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Research Article

Developing a VR Map for the Faculty of Computer Science, Ubon Ratchathani Rajabhat University: A Design Science Approach

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Abstract: This research aims to develop a virtual reality (VR) map for the Faculty of Computer Science at Ubon Ratchathani Rajabhat University and evaluate the satisfaction level of its users. This study used a design science research approach to address real-world issues such as navigating and exploring a university faculty, which can be difficult for new students and visitors. This study's artifact is a working prototype of a VR map of the Faculty of Computer Science building, which was evaluated with 115 student participants using a quantitative questionnaire. The results showed that the VR map received a high level of satisfaction, with a mean score of 4.30 for the overall experience. The users particularly appreciated the system's ease of use, convenience, and readability of the text and images displayed. However, some users suggested improvements such as clearer room signs, more detailed point of interest (POI) information, and the inclusion of multimedia elements such as videos and narrations. The findings of this study can help with the design and development of virtual reality maps for university campuses, as well as future research in this field.

1. Introduction

Virtual reality (VR) technology simulates a wide range of environments and allows users to experience a 360-degree perspective without physically being present. VR-enabled programs can now be easily downloaded and used in a wide range of industries and applications, including tourism, military, medicine, marketing, entertainment, communication, and education, thanks to technological advancements and more affordable in mobile devices and wireless communication technology. The use of VR technology to map virtual worlds within buildings is gaining appeal in both the public and private sectors because it enables users to explore and plan journeys without the concern of getting lost. Additionally, it can be utilized for education or amusement. It aids in maintaining social distancing amid the present pandemic by permitting users to enter the virtual world through VR glasses.

Every semester at Ubon Ratchathani Rajabhat University welcomes new students who are unfamiliar with the premises. The newcomers may become lost in the building and must frequently ask for directions from the lecturers and staff. Additionally, external visitors who need to conduct business with the faculty, such as maintenance personnel or outside lecturers, and so on, face the same challenges. Hence, this research aims to solve those problems by creating a VR map for the Faculty of Computer Science to help first-year students, students from other faculties, and external staff navigate the virtual world of the faculty. It will be able to include points of interest (POI), signs, and multimedia information at specific locations to assist visitors in planning their journeys and understanding the design of building, including the location of the emergency exits. In addition to facilitating student engagement, this virtual world map system of the Faculty of Computer Science can enhance the faculty's reputation as a leader in digital technology.

2. Related Work

2.1 Virtual Reality

VR technology is a computer-generated simulation of various locations that allow users to feel as if they are physically present in the virtual world (Sherman & Craig, 2018). This technology is available on a variety of devices, including desktop computers, laptop computers, and mobile phones with Internet access and sophisticated mobile technologies. With the advancement of wireless data communication and processing, VR applications have become more accessible and user-friendly, resulting in a wide range of applications in fields such as the military, medicine, marketing, entertainment, communication, and education. As VR technology advances and becomes more accessible, we can expect even more creative applications in the future. Users can experience 360-degree virtual reality without being physically present thanks to VR technology, which changes aspects of daily life, travel, and the way we discover and experience new places. For example, VR technology has simplified access to virtual maps in the travel industry, allowing users to examine routes and destinations before traveling, making it a popular tool among tech-savvy, modern travelers.

VR has emerged as a transformative tool in education, offering immersive experiences that enhance learning across various domains. Recent studies and reviews provide a comprehensive overview of VR's application in education, illustrating both its potential benefits and challenges.

Tan *et al*. (2022) conducted a systematic review on augmented reality (AR) and VR technologies in the architecture, engineering, and construction (AEC) industry, highlighting limitations in AR/VR applications for education and training within this sector (Tan *et al*., 2022). Another innovative approach by Wang, Wang, & Perlin (2023) presents a system enabling non-VR instructors to interact with students immersed in VR, facilitating seamless communication and collaboration in VR classes (Wang, Wang, & Perlin, 2023). Pirker & Dengel (2021) discuss the potential of 360-degree VR videos in providing immersive educational experiences, significantly improving learning performance, motivation, and knowledge retention, while also enhancing engagement and empathy (Pirker & Dengel, 2021).

