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Design for Cultural Cooperation.
Interaction, Experience and Heritage Awareness

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Abstract

The design of the museum experience can be improved through an innovative interaction framework that uses digital technology to digitise and make different types of cultural heritage accessible and improve awareness for the management of public and tourist use of heritage sites.

This research aims to protect cultural heritage diversity and enhance its accessibility and dissemination. It presents methods to digitise resources of various heritages and develop experiential design and interactive environments through advanced simulation and representation. The study addresses the development of an interaction design model based on real-time simulations of existing installations and experience environments for cultural sites and the evaluation of the process and design workflow, introducing modelling (CAD/BIM) and simulation environments (Game Engine/AI).

The objectives are to introduce an information model to manage the environment and exhibit design and to develop interactive installations that use diverse media to highlight cultural content and improve cultural attraction and communication efficiency. An itinerary and interactive display of tangible/intangible heritage will be presented and tested through the advanced simulation application to visualise immersive 3D environments. From the BIM, a live connection with the visual development tools of the game engine middleware is possible, which facilitates graphic simulation.

Field tests and process references will benefit from recent research on the Roman Theater of Amman as part of an international cooperation project on the experiential and interactive valorisation of the museum collections of the Popular Traditions Museum of Jordan.

Keywords: *cultural cooperation, cultural landscape, HBIM, simulation, interaction design, Jordan*.

1. Introduction

The cultural heritage of a society is a crucial component of its identity and plays a significant role in driving the local economy. As such, preserving and effectively managing this heritage is vital to ensure its longevity and to pass it on to future generations in good condition (Vecco, 2010).

The research aim is to protect the diversity of cultural heritage and enhance universal accessibility and dissemination of cultural contents; the process presents effective methods to digitise resources based on the different natures of various heritages and figure out experiential design and interactive environments through advanced simulation and representation of museum interiors.

Activities put into practice an operational procedure for the evaluation of the museum experience to foster cultural tourism management within international sites but also the use of a hypertextual model of a "simulated museum" for verification in the creation and design of museum displays and itineraries by institutional operators.

The *Faro Convention* (Council of Europe, 2005) presented the challenging concept of heritage communities (Art. 12, comma b), outlining a social context in which individuals are united by common values linked to a shared cultural heritage, embodying the concept of common good applied to the heritage. (Valiante, Oteri, 2022) The sense of belonging in the museography field develops through the interpretation of heritage, the generation of cultural meanings, and the design of museum installations, which occur through the transcription and communication of events, symbols, and expressions, often ritual, oral, and transmitted in limited geographical areas. The research traces a conceptual path which, starting from the objects considered in their uniqueness, displayed physically or in their digital equivalent, guides the user (or visitor) towards perception and restitution of a contextual nature, capable of integrating the stimuli coming from the objects, environments and those intangible elements characteristic of cultural landscapes.

The international collaboration project for the Museums of Folklore and Popular Traditions at the Roman Theater of Amman has facilitated the exploration of transforming museums into centres of knowledge and experience, utilising digital heritage methodologies. The project emphasises the importance of connecting individuals to their cultural heritage, highlighting the process of representation and dissemination. The Netherlands Museums Association has established a paradigm for museum values, including Collection, Connecting, Education, Experience, and Economics (https://museumvereniging.nl/). The most critical cluster is "Connecting," which operates across all organisational and functional levels of the museum, emphasising its role as a mediator between different social groups (Figure 1).

In the museums under study, digital transformation is implemented using technology to engage new audiences, promote cultural experiences, and attract young people of school age, their families, and foreign visitors. The strategy is developed through a co-planning process, integrating complex actions that address inclusion and intergenerational exchange. This involves transcribing the meanings of museum artifacts into new expressions through various multimedia technologies (Manovich, 2002).

