Virtual tour as an innovative tool for architectural education - from understanding heritage to creativity stimulation

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ABSTRACT: The article presents the potential of the virtual tour in architectural education as an innovative tool to better understand heritage and stimulate creativity. A methodology for creating a virtual tour based on a point cloud obtained from a survey based on 360° camera images is presented. Two different purposes for the use of point clouds are presented from reliable indicators of heritage documentation useful for digital twin modelling and architectural analysis, to the creation of thematic virtual tours enabling the testing of different scenarios. The article focuses on the case of virtual tours that were created as part of the 2023 Gdańsk Summer School associated with the H2020 PROMETHEUS project, in collaboration between Gdańsk University of Technology (Gdańsk Tech), Poland, and the University of Pavia, Italy. A virtual tour was created for a significant part of the Royal Way in Gdańsk. A comparison of the different types of virtual tours is presented in relation to their objectives (educational, tourist, entertainment), the characteristics of the scenarios (place, time, story, characters) and the experience environment (virtual, augmented or immersive space).

INTRODUCTION

Architectural education is evolving rapidly in the digital age, with emerging technologies and new tools reshaping traditional teaching methods. It is visible in many fields starting from the programmes related to heritage and the use of digital tools [1][2], to urban and architectural design, based on parametric design [3], including interactive solutions [4] or support of AI [5]. This article concentrates on the potential of virtual tours in reference to understanding heritage and creativity stimulation, crucial in terms of architectural education as highlighted in another study [6].

The virtual tour represents the next level of the tool known as the city walk enabling a deeper understanding of the urban space and the city life [7]. It aims to provide additional content about the space, monuments and details, while offering interactive experience for the recipients [8]. To make this possible, it is necessary to create a digital environment that enables the experience of the place. While virtual tours can manifest in either real or fictitious spaces, this article focuses on tours situated in real environments, grounded in empirical data acquisition.

Data acquisition is nowadays a highly relevant issue, allowing the creation of digital twins of historical objects, based on point cloud surveying with laser scanners, 360° camera pictures and drone cameras [9-11]. It can also serve as a basis for developing digital reconstructions and presenting them in immersive environments [12]. The results of the digital survey can be used for further analysis based on metric data and 3D modelling or as the environment for virtual tours [13-15].

Virtual tours can be utilised across architectural education at various levels. One of them involves immersive space for architectural project verification, which was the subject of collaboration between the Faculty of Architecture and the Faculty of Electronics, Telecommunications and Informatics, both from Gdańsk University of Technology (Gdańsk Tech), Poland, within the scope of the Immersive 3D Visualisation Lab (I3DVL) [4][16]. This current article examines the potential of virtual tours for such fields as history of architecture, and architectural drawing and documentation, augmented by elements of digital surveying methodologies.

A fundamental premise of this study is that virtual tours can be defined by three basic elements: goal, scenario and the experience environment. In terms of possible goals, one can distinguish between educational, recreational, popular science, the creation of guides or games. The objective is also shaped by the profile of the audience, which in turn influences the design of the scenario. All the analyses are carried out on the proposed models of the scenario and the experience environment to prove the role of the virtual tour in architectural education in terms of the content produced for these goals and new ways of experiencing the place. This study on virtual tours is based on the results of the Virtual Tour Workshop, conducted during the 2023 Gdańsk Summer School in co-operation between Gdańsk Tech and the University of Pavia (UNIPV), Pavia, Italy.

The starting point for this Virtual Tour Workshop was a digital survey conducted between February and April 2023 and drawings and a historical survey in July 2023, all focusing on Long Street (ulica Długa) and Long Market (Długi Targ) in Gdańsk. During the workshop participants were asked to utilise the point cloud and 3DVista software as a foundation for their virtual tour. However, their task extended beyond a simple presentation of the existing place, focusing on the development of diverse tour scenarios to deepen the understanding of the local heritage and develop creative skills.

MAIN COMPONENTS OF THE VIRTUAL TOUR SCENARIO

The virtual tour scenario consists of four several key components allowing for interactive experience (Figure 1). These elements include: story, time, place and characters. The story refers to the narrative of the virtual tour, which can be based on facts or it can be fictional, taking users on an imaginative journey. In terms of time, the virtual tour can offer a glimpse into the past, present or even the future. This allows users to witness architectural changes over the centuries' time or observe possible visions for the place.

