# Integrated Virtual Reality Based Geotourism Learning Model to Enhance Vocational Students' Special Competencies

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***Abstract*—Digital technology is evolving very rapidly during the 21st century and requires vocational education, such as tourism, to keep developing. Part of the greatest challenge in learning about Geotourism is that students have fewer chances to visit tourist places due to financial, time, and accessibility constraints. This will limit their understanding of the 3A concept (Attraction, Accessibility, Amenities) on which tourism business growth hinges. To address this issue, the present study developed and validated an Integrated Virtual Reality-Based Geotourism Learning Model to enhance the particular competencies of Universitas Negeri Jakarta D-4 Travel Business Study Program's vocational students. The study employed a Research and Development (R&D) approach through combining Borg and Gall's model and the System Development Life Cycle (SDLC) Waterfall model. The procedure employed involved needs analysis, model development, 360° Virtual Reality media production, subject matter expert validation (content, media, instructional design, and language), and piloting with lecturers and students. Subject matter expert validation recorded an overall feasibility rating over 88% ("very good"). Student and lecturer feedback also confirmed high efficacy (89.24%) and effectiveness (87.57%). Learning outcomes improved significantly, with mean scores improving from 61.99 (pre-test) to 85.00 (post-test). The total N-Gain value was 0.623 in the medium–high category, and most of the students were found to have moderate to high improvement. Paired t-test results also found significant differences ($p < 0.001$). The findings indicate that Virtual Reality-based Geotourism Learning Model is highly valid, applicable, and effective to develop the vocational students' tourism competencies. The study has theoretical implications for the design of digital learning and practical recommendations for enhancing vocational tourism education in Indonesia and elsewhere.**

***Keywords*—virtual reality, tourism, vocational education, learning model, special competencies**

## I. Introduction

The transformation of education in the 21st century is characterized by the growing role of digital technologies across nearly all aspects of life, including the education sector [1, 2]. The Indonesian Ministry of Education and Culture (Kemendikbud, 2020) [3, 4] stresses that students in the 21st century need to learn how to think critically, solve problems, be creative, work together, use technology, and be aware of the world around them. These issues are much more difficult for vocational education since students need to not only understand theories but also use what they learn in real-life situations that meet the needs of the industry [5]. In the field of tourism, students are required to develop specific competencies in designing, managing, and evaluating travel businesses in accordance with the geographical and socio-cultural characteristics of destinations [6–8].

However, the practice of Geotourism learning in higher education still faces numerous limitations. Generally, teaching is still dominated by conventional methods such as face-to-face lectures, textbooks, or simple digital presentations [9, 10]. This condition hinders students from experiencing authentic tourism objects and attractions. This is compounded by the fact that field exploration opportunities are limited due to cost, distance, and time constraints. The outcome is that students' understanding of the 3A concept, which includes Attraction, Accessibility, and Amenities, remains inadequate [11–13]. Nevertheless, this notion is the fundamental principle for tourism analysis and travel business planning related to geopar.

A pilot study in the D-4 Travel Business Study Program at Universitas Negeri Jakarta proved it clearly. A preliminary online survey showed that 85.42% of the students were struggling to understand how geography affects the tourism business. In addition to that, 91.67% of the students said they needed other learning media to help them understand the concept of 3A. Conversely, over 90% were interested in the application of Virtual Reality (VR) in the learning experience. These findings highlight the urgent need for a groundbreaking educational framework that can provide authentic experiences while avoiding high costs and restrictions related to physical access to tourist destinations [14, 15].

Virtual Reality has become a ubiquitous digital education technology [16, 17]. Virtual Reality enables users to enter virtual three-dimensional spaces and engage with objects in a more concrete manner [18]. Various previous research has proven that VR increases the motivation, engagement, spatial awareness, and critical thinking ability of learners [19–21]. VR and Project-Based Learning (PjBL) have been effective in visual design to improve creativity, quality of idea, and project development speed [22]. VR is also used in tourism education as an alternative potential for difficult-to-attend field experiences but needs to be complemented with experiential learning techniques to maintain the practice realistic [23, 24].