In the museum sector, some of the main applications include:

1. Digitizing museum archives, libraries, and repositories, as well as creating multimedia exhibitions and 3D printing

2. Utilizing VR/AR systems in installations for greater interactivity and immersion, with more adaptable spaces for various uses

3. Introducing a variety of gamification and edutainment options, such as live broadcasts, online lessons, games, and quizzes

4. Employing algorithms and user preference analysis to create personalised visit paths and web-mentoring

5. Involving visitors in the design process through participatory design, co-design, prototyping, and simulation.

6. Providing ongoing training to museum visitors, both in-person and online, to extend the museum experience

Figure 1. The Museum of Popular Traditions at the Roman Theater of Amman. Source: author. (2022)

The experiential design of a cultural space promotes a mediation between environments, cultural content, intangible heritage (contribution of users, their testimonies, cultural practices but also the values of the territory), and the user community, allowing multiple forms of interaction and development (Amoruso, Mironenko, 2019).

Examining the global landscape of the creative industries, the digital museum's role and the need to adapt spaces and contents for a new functional audience is highlighted. The disciplinary consequences in representation and interactive design, technological innovations, and museographic strategies and solutions are illustrated.

2. Aims and objective

Technologies offer methods and tools for the conservation, analysis, and dissemination of heritage, as well as contributing to the creation of new representations of heritage itself. This innovation involves exploring new forms of sharing and disseminating knowledge, which becomes multimedia and interactive (Figure 2).

To fulfil their educational task, cultural spaces must overcome their spaces' physical and tangible dimensions to promote communication and sharing actions of their heritage permanently, also in intangible terms and services related to accessibility. The user is involved in activities and accesses interactive and personalised content, and this process makes our perception of cultural heritage different and the way we regenerate it through cognitive processes; in this regard, how it is made accessible use, for example, gamification and storytelling as tools and guides to connect content to users. The study seeks to enhance the utilisation of Building Information Modeling (BIM) for museum installations (Tucci et al., 2019) by introducing a design process focused on creating sophisticated multimedia and interactive representations using a Hyper-Model connected to the BIM.

The objective is to understand how digital media generates specific outcomes and implement solutions for universal design and accessibility. This approach simulates integrated interiors where visitors can engage with installations, interact with technological elements, and access multimedia content. This methodology facilitates a dynamic exchange of ideas by fostering collaboration among designers, curators, users, and exhibition spaces. To accommodate various design scenarios, such as incorporating digital elements into spaces, it is crucial to document the heritage of collections by transforming them into digital libraries and offering an interactive design tool for fittings, collection management, and museum route verification: the hyper model BIM. Through dynamic visualisations and representations, museum curators can leverage this graphical system to oversee all museum-related information efficiently.

In this research, the focus is on exploring the benefits of Building Information Modeling (BIM) in enhancing the design process for interior spaces, particularly in the context of museums.

Figure 2. Architectural survey of the Roman Theater cavea, Amman. Source: author. (2022)

The study delves into how BIM facilitates collaboration among designers, curators, and digital media, emphasising its role in enabling interactive visualisation and validation of intricate projects tailored for various museum activities. These activities encompass the modernisation and digitisation of collections, interactive exhibits, environmental enhancements, and ensuring accessibility for diverse user groups. By utilising BIM for design simulations, it becomes feasible to assess the repercussions of modifications related to installation layouts, environmental features, and adaptable and advanced equipment, as well as to facilitate seamless information sharing. Furthermore, a key aspect highlighted is the capability of integrating architectural models derived from surveys and 3D scans with temporary interior design solutions to replicate the diverse requirements specified by museum curators. The research demonstrates how to put design strategies into practice, improve awareness through mock-ups and communication artifacts, and engage new audiences. Activities proposed an interaction design model for each museum, starting with the dynamic simulations of visits and engagement with the installations.

3. Methods and/or procedure

The study commenced by evaluating primary BIM parametric modelling and advanced simulation with game engine software. Notably, advanced simulation holds particular significance within the design and architecture field. This software framework is primarily tailored for creating interactive virtual environments and is validated through specific tools such as visors, glasses, caves, virtual theatres, and online platforms. Using specialised libraries and auxiliary programs, simulation enables assessing diverse design components. Furthermore, it innovatively incorporates functional parameters associated with individual physical and multimedia setups like showrooms, museum environments, home automation installations, hospital rooms, and temporary stands. This integration is achieved through novel advanced representation protocols and methodologies.

