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# Developing Character for Virtual Reality Historical Event

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**Abstract**
Telling historical events virtually involves developing three-dimensional historical figures as the main asset to the narrative. The character design aspects should consider presence, immersion, interactivity, storytelling, and semantics. Thus, this paper explores the methodology for developing historical characters with historically engaging personalities reflecting their role in the historical events, which offers educational, aesthetic, and immersive value in a virtual reality (VR) experience. The finding reveals the cultural and historical design elements. It becomes the basis for character transformation from a two-dimensional image into a three-dimensional virtual character, ensuring historical accuracy and narrative coherence in the development of history-based VR applications.

Keywords: Virtual character; virtual reality; historical event; narrative


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## 1.0 Introduction

Current museum activities involve digitising cultural and historical heritage which, produces more virtual heritage assets (Rahim et al., 2017). VR is one of the prominent technologies used for immersive time-space exploration for a museum experience (Hurst et al., 2016). Thus, cultural and historically significant aspects become the vital aspects to be portrayed in the historically virtual world to ensure the visitor becomes immersed during virtual exploration (E. M. Champion, 2019; Debailleux et al., 2018).

The historical event is a notable event that is also referred to as a historic moment or occasion. Historical events documented contain general information about the moment, date, people, location and storyline of what had happened. Besides that, the intangible heritage belonged to a group of inhabitants in a specific historical period, which captured, recorded and restored as historical resources, whether in the form of text or images.

When building the immersive virtual environment, two major aspects need to be analysed; technological and content (Suh & Prophet, 2018). The content of the virtual environment contains virtual objects as stimuli. The virtual objects comprise 3D models of virtual characters, artefacts, background objects and interactions created based on narrative. Narratives are central in contextualising a particular content and become an instrument to capture the feeling of presence. The virtual object will carry the cultural and historical significance.

Dogan & Kan, (2020) highlight that immersive experience is represented by a cyclic threefold, namely; phenomenological (sense of place), narrative and semantic (meaning) levels. Each level is interrelated and complementary. The relation happens through the somatic

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mode of attention by interacting with cultural objects, allowing the user to experience a sense of place and culture. Somatic engagement could be built by simulating the cultural activity of the past people and their cultural materials, such as weapons, ritual tools, or figurines, intended for creating a social world of the historic group. Therefore, the virtual environment should consist of virtual characters with cultural appearance and role, and artefacts to evoke a sense of place, and social presence leads to meaning-making.

Furthermore, the cultural and historical elements portrayed by the historical characters are the key to cinematic features that drive the development of a history-based narrative using the story-driven approach for creating a virtual museum experience (Wolff et al., 2012). Eventually, developing a VR historical event requires profound analysis and interpretation of cultural and historical information before transforming it into an aesthetic, immersive and meaningful VR narrative (Cecotti, 2022; Rahaman, 2018).

Although VR has become an increasingly valuable medium for representing historical events and cultural heritage, existing studies primarily focus on technical performance, user immersion, or narrative construction. Limited attention has been given to establishing systematic guidelines for embedding cultural and historical elements into 3D virtual character design, even though such characters are central to creating meaningful and authentic experiences. Current design practices rely heavily on designer interpretation, which often leads to inconsistent representations and weak cultural grounding. This lack of a structured cultural historical design guideline or framework represents a critical gap that restricts the development of VR applications capable of supporting deep somatic engagement, narrative coherence, and accurate cultural interpretation.

Notably, this research planned to meet two research objectives: 1) to identify and analyse the cultural and historical design elements required for creating authentic three-dimensional virtual characters in history-based VR applications based on the immersive experience framework, and 2) to explain the process of developing the 3D character based on the ADDIE model for VR historical event (VRHE) application. The aim is to develop a guideline for cultural and historical design elements, which will serve as a foundational blueprint for producing authentic and meaningful three-dimensional virtual characters for history-based VR applications. This guideline aims to improve design consistency, enhance production efficiency, and strengthen the cultural and narrative quality of VR historical experiences.

