Virtual Tours to Facilities for Educational Purposes: A Review

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***Abstract* – A virtual tour is a guided tour facilitated through Virtual Reality (VR) technology. The primary focus of this paper is on Virtual Tours of Facilities (VTF) within academic contexts. These VTFs employ VR as a medium to provide immersive educational experiences within facilities, such as laboratories, industrial sites, and universities. Our study advances three hypotheses: firstly, that continuous variables distinguish VTFs; secondly, that VTFs offer distinct inherent advantages and disadvantages in comparison to conventional in-person visits; and thirdly, that various software types and developmental approaches for virtual tours can be systematically categorized based on their technical attributes and usability factors. Through a snowball rolling literature review method, we analyze 32 studies to identify current research trends, pinpoint gaps, and highlight areas of interest related to VTF. The ensuing analysis explores VTF applications, associated challenges, and potential technologies, culminating in a comprehensive and insightful overview of the field.**

***Keywords* – Virtual reality, virtual tour, education experiences, facilities, technology.**

1. Introduction

A virtual experience [1] refers to an individual's encounter within a computer-mediated environment.

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Furthermore, a Virtual Tour (VT) represents a unique classification within the realm of virtual experiences, specifically designed to simulate the experience of exploring a travel destination. Virtual laboratories refer to e-learning tools that enable individuals to gain hands-on experience in practical experimentation without the need for direct physical involvement in real-life laboratory work [2].

Virtual tours have found several applications for educational purposes: from visiting heritage sites to industrial plants. In this context, our focus is on academic experiences generated through the utilization of Virtual Reality (VR). The application of VR technologies is experiencing a growing trend in the realm of learning and education.

Numerous studies have explored the ways in which virtual labs support student learning. However, a comprehensive publication encompassing key aspects of utilizing virtual tours for educational purposes within the academic context, ranging from aiding decisions about future education and professional paths to enhancing learning experiences, remains absent.

Our research aims to address the following inquiries:

Research Question 1 (RQ1): What are the most important features to characterize VTFs?

Research Question 2 (RQ2): What are the inherent advantages and disadvantages associated with virtual tours?

Research Question 3 (RQ3): How can we categorize different types of software and approaches used in virtual tour development?

The primary contribution of this paper lies in the synthesis and classification of the existing knowledge regarding the use of virtual tours for educational purposes, specifically in facilities. This report not only evaluates the pros and cons of virtual tours when contrasted with traditional in-person visits but also offers insights into current trends within virtual reality technology.

2. Related Work

Because the virtual/real dichotomy is ontologically problematic that is, it raises questions about the nature of existence, it is best to avoid using the term 'real' to describe non-virtual experiences [3]. Despite the conceptual difficulties associated with the notion of reality, it would be incorrect to classify virtual experiences as unreal and non-virtual experiences as real. Indeed, corporeality does not define reality. Instead, we must recognize that reality is multi-dimensional and extends beyond the physical world [3].

Three modes of tourist experiences can be established: physical (or corporeal), imaginative, and virtual [4]. Physical travel involves a person's physical movement to a destination and is the most obvious form of travel. Imaginative travel involves a person traveling without physically moving, while virtual tourism occurs when people use modern technology to experience new places without ever leaving their homes.

Physical traveling is an important activity; in some countries, it is one of the largest industries. Travelers are interested to know new places and other cultures. They have the option of utilizing traditional sources of information such as television, printed materials, newspapers, word-of-mouth recommendations, and their past vacation experiences. To reduce the perceived risks and difficulties of in-person traveling. VT can provide information about tourist destinations in a more vivid and interactive way [1].

A virtual tour can help make better decisions, not only for physical traveling; for instance, prospective students can obtain information on the campus of the university they are interested in [5].

Field trips (physical traveling) help students build skills, integrate knowledge, and get ready for lifetime learning. Visiting technical facilities related to course material can enhance the education, involvement, and drive of engineering students. [6]. Virtual field trips (VFT) are used to complement or replace field trips; they are commonly used in social studies, geography, life science, and ancient civilization curriculum. The findings indicate that students have responded extremely positively to virtual field trips, which have resulted in a more valuable learning experience and increased enjoyment [7], [8], and a significant improvement of a spatial situation model of the visited place [8].

3. Method

For this study, the snowballing approach was chosen as the research methodology.