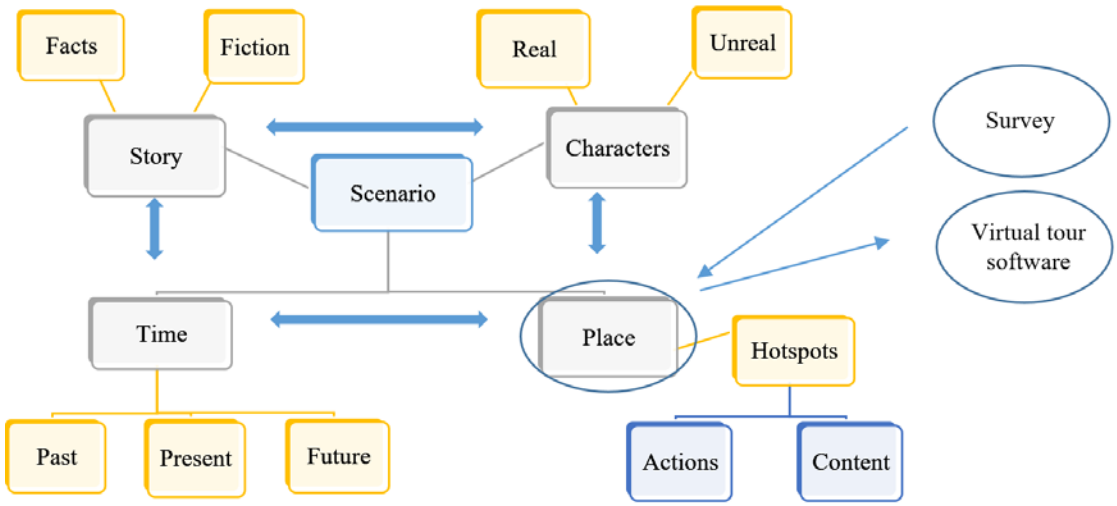

Figure 1: Diagram presenting the main components of the scenario.

The place is crucial to the virtual tour, creating the background for the experience and offering the hotspots to acquire additional content, like information, photos, audio, video, etc, or to change the filters of the place, representing common features of buildings, e.g. one architectural style, or to switch possible actions, related to the movement of the recipient, like walking through streets, flying over landscapes, jumping over obstacles, interacting with objects, etc. Hotspots constitute the signposts, allowing for navigation in the virtual space. Lastly, the virtual tour can be enriched with characters, both real and unreal, who guide users through the experience.

POSSIBLE EXPERIENCE ENVIRONMENT OF THE VIRTUAL TOUR

By integrating main elements of the scenario, virtual tours can offer engaging experiences that take users to new worlds. However, the process varies depending on the environment of experience, enabling varied levels of interaction. Three primary types of the experience environment can be distinguished: virtual, augmented and immersive (Figure 2).

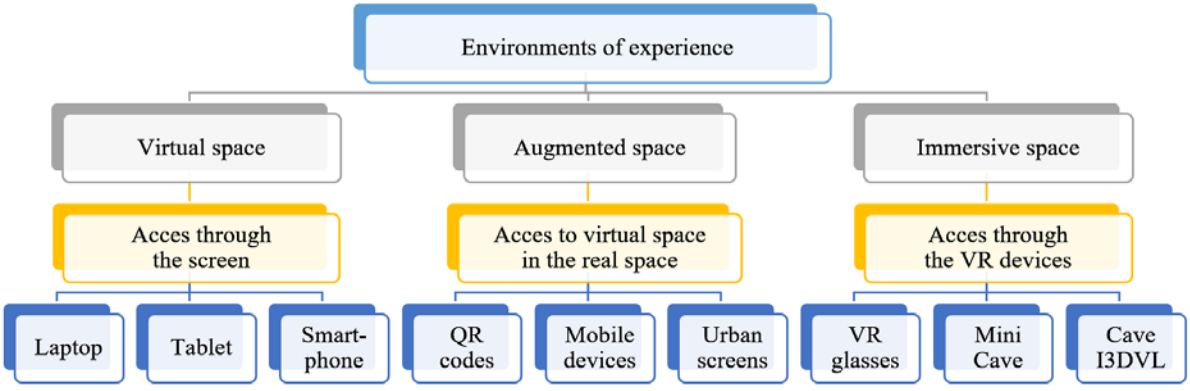

Figure 2: Diagram presenting possible experience environments of the virtual tour.