Experimentations benefit from the recent international cooperation project to valorise the museum collections of the Popular Traditions Museum of Jordan. The testing and verification process of the procedures took place at the Roman Theater site in Amman, where the Folklore Museum and the Popular Traditions Museum are situated. These museums have undergone a comprehensive reorganisation program based on experiential design and universal accessibility principles. The research focused on modelling environments using laser scanning survey data, checking the functionality of installations, simulating user experience, interacting with multimedia devices, and evaluating digital content related to the displayed objects (Figure 3).

The process follows an interaction design layout to enhance cultural content and improve cultural attraction and communication efficiency of exhibits, rather than just an isolated and interesting interactive entertainment device.

An itinerary and interactive display of tangible/intangible heritage will be presented to future visitors and tested in advance through the simulation application to visualise immersive 3D environments.

Figure 3. The Museum of Popular Traditions entrance with a view of the ground floor layout. Source: author (2023)

The concept that multi-sensory immersion can be used to engage audiences and heighten emotional experience is not new. In the past century, museums have used dioramas, film projections, sound effects, voice tracks, and the occasional smoke and mirrors to contextualise cultural artifacts and historical objects with immersive environments. They have drawn on the staging and mise-en-scene techniques commonly used in theatre and film. They have, at times, dared to use cutting-edge technologies, such as stereoscopic 3D when it was first popularised in the 1840s, to appeal to a wider audience (Stogner, 2011).

The BIM ARCHICAD software offers an enhanced hypertext model that can be exported to mobile or desktop applications, expanding its reach. This feature transforms the model into an interactive museum space by integrating technical visualisations and product datasheets. Users can access information about the museum's elements, such as finishes, dimensions, and quantities, in a hypertextual manner. The real-time navigation feature allows for a simulated virtual tour, enhancing user interaction with parametric objects. The hypertext graphic representation of the BIM model connects technical visualisations with interactive fruition, improving design component visualisation and understanding of spatial forms. This feature also consolidates all technical documentation related to performance, materials, and technical specifications into a single virtual model, a shared graphic database. BIM also enables the creation of custom objects and construction systems on a collaborative platform, prioritising and enhancing the 3D model's information characteristics. It facilitates communication among project participants by offering multi-scale, multi-dimensional design. Compared to traditional CAD design, BIM requires multidisciplinary knowledge of technological solutions to represent the model correctly,

aligning with the technological standards of the professional and industrial sectors. The BIM model allows for flexibly managing advanced representation and interaction with the model. There are various ways to share, publish, and present the project through dynamic, immersive experiences, such as real-time simulation of interiors, photorealistic renderings, or NPR graphic filters. BIMx is an ARCHICAD tool that enables users to present the project in a dynamic and virtual visit mode, allowing them to verify paths and interactions with planned installations. The experimentation process allows for the definition of classification, properties, functions, and information on design elements that can be utilised for other specialised applications. The model, published through the wizard integration of its views, is intended for wide sharing, enabling even those who did not participate in the design to explore the project. The hyper model is beneficial for designers and curators in the interactive verification of installations, and also for visitors who visit the museum online. The main result of the experimentation was the verification of the user experience, the functioning of the museum setting, and the integration of the 3D model with historical documentation and the inventory of the museum collection. The physical structure of the museum building was simulated and reproduced through BIM modelling procedures, including parametric detail information and the main characteristics of architectural surfaces and materials. Environments are complex due to the incorporation of original structures belonging to the Roman theatre and the rich presence of museum collections, objects, exhibitors, and installations. Thanks to the hyper model, it has been possible to navigate in real-time and make checks that can assist in decision-making processes and cost evaluation. The Hyper-Model can contain the entire documentation of the project, including the 3D model, layout of elevations, 3D sections, axonometry, perspectives, datasheets, and the visit path (Amoruso, Mironenko, 2022).