However, bibliometric assessments of international publications from 2015 to 2022 indicate that research linking VR with geotourism education is still somewhat scarce. The prevalent keywords are "geotourism," "geoheritage," and "education"; however, no research has been found that explicitly combines virtual reality with Geotourism learning models rooted in experiential or project-based learning [25–27]. This underscores a distinct research deficiency that can be remedied by the formulation of a more cohesive learning model.

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The contribution of this study is not only in applying VR technology to tourism education but in creating a holistic pedagogical grammar that bridges Experiential Learning and Project-Based Learning into a 5-step approach: (1) orientation, (2) VR exploration, (3) reflective discussion, (4) project design, and (5) evaluation. This mix allows for students to first experience a virtual simulation of real tourism objects, second reflect on the essence of these experiences, and finally transform them into tangible outputs of tourism projects. This fusion covers an important gap in the literature in that it offers a structured learning process linking theory and practice more effectively than conventional VR techniques, which all too often stop short at the stage of exploration without structured reflection and project development.

This project addresses a recognized necessity by creating a Virtual Reality-Integrated Geotourism Learning Model to improve vocational students' professional competencies. This model integrates the experiential learning strengths of focusing on direct experience and project-based learning of solving real-world problems through organized projects [28, 29]. The students can learn about 3A directly in an interactive virtual world using VR media created from 360° photos and videos of Subang and Tidung Island [30, 31].

This study has two contributions. First, theoretically, this study fills a literature void because this proposed research offers a conceptual model that integrates immersive VR experiences with a systematic five-stage experiential-project learning cycle, which can act as a blueprint for future research on technology-facilitated vocational learning. Second, from the practical aspect, it provides an alternative solution to Indonesian vocational education, where economic constraints, spatial constraints, and limited access to tourism destinations at times are barriers to graduate learning outcomes (CPL) achievements. This model allows learners to acquire knowledge in way quite similar to how things are done in the real world while continuing to build analytical and practical skills that can be transferred into the workplace.

The goals of this study are to: (1) create a valid, useful, and effective Virtual Reality-based Geotourism learning model; (2) test the model's feasibility by having experts in instructional design, content, media, and language validate it; and (3) test the model's effectiveness by having students and teachers try it out. The results are anticipated to provide a framework for the advancement of creative learning models in tourist education, while also significantly enhancing the quality of vocational education in Indonesia and globally.

## II. Materials and Methods

### A. Research Design

This study utilized a Research and Development (R&D) methodology to design, develop, and validate the Virtual Reality-Integrated Geotourism Learning Model. The development process utilized the phases of Borg & Gall, integrated with the System Development Life Cycle (SDLC) Waterfall model, culminating in a final product that includes both a learning model and 360° VR-based media [32].

### B. Participants

The study was carried out inside the Travel Business Study Program. The participants included students enrolled in the Geotourism course, together with various lecturers from the same course who contributed expert assessments on the model's practicality. The student respondents numbered 40, representing the entire population of the Geotourism course (convenience sampling). This approach yielded complete participation from the class but might limit generalizability due to selection bias. The inclusion criteria were that the participants should be studying in the course within the semester and were willing to participate voluntarily. Approval for the research was obtained from the institutional ethics committee, and informed consent was received from the participants before data collection.

### C. Research Procedure

The research procedure consisted of six main stages, namely:

#### 1) Needs analysis

Data were collected through digital questionnaires, lecturer interviews, and classroom observations [33]. The results showed that most students had trouble comprehending how geography affects tourism, but they were very interested in using Virtual Reality-based learning tools.

#### 2) Literature review and data analysis

The findings from the preliminary study were complemented by an international literature review on the application of VR, experience-based learning models, and project-based learning in tourism education.

#### 3) Model planning and design

At this stage, a learning model was designed with syntax that integrates Experiential Learning and Project-Based Learning [28]. The design process included defining instructional objectives, learning strategies, evaluation instruments, as well as creating a storyboard for the development of VR media.