Snowballing, a literature review technique introduced by Wohlin et al. in 2014 [9], involves systematically exploring references and citations within collected literature. This iterative process incorporates both backward and forward snowballing to identify new papers and complete the snowballing cycle. The procedure is divided into the following steps: i) Identification of relevant keywords and formulation of search strings, and ii) Utilization of references from the selected papers to discover additional relevant literature to be included in the study.

3.1. Search Query

We employ the Scopus repository for querying the following string:

"VIRTUAL Tour" AND (facilities OR educational OR industry)

our search scope is confined to *articles* released in the English language.

After conducting the string search, we retrieved 99 papers from the Scopus database. The titles and abstracts of these papers were analyzed by two of the authors of this paper as part of the initial selection process.

3.2. Inclusion Criteria

We establish the subsequent inclusion criteria for the purpose of identifying the documents eligible for incorporation into this review:

I1. The article outlines a virtual reality (VR) system pertaining to a particular facility.

I2. The authors address certain research questions, specifically RQ1 to RQ3.

After the full review experimenters selected seven papers that accomplished the inclusion criteria.

3.3. Snowballing Approach

We utilized the snowball method across the seven selected papers in the following manner: for each retrieved paper, we expanded our search by examining the bibliography to identify pertinent papers. Any paper meeting at least one inclusion criteria I1-I2, was included in the selection; and the iterative procedure persisted. Upon completing this stage, a total of 32 papers were accumulated.

4. Results

4.1. Classification of Virtual Tours

As shown in Figure 1, virtual tours can be allocated in three-dimensional space, i.e., (i) type of world, (ii) level of immersion, and (iii) capture time. The following paragraphs describe these continuous dimensions.

Level of Immersion. The degree of immersion in a virtual reality (VR) system is contingent on the system's capacity to seamlessly substitute the perceptual experience of the physical environment with that of the simulated environment in virtual reality, thereby eliciting the user's perception through natural sensorimotor contingencies [10], [11].

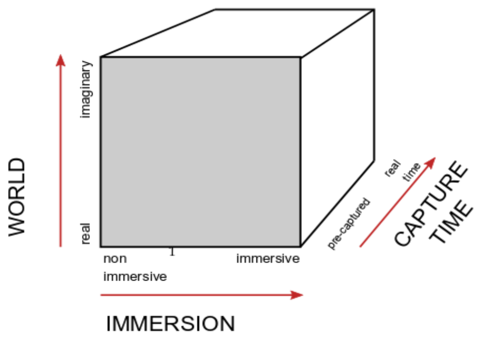

Figure 1. Three-dimensional space of virtual tours

A common classification considers three levels of immersion (non-immersive, semi-immersive, and immersive). For instance, [12] considers 3D worlds presented on a computer screen and controlled with the mouse as non-immersive; full-dome, floor projection, and smart glasses that add information to what the user sees is considered semi-immersive. Finally, head-mounted displays are considered immersive.

Capture-time. In virtual reality, the world is captured using two distinct techniques: pre-captured and real-time. The pre-caught approach signifies that the site visit content has been captured onsite before the virtual field trip begins. Using a real-time approach, however, visitors experience a live virtual field excursion where the virtual world is generated in real-time, and visitors can explore the site as if they were on-site [1].

Type of world. Virtual trips can be categorized as either simulated or real, depending on the physical properties of the environment being replicated [14]. A virtual world is a computer-based environment in which people can create and share a custom-built virtual space in which they can interact.

Simulated worlds, such as those found in video games and other entertainment media, often draw heavily on fantasy, sci-fi, and anime literature and movies.

On the other hand, exploring landscapes, industrial facilities, or industrial plants are examples of real spaces. These social virtual worlds are becoming popular in educational, governmental, commercial, and other groups.

A remarkable application of real virtual trips is the digital twins. A digital twin is a computerized representation of an object that updates in real-time to reflect any changes made to the physical object.

Depending on their granularity, one can consider different types of digital twins. The fundamental elements of twinning include asset twins (duplicating two or more components), system or unit twins (replicating two or more assets), and process twins (macro-level replication that exposes how systems collaborate to create a complete production facility).

The key benefit of digital twins is their capacity to store diverse data models associated with a product or asset, encompassing manufacturing, supply chain, service delivery, and customer information, among other significant advantages.

The feasibility of generating a digital representation (digital twin) to enhance the competitiveness of the tourism industry has been shown [15].