Nicola, Stoicu-Tivadar, & Patrascoiu (2018) found that incorporating VR technology into the learning process, such as for the bubble sort algorithm, led to a more effective learning experience. Similarly, a study by Lee *et al*. (2021) explores VR's use in fashion design education, promoting creativity through collaborative exploration in a VR environment. Brooks (2020) discusses the potential use of extended reality (XR) technologies, including VR, for practical skills training in various educational settings, suggesting its applicability in medical education and industry training.

The exponential growth in the adoption of AR and VR in education, as noted by Al-Ansi *et al*. (2023), indicates a significant role for wearable devices in these technologies. However, there remains a gap in swiftly implementing and customizing these technologies within educational institutions (Al-Ansi *et al*., 2023). This gap underscores the need for continued research and development to fully leverage VR's potential in educational contexts.

In summary, VR in education offers promising avenues for enhancing learning experiences across diverse fields. While challenges exist, particularly in technology integration and customization, the continued evolution of VR technologies holds the potential to revolutionize educational methodologies and outcomes.

2.2 Virtual Reality Map

The virtual reality map (VR map) allows users to navigate a complex building without relying on physical signs or directions, which is one of its primary advantages. Furthermore, using a VR headset or other device, users can access VR maps that provide a 3D representation of the building, allowing them to view the layout and location of various rooms and facilities. This is particularly useful for large or unfamiliar buildings, enabling users to navigate and locate specific locations easily. In addition, VR maps can be customized to include additional information, such as room names and descriptions, to make it even simpler for users to find what they need. Moreover, the use of virtual reality as a map in a facility might enhance security by allowing people to plot their paths and avoid hazards. Virtual reality maps are helpful for both building owners and visitors since they allow for quick and easy orientation.

The utilization of virtual environments in the development of maps and navigation systems has been a famous research topic since 2002, as demonstrated by Cho, Wang, & Fesenmaier (2002). However, VR technologies were not as developed as they are today. The advent of VR technology has further facilitated the creation of virtual tours, as exemplified by Chiao, Chen, & Huang (2018), who applied VR in the development of a virtual tourist map for cultural tourism. The application of virtual environments in tourism has also been explored by Osman, Wahab, & Ismail (2009).

The core element of VR map development is the implementation of 360-degree photography, often known as spherical or panoramic images, which capture the complete surrounding environment in a single shot. They are created by utilizing a specialized camera or a series of cameras to capture many images from various angles and then stitch them together with computer software. This results in an immersive, panoramic perspective that allows the viewer to explore the shot virtually. These images have been discovered to be a powerful tool for providing an immersive experience, allowing the spectator to investigate the surroundings more naturally because they may look about in any direction.

2.3 Design Science Research

Research in the field of information systems primarily falls into two categories: behavioral science and design science research (DSR) (Hevner *et al*., 2004). Behavioral science research aims to develop theories that predict or explain the phenomena associated with the utilization of existing information technology (IT) artifacts within organizational contexts. Design science research entails creating and evaluating artifacts such as products, systems, processes, or services to address an identified, unsolved, and significant problem (Hevner *et al*., 2004). DSR typically involves several key phases: problem identification, design and development, evaluation, and dissemination. DSR has been applied in a wide range of fields, including software engineering, human-computer interaction, and business management (Hevner & Chatterjee, 2010). Studies have shown that it is well-suited for research that aims to generate new