In the case of virtual space, this environment is accessible through the screen and suitable interface, so interaction can be achieved via laptops, tablets or smartphones. A more advanced form of interaction is augmented space, where virtual space is simultaneously integrated with the real world. The virtual tour can be accessible through QR codes embedded

in paper brochures or some panels located in real space. An augmented reality experience can be obtained also by mobile devices, in real locations or different urban screens. The most advanced environment of the experience is immersive space, enabling users to interact with virtual environments through VR devices as VR glasses, miniCAVEs or specialised laboratories as CAVE in the Immersive 3D Visualisation Lab (I3DVL) at Gdańsk Tech. Such an immersion allows for a high level of engagement and interaction, transcending boundaries of space and time.

DATA ACQUISITION AS THE STARTING POINT OF THE IMMERSIVE VIRTUAL TOUR

To allow the realisation of the immersive virtual tour during the workshop, the 3D digital documentation of Long Street and Long Market was prepared. The phase of documentation and data acquisition of Long Street and Long Market was conducted using cameras for photographic acquisitions and a terrestrial laser scanner with an integrated camera for geometric reliability and for the acquisition of the colour and material data of buildings. The terrestrial laser scanning (TLS) survey phase was conducted using Leica Geosystem RTC360 and was designed not only as exportable data from which to construct the virtual tour, but also to obtain morphologically validated outputs of the context that were used to populate the virtual tour with information. In addition to the point cloud by the laser scanner with HDR colorimetric data integrated, a photographic acquisition campaign was conducted for documentation and photogrammetry using the structure from motion (SfM) photogrammetry technique (Figure 3).

