dataset comprised 360° panoramic videos from three tourism destinations and evaluation data from 97 respondents, which informed virtual tour requirement. The results showed that Kali Sembra, Sasnek Waterfall, and Panta Kapal River possess strong visual potential but lack adequate digital documentation, forming the basis for content design, experience flow, and technical specifications of the virtual tour [30].

Functional Requirements

Virtual tours should present stable and realistic 360° videos accessible on both VR and non-VR devices, supported by simple route information and brief narratives to provide users with an informative overview of the destination [16].

Non-Functional Requirements

Non-functional requirements include software and hardware, as listed in Table 1 and Table 2.

Table 1. Non-functional software requirements

No.	Software	Description
1.	Insta360 Studio	360° Video Editing Software
2.	Operating System Windows 10 64 bit	Operating System
3.	VLC Media Player	Preview 360° Video Results

Table 2. Non-functional hardware requirements

No.	Hardware	Description
1.	Camera 360°	Hardware for recording VR videos
2.	PC/Laptop	Video processing and VR rendering hardware
3.	VR Headset	Hardware for immersive experience testing.
4.	Smartphone	Hardware for testing the accessibility of virtual tours without VR devices.
5.	Tripod	For stability when taking 360° videos

Tables 8 and 9 present the non-functional requirements at the analysis stage, including the software and hardware needed to support 360° video recording, processing, and testing. Required software includes Insta360 Studio, Windows 10, and VLC, while hardware comprises 360° cameras, PCs/laptops, VR headsets, smartphones, and tripods to ensure smooth production and evaluation of the virtual tour.

Design

In the design phase, the input from the analysis stage was translated into a structured storyboard to define the virtual tour experience. In the design phase, a structured storyboard was developed to define capture points, navigation flow, visual narratives, and brief destination information, serving as a blueprint for the subsequent development stage [31], [32]. Example of a 360° video storyboard at the Sasnek Waterfall tourist site, shown in Table 10 as a reference for content development.

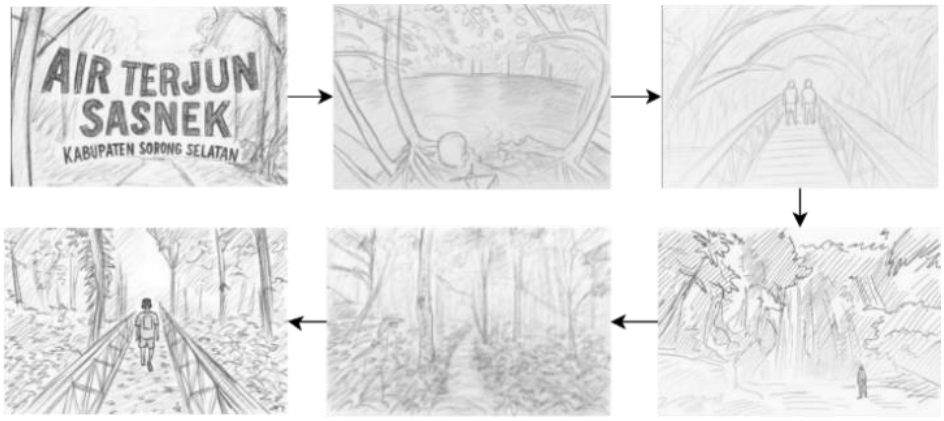

Figure 2. Storyboard for the Virtual Tour of Sasnek Waterfall – South Sorong Regency

The storyboard in Figure 2 serves as a guideline for recording and compiling 360° videos, so that each panorama and narrative can be realized according to the design plan and support the next stage of development.

Development

In the development phase, a 360° video-based virtual tour was produced through video stitching, stabilization, color correction, audio enhancement, and narration integration, following the approved storyboard [33], [34]. Figure 3 show the example of video editing using insta360 studio software.