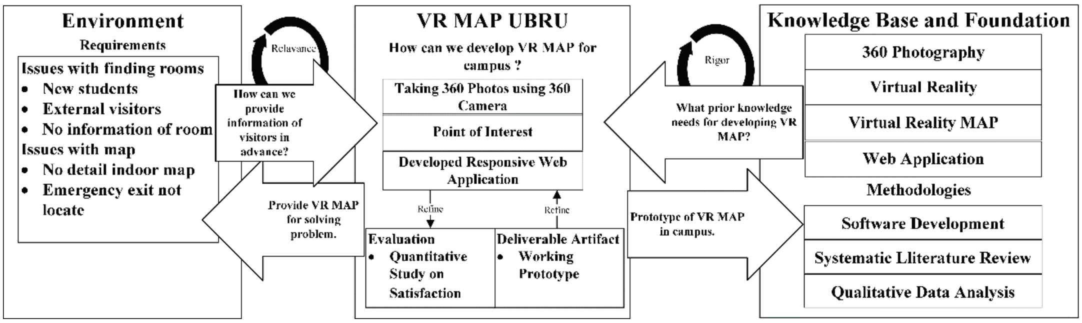

Figure 1. Research model of the study

knowledge and innovations to solve problems and create opportunities.

Hevner *et al*. (2004) established seven guidelines for effective design science research to successfully develop and evaluate IT artifacts. These guidelines are: 1) producing an innovative and purposeful artifact, 2) developing the artifact specifically to address an important and unsolved business problem, 3) evaluating the design artifact, 4) making verifiable research contributions, 5) utilizing rigorous methods in the construction and evaluation of the design artifact, 6) viewing the design artifact as a search process that utilizes available resources, and 7) effectively communicating the research to appropriate audiences.

The selection of DSR as the research methodology for this study is academically justified due to its suitability for addressing complex, real-world problems through the creation and evaluation of innovative artifacts. DSR is particularly relevant in the field of information systems, where the development of practical solutions to address identified issues is paramount. This methodology aligns with the study's goals, which involve developing a VR map to improve navigation within the Faculty of Computer Science at Ubon Ratchathani Rajabhat University.

3. Materials and Methods

Design science is a research approach that concentrates on developing and accessing objects, such as technologies or designs, that can address problems in the real world. Hence, in this study, we applied design science methodology to tackle the issue of the indoor map of the university campus at the Faculty of Computer Science, Ubon Ratchathani Rajabhat University, Ubon Ratchathani Province, Thailand. This research will follow the guidelines of the DSR methodology proposed by Hevner *et al*. (2004) and Peffers *et al*. (2007), including problem identification and motivation, the definition of the objectives for a solution, design and development, demonstration, evaluation, and communication. Table 1 provides a detailed explanation of each stage in this study. Therefore, Figure 1 depicts the research model of this study based on the DSR methodology (Hevner *et al*., 2004).

3.1 Problem Identification and Motivation

During the new semester at Ubon Ratchathani Rajabhat University, new first-year students and students from various other faculties have difficulty finding their assigned classrooms, resulting in increased class lateness. This issue is causing classroom disruptions, decreasing student productivity, and significantly affecting the teaching and learning environment. Moreover, this issue may cause anger and unhappiness among faculty members and staff who are forced to assist students with navigation, resulting in possible harm to the university's reputation and student relationships.

External visitors, such as delivery workers, equipment maintenance professionals, contractors, trainers, trainees, etc., sometimes get lost within the faculty premises, wasting valuable time and interfering with their jobs. This causes delays in delivering goods and services, difficulties in executing necessary repairs and maintenance, and a detrimental impact on the university's overall operations, resulting in harm to the university's reputation and connections with outside parties.

3.2 Definition of the Objectives for a Solution

The proposed solution for addressing the difficulties faced by new students and external visitors in navigating the campus of Ubon Ratchathani Rajabhat University is the implementation of a VR-based map. This solution utilizes 360-degree imaging technology to create a virtual representation of the university's buildings and facilities. Users can interact with the map through a VR headset or a web-based platform, allowing them to explore the campus in a virtual environment and easily locate their desired destination. We proposed research question as follows:

"What is the impact of using a VR map on the user's experience and satisfaction in navigating a computer science department at Ubon Ratchathani Rajabhat University?"

Hence, the objectives of this research were:

1) To develop a prototype of a VR-based campus map for the Faculty of Computer Science at Ubon Ratchathani Rajabhat University.
2) To evaluate user satisfaction with the prototype VR-based campus map for the Faculty of Computer Science at Ubon Ratchathani Rajabhat University.