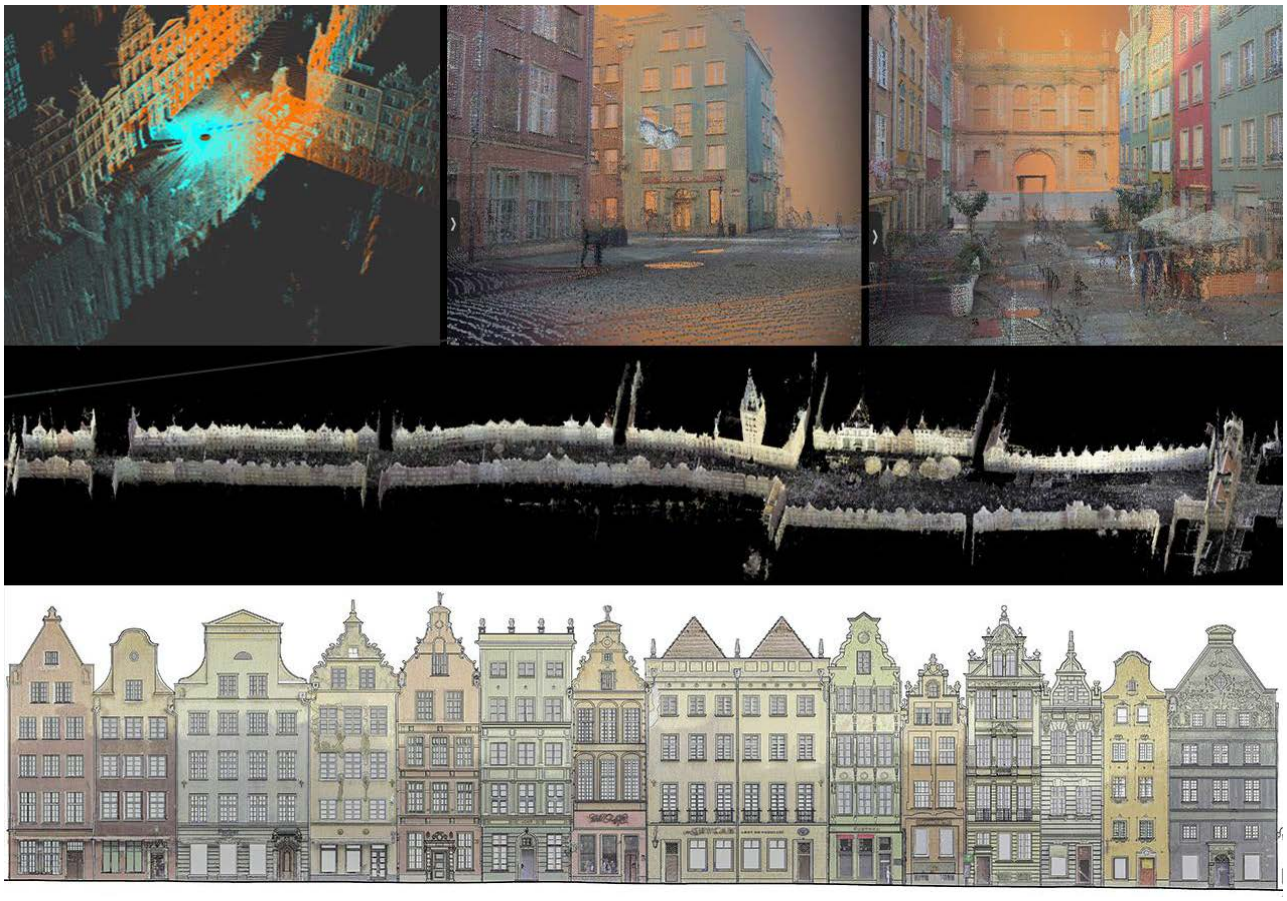

Figure 3: TLS and drawings outputs: streets view, top view and a part of the silhouette of the street (image by E. Doria).

The documentation campaign focused on buildings selected because of the archival research. Buildings of obvious importance to the city's history were selected to analyse them in more detail and reconstruct their historical phases. Photographs of environmental documentation and architectural details were taken. Some of them were also found in historical archives. The shots were taken using cameras and 360° lenses (Insta360) to capture images also suitable for use in immersive virtual reality systems for spatial viewing. The 360° shots were taken every 5 metres along the entire street and square, a length of approximately 530 metres, so that close-ups could be obtained for a detailed virtual tour, but also so that they could be used at a greater distance from each other for faster completion. Starting with the outputs of the survey, digital products were created and incorporated as information elements into the immersive virtual tour.

The realised products are related to the theme of the historical memory of the city, the changes in the buildings and the current decorations and architectural elements. These include hand-drawn preliminary studies comparing historical photographs with the current condition; reliable vector drawings of building façades and colour orthoimages; three-dimensional reality-based models; three-dimensional mesh models made using the SfM technique of decorative elements, such as statues and gates; point cloud elaborations that can be navigated by users of the virtual tour; census cards to be used as guide to the history of the site and the process used in the project.

COMPARISON OF FOUR SCENARIOS OF THE VIRTUAL TOUR AS A RESULT OF THE WORKSHOP

During the workshop, four scenarios for virtual tours were developed based on the obtained point cloud. The first scenario (S.1), called: *More than Urban Tourism*, concentrates on the most significant buildings from Long Street and Long Market. It explored various architectural styles of monuments and the extent of war damage from World War II. The second scenario (S.2), titled *Invisible History of Long Street*, meticulously traced the evolution of tenement houses' appearances from the late 19th Century to the present day. Next, the *Knock, Knock, Who's there* scenario (S.3), unfolded interesting tales behind the intriguing doors of tenement houses, unveiling the rich history embedded within the buildings. Lastly, the enchanting *Swan and the Princess* scenario (S.4), wove a fairy tale narrative around the chosen sculptures located at Long Street and Long Market, inviting participants to engage in an urban game by seeking out subsequent sculptures referenced in the tale. The topics of the first two scenarios were suggested by the supervisors, while the other two were the ideas of the workshop participants.

Participants worked in two groups of six students. Both groups worked together on scenario 1 (S.1) and on variants of scenario 2 (S.2), and separately on scenario 3 (S.3) and scenario 4 (S.4). Below, all scenarios are compared, considering the educational field connected to the virtual tour's objectives, the goal of the virtual tour, and additional elements realised within the scenario (Table 1). Moreover, four main components of the scenario were compared (Table 2), in relation to the scope of the content and actions accessible through hotspots (Table 3).

Table 1: Comparison of the scenarios in regard to the scope of educational fields and the goal of the virtual tour.

	Educational field				Goal of the virtual tour				
Scenario	City tour	History of architecture	Architectural drawing	Survey	E	EN	G	GM	PS
S. 1	x	x	x		x		x		x
S. 2	x	x	x		x		x		x
S. 3	x	x	x	x	x	x	x		x
S. 4	x	x		x		x		x	

*Note: Legend: E - education, EN - entertainment, G - guide, GM - game, PS - popular science

Table 2: Comparison of the scenarios in regard to the scope of the main components of the scenario.