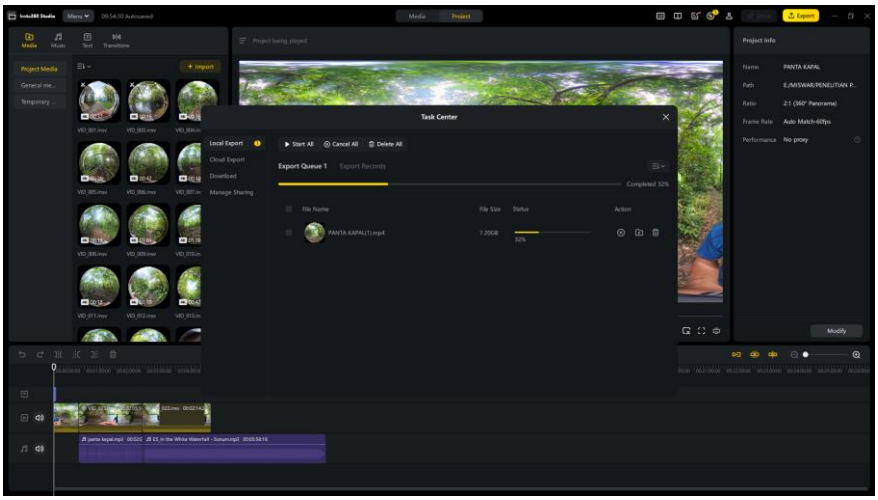

Figure 3. 360° Video Editing and Rendering Process

Figure 3 illustrates workflow for editing 360° video using Insta360 Studio software from stitching two lenses of a 360° camera together to achieve complete spherical capture, & adjusting colouration, stabilization & adding audio and narration.

Implementation

The implementation phase involved deploying the developed virtual tour for testing across multiple devices, including VR headsets, laptops, and smartphones. A pilot test was first conducted with five participants to ensure technical functionality and accessibility. Following this stage, the virtual tour was implemented for broader user evaluation involving 97 respondents. Figure 4 presents the demographic characteristics of respondents involved in the implementation phase.

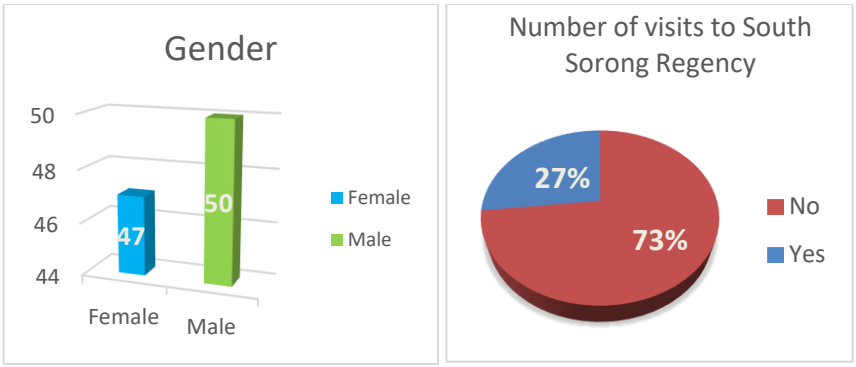

Figure 4. Respondent data

Figure 4 shows the results of testing conducted on prospective tourists or the public. The virtual tour was tested with 97 respondents (50 men and 47 women), most of whom were aged 20–30 years and showed that 27% of them had visited South Sorong before, while 73% had not.

Evaluation

The evaluation phase assessed the effectiveness and feasibility of the 360° virtual tour using pre-test and post-test measurements, user response questionnaires, and expert validation [35]. Pre-tests were conducted before users experienced the virtual tour and post-tests afterward to measure changes in user understanding and interest, using a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5) [36], Usability and acceptance were evaluated through questionnaires, while media and material experts validated visual quality, content accuracy, and presentation suitability. Feedback from users and experts was used to refine the virtual tour content prior to finalization. The list of pre-test and post-test questionnaires can be seen in table 3.