3.3 Design and Development

As a case study, this research aims to propose a working prototype for the VR map using the Faculty of Computer Science. The faculty consists of six floors, with four floors accessible to the public. Consequently, the VR map only encompassed four floors of the faculty. The 360-degree photography of the

Figure 2. Research model of the study

Figure 3. Example 360-degree photography from the Insta360 One X

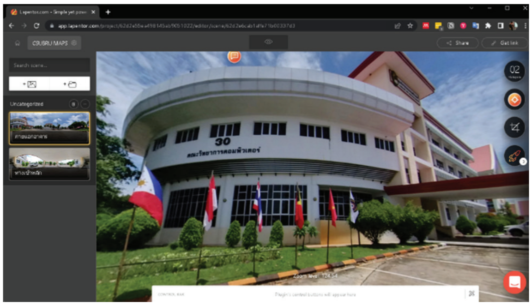

Figure 4. Example 360-degree photography from the Insta360 One X

building and path on every floor was performed using a proprietary 360 camera device name Insta360 One X (Insta360, 2021). This camera features two lenses with a 180-degree field of view on each, located on opposite sides of the device. It has a higher resolution at 18 MP (6080*3040), which is sufficient for seeing details of objects in the image, such as room numbers, room names, or the location of the branch in front of the room. When taking photographs, the camera's software will seamlessly stitch together the images captured by each lens to create a single 360-degree image, as illustrated in Figure 2. Moreover, Figure 3 shows the example photograph, showcasing the device's capabilities.

Due to the inability of the Insta360 application on mobile devices to export 360-degree images with the highest possible resolution, the Insta360 Studio 2022 was used, a Windows-based application that is capable of stitching and exporting 360-degree images with the highest possible resolution.

In addition to recording 360-degree photography, the process of incorporating these images into a virtual world travel map system is also crucial. This includes light enhancement of images, collecting POIs, connecting the path of each 360-degree image, and front-end coding for user interface access through web applications such as navigation buttons, audio, video, and still images. In this research, we compared numerous navigation software. The Lapentor (Lapentor – 360 Virtual tour platform pricing, 2022) was used for creating a VR map from 360-degree

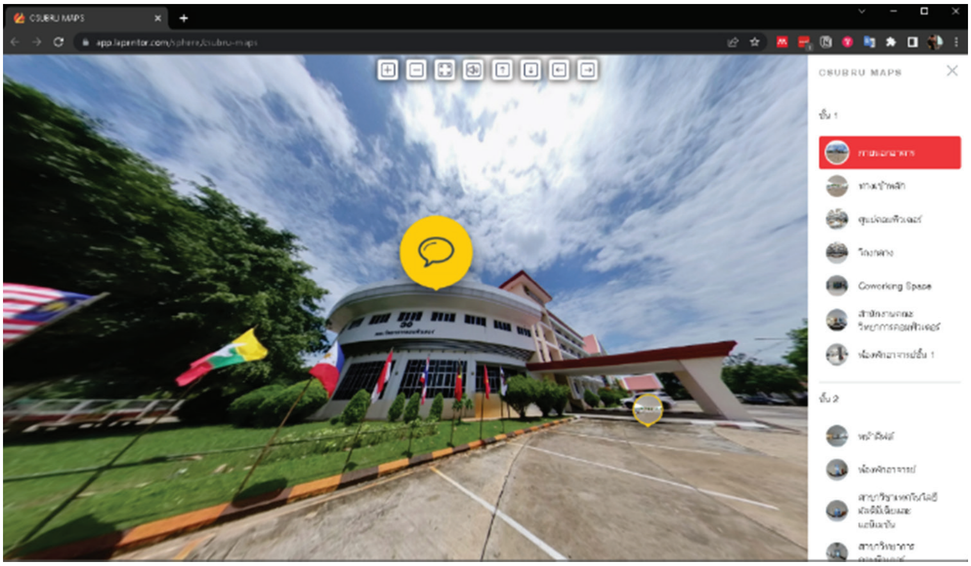

Figure 5. The starting point of the VR map

photography. It is developed by Vietnamese developers. It has the advantage that it can be used directly via a web browser without having to install any additional programs, can be used easily, and can create hotspots or various points of interest.