Scenario	Story		Characters		Time			Place
S. 1	Facts	Fiction	Real	Unreal	Past	Present	Future	Hotspots
S. 2	x				x	x		Façades, ground
S. 3	x				x	x		Façades, ground
S. 4	x	x	x	x	x	x		Doors, ground
S. 1	x	x		x	x	x		Sculptures, ground

The conducted analysis reveals that the most impactful scenarios in terms of their effect on educational fields were scenario 3 (S.3) (Table 1) and, concerning the components of the scenario, scenario 4 (S.4) (Table 2), both proposed by participants. In contrast, scenarios proposed by supervisors, scenario 1 (S.1) and scenario 2 (S.2), exhibited a greater depth of content (Table 3), focusing on elements oriented toward the workshop's main goal of understanding heritage.

Table 3: Comparison of the scenarios in regard to the scope of content and possible actions.

Scenario	Content									Actions
	Filter	Info.	Sketches	Figures	Postcards	Photos	Archives	UAV video	SfM	Walking
S. 1	x	x	x			x	x			x
S. 2		x	x		x	x	x			x
S. 3		x	x	x					x	x
S. 4		x				x		x		x

*Note: Legend: UAV - unmanned aerial vehicle, SfM - structure from motion products

Encouraging participants to create additional scenarios aimed at stimulating their creativity. It is visible that the objectives of the virtual tours in scenario 3 (S.3) and scenario 4 (S.4) have been expanded to include elements of surveying, entertainment and games (Table 1). This demonstrates that virtual tours can have a positive impact on creative skills. This is evidenced not only by the proposed creative content, such as sketches and postcards or nature of characters (Table 3), but also in terms of narratives using elements of fiction and figures. These elements greatly enriched the virtual tour and could potentially be turned into avatars in more advanced virtual tours.

REALISATION OF THE VIRTUAL TOUR

The Virtual Tour Workshop was conducted by the supervisors: K. Życzkowska from Gdańsk Tech and E. Doria from the UNIPV, with the support of P. Samól form Gdańsk Tech, and co-ordinated by organisers of the Summer School:

F. Picchio from the UNIPV and J. Borucka from Gdańsk Tech. The result of the Virtual Tour Workshop consisted of three elements: the digital virtual tour, presentation, and brochures, also distributed in a paper copy, presenting the topic of the chosen tour. Each group selected the 360° photographs - human view position - to be used as the basis for the tour. The 3DVista virtual tour software was used to create the interactive tour, which can be viewed either from a personal computer and tablet/mobile phone or through a virtual reality visor. The virtual tour can be made informative by associating several hotspots connected to the place (Table 2).

Texts, downloadable pdf files, image galleries, links to external pages, such as three-dimensional model viewers or Web sites of the city's museums or historical archives consulted, videos and sounds, and all contents mentioned in Table 3, have been linked to these hotspots; in addition, each virtual tour contains a navigable floor plan showing its position on the map and a radar updated in real time to facilitate orientation.

All the scenarios were released in the virtual space as is shown in Table 4. Moreover, scenario 3 and 4 were explored in the augmented space due to QR codes embedded to the above-mentioned brochures. The result includes all cultural scenarios designed by the two groups, summarised in a single tour in which the information points are visible separately thanks to different graphic designs (Figure 4). The brochures were the synthesis of the creative idea that the virtual tour should narrate and were also distributed on the presentation day of the final products to the tourists and citizens present. The design of the brochures was used by the supervisors to develop in the participants a critical and synthetic process of what they wanted to highlight in the virtual tour.

Table 4: Environment of experience and additional elements used to realise the four scenarios of the virtual tour.

	Environment of experience			Additional elements
Scenario	Virtual space	Augmented space	Immersive space	
Scenario 1	Access using screen		VR glasses, I3DVL	Presentation
Scenario 2	Access using screen			Digital postcards
Scenario 3	Access using screen	City tour + brochure + QR codes		Brochure
Scenario 4	Access using screen	City tour + brochure + QR codes		Brochure