Table 1. Work summary

Work	***Visited Place***
University facilities	
[28]	Asia Pacific University of Technology and Innovation (APU)
[29]	MU's Auckland campus library
[5]	Telkom University (Tel-U)
Industrial Environments	
[30]	simulated industrial company for the artisan manufacture of chocolates
[31]	phases of cheese production
[32]	a machine-building plant
[6]	Université Laval, central heating plant and mechanical rooms in buildings
[33]	A typical charcoal mini-blast furnace (CMBF) plant in Brazil
[34]	An assembly Line
Labs	
[35]	Guided virtual tour of a university laboratory
[25]	The Photovoltaic (PV) Applied Research and Testing (PART) Lab
Other facilities	
[24]	Hospital tours during residency interviews
[14]	Gemini South telescope, located at an elevation of over 700 meters

4.2. Pros and Cons of Virtual Tours

Comparing objectively the results between Virtual with Corporeal tours is not an easy task. Some experiments try to expose participants to similar scenarios, but this implies that VT must be limited, as it can use different mediums to present information [16].

Perceived learning. Researchers that evaluate learning gains by presenting similar information found that there are no significant learning differences between virtual and physical trips that expose students to similar content [17]. In contrast, studies that present different information [16], [18] state that has more learning gains compared to CT. Immersive VFTs offer educational opportunities that generate heightened feelings of presence; but an augmented sense of presence does not inevitably result in an increase in an enhanced perception of learning among elementary students [19].

*Health risks***.** Potential health risks of using VR are eye strain, mental exhaustion, headaches, injuries, radiation, neurological and mental illnesses [20]. The symptoms of simulation sickness are nausea, stomach awareness, blurred vision, vertigo, and concentration difficulty. These symptoms can be of great importance for long exposition to VR devices [21]. Immersive virtual reality is known to cause motion sickness symptoms [22].

Feasibility and Cost. Feasibility is the possibility that something can be made, done, or achieved. An obvious requirement for VR systems is having the hardware and software. Recent restrictions on mobility, caused by the COVID pandemic, have sparked innovative forms of tourism, such as the virtual tour. This does not eliminate the possibility of tourists choosing to visit the locations they have virtually experienced in person [23]. But it might be more feasible to visit some places virtually than physically. This can be caused by the difficulty of accessing the place, as in [14] or the physical trip could be exhausting enough to make it infeasible for some guests.

Some studies on VTF show that the time spent is lower for virtual than physical visits without affecting the understanding of the visited place [1]. Another advantage of VTF over physical trips is flexibility. Virtual tours enable users to explore at their own pace and expand their learning experience by providing additional features, such as the ability to read technical drawings. Finally, incorporating a VT into some projects has resulted in time and cost savings [24].

Fun and Interest. Some studies compare the fun generated with virtual trips with the fun of a physical one.

Students gave positive remarks regarding the VR experience, with most of them stating that VRF was fun [25], [26]. The findings demonstrate that learners found wearable VR guides to be novel and challenging and that they can raise situational interest. Additionally, they state that the VR group enhanced their learning. Authors generally state that virtual tours make the experience more fun and interesting than a physical visit [27].

4.3. Technology

Articles related to VT to facilities educational purposes are summarized in Table 2. These works can be organized according to the software they use.

Table 2. Virtual tour creation software in reviewed literature

Software	***Description***	***Works***
University facilities		
Pano2VR	Pano2VR is a powerful virtual tour software that converts your panoramic or 360° photos and videos into interactive experiences	[36],[37]
HoloBuilder	Capture, view, and control project progress with 360° photos, enabling teams to stay on schedule and on budget	[35]
Mozilla Hubs	Online communities with a fully open-source virtual world platform	[38]
Cupix	Deliver 3D digital twin platform to builders and owners	[5], [28]
Virtual Tour PRO, 3D Vista	Create interactive 360º virtual tours in the easiest and most pleasant way: 360º views (panoramas), 360º videos, embedded sounds, videos and photos, floor plans, and fully customizable frames	[5],[34]
Google Cardboard	Cardboard puts virtual reality on your smartphone	[32]
CAD to virtual tours		
Comos Walkinside	A virtual reality platform for Asset Lifecycle Management (ALM)	[33]
Revit	is used to design, document, visualize and deliver architecture, engineering, and construction projects	[39]
Game engine		
Unity	Unity is the game engine that provided the platform for adding models, scripts, animations, and building the application	[31],[34], [40]

As described in Table 2, we can categorize software into four main types for constructing virtual tours: (i) software that transforms Panoramic (or 360) photos into virtual tours, (ii) software that transforms CAD models into virtual tours, (iii) general game engines, and (iv) 3D model viewers.