The selected historical event is titled The Assassination of J.W.W. Birch in Pasir Salak. Its central concept and visual reference is a diorama displayed at the Pasir Salak Museum Complex (Figure 1). The storyline depicts the assassination of the British Resident, J.W.W. Birch, by Malay men in Pasir Salak Village under the leadership of Dato' Maharaja Lela, also known as Lela Pandak Lam. The nationalist resistance against British forces in Pasir Salak subsequently contributed to the rise of nationalism in Perak. Accordingly, the primary interactable objects in the virtual village consist of virtual characters and artefacts (weapons). The development of each character incorporates specific design considerations to ensure the application aligns with historical accuracy, aesthetic quality, and educational value.


Fig. 1: Diorama of 'The Assassination of J.W.W. Birch'

## 2.0 Literature Review

Telling historical events using VR requires constructing and replicating the cultural and historical information into a 3D virtual environment to portray and present a group of people with unique cultural traditions and customs (E. Champion, 2019; Rizvic et al., 2020). For example, costume reflects the origin, culture, identity, location, and background of a group of people. Immersive storytelling of historical stories involves designing 3D assets; the virtual characters complete with their physical appearance, face, body, costumes and accessories such as working and ritual tools, weapons based on ethnic, role, and social status within their community (E. Champion, 2015). Then, the detailing of the costume design, such as cloth material, texture or pattern, is done to originally reflect the culture. For example, the design of tengkolok or Malay headdress with different fabric folding styles represents the historical figures' social status. The social status information will become the character's profile and will be rendered into a visual representation to establish the character's personality. As a result, the designing of virtual characters implicates an aspect of realism (Vinayagamoorthy et al., 2004).

In a historical-based VR context, character development requires standard creation needs or expectations, especially on realism and accuracy to foster learning and evoke empathy (Rativa, 2022). Representation fidelity of VR content should fulfil historical knowledge dissemination in global education (Al-Jundi & Emad, 2022). Inconsistency in the level of realism of 3D characters could cause an uncanny valley phenomenon (Misselhorn, 2009; Mori et al., 2012). Therefore, the designer needs to address the uncertainty by knowing

how to avoid the uncanny valley. However, the advancement of Artificial Intelligence (AI) technology has facilitated virtual environment development by enhancing the realism, personalisation, and functionality of VR experiences (Regassa Hunde & Debebe Woldeyohannes, 2022). Well-developed virtual characters will help us to decrease mental workload and increase cultural and social presence.

Furthermore, another technical aspect is the movement of virtual characters, which requires animation for body action, facial, cloth and accessories such as weapon animation and special effects, as well as the number of animated virtual characters needed in the scene (Vosinakis, 2017). These assets will increase the size of the application file, which also affects application performance and platform suitability. Therefore, the developer needs to establish feasibility and explore design alternatives at the early production stage, as well as initial design refinements of chosen concepts through detailed analysis (Gillies, 2018).

In addition, a well-developed virtual character should start from the conceptual phase, according to the conceptual or theoretical framework throughout the production timeline. Asset development could implement a design and development model, the ADDIE model as a production pipeline which structured five main stages: Analysis, Design, Development, Implementation and Evaluation (Mufarocha et al., 2023). Implementing the ADDIE model laterally allows asset development monitoring and modification to intertwine with VR interaction instructional aspects. The asset creation is planned by determining detailed processes, especially in the analysis stage. During analysis, the concept is developed by integrating cultural and historical elements with the content and technological aspects of the immersive VR experience (Blonna et al., 2018; Dogan & Kan, 2020).

Although prior research on history-based VR has examined user immersion, narrative engagement, and technical performance, systematic guidelines for incorporating cultural and historical elements into 3D virtual character design remain lacking. Most studies focus either on technical character creation or general VR narrative construction, leaving designers to rely on intuition, which can compromise historical accuracy, cultural authenticity, and narrative meaning. This gap underscores the need for a more structured guideline and process to guide the design and production of virtual characters that are both historically faithful and culturally meaningful, enhancing immersive and educational VR experiences.