From the BIM, it is possible to make a live connection with the visual development tools of the game engine suite, which provides functions that facilitate graphic simulation and audio, kinematics, and with the support of artificial intelligence (AI). The research tested the connection between the BIM model and the visual development tool included in the game engine suite. (Amoruso, Buratti, 2022) This suite offers features that simplify graphical simulation and provides tools for adding multimedia elements such as audio, motion simulation, and artificial intelligence applications for environmental design. These game engines, called “middleware,” offer a flexible and reusable software platform that integrates all the functionality needed to develop an experiential application, thus reducing complexity and costs and providing predictions, verification, and solutions. TWINMOTION, a real-time rendering engine part of the Unreal Engine suite developed by Epic Games, was tested in a specific case. This tool supported the design of the Roman Theater exhibition, envisioning an experience with tactile, visual, and digital installations. Using Mixed Reality applications, digital prototypes were verified through advanced simulation in immersive environments using a virtual theatre-like infrastructure (Figure 4).

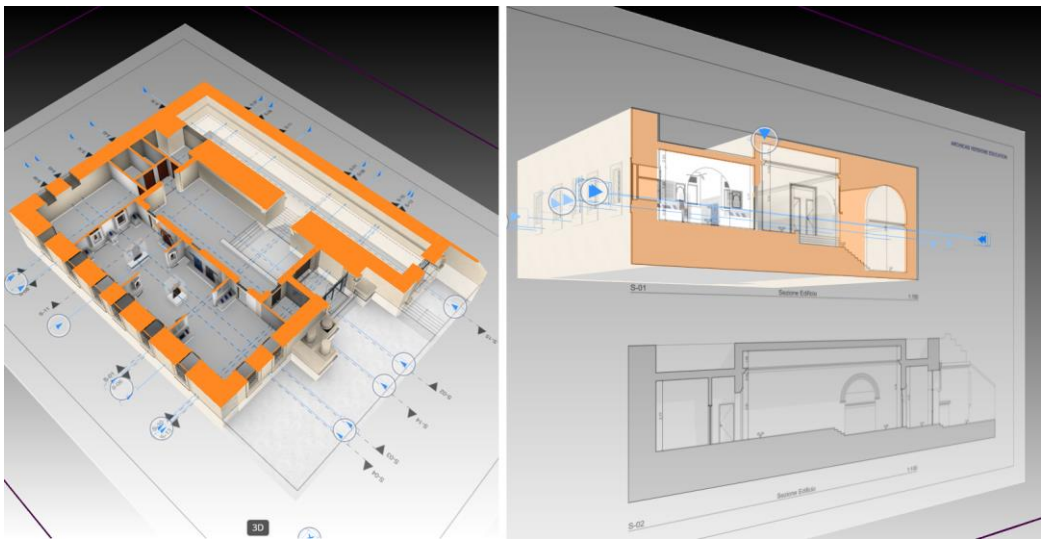

Figure 4. BIMx model and the interaction with the design layout from the BIM model. Source: author (2024)

4. Results

The new museological perspective for museums of cultures or, as defined by UNESCO, cultural landscapes, recognises the power of storytelling as a means of redefining the identity of cultural institutions, such as museums and libraries, often situated in peripheral and marginalised locations compared to large national galleries or art museums.

For instance, the project implemented experimental procedures for the Popular Traditions Museum, enhancing visitor engagement with the exhibits and promoting experiential learning dynamics.

Considering the unique nature of the museum's collections, which primarily consist of handcrafted objects produced through intricate and fragile techniques, special display conditions are necessary to ensure proper preservation and display. This includes appropriate lighting, furniture, displays, and accessories. To achieve the appropriate awareness, routine testing of visual and algorithmic programming was conducted utilising the parametric libraries of BIM software to verify the optimal setup solution and accessory provision for each artisan category. This ensures the exhibits' safe and effective conservation and display of jewels, dresses, and accessories.

BIM software's parametric and algorithmic components offer a specific application for the exhibition and interior design sector, enabling the museum to optimise the setup and accessory provision for each artisan category, thereby enhancing and preserving the exhibits' display.