Transforming panoramic photos into virtual tours offers several advantages, including ease of use, cost-effectiveness, realism, and rapid creation. However, it has limitations concerning interactivity and image quality.

On the other hand, generating virtual tours from CAD models provides distinct advantages such as high accuracy, interactivity, professional presentation, and ease of updating. Nevertheless, this method may require technical expertise to address potential development complexities.

Using a general game engine for virtual tours results in real-time interactivity, high-quality graphics, multimedia integration, and platform versatility. However, it requires technical proficiency to manage the potential challenges during development.

Finally, employing 3D model viewers for virtual tours is simple, facilitating ease of sharing, and enhancing collaboration capabilities, making it applicable across various industries. Nevertheless, it may have limitations in terms of interactivity and realism compared to other methods.

An approach that integrates mesh from video and enhances it with virtual objects is presented in [13]. This method involves creating a 3D virtual tour (VT) using unmanned Aerial Vehicles (UAVs) to capture video footage of a real location, such as a campus. The collected video content is then used to generate images and construct a detailed 3D mesh model. These 3D models are then textured and seamlessly integrated into a general game engine model, such as Unity.

To overcome common difficulties, the approach described in [13] employs high-resolution images and optimization techniques, including occlusion culling and space subdivision. These techniques help to avoid potential issues that may arise when transferring high-poly models to game engines. Furthermore, this approach enriches the 3D models with additional virtual objects, such as trees, arbors, etc., which are included in Unity's assets.

An alternative method involves the utilization of 3D color laser scanners. An illustrative instance can be found in reference [40], where this technique is employed for the Virtual Musealization of the Spezieria di Santa Maria della Scala in Rome.

5. Conclusion

Offering academic experiences through virtual reality is an important task with potential applications in academic contexts such as visiting university facilities, industrial environments, labs, and other facilities. Through a review of related work, we were able to confirm that there are many advantages of VRF. It has been shown that perceived learning is like physical trips they are feasible, fun, and interesting. Despite all these advantages, people usually want to experience physical traveling.

In conclusion, this work presents a comprehensive and innovative classification framework for Virtual Tours to Facilities for Educational Purposes (VTFs) based on three essential dimensions: the type of world, the level of immersion, and the capture time.

The classification of VTFs into real or imaginary worlds marks a significant step forward in tailoring educational experiences to specific learning objectives. Real-world VTFs offer students a tangible and authentic connection to physical facilities, facilitating practical understanding and knowledge retention. On the other hand, imaginary world VTFs foster creativity and inspire learners to explore beyond conventional boundaries, stimulating their imagination and critical thinking.

VTFs can offer different immersion levels. Non-immersive VTFs, require minimal technical requirements; Semi-immersive and completely immersive VTFs, create captivating and deeply engaging educational journeys, providing students with a profound sense of presence and immersion in the virtual environment.

The capture time dimension considers the temporal aspect of a VTF. Pre-captured VTFs offer consistency and stability, ensuring a reliable educational resource that can be accessed and revisited at any time. Real-time VTFs, by contrast, provide dynamic and up-to-date experiences, reflecting the current state of physical facilities and accommodating changes as they occur, offering students a more dynamic and interactive learning experience.

This classification framework serves as a pivotal tool for educators, instructional designers, and developers, empowering them to make informed decisions about which type of VTF best aligns with their pedagogical goals and learners' needs.

By embracing this classification framework, educators can leverage the power of virtual environments to create transformative educational experiences that inspire curiosity, creativity, and a lifelong love for learning. Current challenges for universities can be faced using Virtual Tours.

Such challenges include attracting talented students, offering complementary approaches to learning, visiting dangerous places, etc. In conclusion, investing in non-tangible resources like VR in schools can help students make better academic decisions, learn more, and become better professionals. Long-term, this can help those countries' economies.

Finally, this work explores four main types of software utilized for constructing virtual tours: (i) software that transforms panoramic photos into virtual tours, (ii) software that converts CAD models into virtual tours, (iii) general game engines, and (iv) 3D model viewers. It is worth noting that employing a combination of these tools can lead to improved results in terms of faster integration and enhanced interactivity.

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