## 3.0 Methodology

The 3D asset creation is based on the ADDIE model, implementing a five-step improvisatory process for developing interactive content. All five phases are equally important, but in practice, most effort is often put into the Design and Development stages, while the Analysis, Implementation, and Evaluation phases are usually less well done. However, in this project, the analysis becomes the vital stage for skimming over the critical yet unseen elements before starting tangible work in the design and development phase. The virtual character creation process for building the animated scene is shown in Figure 2 below.

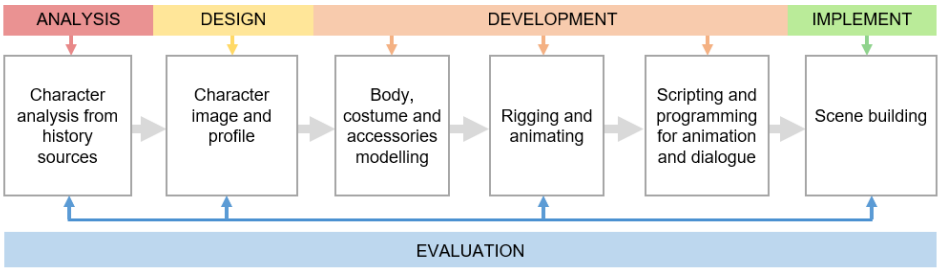


Fig 2: Virtual character creation process

Idea and concept creation activities should be scheduled according to the intended needs of the VRHE application: context, content, theme, targeted user, objective, and time constraints. The information analyses from storyline and historical event reference materials are general knowledge; date, year, location, name, and race or ethnicity of the historic figure, and story plot of the historical event, also a history lesson. Cultural and historical significance is represented by character appearance, personality, costume, and dialogue. Then, the conceptualisation of the narrative, together with asset creation, is conducted. Technical considerations during virtual character development are determined and planned based on historical event facts and information, as listed in Figure 3 regarding appearance, costume, action or movement, dialogue, and interactivity. As a result, a good virtual character could be built based on the analysis results. Finally, once the narrative has been designed, the development stage focuses on creating and developing those assets and experiences on the track.

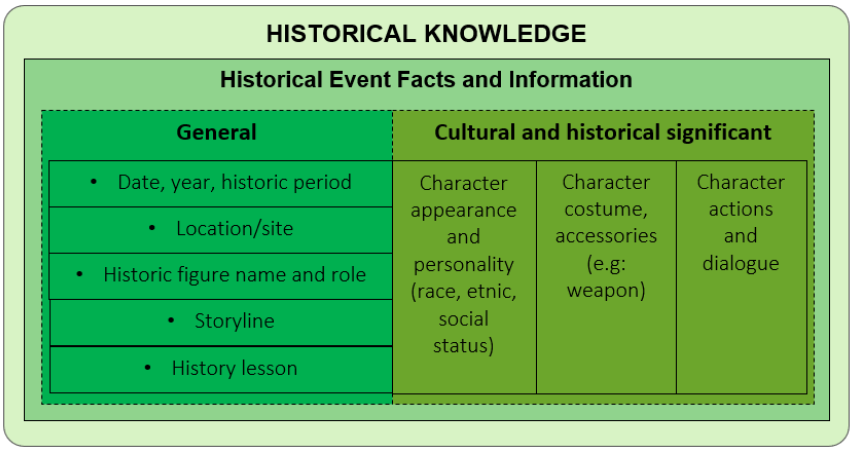


Fig. 3: Cultural and historical significance of VRHE

*3.1 Analysis stage*

A proper and systematic grounded study is conducted to analyse and gather historical knowledge about the historical event from tangible and intangible materials, existing history resources and references such as books, articles, dioramas, documentaries, interviews with the museum curator, and artwork produced by humans. For example, illustration and painting. Historical knowledge is being interpreted to build context and content through the VR narrative development process. The references conceptualise the virtual environment, character, and interaction. In fact, in this project, the actual photo or image of the historical figure cannot be identified. Thus, their face design is referred to in the illustration (Figure 4). Therefore, the character design can be created based on the designer's imagination and creativity as long as the historical knowledge is well presented.