#### 4) Prototype development

The prototype model was created at the same time as VR media, utilizing 3D Vista software and a camera that could see in all directions. We chose two tourist spots as case studies: Cisaat Village in Subang (which is in a highland location) and Tidung Island in Kepulauan Seribu (which is in a coastal area). The VR content included 360-degree photographs and movies, interactive information, quizzes, and instructional games around the 3A concept (Attraction, Accessibility, Amenities).

#### 5) Expert validation

Four groups of specialists tested the prototype: language experts, media experts, instructional design experts, and subject matter experts. Each group had three people who looked at things including the clarity of the language, the quality of the medium, the feasibility of the material, and the goals of the training.

#### 6) Trial implementation

Application of VR used 3D Vista software, 360° cameras, and VR Glasses for Smartphone. Media was accessed through PCs and smartphones for flexibility. Trials were carried out in two stages: a small group trial with 16 students and a larger group trial with 40 students. In addition, lecturers teaching the Geotourism course also provided evaluations

regarding the clarity, feasibility, and effectiveness of the learning model.

Prior to the implementation of the VR-based model, students were taught using traditional lecture-style instruction and static digital presentations. No interactive or field-based learning activities were conducted during the baseline period, which puts the pre-test scores in the perspective of being representative of traditional instruction

### D. Instruments

Research instruments utilized were:

- Expert validation questionnaires on instructional design, content, media, and language aspects.;
- Student and lecturer response questionnaires assessing clarity, feasibility, perceived learning impact, and usability of Virtual Reality-based media.
- Observation sheets used to record the implementation of the model in classroom settings.

### E. Data Analysis

Data were analyzed using descriptive quantitative methods. The scores obtained from expert validation, student trials, and lecturer assessments were converted into percentages and categorized into the criteria of "very good," "good," "fair," and "poor." In addition, the effectiveness of the model was examined through the comparison of students' learning outcomes before and after the implementation by applying the N-Gain Test [34].

## III. Result and Discussion

This section provides an in-depth explanation of the research findings, structured in accordance with the procedural stages carried out during the study. The analysis draws upon empirical data, expert validation results, and relevant literature reviews. The primary objective of the discussion is to interpret the findings, connect them with existing theories and previous studies, and assess their implications for the development of Virtual Reality-based Geotourism Learning. Accordingly, the discussion is systematically organized following the research stages, beginning with the needs analysis and culminating in the field trials.

### A. Needs Analysis

The needs analysis showed that most students had trouble grasping the 3A idea (Attraction, Accessibility, Amenities) because they didn't have many chances to visit the field. The survey results showed that 76% of students said they had trouble understanding the content without direct practice, 14% said they couldn't travel because they didn't have enough money, and 10% said they had technological problems [35].

These results align with the work of Putri *et al.* [36] who underscored the necessity for tourism students to utilize field simulation media to enhance spatial comprehension. In the realm of geotourism education, immersive technologies like Virtual Reality can offer educational experiences that closely mimic authentic environments, while mitigating challenges related to cost, time, and accessibility to tourist locations. So, VR may be used not just instead of field trips but also as a teaching tool to help students understand concepts better, improve their analytical skills, and get more involved in the learning process.

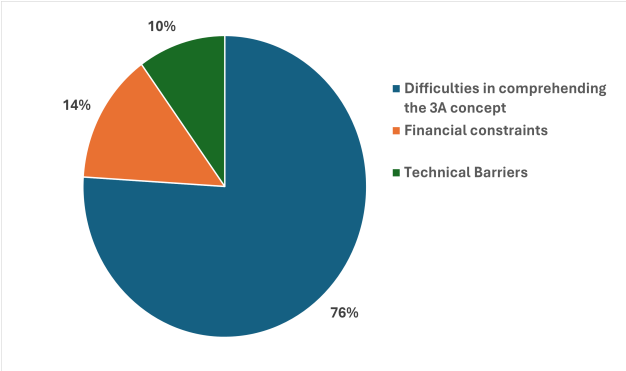


Fig. 1. Diagram of student constraints in Geotourism learning.

The pie chart (Fig. 1) shows three types of barriers experienced by respondents. The majority (76%) had difficulty understanding the 3A concept, making it the primary obstacle. Financial barriers contributed 14%, while technical barriers contributed 10%. These findings confirm that conceptual understanding is a primary focus for improvement in learning.

