GIS-BASED EDUCATIONAL GAME THROUGH LOW-COST VIRTUAL TOUR EXPERIENCE

Khan Game

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Abstract. The pandemic brought new norms and techniques of pedagogical strategies in formal education. The synchronous/asynchronous video streaming brought an emphasis on virtual and augmented realities, which are rapidly replacing textbooks as the main medium for learning and teaching. This transformation requires more extensive online and interactive content with simpler user interfaces. The aim of this study is to report on the design, implementation, and testing of a game based on low-cost and user-friendly content for digital cultural heritage. In this project, a game aimed at inclusive and equitable education was developed using 360° images of the targeted architectural heritage geographically distributed in a pilot site. We promote lifelong learning opportunities for all, following the SDG4, aiming for quality education with the easy-to-use online platform and easy access to immersive education through mobile platforms. Towards a post-carbon future without the need for travel, computational design methods such as using 360° videos and images in combination with virtual reality (VR) headsets allow a low-cost approach to remotely experiencing cultural heritage. We propose developing and testing a GIS-based educational game using a low-cost 360° virtual tour of architectural heritage, more specifically, caravanserais of Anatolia.

Keywords. Digital Heritage; 360° Images; Educational Games; Caravanserais; SDG 4.

1. Introduction

The academic year of 2020 inevitably brought changes and challenges in formal education due to the pandemic. Consequently, the studies on online education in design, still experiential to date, explore both teaching and learning methods. The process of learning through experience, or "learning through reflection on doing," aka experiential learning, is an important part of architectural education. It has become a great opportunity to rethink conventional pedagogical methods and current pandemic experiments, using emerging technologies, and transporting instruction outside of the digital classroom (Estrina et al., 2021). The availability of synchronous/asynchronous video streaming brought an emphasis on virtual and augmented realities, which are rapidly replacing textbooks as the main medium for learning and teaching. However, the current multiplicity and complexity of online and interactive content created a need for simpler user interfaces.

This study aims to describe the design, implementation, and testing of a game based on low-cost and user-friendly content for digital cultural heritage. The game described in this study was developed using 360° images of the targeted architectural heritage, which are geographically distributed in a pilot site. This educational game aims to ensure inclusive and equitable education and promote lifelong learning opportunities for all. As stated by the United Nations' sustainable development goals, among the visions for 2030 are increasing gender equality, and providing equal access to all levels of education to vulnerable persons with disabilities, indigenous people, and children of both genders (UN, 2015). Thus, we assume that the aim of digital learning and teaching tools should be to ensure affordable and quality university education (SDG4). We promote lifelong learning opportunities for all through the easy-to-use online platform and easy access to immersive education through mobile platforms. The original contribution of this study is at two levels: visualisation and immersion. Immersion in interactive technologies is defined as the perception of a presence in the non-physical world; presence refers to the user's reaction to immersion (Slater, 2003). Immersion may be achieved by visual aspects, auditory images, and also narrative.

Digital Heritage, as defined by UNESCO (2009), "is made up of computer-based materials of enduring value that should be kept for future generations." The cultural heritage has a concrete value derived from its authenticity, as well as its digital interpretation, which has its own value (Aydin and Schnabel, 2015). Serious games (SG) -videogames designed for educational objectives- on cultural heritage, as one of many interpretations, are a new tool aiming to increase engagement with cultural content. Mortara et al. (2014, 318) argue that "the design process of an SG differs from the one of a common e-learning application as an intrinsic balance between learning and gaming should be found." Thus, the learning content has a key role, as the game interactions and mechanics cannot be regarded as a separate layer, but rather, are highly dependent on the heritage content.

Games have much in common with the architectural design process, including the emphasis of graphical representations, the dominance of a narrative, and possibilities of collaborative teamwork (Di Mascio, 2017). Similarly, Zarzycki (2016) highlights the similarity between building and video game design because, besides the visual quality, both are based on narrative. Current video games are complex and costly by nature, and this is leading scholars to explore simpler, cost-effective tools and methods.