Fig. 4: Historic figures' faces illustrated by an artist

More focus is also given to character movement as the action is the main shot to deliver the storyline. Also, an analysis of user and experience requirements is constructed to meet the application performance analysis. After completing the character profile and narrative, a list of appropriate software and hardware is prepared, with its best application and performance capability to ensure the successful transformation of the narrative into a complete VR application. The 3D character development requires modelling and animation software, including artificial intelligence (AI) applications such as Character Creator and Marvelous Design, VR development software, Unity and image editing software, Adobe Photoshop and Illustrator.

The layout design is built based on the diorama. However, some adjustments are made to the animation flow to direct the user's point of interest (POI) in the animated scene before pursuing other interactions. A list of character actions is created to ensure a smooth combining animation process in Unity. All information gathered is based on Dogan & Kan (2020) model, which lists phenomenological, semantic, and narrative perspectives and elements, namely, sense of place, uniqueness, play, representation, site-specific, myths, voices, story and interaction. The three aspects explain how historical knowledge and cultural significance could be delivered within an immersive virtual environment through the interaction of virtual objects or somatic engagement. Interactable objects (IO) or non-interactable objects could be specified according to the narrative to build user engagement within virtual space.

*3.2 Design stage*

The character's appearance and personality are visualised and sketched during the design stage based on the character profile and initial design concept. The project involves the development of ten virtual characters from Malay, English and Sikh. Designers brainstorm and generate multiple designs using creativity to visualise the final look of the 3D virtual characters. For example, the colours of the costume and headdress. The fabric pattern is the cultural element that represents aesthetic value, hence accentuating the uniqueness of its creation. For example, a filigree on the sundang and keris. The main aim is to make the character look historically uniform within the whole composition of the virtual environment of Pasir Salak village. Hence, emphasising the aesthetic value could make the virtual environment captivating and plausible.

*3.3 Develop stage*

At this stage, 3D character models are developed using modelling and animation software that is accessible to give the best result of the final animated character. The face is created in Character Creator software, which allows the generation, import and customisation

of stylised or realistic character assets for use with iClone, Maya, Blender, Unreal Engine, Unity, or any other 3D tools. The image or illustration of the character's face is imported and mapped onto the face model.

Main body and costume modelling are done in Marvelous Design software, while some weapons and accessories are created in Autodesk Maya software, including the mapping and texturing process. Marvelous Designer is a 3D computer graphics software program used to create 3D models of clothing and fabric simulations. The software uses a pattern-based approach to clothing design, allowing designers to import 2D patterns and use them to create 3D clothing designs.

The mapping and texturing process allows the detailing of the character's face and costume. The texture files are downloaded from an online image gallery or photographs of the real object. However, this process needs to be done with proper planning. The 3D object needs to be modelled with minimal polygonal counts to avoid large file sizes. Similar to the imported texture files, a standard requirement of file format needs to be complied with to avoid significant bytes of texture files, thus causing a stuck or lag in VR navigation. The proper management of texture files is also important to avoid a jagged rendered image. For example, in Figure 5, the headdress models are created in Autodesk Maya with minimal polygonal count.

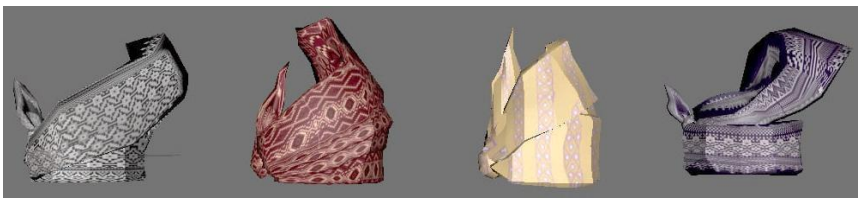

Fig. 5: The design of the Malay headdress

The character action requires a skeletal rig and an animating process. The character movement is constructed using Mixamo software. Maximo used machine learning methods to automate the steps of the character animation process, including 3D modelling, rigging and 3D animation. It allows direct rigging and assigned animations from its library to a virtual character. Figure 6 shows Mixamo's interface during the animation process.