3.4 Demonstration and Evaluation

The demonstration of the virtual travel map system is the working prototype of its use as a web application. It is able to navigate through the faculty of the computer science building, POIs, videos, and other information, and the user can interact with the map through buttons and links. The demonstration also included a walk-through of the VR map for our study participants. After the demonstration, black box testing will be used to assess the system's functionality and usability. Black box testing, also known as functional testing, focuses on the system's external behavior rather than its internal structure or code. This method is ideal for testing the system's ability to meet user requirements and expectations. The participants each had about 30 minutes to try out every feature of the prototype as they saw fit.

The evaluation of the VR map involved assessing its satisfaction from the participants using a survey, which will be conducted to gather feedback from users on their overall experience with the system, graphical representation of the system, correctness, and performance, as well as any suggestions for improvement.

The survey data was analyzed using a variety of statistical approaches. The first stage was to clean and organize the data to ensure its accuracy and consistency. This entailed looking for missing values, outliers, and errors and making any necessary adjustments. The data was then summarized using descriptive statistics

Figure 6. Floating control panel

Table 1. Demographic statistics of participants

Variable	Frequency	Percent
Gender		
Male	50	43.5
Female	63	54.8
Other	2	1.7
Total	**115**	**100**
Year of students		
1	74	64.34
2	23	20
3	14	12.17
4	4	3.47
Total	**115**	**100**
Faculties of students		
Faculty of Humanities and Social Sciences	21	18.3
Faculty of Education	19	16.5
Faculty of Industrial Technology	9	7.8
Faculty of Public Health	6	5.2
Faculty of Business Administration and Management	15	13.0
Faculty of Science	9	7.8
Faculty of Law	2	1.7
Faculty of Computer Science	34	29.6
Total	**115**	**100**

to provide a general overview of the results, including mean, median, mode, and standard deviation values, as well as frequency distributions.

3.5 Participants and Data Collection

This study's target population is the tertiary students of Ubon Ratchathani Rajabhat University. A convenience sample method was used to choose the study's participants. The data was gathered via a self-administered online questionnaire. Participants was answered the questionnaire after using and testing the prototype.

The questionnaire had two sections. The first section collected demographic information and participants' satisfaction was covered in the second section. The satisfaction variables were evaluated using a five-point Likert scale, with one indicating "strongly disagree", and five indicating "strongly agree". As a result, 156 people completed the survey. However, 41 did not meet the screening criteria. Hence, 115 datasets (N=115) were chosen in the final analysis to test the hypotheses. Table 1 shows the descriptive statistics of participants. Most of the participants were first-year students as they were new students who might not be familiar with the place.

4. Results

4.1 Working Prototype as an Artifact

This study's working prototype of the VR map is publicly accessible via the URL https://app.lapentor.com/sphere/csubru-maps. Figure 5 shows an example of accessing maps from the web browser on a PC using Google Chrome

Users can use their mouse to click on the desired position. They can also use the scrolling button on their mouse to zoom in or out to see the angle they need. Furthermore, there is a floating control bar tool that also provides navigation commands (see Figure 6), including movement, zooming in and out, viewing the map in full screen, turning left and turning right.

As mentioned, there are four floors on the map. Users can teleport directly to different floors with a click using a navigation map (Figure 7) on the side of the screen without the need to walk up the stairs, which would take a lot of time to navigate by clicking on the control panel.

There are two types of POIs. Firstly, the information provider type showed in Figure 8. Clicking on this POI in Figure 8 will display the relevant messages in the specified image. Clicking on the POI in Figure 9 will teleport the user to the location in the following picture. Figure 10 shows the VR map listed at the right side of the window.