360° videos together with images and virtual reality (VR) headsets are a low-cost way of remotely experiencing cultural heritage. In contrast to previous attempts at using 360° videos, we propose developing and testing a GIS-based educational game using a low-cost 360° virtual tour of architectural heritage, more specifically, the caravanserais of Anatolia.

The main aim of the Digital Caravanserai Project is to create a geolocated virtual experience of the caravanserais, allowing the exploration of Anatolian networks of the past. Using this heritage data, we aim to address the following three questions: How can we extend the notion of a relational database into a more holistic geolocated system? How can 360° photographic images be used as an immersive experience using simple and low-cost systems? How can the photogrammetric reality and game elements create an authentic self? The project consists of three stages. In the first, we collected data on caravanserais in architectural literature and also studied the heritage objects in the field, both to experience their geographical context and to collect images with 360° cameras. Second, through these collected panoramic images, we designed and implemented both virtual tours and an educational game using 3dvista Virtual Tour PRO software. Finally, we designed the game to encourage users to visit all the virtual sites and interact with the content, providing exhaustive coverage on the material. The game involves puzzle-solving using the learned information, which further guarantees the users attend to the content. The user interaction is monitored and stored in online platforms, allowing assessment of the interaction rate of all elements, which can be used to improve later versions of the game.

2. Immersion and Visualisation in Heritage Game

Game design is about the design and aesthetics of creating a game for entertainment, while educational or serious game design focuses specifically on supporting learning on certain subjects, skills, etc. Whether educational or not, game mechanics are constraints of rules and feedback loops intended to produce enjoyable gameplay. Gameplay is the way in which players interact with a game. Educational games and game-based learning have become prominent tools in delivering an innovative learning experience. The tradition of learning by doing was conceived of by Bauhaus, and an extension of this conception is learning by playing. This is the focus of an increasing number of studies on emerging technologies, which move instruction beyond the digital classroom (Estrina et al., 2021). Before the pandemic, a few futuristic studies had already emerged on the integration of architectural education and immersive technologies, such as Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), but the online teaching era brought many more explorations of the interaction potential of live tools. Also, at the same time, there was an expansion of interaction from simple chatting to more attention-demanding tools, such as games.

Within the focus on heritage educational games, two definitions need to be clarified: immersion and visualisation. Immersion in interactive technologies is defined as the perception of the presence in the non-physical world. Presence is the user's reaction to immersion (Slater, 2003). Immersion may be achieved by visual aspects, auditory images, and also narrative; visualisation, on the other hand, is any technique for creating images to communicate a message. The use of immersive visualisation and more natural interaction increases the sense of presence, creating an enhanced game

experience.

This paper is a combined effort incorporating two text-based games designed and implemented by the authors: one on Iranian caravanserais (Eshaghi et al., 2021) and another on Anatolian caravanserais (Vaez Afshar et al., 2021). Also, further research has been published covering other heritage sites: a mobile platform game (Varinlioglu et al., 2017), a virtual reality application (Varinlioglu and Kasali, 2018), and an augmented reality application (Varinlioglu and Halici, 2019). Drawing on the authors' expertise both in the subject of caravanserais and in various immersion and visualization methods, this paper focuses on two components of the Khan Game: GIS-based and 360° immersive experiences.

Maps have always been an integral component of games, as the contextual layer for a gaming experience, (Tomaszewski et al., 2018: 369). An early use of geographic information was the strategy board game Risk and its video game version in 1988, based on a political map of the world. Similarly, Microsoft Flight Simulator 2.0 in 1984 portrays planet Earth with varying degrees of detail, both major landmarks and populous cities, and with a sparse landscape. The Stanford Geospatial Network Model of the Roman World (ORBIS, 2013) portrays the Roman world, not as it would have physically appeared from space, but captures environmental constraints that govern the flows of people, goods, and information. By simulating movement along the principal routes of the Roman network, the main navigable rivers, and sea routes, this interactive model reconstructs the duration and financial cost of travel in antiquity. Although produced as a commercial game, this interactive model is a unique educational source for understanding pre-modern society.