### B. Model Design

The model was designed by integrating Experiential Learning and Project-Based Learning (PjBL). The learning syntax consists of five stages: orientation, VR exploration, reflective discussion, project design, and evaluation (Fig. 2).

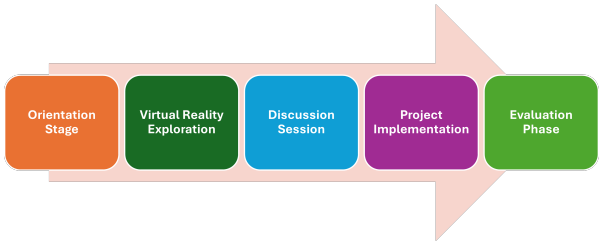


Fig. 2. Syntax of the virtual reality-integrated Geotourism learning model.

This design ensures that students are not merely passive recipients of information but are instead actively engaged in virtually exploring destinations and applying their insights to structured, real-world case-based projects.

### C. Development of VR Media

The VR material was made at the same time as the learning methodology was designed. We made the VR footage with a 360-degree camera and 3D Vista software. We chose two places to give students a variety of geographical learning experiences:

1) Cisaat Village, Subang, which is located in a mountainous area
2) Tidung Island, Kepulauan Seribu—this is a coastal area

These places were chosen because they could show different geotourism settings in terms of topography and socio-economic factors.

The media content was created in the following steps:

- Taking pictures and videos in all directions with a 360-degree camera.
- Making a storyboard to plan out the order of the exploration.
- Adding interactive hotspots to important things like

attractions, accessibility, and amenities.

- Creating quizzes that students may take in real time to see how well they comprehend.
- Adding VR mini-games to get students to do fundamental analysis of tourism potential.

Table 1. Main content of the Geotourism VR Media

| Media Component | Description |
|---|---|
| 360° Photos & Videos | Visual documentation of Subang (mountainous) and Tidung Island (coastal) |
| Interactive Hotspots | Navigation points containing information on attractions, accessibility, amenities |
| Interactive Quizzes | Multiple-choice questions contextualized within the destinations |
| VR Mini-Games | Simulation of tourism potential analysis based on real case scenarios |

Table 1 highlights the essential components of the VR Geotourism media. The visual aspect in the 360-degree photos and videos highlights the features of the mountainous area of Subang and the coastal area of Tidung Island. Destination information is provided in the hotspots features. The use of questions in the interaction features builds concepts. On the other hand, the VR mini-game gives simulation results of tourism potential analysis with actual cases.

### D. Visualization of the Developed Media

The Fig. 3 illustrates a 360-degree perspective of Cisaat Village, highlighting the Geotourism environment depicted in a virtual panoramic perspective.

Fig. 3. Initial interface of the VR media—Cisaat Village.

Fig. 4. VR media interface—Tidung Island.

This Fig 4 depicts the 360° panoramic view of Tidung Island, emphasizing its coastal region and important features for Geotourism.

Fig. 5 demonstrated in the figure showing the storyboard communicating the layout and order of the VR Media menu items from the VR Media menu user interface.

The VR media created in this study demonstrates various strengths:

1) Contextual—material was recorded directly from current destinations, hence authenticity.
2) Interactive—hotspots, quizzes, and games ensure heightened student involvement.
3) Flexible—playable on laptops or VR headsets.
4) Embedded in the learning model—the media is not a standalone output but embedded in the experiential and project-based learning syntax.

This is also in line with Allcoat and von Mühlenen, who noted that VR results in improved retention of knowledge through the application of immersive visual experiences.