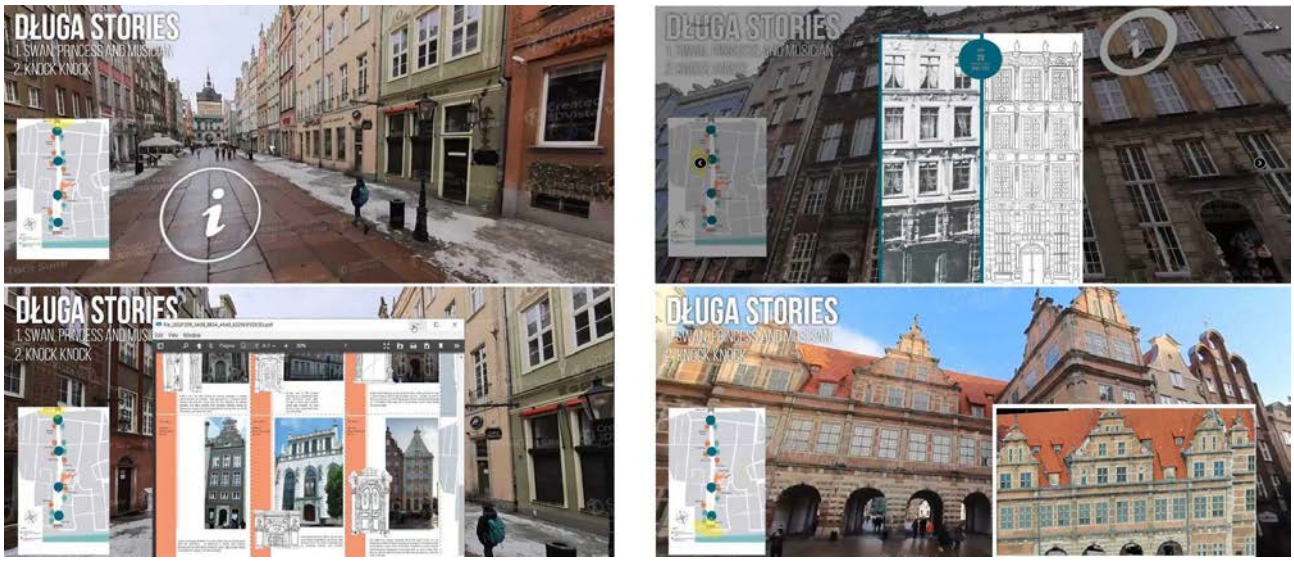

Figure 4: Images of the exemplary virtual tour realised during the Virtual Tour Workshop (image by E. Doria).

Each brochure contains QR codes to view the virtual tour and associated information, and some copies were available at the presentation venue – the Institute of Urban Culture in Gdańsk. The final product represents the process of information analysis, critical synthesis and design representation of the idea conceptualised by the participants in the first workshop phase and materialised with the design and implementation of the immersive virtual tour and brochures. It is worth mentioning that scenario 1 was partly realised in immersive space (Table 4), but just in reference to the presentation of a short part of Long Street, it was the work going beyond the workshop activity. Further research in co-operation with J. Lebiedź and his team from the Faculty of Electronics, Informatics and Communications from Gdańsk Tech allowed the application of part of the point cloud into the I3DVL CAVE as a background of future immersive virtual tours. Moreover, an immersive environment for this part of Long Street, using VR glasses, was presented during the H2020 PROMETHEUS conference at the Institute of Urban Culture in Gdańsk in October 2023.

DISCUSSION AND CONCLUSIONS

The conducted research related to the creation of a virtual tour stresses the potential of digital scenarios in such fields of architectural education as history of architecture and architectural drawing and documentation. This educational aim is developed by engaging students in the research phase, producing content and participating in the survey phase to

acquire detailed and updated data. In addition, as students have to structure a highly usable virtual tour for a wide range of target users, they have to carry out critical analysis activities to understand which elements should be included in such a product. The topic of the workshop was mainly oriented towards understanding and documenting the local heritage. However, through realisations of different scenarios, creative skills were also developed in terms of the proposed stories, characters, way of presentations, creation of brochures, postcards and other elements constituting the content of the virtual tour.

The scenarios developed during the workshop were mainly oriented towards a comparison of the past and the present. However, it is important to mention that the virtual tour could be also used to visualise the future to show and verify possible variants of transformations of the place using the design of new buildings or new urban structures. Thus, another area of using virtual tours in architectural education is visible, i.e. in the classes of architectural design. These processes of creation virtual tours offer experiences that enhance understanding of the local heritage, the place and stimulate creativity. It can be utilised for creating digital twins not only of single monuments, but also complex urban structures, such as Long Street and Long Market; it allows to present content in innovative ways. Moreover, virtual tours could facilitate design verification and foster creative work on architectural projects. Besides time frames, all scenarios can be realised in different experiment environments, allowing not only for an interactive experience but also an immersive one.