The VR game design combines the audience's live experience, using 360° panorama shooting, 3D modelling, virtual reality, and intelligent question-answering technology. Some studies suggest simpler methods and tools such as 360° videos, excluding even the headsets to prevent distraction by virtual reality (Alamäki et al., 2021). 360° videos and panoramic photos have only recently been introduced in the heritage sector, for example, Argyriou et al. 2020 produced a set of design tasks and techniques to exploit immersion in cultural heritage tour applications. Thus, our case study, as a solution to the high-cost content creation for VR, is designed to apply low-cost immersion and visualisation techniques to the phenomenon of caravanserais, the waypoints along the Silk Roads.

The Silk Roads were a network of routes connecting the ancient societies of East, Central, and Western Asia with the Mediterranean (Frankopan, 2015). This network represents one of the world's preeminent long-distance communication networks, covering the Anatolian landscape through caravan routes (UNESCO 2013). ICOMOS's thematic study on Silk Roads covers the east-west extent as far as Antioch - modern-day Antakya. Despite the importance of Anatolia in this respect, there is still doubt over Turkey's full involvement in this project, and thus over the inclusion of the Silk Road network in Anatolia (Williams 2014).

A caravanserai, caravan palace, or han in Turkish, is a roadside inn for travellers to rest during long journeys. These are deliberately positioned within a day's journey apart, on average of every 30-40 kilometres. According to the Project Old World Trade Routes (OWTRAD), there are 154 Seljuk caravanserais on the route from Denizli to Doğubeyazıt, Turkey (Ciolek, 1999). Independent studies on Anatolian urban

networks include an in-depth but accessible research project by Branning (2019) on the Turkish khans, and studies on Anatolian caravanserais (Erdmann, 1961; İlter, 1969; Özergin, 1965; Tuncer, 2007). In contrast to these more general studies, the specific focus of the current study will be the caravanserais of Southern Anatolia during the Anatolian Seljuk State. Our pilot location is Antalya, the intersection of eight caravan roads, and thus, a prominent focus in the discovery of ancient Anatolian networks (Bakkal, 2019).

3. Game Design, Implementation, Playtesting, and Web Analytics

The design and development of Khan Game involved an interdisciplinary team of designers, architectural historians, and engineers collaborating to explore the possibilities offered by an easy-to-use virtual tour platform of the software, e.g., 3dvista Virtual Tour PRO. Through the modification of 360° images of existing caravanserais, the game encourages the user to solve puzzles based on historical facts in a game scenario. In the game, the avatar, a digital archaeologist, explores the geographically distributed caravanserais, each of which has a unique puzzle game that involves finding missing pieces of an inscription or other missing objects. These caravanserais are presented in an online 3D map of Anatolia, and by clicking a particular one, users can access its puzzle.
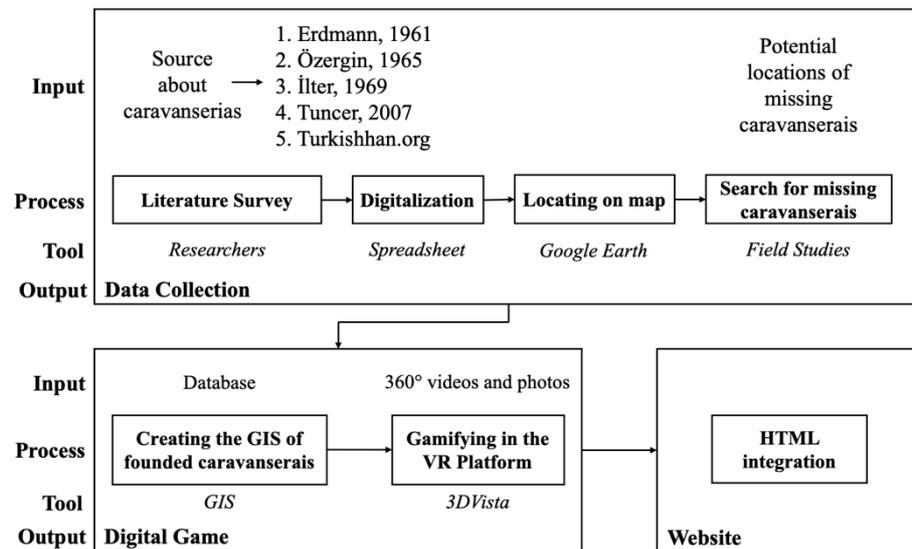