Figure 7. Navigation map for teleportation

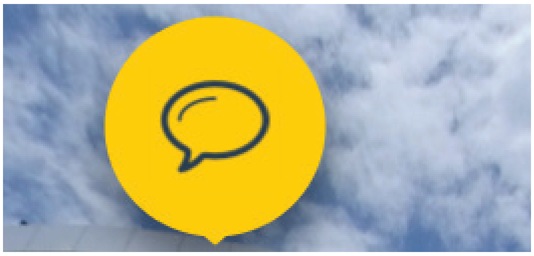

Figure 8. Point of interest that provides information

Figure 9. Point of Interest that the user can teleport to

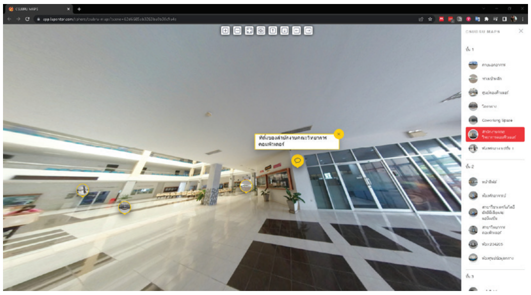

Figure 10. Indoor VR map

4.2 Artifact Evaluation

The assessment of the system has four parts, including overall experience with the system, graphical representation of the system, correctness, and performance, as well as any suggestions for improvement. The result of the analysis of data is shown in Table 2.

Table 2 shows that the participants favorably appreciated the VR map system. The mean scores for graphical representation, correctness, performance, and overall experience were 4.13, 4.28, 4.24, and 4.30, respectively, with standard deviations ranging from 0.64 to 0.84, respectively, with standard deviations ranging from 0.64 to 0.84. These scores indicate that the participants generally had a positive experience with the VR map system, with the highest scores being awarded to the clarity of images displayed and the overall experience.

The user interface and the readability of the text were also well received, with mean scores of 4.10 and 4.21, respectively. The dialog delivered a clear message, with a mean score of 4.06, although there is room for improvement in this area.

Table 2. Descriptive statistics of participants

	Satisfaction Factors	Mean	Std. Dev
graphical representation of the system		4.13	
1	The user interface made it interesting to deliver information	4.10	0.70
2	The readability of the text displayed on the monitor	4.21	0.71
3	Clarity of the images displayed	4.16	0.81
4	The dialog delivers a clear message	4.06	0.84
Correctness		4.28	
1	completeness and precision of map data	4.27	0.81
2	Timeliness of data	4.32	0.76
3	The maps of buildings are understandable and usable	4.25	0.76
Performance		4.24	
1	system responsiveness	4.28	0.76
2	The teleportation speed of each location.	4.26	0.77
3	The system makes it easier for me to find a classroom.	4.18	0.79
Overall experience		4.30	
1	Ease of use of the system	4.27	0.74
2	Convenient and uncomplicated.	4.29	0.71
3	The menu is easy to follow	4.39	0.65
4	overall experience	4.28	0.64
5	The system's operational procedures are appropriate, adaptable, and easy to understand.	4.27	0.73

Regarding correctness, the completeness and precision of map data were highly rated, with a mean score of 4.27. In addition, the timeliness of data and the usability of building maps were well received, with mean scores of 4.32 and 4.25, respectively.

In terms of performance, the system responsiveness, teleportation speed, and ease of finding classrooms were highly rated, with mean scores of 4.28, 4.26, and 4.18, respectively.

Overall, the participants found the system easy to use, convenient and uncomplicated, with a mean score of 4.27 for ease of use and 4.29 for convenience. In addition, the menu was easy to follow, with a mean score of 4.39. The participants also found that the system's operational procedures were appropriate, adaptable, and easy to understand, with a mean score of 4.27.

Therefore, the VR map system was well accepted by the participants and proved helpful for navigating the university campus. The system has been favorably welcomed in terms of graphical representation, correctness, performance, and overall experience. However, there is still potential for improvement in areas such as dialog delivery, precise message delivery, and the system's operational procedures.