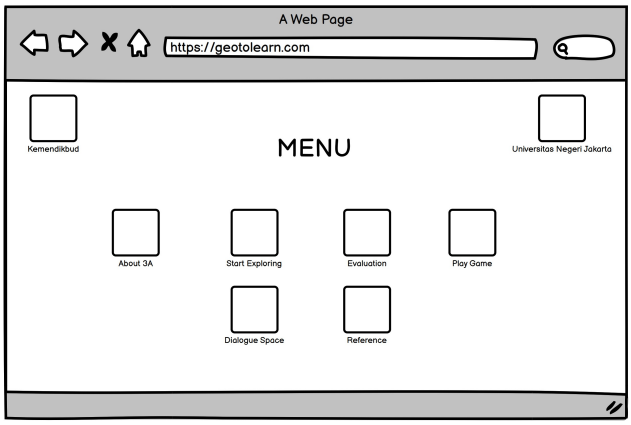


Fig. 5. Geotourism VR media storyboard.

### E. Understanding the Outcomes of Expert Validation

Expert verification showed that the Virtual Reality-Integrated Geotourism Learning Model (see Table 2) was excellent in various points. The model was tested by four expert teams: language experts, media experts, subject matter experts, and instructional design experts. The average value of verification was over 88%, which reflects that instruction quality, content, media design, and application of language were excellent.

Table 2. Results of expert validation of the virtual reality-based Geotourism learning model

| Type of Expert | Evaluation Aspects | Average (%) | Criteria |
|---|---|---|---|
| Instructional Design | Objectives, clarity, impact, feasibility | 88.87 | Very Good |
| Subject Matter | Content design, material presentation | 89.52 | Very Good |
| Media | Interface, quality, effectiveness, VR usability | 89.12 | Very Good |
| Language | Clarity, rule conformity, terminology usage | 90.00 | Very Good |

Overall, the expert validation confirmed that the model can be considered as an achievable and creative geotourism learning alternative. The clarity of instructional objectives, conciseness of language, and interactive Virtual Reality-based media design contributed significantly to high validation scores.

### F. Trial Results

The last step was a small test. The trial was conducted with two groups: a small group of 16 students and a bigger group of 40 students. Several Geotourism course teachers were also participating. The trial's goal was to see if the model would work and be useful before it was used on a larger scale. After the validation stage, students and teachers put the model to the test. The average score for students was 89.24% (very good category), and the average score for lecturers was 87.57% (very good category). These results show that

students learned the 3A idea (Attraction, Accessibility, Amenities) better through VR exploration than through more traditional approaches. In the meanwhile, teachers thought the model was useful and fit with the goals of the lesson, but it needed to be set up properly on the devices (Fig. 6).

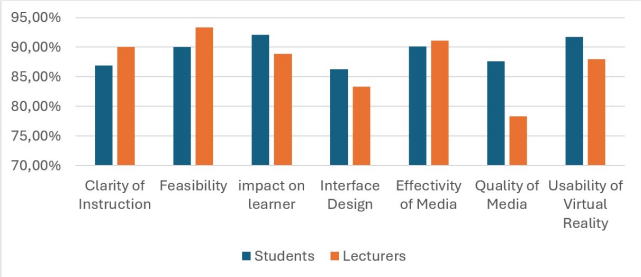


Fig. 6. Trial results by students and lecturers.

These trial results are consistent with the study by Jiang & Fryer, which stated that VR can enhance student learning motivation while reducing the gap between theory and practice. In the context of this study, students were able to link Geotourism theory with real-world destination conditions through VR simulation, thereby improving their specific competencies.

The effectiveness of the model was tested using pre-test and post-test on 40 students (see Table 3). The results showed a significant increase in scores.

Table 3. Results of pre-test, post-test, and *N*-Gain ($n = 40$)

| Statistic | Value |
|---|---|
| Mean Pre-test Score | 61.99 |
| Mean Post-test Score | 85.00 |
| Mean N-Gain | 0.623 |
| SD of N-Gain | 0.182 |
| 95% CI for N-Gain | 0.567–0.680 |
| t-statistic (paired t-test) | 26.039 |
| p-value | < 0.001 |

The *N*-Gain calculation showed a significant improvement in students' mastery of competencies after participating in Virtual Reality-based learning. With an average *N*-Gain of 0.623, this finding falls into the medium-to-high category, which means that the learning process provided a tangible impact on improving student competencies.