Figure 1. Methodology of the Khan Game design

There were three steps to developing the game. First, information about the selected architectural heritage, i.e., Caravanserais of Antalya, was accessed from the existing academic literature, consisting of publications, book chapters, and unpublished research, as well as notes and blogs of travellers, tourist guides, and local people (Fig. 1). We compiled this unstructured data into a spreadsheet, allowing us to test the validity of information on the location of the caravanserais, the interpretations of its

characteristics, date of construction, and other relevant aspects. The location data was compiled on the Google Earth platform, both to geolocate the data and allow comparisons within this collaborative geodatabase. The next step was the field studies, where the geo-data was reassessed to resolve any conflicting information. Finally, for each caravanserai, 360° images were carefully collected using low-budget devices, e.g., Go Pro max. This visual data was further used in virtual tours of the caravanserais.

Second, to achieve a distinctive visual language, the 360° images were compiled, and used in the design and implementation of a web-based virtual tour. For this stage, we used a commercial 3D virtual tour tool, i.e., 3dvista Virtual Tour PRO. This tool, which enables the creation of interactive virtual tours using 360° images, and is compatible with virtual reality devices and smart devices running Web browsers. Easy to publish web-based tours require no reviewing time, unlike in AppStore or Google Play. 3dvista also allows adding information boxes, media, URLs, etc. These capabilities allow the user to increase the content's immersiveness and interactivity for the target audience (Nemtinov et al. 2020). E-learning functions, which have been recently incorporated in the software, enabled generating educational virtual tours. However, while gaming is not the main aim of the software, the presence of question or quiz cards, integrated scoring, and the reporting system allows the creation of an entertaining treasure hunt game. Additionally, while studies in the literature are available using the virtual tour-making capability of the 3dvista (Perdana et al., 2019), there seems to be little research exploiting this opportunity for game development. Hence, this novel technology is worthy of deeper consideration.

Figure 2. Visual language and layers of the game

For the game's visual language, first, we edited the 360° photos to create an atmosphere of fantasy, while sharpening the focus of the architectural heritage objects and sites. Artistic experimentation resulted in 360° images composed of three layers - a layer of "heritage", displaying the currently existing architectural values of caravanserais, a layer of "landscape", displaying the actual context of caravanserais, and a layer of "fiction", narrating the scenario (Fig. 2). The team created sprite sheets

of the characters and artefacts, as well as typefaces for the visual language components of the game. The content of these tours was provided through drone and 360° videos to enhance the immersion, with the addition of maps, photos, and other information collected through the literature review.