The outcomes of this study, demonstrating high user satisfaction with the VR map, resonate with and extend the findings from existing literature on the utility and effectiveness of VR technology in educational and navigational contexts. Specifically, the integration of 360-degree photography and user-friendly navigation interfaces aligns with research by Cho, Wang, & Fesenmaier (2002) and Chiao, Chen, & Huang (2018), who have underscored the transformative potential of VR in enhancing user experiences and engagement in virtual environments. Furthermore, the feedback on desired improvements suggests a pathway for future enhancements that is consistent with guidelines from Hevner *et al*. (2004) on design science research, emphasizing iterative development and the importance of user feedback in creating impactful technological solutions. By addressing real-world navigation challenges within university settings, this study contributes to the growing body of evidence supporting VR's role in improving spatial orientation, a critical aspect highlighted by Osman, Wahab, & Ismail (2009) in the context of tourism, now effectively adapted to the educational sector.

Table 3. Open-end answer about the artifact

Category	Description	Example Suggestions
Navigation Clarity	Feedback related to the ease of navigating within the VR environment, including clarity of map markers and directions.	Add more distinct signage and interactive waypoints.
Content Detailing	Suggestions on enhancing the detail and accuracy of content within the VR map, such as landmarks and informational points.	Update the VR map with real-time information and more detailed descriptions of key locations.
System Expansion	Ideas for expanding the coverage of the VR map to include more areas of the university campus.	Extend the VR map to cover student accommodation areas and recreational facilities.
User Experience	Comments on the overall user experience, including interface design, interactivity, and user engagement.	Improve the VR interface for easier navigation and incorporate feedback mechanisms.
Multimedia Integration	Proposals for integrating multimedia elements like videos, photos, and 3D models to enrich the VR experience.	Incorporate 360-degree videos of key campus locations and virtual tours.

5. Conclusion

The objectives of this research were to 1) build a prototype of a VR-based campus map for the Faculty of Computer Science at Ubon Ratchathani Rajabhat University and 2) evaluate user satisfaction with the prototype VR-based campus map for the Faculty of Computer Science at Ubon Ratchathani Rajabhat University. Based on design science methodology, we proposed a research model and methodologies. The process of developing a virtual journey map system was investigated, and several development tools were reviewed. As an artifact, the system demonstration featured a working prototype. It was tested using black box techniques to assure user functionality, contentment, and usability. In addition, data from system surveys were evaluated to gain input and identify areas for improvement. The findings of this study emphasize the relevance of contemplating delivering a VR map service on university campuses.

Furthermore, the study introduces novel insights into the design and development process of VR applications for campus navigation, addressing the gap identified in the literature regarding practical implementations of VR in educational environments. By detailing the iterative design process, user feedback, and evaluation outcomes, this research contributes to the broader knowledge base on VR technology's application and user-centered design in educational settings.

The creation of the VR-based campus map was informed by a comprehensive analysis of existing navigational challenges, drawing upon both international and national literature on VR applications in education and navigation. This initiative aligns with the growing recognition of VR's potential to transform educational experiences, as supported by the work of Cho, Wang, & Fesenmaier (2002) and Chiao, Chen, & Huang (2018), who have highlighted the effectiveness of VR in engaging and immersive learning environments. The successful development of the prototype VR map not only demonstrates the feasibility of employing VR for campus navigation but also contributes to the body of knowledge by showcasing a practical application of VR technology in enhancing the accessibility and usability of campus facilities.

The evaluation of user satisfaction revealed a positive reception towards the VR map, with participants appreciating the ease of navigation, the immersive experience provided, and the clarity of the visual and textual information presented within the VR environment. These findings are consistent with Osman, Wahab, & Ismail (2009), who emphasized the importance of user experience in the adoption of VR technologies for tourism and educational purposes. The high levels of user satisfaction underscore the VR map's potential to significantly improve campus navigation and foster a more engaging and interactive educational landscape.

5.1 Limitations and Future Research

Considering the security and privacy of the classrooms, it was decided to exclude 360-degree photographs of the interior of the classrooms from the VR Map. This precautionary measure was taken to prevent potential criminals from utilizing the photographs as a means of gathering information to plan illegal operations, such as user experience (UX) optimization process, identifying valuable assets, determining entrance and exit points, and so forth. In future research endeavors, we intend to expand the scope of our VR map by incorporating additional areas of the university campus. Additionally, we aim to explore the potential utility of the VR map in other fields, such as architecture and tourism.

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