The ARCHICAD design environment was used to develop an experimental application for museum installations and the digital museum in collaboration with curators and the Department of Jordanian Antiquities. In the context of Building Information Modeling (BIM), architectural objects, such as furniture, installations, and building components, play a crucial role in the design process, starting from the initial stages of architectural planning. These objects are not just visual elements but contain data and parameters anticipating their installation and usage over time. They serve as the interface between design and space functions, for example, forming a personal library for museum design, which contains all the components of a multimedia exhibition. The ARCHICAD Standard Library integrates many parametric elements that can be enriched with additional objects and textures from online catalogs. These platforms often offer parametric objects in the GSM format recognised by ARCHICAD, such as BIM Components and BIM Object, which can be accessed directly from the software (Figure 5).

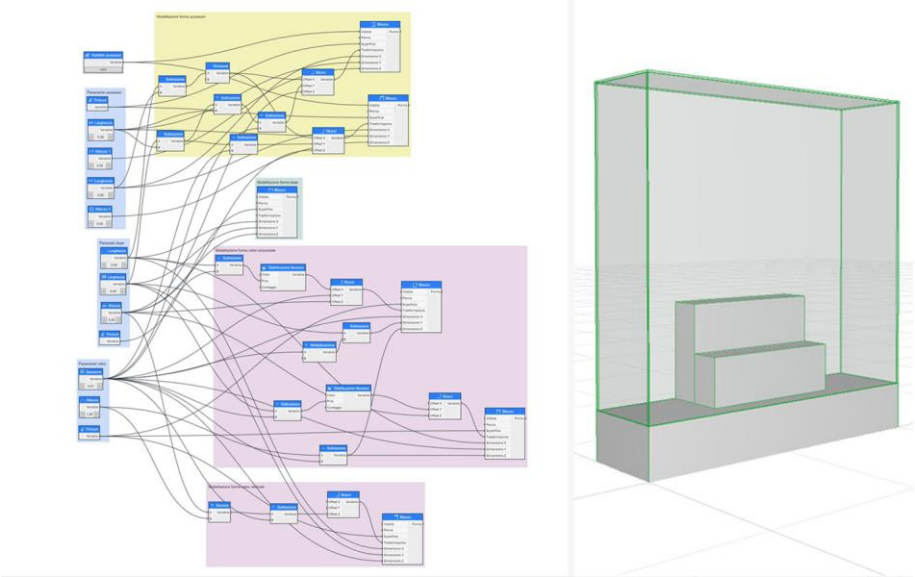

Figure 5. Visual algorithm for a parametric showcase at the Museum of Popular Traditions, designed with the PARAM-O ArchiCAD tool. Source: Amoruso, Mironenko (2021)

The main focus is the use of parametric programming in ARCHICAD to create customised libraries in BIM, specifically for the display of jewellery and traditional costumes. ARCHICAD's PARAM-O algorithmic tool has been tested to verify its parametric programming characteristics and how the visual node interface replaces scripts,

integrating and extending the parametric modelling commands already typical of BIM, allowing users to create parametric elements of the library without directly writing the code in the Geometric Description Language (GDL).

The methodology involves fixing the "nodes," parametric modules, and their connections, leading to the complete installation of the structure, panels, plants, and accessories. The nodes allow the completion of the parametric and algorithmic model with its shapes, qualities, materials, colours, and accessories. The more parameters an object has, the more flexible it is. By saving the created object in PARAM-O, it becomes a native ARCHICAD library element. This tool provides infinite design variations and options for designers and curators, enabling them to dialogue through interactive simulations to test new outfitting solutions, choose collections, and refine the museum layout based on user experience. The research presents the models developed as an experimental set: on the one hand, the BIM model extended in the BIMx version to test its hypertextual and informative potential; on the other, the analogous simulation model, exploiting the Game Engine middleware, allows the advanced representation of set-up, experiential and satisfaction and accessibility verification actions and operations.

Visual information technologies, used for design and representation, offer an immersive experience of museum spaces. These can be used both to create multimedia content and to allow active interaction with the collections through displays and installations. The use of applications from video games allows us to verify, through iterative cycles of modelling, representation, and rendering in real-time, the accessibility, interaction, and general functionality of the museum environment (Figure 6-7).

The research concludes its critical path by examining the social context of the ongoing transformation, considering the digital products and services that the digital museum can offer for adequate cultural activity. In addition to the simple visit, often limited in space and time, research on the social impact of museums and libraries and the applications of technologies raise the question of experience and participation in the museum environment, an aspect that also concerns design, communication, and related cultural products.