The final step was incorporating a narrative in order to develop the gameplay. A story involving a female archaeologist was verbally and visually transcribed, set in one of the distinctive locations of the ancient site. Through intuitive movements, the player directly navigates the realm of immersive space t in these 360° settings, allowing interaction with the architectural settings. Further, through the short quizzes and puzzle games, the user is able to absorb the historical information in an attractive and easy-to-digest form. The inspiration for the game's story came from real information about the Alarahan, one of the caravanserais on the list. According to Branning (2019), the upper part of the inscription at the top of the entry door of the Alarahan is missing. This information inspired us to create a story in which, during her journey, an archaeologist, the game's main character, encounters a thief in a caravanserai stealing a part of an inscription. The main goal of the game's scenario is to find the thief, but in the search, the archaeologist experiences a mysterious journey, seeking hidden objects, answering questions, and finding clues to the correct route through the caravanserai. The player first encounters the clues to find the answer to questions during the gameplay, then needs to retain that content to progress to the next part of the game, and achieve a certain score within a time limit. Hence, the game's structure encourages d players to retain the provided information (Fig. 3). After completing the first level of the game in the first caravanserai, the archaeologist follows the thief's footprints through other caravanserais. The game map includes caravanserais from the Seljuk period located on the Silk Roads, and was created in the GIS using geographical locations identified during the data gathering stage.
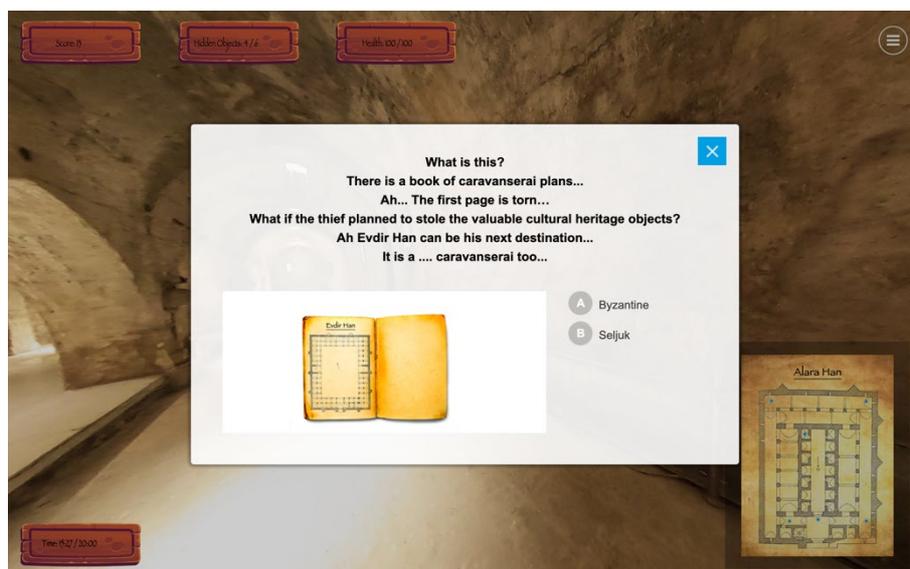

Figure 3. Screenshot of the game

Khan game is a web-based game hosted on a Linux server. When the users enter the game, a 3D map opens up displaying the terrain and the caravanserais (https://makingindigital.com/khangame/). This main map is implemented using Mapbox GL JS map service, a JavaScript-based map library. With the use of Mapbox, it is possible to create a web-based map, and it is also possible to link data from GIS to show up on the map. We imported the caravanserais' database location data in the game map in the form of the GeoJSON file. Moreover, it is possible to adapt the maps with the use of Mapbox Studio. Links to the other caravanserai games developed with 3dvista are visible on the info windows for each caravanserai. Within each game, users interact with puzzles and gain points when they find the objects but lose health points if they exceed the time limit. This data on the users' interaction with the puzzles, scores, health points, and user information is stored in a firebase server.

We conducted a playtest session with 30 students in November 2021 using different mediums, such as computers and mobiles. Their interactions were recorded with Google Analytics and a script. Google Analytics records all user clicks along with other anonymous user information, such as location and the browser used. The script stores the scores of each user originating from the different caravanserai games in a database. These features make it possible to track users to determine which parts of the caravanserais are less visited and which puzzles are more difficult.

4. Conclusion

In this era, there is a growing need for quality content creation in the heritage field, and to meet this need, 360° images and videos provide a cost-efficient immersive experience. To maximise its learning potential, this immersive content requires game elements to be incorporated. This research showcases a methodology for creating serious games in the heritage field. Developing a game requires expertise in programming along with many different types of software. This method allows the creation of games in a time- and cost-efficient way. However, the game is limited to the functions of 3dvista, and extra work is needed, for example, to connect the game to a database to store scores, which involves editing the game's script files. The currently available software functions in the e-learning part were not originally designed specifically for game development, but can, if used imaginatively, enable the user to create immersive and educational gameplay. In conclusion, the contribution of this study is its exploration of the intersection of game studies and heritage supported by a multidisciplinary group of professionals, without the need for popular gaming engines. The immersiveness of the 360° images is the key to maintaining a high level of engagement. As future work, we aim to shift the focus from the architectural buildings to the intangible heritage. While tangible heritage is still visible to people and is touchable, to achieve a more holistic approach to the exploration of the era of Anatolian Seljuks, we aim to gather data on their lifestyles, including their clothing, tools, mechanical devices, and other material details, as well as data on the landscape. These data are more abstract, and thus in more danger being lost. This valuable information holds within it the spirit of ancient times, and deserves to be in the spotlight of current studies.

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