Most students (70%) were in the medium category, showing that this learning model was effective in improving understanding of the 3A concept (Attraction, Accessibility, Amenities). Interestingly, 27.5% of students were in the high category, indicating that a group of students gained maximum benefit from using VR. Only 2.5% of students were in the low category, most likely due to individual factors such as limited adaptation to technology or low learning motivation.

The paired t-test strengthened this finding with results of $t = 26.039$; $p < 0.001$, which means the increase in post-test scores compared to pre-test scores was statistically significant. This finding is consistent with the studies of J. Chen *et al.* and Chesokela, which stated that VR integration can significantly enhance student motivation, engagement, and spatial understanding [37, 38].

Thus, the calculation of N-Gain provides quantitative information validating that the Virtual Reality-Integrated Geotourism Learning Model is not only theoretically viable but also empirically effective in improving learners' capabilities.

In addition to quantitative results, qualitative feedback was informally gathered from student and lecturer participants. Students suggested that the VR-supported classes were inspiring, stimulating, and enabled them to visualize tourist destinations more vividly than traditional lectures. Lecturers identified the potential of the model for consolidating tourism concepts and for active learning.

A number of direct participant quotes were captured to gain a richer qualitative insight. One student commented, "I felt I was at the destination when I utilized the VR media rather than learning from slides." Another student commented, "The immersive point of view made me understand the concept of accessibility better since I was able to plot the routes and facilities firsthand." A lecturer also stated, "This model encouraged students to become more participatory in class discussion, and they were obviously more inquisitive than in conventional sessions."

These qualitative results serve to enhance the quantitative results, demonstrating that not only was the model successful statistically but also that it was perceived as useful and enjoyable by its users.

### G. Discussion

Based on the entire research process, it is argued that integrating VR in the Geotourism Learning Model has a significant role to play in the students' understanding. The outcome of this research demonstrates that integrating Virtual Reality (VR) in the Geotourism Learning Model significantly improved competencies among learners, as shown by the average value of N-Gain being 0.623 (which is in the medium to high category). Most effective learning occurs when students work directly with concrete experiences, examine them reflectively, and finally apply them in real-life situations. VR enables students to visit destination sites interactively by navigating 360° images and videos, information hotspots, and context-specific quizzes. VR does not merely substitute real experience but also facilitates more sophisticated spatial visualizations in the learning process. The success of the model relies not only on VR technology but also on instructional design that integrates experiential learning and project-based learning [39, 40].

This study is not without several limitations that are to be discussed critically. The first limitation is that the trial scope was confined to only one study program only, i.e., the D-4 Tourism Business program at Universitas Negeri Jakarta, with only 40 student participants. This context limits generalizing the findings to other vocational tourism education environments, particularly globally. Variation in student backgrounds, study programs, and levels of digital literacy among the institutions may influence successful implementation of the learning model with VR. Second, the VR media in the present study were only created for two tourist attractions, Desa Cisaat (representing a highland area) and Pulau Tidung (representing a coastal area). Whereas these two sites were selected specifically to illustrate the various types of tourism ecosystems, even this reporting is incomplete and does not yet illustrate the full Indonesian geotourism scenario. Indonesia in fact has hundreds of geoparks, national parks, and sites with extremely diverse geological attributes. This limitation highlights the need for

greater evolution in VR content representing a wider typology of destinations (i.e., beaches, caves, volcanoes, volcanic lakes, etc.), thereby enriching the learning process of students and making it more application-based. Third, hardware limitations also cause issues in implementing Virtual Reality-based learning. Not every student has a VR headset or a smartphone with the desired specifications. During the trial, students in some cases were limited to using laptops or simple smartphones to view the media, which of course reduced the level of immersiveness of the learning environment. Moreover, the use of VR with large classes may be hindered by technical limitations such as device shortages, internet connectivity uncertainty, and equipment maintenance requirements.

The significance of this study is that vocational higher education institutions must include VR as an integral part of their curriculum, particularly in those courses that entail field experiences [41, 42]. Subsequent studies can expand the range of destinations, cover more heterogeneous higher education institutions, and integrate VR with other emerging-age technologies such as Augmented Reality (AR) or Artificial Intelligence (AI) to further enrich the students' learning experience.