Table 3. List of Questioner Pre-Test dan Post-test

Pre/Post Test	Assessment Aspect	Indicators	Items	Q-Number
Pre/Post Test	Respondent Data (DA)	Name, Gender, Age, Visiting experience / VR experience	4	1,2,3,4
Pre-Test	Initial Knowledge (IK)	Tourism potential, promotion, destination discovery, easily accessible information, 360° VR Knowledge	5	5,6,7,8,11
	Early Interest (EI)	Interest in images/articles, interest in digital technology, interest in trying virtual tours	3	9,10,14
	Media Perception (MP)	VR enhances promotion, while regular videos provide a general overview.	2	12-13
	Initial Visit Intentions (IV)	Visit plans, recommendations, perceptions of destination suitability	3	15,16,17
Post-Test	Post-Knowledge (PK)	Destination understanding, information, real picture, knowledge enhancement	4	5,6,7,8
	Media Quality (Q)	Visual, audio, realistic experience, 360° exploration	4	9,10,11,12
	Technical Aspects (T)	Easy access, ease of use	2	13,14
	Post-Interest (PI)	Interested in visiting after watching the VT, want to see the destination	2	15,16
	Effectiveness (E)	Promotion, link sharing, belief in feasibility, effectiveness of VR	4	17,18,19,20

Then, the effectiveness of the improvement from the pre-test and post-test results was analyzed using the N-Gain method [37], using the Equation 1

$$\textbf{\textit{N-Gain}} = \frac{(Skor_{Post} - Skor_{Pre})}{(Skor_{Max} - Skor_{Pre})} \quad (1)$$

The N-Gain results are then categorized into:

Table 4. N-Gain Value

N-Gain Value	Description
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

User response surveys were conducted to assess user experience, including ease of use, visual quality, navigation, and content appeal. Likert scale-based surveys were analyzed using suitability percentages to determine user acceptance levels [38]. Table 4 shows that these questionnaire aspects measure acceptance, ease of access, and quality of user experience with virtual tours.

Table 5. Survey response questions

No	Response Aspect	Indicators
1	Added Experience Value	The virtual tour provides added value before an actual visit
2	Content Development	The virtual tour should be developed for other destinations
3	Visual Quality	360° images/videos are attractive and realistic
4	Audio Quality	Narration and sound are clear and supportive
5	Accessibility	The virtual tour is easy to access and run on devices
6	Navigation	360° viewing/navigation is easy to control
7	Information Relevance	Information matches the theme of South Sorong tourism
8	Knowledge Gain	The content enhances my knowledge about the destination
9	Visit Interest	The virtual tour increases my interest in visiting South Sorong
10	User Satisfaction	I feel satisfied with the experience of using the virtual tour

The virtual tour was evaluated through material and media expert validation. Material experts assessed content accuracy and relevance, while media experts evaluated visual quality, interface design, and technical feasibility. [39]. Table 5 and 6 present the validation items used to ensure the content and 360° video quality meet feasibility standards.

Table 6. Expert material validator questions

No.	Assessment Aspect	Summary of Indicators
1.	Material Relevance	Alignment with research objectives., Suitability with South Sorong tourism context, Relevance to destination themes.
2.	Accuracy of Information	Information is factual and accountable, Data matches real destination conditions., No misleading content.
3.	Completeness of Material	Sufficient explanation without excess, Covers essential aspects (location, access, attractions)., Appropriate depth for user needs.
4.	Clarity & Language Quality	Language is clear and easy to understand, Free from grammatical errors, Information delivered.
5.	Suitability for Virtual Tour	Material aligns with 360° visuals, Narration supports displayed visuals, Content fits VR characteristics.

Table 7. Expert media validator questions

No.	Assessment Aspect	Summary of Indicators
1.	Visual & Design Quality	Clarity of 360° visuals, good composition and lighting, Smooth transitions, and proper color balance, UI/UX simple and user-friendly.
2.	Audio & Narration	Clear narration, Balanced audio levels, Supportive sound effects, Minimal noise.
3.	Content & Information	Relevant and accurate information, Content aligned with research goals, presentation; appropriate duration, Strong alignment between narration and visuals.
4.	Technical Performance	Accessible across devices, Acceptable loading time, Compatible file format, Stable performance without crashes.
5.	Innovative Value	Provides a new experience, Engaging and interactive, Appropriate use of VR for tourism promotion.