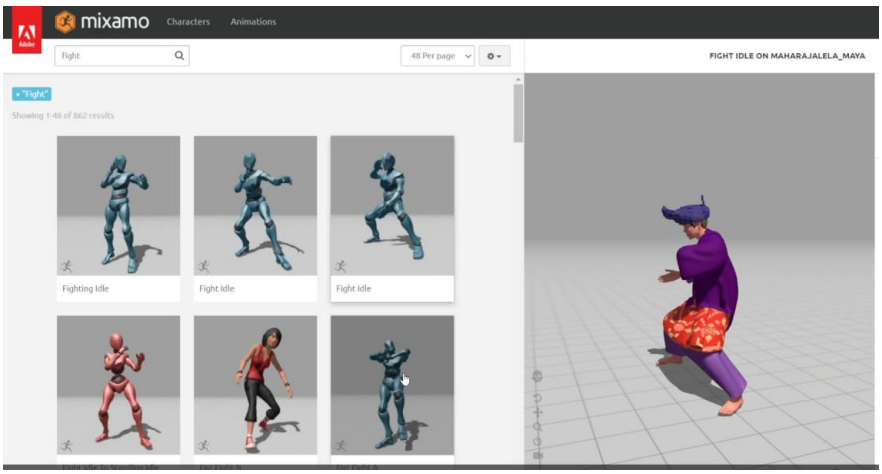


Fig. 6: Character action built in Mixamo

*3.4 Implementation stage*

Overall, the implementation stage consists of the execution and delivery of the content. In this stage, the characters are imported into the Unity scene and scripted according to the planned shots outlined in the storyboard. Weapon-movement animations are also created in Unity, with some animation processes requiring additional scripting. During this phase, optimisation is carried out, as errors may arise that require time to resolve. This is achieved through iterative building and testing of the animations.

After the animation process, the animated sequence is built and tested as a VR scene. This stage involves integrating all four VR environments; Portal (Introduction), Historical Site (Village Life), Animated Event, Static Exhibition, and Portal (Exit), into a single, cohesive VR application. As before, iterative building and testing are conducted throughout the process, with modifications and optimisation applied whenever issues or uncertainties are identified. For the VRHE project, the completed scenes are explored using the Oculus Quest 2 headset and its handheld controllers. As noted earlier, the design and development phases can be executed more effectively during implementation when all relevant aspects have been thoroughly analysed in the initial analysis stage.

*3.5 Evaluation stage*

The Evaluation stage is used to assess the quality and effectiveness of the application development process. In the current well-organised practice, evaluation has always been part of every stage. Thus, the evaluation involves a test run, modification, and optimisation process from the start of the analysis stage until the application is distributed and loaded by the targeted user.

## 4.0 Findings

The construction of characters in VRHE can be conducted based on the ADDIE model. During the Analysis stage, the cultural and historical elements of Malay warriors are effectively identified based on historical event knowledge gathered from historical resources, namely; books, articles, dioramas, documentaries, illustrations, and interviews with the museum curator. The historical event knowledge is classified based on location and storyline. Then, the detailed information is structured based on a methodological review of conceptual immersive experience theory, thus becoming the guideline of the concept and principles of VRHE virtual character design.

The guideline is applied to character development, which is then evaluated by experts. During the analysis stage of the ADDIE model, experts play a pivotal role in the development of historical virtual characters, ensuring that design decisions are grounded in historical accuracy and cultural authenticity. Historians and museum experts review character concepts, attire, gestures, and interactions to identify inaccuracies or inconsistencies, while also assessing how characters support the narrative, social presence, and immersive experience. Their feedback informs both aesthetic and technical aspects, including modelling, animation, and behaviour realism, guiding iterative refinements. By integrating history and VR expert input early in the Analysis stage and throughout testing, developers can enhance the fidelity, cultural sensitivity, and narrative coherence of virtual characters, ultimately producing immersive, meaningful, and educational history-based VR content that aligns with design objectives and project timelines. The guideline is summarised in Figure 7 below.