In addition the considerable short-term gain noted in skill levels among learners, long-term acquisition and use of what is learned using VR-based learning to actual tourism settings need to be investigated through additional research. Knowing how well students can actually utilize the 3A (Attraction, Accessibility, Amenities) model in real-fieldwork would further enhance the evidence base for this method of teaching.

From the implementation perspective, potential challenges are hardware availability (VR headsets, supporting devices), training needs for students, and the complexity of aligning VR activities with existing curricula. These concerns must be well considered by institutions planning to adopt the model.

## IV. Conclusion

This study was able to develop an Integrated Virtual Reality-Based Geotourism Learning Model that enhances vocational students' desired competencies, namely learning and dissecting the 3A concepts (Attraction, Accessibility, and Amenities) of tourist destinations. The design process was a Research and Development (R&D) design using an adaptation of Borg & Gall's steps with the System Development Life Cycle (SDLC) Waterfall model that culminated in a valid, useful, and effective learning product.

Professional verification revealed a total score of more than 88%, which was "very good," in instructional design, content material, media quality, and language use. The findings validate the high theoretical practicability of the developed model. Moreover, trials run between students and lecturers yielded average scores of 89.24% and 87.57%, respectively (both within the range of "very good"), validating that the model is not only valid but also practicable to be implemented in real teaching and learning settings.

The research results concur with international literature that testifies to Virtual Reality (VR) raising the interest, motivation, and cognitive knowledge of learners. The integration of VR with Experiential Learning offered experiential learning sessions with imitations of real environment conditions even without the real field visits. Additionally, the application of Project-Based Learning (PjBL) made it possible for learners to connect these experiences with structured projects geared to the tourism industry.

The contributions of the current research can be categorized into two wider areas. Theoretically, it complements the literature gap regarding VR integration in Geotourism education and broadens the conceptual model of technology-mediated vocational learning. Practically, it offers an alternative solution to overcoming the usual problems of cost, distance, and accessibility faced by students in acquiring field experience. Therefore, this model is usable by other Indonesian vocational higher education universities and even globally, resulting in tourism education quality development in the digital era.

But this study has some limitations. The trial was based on one study program, and the VR media covered only two tourist destinations, which may limit the generalizability of the findings. In addition, hardware availability (VR headsets and compatible devices) posed minor logistical challenges that could affect the scalability of the model in other institutions. Besides, the present study possessed only a single control class, and the future studies can possess more than a single control and experimental group to allow for more effective comparisons and stronger statistical analysis. It is strongly advisable that further research use wider ranges of tourist objects, involve subjects from more than one institution, and study how VR could be integrated with other new technologies such as Augmented Reality (AR) and Artificial Intelligence (AI) in order to provide more holistic and sustainable learning experiences.

Future use of the model should consider implementation in diverse institutional contexts, especially those with constrained technology infrastructures or different levels of student digital literacy. Scalable deployment may require other device configurations (e.g., mobile-based VR, low-bandwidth deployments) and professional development time to build digital proficiency among students.

While the study establishes the validity, feasibility, and efficacy of the model, future studies would have to examine its long-term learning impact, for example, recall of learning outcomes and sustainability of large-scale deployment across institutions of different levels of technological readiness. Incorporating structured qualitative data would also provide greater insight into user experience and inform future model improvements.

In general, this research concludes that the Integrated Virtual Reality-Based Geotourism Learning Model is a pedagogical innovation that is valid, practical, and useful in improving vocational students' certain competencies, and is highly suitable to be applied within 21st-century education paradigm.

## Conflict of Interest

The authors declare no conflict of interest.

## Author Contributions

All authors contributed to the completion of this study and the writing of the article. Ari Apriyansa was responsible for conceptualization, methodology design, data management,

and drafting the original manuscript. Etin Solihatin contributed to validation, supervision, and project administration. Mohamad Syarif Sumantri was involved in software development, data visualization, formal analysis, as well as reviewing and editing the manuscript. All authors have read, reviewed, and approved the final version of this article.

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