Expert assessments were analysed using a percentage of feasibility to determine the validity level of the product [40]. The results of expert validation became the basis for improvements before the virtual tour was declared feasible for implementation as a tourism promotion medium [41]. The feasibility level was determined using the Equation 2:

$$\textbf{\textit{Percentage of Eligibility (\%)}} = \frac{\sum \textit{Score Obtained}}{\sum \textit{Maksimum Score}} \times 100\% \quad (2)$$

$\sum Score\ Obtained$ is the total score obtained from all questionnaire items, while $\sum Maksimum\ Score$ is the maximum score calculated from the number of respondents (97) multiplied by the number of items (10) and the maximum value of each item (5), and the calculation results in percentage form are used to determine the eligibility category can be seen in table 8. The eligibility percentage results obtained are then categorized based on Table 7 of eligibility percentages.

Table 8. Suitability percentage

Suitability percentage	Eligibility category
81% - 100%	Highly Suitable
61% - 80%	Suitable
41% - 60%	Fairly Suitable
21% - 40%	Less Suitable
0% - 20%	Not Suitable

After calculating feasibility, the percentages from expert validation and user response questionnaires are interpreted to classify the virtual tour as feasible, requiring revision, or not feasible [42]. Low score items drive the refinements on media and contents quality to meet its required level as reference of feasibility of final product before being applied as a medium in tourism promotion [43].

RESULT AND DISCUSSION

This section presents the outcomes of the virtual tour development and evaluation, including media preprocessing results, user evaluation, and expert validation, followed by a discussion of the key findings in relation to previous studies and their implications for VR-based tourism promotion.

Media Preprocessing

The media preprocessing stage produced three 360° panoramic videos representing the selected tourism destinations. Table 9 presents the technical specifications of the processed 360° panoramic videos.

Table 9. Media Preprocessing Output of 360° Virtual Tour Videos

Tourism Destination	Resolution	Aspect Ratio	Frame Rate	Bitrate (Mbps)	Encoding Format	Duration
Sasnek Waterfall	3840 × 1920 (4K)	360° Panorama	60 fps	120	H.265 (HEVC)	00:05:12
Kali Sembra	3840 × 1920 (4K)	360° Panorama	60 fps	120	H.265 (HEVC)	00:03:50
Panta Kapal River	3840 × 1920 (4K)	360° Panorama	60 fps	120	H.265 (HEVC)	00:05:09

The media preprocessing stage produced three standardized 360° panoramic videos, as summarized in Table 9, with consistent technical specifications to ensure visual quality and playback compatibility.

User Evaluation Results

The effectiveness evaluation was conducted by comparing the pre-test and post-test results filled out by all respondents before and after using the virtual tour. The pre-test results represented a baseline condition of respondents' knowledge about South Sorong as a tourist area and the post-test used to measure the elevation of understanding after being shown 360° video. The pre- and post-test results before and after the application of virtual tour for respondents are presented as Table 10.

Table 10. Average Pre-Test and Post-Test Results

	Aspect	Average
Pre-Test	Initial Knowledge (IK)	3.2
	Early Interest (EI)	3.8
	Media Perception (MP)	3.5
	Initial Visit Intention (IV)	3.7
Average		3.6
Pre-Test	Post-knowledge (PK)	4.1
	Media quality (Q)	4.4
	Technical (T)	4.7
	Post-interest (PI)	4.6
	Effectiveness (E)	4.7
Average		4.5

Next, calculate the N-Gain value to determine the categories of the result in Equation 3.

$$N\text{-}Gain = \frac{(4.6 - 3.6)}{(5 - 3.6)} = \frac{(0.9)}{(1.4)} = 0.64 \quad (3)$$

As shown in the means of Table 10, significant mean differences between the pre-test (3.6) and post-test (4.5) are observed for dimensions such as knowledge, interest, intention to visit, and perception of VR media after they received access to the virtual tour. Such increase is supported by N-Gain value of 0.64, which belongs to "moderate-high" category exposing that the virtual tour helps much in enhancing participants' understanding, interest and positive perceptions toward South Sorong as a tourism object.

Response Survey Evaluation

Next, the response questionnaire scores were calculated to assess the suitability of the media based on user perceptions, so that it could be seen whether the media met quality standards and user needs. The calculation was performed using the scores obtained and the maximum scores from the Likert scale to obtain the suitability percentage for each assessment aspect. Table 11 shows the average data for each response questionnaire indicator.