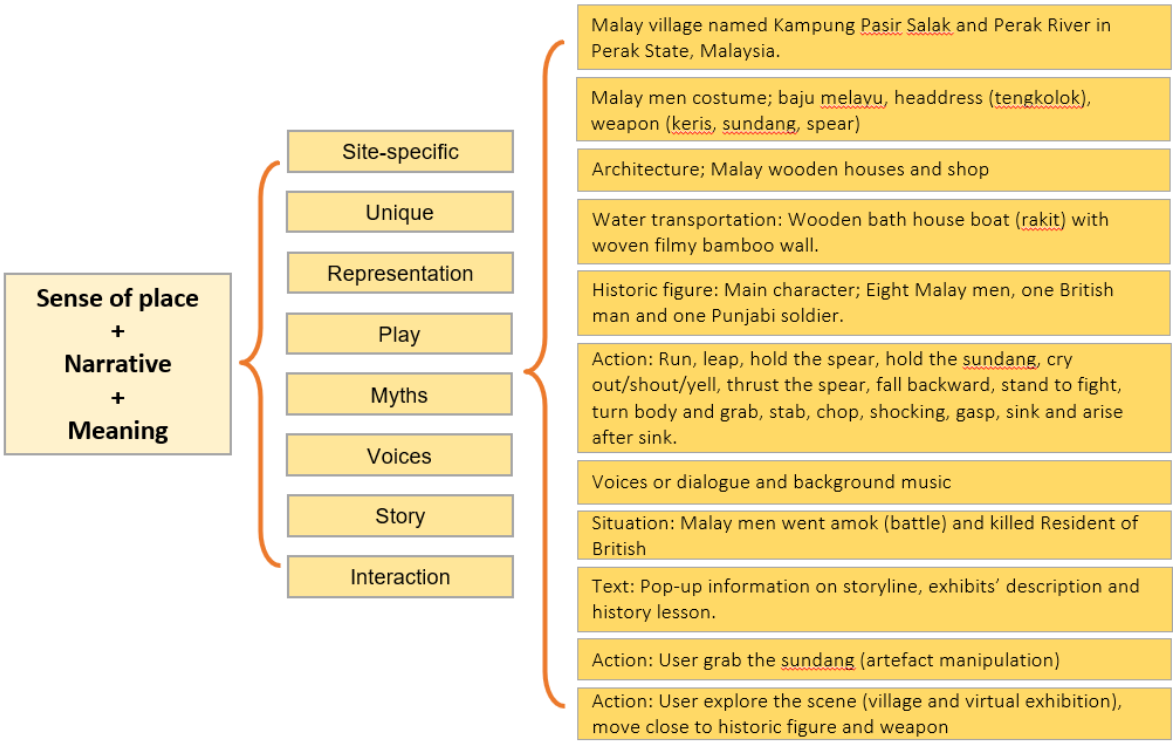


Fig. 7: Elements of character design

Fig. 8: Three of the Malay warriors

The historical knowledge represented by the virtual character of Malay men and their actions is a convincing aspect that evokes a sense of presence, a sense of place, and a sense of culture while exploring the virtual environment, the Pasir Salak Village. The costume

design highlighted the Malay cultural elements and the aesthetic of Malay clothing. The costume consists of baju Melayu (shirt and pants), samping (skirt), tengkolok, weapons; keris, sundang and spear. The cloths are textured using materials of textile; velvet, songket, batik and pelekat depict various patterns and fabric art of Malay clothing. The final look of virtual character models and their action pose is in Figure 8

The weapons are keris, sundang and spear. Sundang is an interactable object which can be manipulated by grabbing and holding it, zooming in to look at the details on sundang. The final look of the weapon models is in Figure 9.

Fig. 9: 3D Model of keris and sundang as primary weapons

By presenting the details, the contextual function of the character within the narrative is delivered well. The interaction with Malay men and weapons provides a somatic mode of attention for the visitor's bodily engagement with past culture, hence supporting knowledge acquisition. Visitors will encounter the character and artefact to analyse human activity, complete the exploration and undergo an immersive experience.

## 5.0 Discussion

The conceptualisation of virtual characters in historical-based VR applications requires a systematic study of their historical and cultural significance, guided by the immersive experience theory, which comprises three interconnected components: phenomenological, narrative, and semantic (Dogan & Kan, 2020). Historical knowledge must be carefully identified, mapped, and structured according to these components to support the development of coherent and meaningful VR narratives. Additionally, artistic details of characters should be defined at the early stages to ensure authenticity and aesthetic fidelity in their visual representation.