A new interactive, universal, and flexible use is envisaged that responds to the different expectations of communities and visitors, who are increasingly cultural tourists, digital natives, activists, and creatives. The ideal experience of the user, visitor, and tourist is no longer limited to the cultural sphere of the "walls" or a single episode but extends the concept of the visit, including the planning phase, the use of resources available online, the consideration of pedagogical tools for school children, providing interaction and participation in events, initiatives and also continuous access to information and digitised collections.

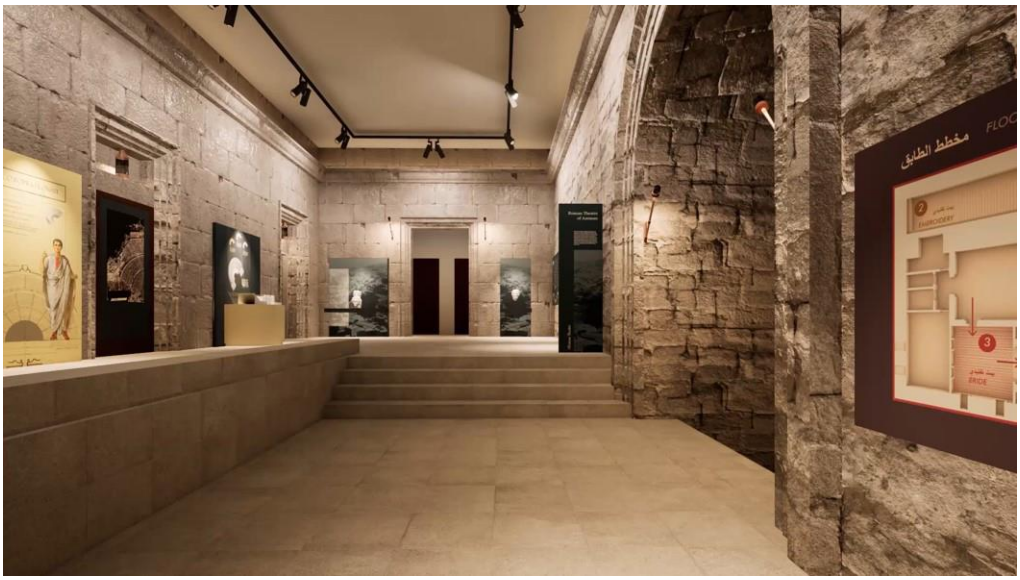

Figure 6. The Museum of Popular Traditions, the Roman Theatre exhibition entrance, infographics, and tactile replicas. Source: author (2022)

Figure 7. The Museum of Popular Traditions, the Roman Theatre exhibition, infographics, and a proposal for the tactile replica of the architectural model. Source: author (2022)

5. Conclusions

The application of Building Information Modeling (BIM) in museum design and management includes the introduction of an innovative workflow for the customisation and management of BIM models, reorganisation through digitisation and visualisation of collections, linking items to interactive visual environments, and the creation of an information archive and Hyper-Model.

The research methodology combines advanced methods of representation to address the various needs of digitisation in museum design with the scope to preserve memory and practices, enhancing the digital experience. Narrating heritage through digital media is an innovative strategy for preserving and sharing memories and practices with new content. The further step is to design a knowledge-based repository for gathering (workshop), maintaining (digital platform), and disseminating (augmented experience on site) the knowledge of the artisans and communities (Figure 8).

The BIM tool creates a seamless and efficient process for managing the technical design phases, from the preliminary stages to the final concept, while incorporating elements like disability issues and environmental safety parameters. The final Hyper-Model includes the technical and architectural layouts and information accessible to different figures operating in the museum system, promoting collaboration and inclusivity. This tool allows curators to link collections, usually listed by inventory cards, to an interactive visual environment. This environment contains the set-up solutions defined by parameters, libraries, and visual programming algorithms, providing a more engaging and accessible way to explore museum collections.