Table 11. response survey results

Questions	Aspects	Score
Q1	Added Experience Value	460
Q2	Content Development	458
Q3	Visual Quality	452
Q4	Audio Quality	454
Q5	Accessibility	455
Q6	Navigation	448
Q7	Information Relevance	448
Q8	Knowledge Gain	449
Q9	Visit Interest	452
Q10	User Satisfaction	457
	Score	4533
	Score Max	4850

Next, calculate the percentage of eligibility using the Equation 4:

$$\boldsymbol{EP}\ (\%) = \frac{\sum \boldsymbol{Score\ Obtained}}{\sum \boldsymbol{Maksimum\ Score}} \times \mathbf{100}\% = \frac{\mathbf{4533}}{\mathbf{4850}} \times \mathbf{100}\% = \mathbf{0.93} \times \mathbf{100}\% = \mathbf{93}\% \quad (4)$$

Based on the results of the response questionnaire in Equation 4, a percentage of 93% was obtained in the Highly Suitable category, indicating that users consider virtual reality media based on virtual tours to be very feasible, interesting, easy to use, and effective in increasing understanding and interest in tourist destinations.

Expert Validation Results

Expert validations were conducted to ensure that the developed Virtual Tour met feasibility standards in terms of visual quality and content accuracy. The validation results were used to determine whether the media was ready for use or required further revision. Table 12 presents the responses from the expert validators.

Table 12. Results of responses from media and material expert validators

Media Expert Aspect	Score	Materi Expert Aspect	Score
Visual Appearance & Media Design Aspects	30	Material Suitability	20
Audio & Narrative Aspects	17	Accuracy and Truthfulness of Information	13
Content & Information Aspects	23	Completeness and Depth of Material	13
Technical Aspects	17	Comprehensibility and Language	14
Novelty Aspects	15	Suitability for Virtual Tour Media	15
Score obtained	102	Score obtained	75
Maximum Score	115	Maximum Score	80
Percentage ((Score Obtained / Maximum Score) x 100%)	89%	Percentage ((Score Obtained / Maximum Score) x 100%)	94%

The expert validation results from Table 12 show that Virtual Tour scored 89% from media experts and 94% from subject matter experts. Media experts rated the visual appearance, design, content, narration, and technical aspects as very good. Meanwhile, subject matter experts gave very high ratings for material

suitability, information accuracy, content completeness, language, and suitability with the characteristics of Virtual Tour. Overall, both validators stated that the developed media falls into the highly suitable category for use with minor revisions.

The findings of this study demonstrate that a virtual tour media developed 360° VR-based virtual tour can function not only as a visual promotional medium but also as an effective applied informatics tool for enhancing users' understanding and engagement with tourism destinations. Consistent with prior VR tourism studies highlighting the role of immersive visualization in influencing tourist perception and intention [44], [45], this research extends existing work by integrating multi-destination content within a structured Analysis, Design, Development, Implementation, and Evaluation framework. Unlike earlier studies that predominantly emphasized usability testing or single-site visualization [46], [47], the proposed approach combines learning-effect evaluation, user acceptance assessment, and expert validation to provide a more comprehensive and methodologically robust evaluation. This contribution underscores the applicability of VR-based virtual tours for strengthening digital tourism promotion in underdeveloped and geographically remote regions.

CONCLUSION

The results of this study indicate that the 360° VR–based virtual tour developed using the Analysis, Design, Development, Implementation, and Evaluation model is effective and feasible as a digital tourism promotion medium for South Sorong Regency. This is demonstrated by improvements in users' understanding and interest, as reflected in increased pre-test and post-test scores with a moderate-to-high N-Gain value of 0.64, accompanied by high user acceptance (93%). Expert feasibility evaluation further confirmed the technical reliability and content suitability of the developed media, with agreement scores of 89% from media experts and 94% from material experts. These findings highlight the potential of immersive visualization, interactive 360° navigation, and structured content presentation to enhance information delivery and user engagement, particularly for destinations with limited digital documentation and geographical constraints. Future research is recommended to incorporate more interactive features and personalization mechanisms, involve larger and more diverse user groups, and conduct comparative studies with other digital tourism promotion media to further evaluate the scalability and long-term effectiveness of VR-based virtual tours.

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