The implementation of the ADDIE model enhances the efficiency of the character creation process, allowing production activities to meet deadlines while maintaining quality. Successful asset creation relies on adherence to a structured development timeline, with particular emphasis on the Analysis stage. During this stage, designers must conduct a systematic and in-depth study of historical events by searching, gathering, analysing, and interpreting relevant materials, thereby forming a solid foundation of historical knowledge.

Well-designed historical virtual characters stimulate social practice and somatic engagement within educational contexts. The analysis stage must therefore comprehensively determine the role of each character within a scene, as these characters are crucial for accurately representing historical moments, evoking a sense of place, and strengthening narrative meaning. Effective execution of this stage leads to engaging and immersive VR content that meets both educational and experiential objectives.

Technical considerations are also essential, particularly for characters that perform actions or interact with objects. Modelling and animation must be carefully planned to achieve the desired level of functionality and realism. Advances in AI-driven technologies have revolutionised virtual character creation, enabling more lifelike and relatable interactions, which address issues of realism. However, in historical-based VR applications, cultural uniqueness and mythological significance must be emphasised to preserve representation fidelity, enhance social presence, and foster meaningful engagement with historical narratives.

## 6.0 Conclusion & Recommendations

In conclusion, this study has met the research objectives; 1) to identify cultural and historical significance based on the immersive experience development framework, and 2) to explain the process of developing the 3D character based on the ADDIE model for VR historical events. The conceptual elements of character design are relevant to the development of 3D animated characters for virtual environments. Moreover, the study is significant in the Human-Computer Interaction (HCI), art, and heritage sectors.

However, this study is limited by its context-specific cultural scope, as the cultural and historical elements examined focus on a particular community, and time period, which may reduce the generalisability of the proposed guideline. Additionally, the study solely

concentrated on cultural and historical aspects of 3D virtual character design, excluding other immersive components such as environmental settings, sound design, and behavioural modelling that also shape user experience. Technological constraints further influence the applicability of the guideline, as current VR hardware and software may restrict the level of realism and interactive fidelity achievable in virtual character representation.

Future research should extend the guideline to cover a wide range of cultural contexts, enhancing its applicability across diverse heritage settings. The scope could also be expanded to include environmental design, soundscapes, and character behaviour, providing a more holistic framework for creating culturally rich and immersive VR experiences. Empirical user testing and expert validation across different VR platforms are recommended to evaluate and refine the guidelines in line with advances in VR technology and design practices. Additionally, generative AI and machine learning models could be leveraged to improve the naturalness of interactions between users and virtual characters. Further studies should focus on integrating virtual characters as active participants or "virtual actors" in heritage experiences, supporting cultural and social presence, fostering user empathy, and making VR historical narratives more meaningful and engaging.

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## Paper Contribution to Related Field of Study

This study generates a new finding relating to the issue of virtual character design, which required significant practical apprehensions to immersive art forms within the heritage sector and enticed researchers and developers of HCI and the art field to work on the resolution. The conceptual elements of character design apply to the development of 3D animated characters for historical-based virtual environments in enhancing immersive experiences. The study found that the virtual character design based on the current immersive experience theory significantly fulfils the increasing demand for virtual actors in new media and heritage fields.

## References

Al-Jundi, H. A., & Emad, Y. T. (2022). A Framework For Fidelity Evaluation of Immersive Virtual Reality Systems. *Virtual Reality 26(5):1-20 DOI: 10.1007/S10055-021-00618-y*.

Blonna, R., Tan, M. S., Tan, V., Mora, A. P., & Atienza, R. (2018). VREX: A Framework for Immersive Virtual Reality Experiences. *2018 IEEE Region 10 Symposium, Tensymp 2018*, 118–123. https://doi.org/10.1109/TENCONSpring.2018.8692018

Cecotti, H. (2022). Cultural Heritage in Fully Immersive Virtual Reality. *Virtual Worlds*, *1*(1), 82–102. https://doi.org/10.3390/virtualworlds1010006

Champion, E. (2015). Defining cultural agents for virtual heritage environments. *Presence: Teleoperators and Virtual Environments*, *24*(3), 179–186. https://doi.org/10.1162/PRES_a_00234

Champion, E. M. (2019). *From Historical Models to Virtual Heritage Simulations*.