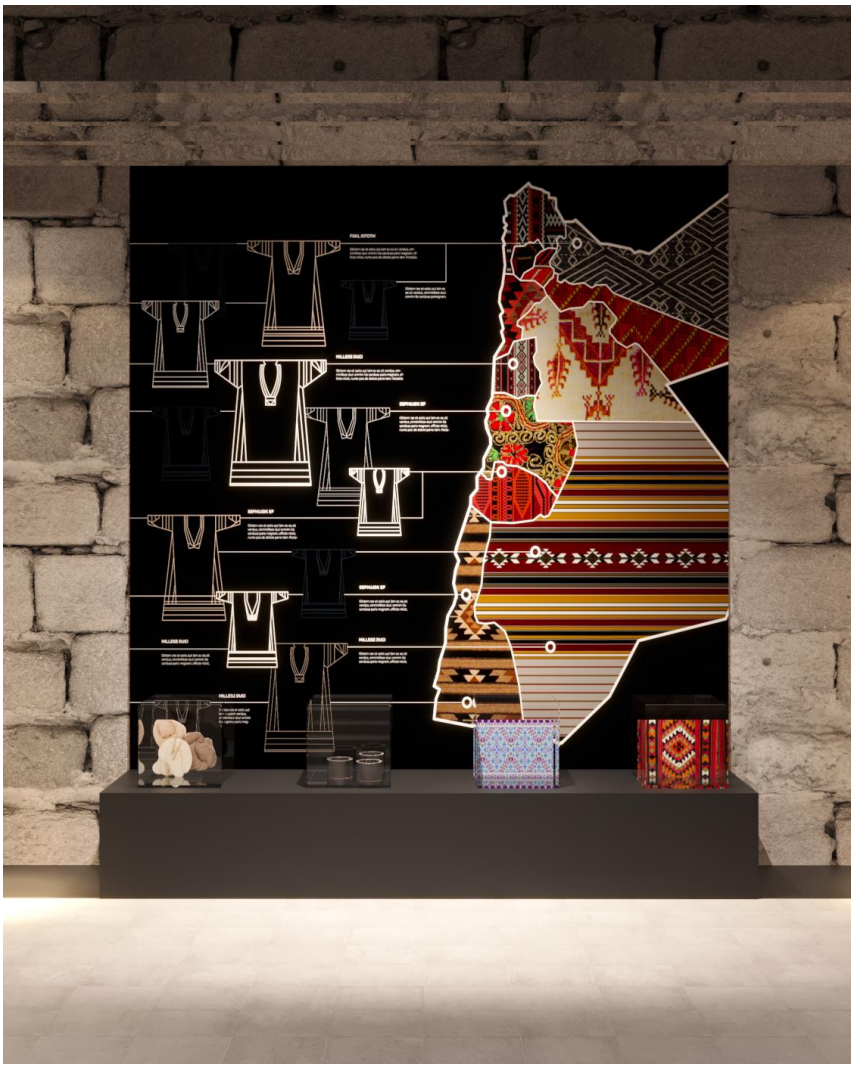

Figure 8. The Museum of Popular Traditions, the visual glossary of traditional dresses, an interactive installation with the pattern book of dress typologies and material board. Source: author (2023)

The ongoing experimentation aims to reorganise the museum, starting with digitising the inventory, promoting a more efficient and accessible approach to museum practices, and extending field visits to digital experience and remote access to web-based resources. The BIM model can be customised and oriented towards management, maintenance, and verification of environmental safety parameters rather than just exhibit design and content visualisation. Besides, the BIM procedure offers a representation environment that develops from the architectural survey and increases the model in the different levels of information required by the museum installations and maintenance. In conclusion, the introduction of BIM in museum design highlights its potential for improving efficiency, accessibility, and collaboration management in the museum sector.

The objective of this research is to foster a deeper understanding and appreciation of the artefacts displayed in the two museums and their connection to the Jordanian landscape. By achieving this, the research aims to create a continuous growth cycle in awareness of the rich and diverse cultural heritage. Ultimately, the goal is to inspire future generations to incorporate tradition into their lives through their thoughts, emotions, and actions.

6. Fundings

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7. Acknowledgements

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