In summary, virtual tours allow for the exploration of past, present and future environments that have significant impacts on educational fields, providing opportunities for historical exploration, contemporary analysis and futuristic envisioning, promoting creativity, allowing for experiments and presentations in innovative digital environments, which is crucial in terms of contemporary education. Virtual tours can be used as a teaching tool to enrich lessons and projects, allowing students to develop spatial observation and analysis skills in an innovative way.

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REFERENCES

1. Borucka, J. and Parrinello, S., VREA project - a digital curator for architecture and digital perspectives for heritage management and enhancement. *The Inter. Archives of the Photogrammetry, Remote Sensing Spatial Infor. Sciences*, 48, 289-296 (2023).
2. Borucka, J., Parrinello, S. and Picchio, F., Digital data and tools in transformative education to preserve architecture and cultural heritage: case studies from Italy and Poland. *Global J. of Engng. Educ.*, 25, **2**, 129-134 (2023).
3. Nyka, L., Cudzik, J. and Urbanowicz, K., The CDIO model in architectural education and research by design. *World Trans. of Engng. and Technol. Educ.*, 18, **2**, 85-90 (2020).
4. Życzkowska, K. and Urbanowicz, K., Architectural education and digital tools: the challenges and opportunities. *World Trans. on Engng. and Technol. Educ.*, 17, **3**, 326-331 (2019).
5. Cudzik, J., Nyka, L. and Szczepański, J., Artificial intelligence in architectural education - green campus development research. *Global J. of Engng. Educ.*, 26, **1**, 20-25 (2024).
6. Życzkowska, K. and Krawczyk-Bryłka B., Levels of creativity in architectural education. *Global J. of Engng. Educ.*, 25, **2**, 106-111 (2023).
7. Borucka, J., City walk: a didactic innovative experiment in architectural education. *World Trans of Engng. and Technol. Educ.*, 17, **2**, 158-163 (2019).
8. Urbanowicz, K. and Nyka, L., Interactive and media architecture - from social encounters to city planning strategies. *Procedia Engng.*, 161, 1330-1337 (2016).
9. Argyriou, L., Economou, D. and Bouki, V., Design methodology for 360 immersive video applications: the case study of a cultural heritage virtual tour. *Personal and Ubiquitous Computing*, 24, 843-859 (2020).
10. Doria, E., Galasso, F. and Morandotti, M., Heritage documentation and management processes: Castiglioni Chapel in Pavia. *Acta IMEKO*, 11, **1**, 1-9 (2022).
11. Lowenthal, D., *Stewarding the Past in a Perplexing Present*. In: Avrami, E.C., Randall M., De la Torre, M. (Eds), Values and Heritage Conservation: Research Report. Los Angeles, CA: Getty Conservation Institute, 18-25 (2000).
12. Pettineo, A., La Placa, S. and Kowalski, S., From archives sources to virtual 3D reconstruction of military heritage - the case study of Port Battery, Gdańsk. *The Inter. Archives of the Photogrammetry, Remote Sensing and Spatial Infor. Sciences*, 48, 885-893 (2023).

13. De Fino, M., Ceppi, C. and Fatiguso, F., Virtual tours and informational models for improving territorial attractiveness and the smart management of architectural heritage: the 3d-imp-act project. *The Inter. Archives of the Photogrammetry, Remote Sensing and Spatial Infor. Sciences*, 44, 473-480 (2020).
14. Parrinello, S. and Picchio, F., Digital strategies to enhance cultural heritage routes: from integrated survey to digital twins of different European architectural scenarios. *Drones*, 7, **9**, 576 (2023).
15. Kersten, T. P. and Lindstaedt, M., Virtual architectural 3D model of the imperial cathedral (Kaiserdom) of Königslutter, Germany through terrestrial laser scanning. *Proc. of 4th Inter. Conf. on Progress in Cultural Heritage Preservation, EuroMed 2012*, Limassol, Cyprus; Berlin, Heidelberg: Springer, 201-210 (2012).
16. Lebiedź, J. and Szwoch, M., Virtual sightseeing in immersive 3D visualization lab. *Proc. Federated Conf. on Computer Science and Infor. Systems (FedCSIS)*, IEEE, 1641-1645 (2016).