Debailleux, L., Hismans, G., & Duroisin, N. (2018). Digital Cultural Heritage Using Virtual Reality. *In M., Ioannides (Ed.). Digital Cultural Heritage.* https://doi.org/10.1007/978-3-319-75826-8

Dogan, E., & Kan, M. H. (2020). Bringing heritage sites to life for visitors: Towards a conceptual framework for immersive experience. *Advances in Hospitality and Tourism Research*, *8*(1). https://doi.org/10.30519/ahtr.630783

Gillies, M. (2018, June 28). Creating virtual characters. *ACM International Conference Proceeding Series*. https://doi.org/10.1145/3212721.3212835

Hurst, W., De Boer, B., Florijn, W., & Tan, X. J. (2016). Creating new museum experiences for virtual reality. *2016 IEEE International Conference on Multimedia and Expo Workshop, ICMEW 2016*. https://doi.org/10.1109/ICMEW.2016.7574692

Martingano, A. J., Hererra, F., & Konrath, S. (2021). Virtual reality improves emotional but not cognitive empathy: A meta-analysis. *Technology, Mind, and Behavior*, *2*(1). https://doi.org/10.1037/tmb0000034

Misselhorn, C. (2009). Empathy with inanimate objects and the uncanny valley. *Minds and Machines*, *19*(3), 345–359. https://doi.org/10.1007/s11023-009-9158-2

Mori, M., MacDorman, K. F., & Kageki, N. (2012). The uncanny valley. *IEEE Robotics and Automation Magazine*, *19*(2), 98–100. https://doi.org/10.1109/MRA.2012.2192811

Mufarocha, I., Fatirul, A. N., & Waluyo, D. A. (2023). Development of History Teaching Materials with Addie. *EDUCATION : Journal Of Education*, *8*(2).

Rahaman, H. (2018). Digital heritage interpretation: a conceptual framework. *Digital Creativity*, *29*(2–3), 208–234. https://doi.org/10.1080/14626268.2018.1511602

Rahim, N., Siti, T., Wook, M. T., Azan, N., & Zin, M. (2017). *Analysis on user Interaction in Virtual Heritage: Virtual Museum Environment*. https://doi.org/10.17485/ijst/2017/v10i48/120775

Rativa, S. (2022). *Tilburg University Virtual Character Design and its potential to foster Empathy, Immersion, and 21st Century Learning Skills in Video Games and Virtual Reality Simulations*. Tilburg University.

Regassa Hunde, B., & Debebe Woldeyohannes, A. (2022). Future prospects of computer-aided design (CAD) – A review from the perspective of artificial intelligence (AI), extended reality, and 3D printing. In *Results in Engineering* (Vol. 14). https://doi.org/10.1016/j.rineng.2022.100478

Rizvic, S., Boskovic, D., Bruno, F., Petriaggi, B. D., Sljivo, S., & Cozza, M. (2020). *Actors in VR storytelling*. https://doi.org/10.1109/VS-Games.2019.8864520

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior*, *86*, 77–90. https://doi.org/10.1016/j.chb.2018.04.019

Vinayagamoorthy, V., Brogni, A., Gillies, M., Slater, M., & Steed, A. (2004). An Investigation of Presence Response across Variations in Visual Realism. *The 7th Annual International Presence Workshop*, 148–155.

Vosinakis, S. (2017). Digital Characters in Cultural Heritage Applications. *International Journal of Computational Methods in Heritage Science*, *1*(2), 1–20. https://doi.org/10.4018/ijcmhs.2017070101

Wolff, A., Mulholland, P., & Collins, T. (2012). Storyspace: A story-driven approach for creating museum narratives. *HT'12 - Proceedings of 23rd ACM Conference on Hypertext and Social Media*, 89–98. https://doi.org/10.1145/2309996.2310012