Augmented Reality Storytelling and Cultural Heritage Knowledge Co-Production, Co-Curation, and Consumption from a Historical African Smelter

Dr Izak Frederik Potgieter
Department of Humanities, Metaverse Research Unit, University of Johannesburg
izakp@uj.ac.za

Abstract

This paper examines knowledge co-production, co-curation and consumption in the development of an augmented reality (AR) heritage experience at the Melville Koppies smelting site in Johannesburg, South Africa. Using Wessels et al.'s (2022) framework of multi-vocality, agency and proximity as a guiding design methodology, the project addresses a significant gap in the field: existing AR-for-cultural-heritage scholarship is concentrated almost entirely in the European Union and China, with no prior documented implementation in Africa. Knowledge co-production was driven by wide stakeholder consultation and a multi-vocal design-thinking process; knowledge co-curation drew on a hierarchy of data sources and digital storytelling to construct a speculative "local hero" narrator, reframing the site's lost intangible heritage as a living, contestable representation rather than a fixed reconstruction; and knowledge consumption was shaped by attention to affordable, low-bandwidth access and multilingual narration in Setswana, isiZulu, Afrikaans and English. Early user engagement data suggest meaningful uptake across all four language versions. The paper argues that this design methodology offers a replicable, decolonial approach to representing intangible cultural heritage in XR, particularly for underrepresented sites across the Global South.

Keywords: Augmented Reality, Cultural Heritage, Extended Reality, Cultural Knowledge Systems, Heritage Representation

Acronyms: AR - Augmented Reality; CH - Cultural Heritage; ICH - Intangible Cultural Heritage; VR - Virtual Reality; XR - Extended Reality, the umbrella term for both AR and VR together; Koppie - a distinct southern African landform: a steep-sided, isolated rock outcrop

1 Introduction

This paper looks at knowledge co-production, co-curation and consumption during the implementation of an augmented reality (AR) heritage experience at the Melville Koppies smelting site (Motumi, 2026), an iron smelting site dated to within the last 1000 – 200 years (Mason, 1971, p. 14).

The mediation of cultural heritage through augmented reality (AR) technologies is becoming increasingly common (Fig 1), (Chatsiopoulou and Michailidis, 2025, p. 8) However, much of this work, concentrates on representing the physical form of a heritage site, often neglecting the site's intangible cultural heritage (European Commission, 2020, p. 41). In addition, Chatsiopoulou and Michailidis (2025, p. 8) have found that the vast majority AR experiences of CH are located within the European Union and the People's Republic of China, with not a single AR for CH experience identified in all of Africa. The Melville Koppies Smelter in AR experience, presents a practical first step towards the implementation of this underrepresented technology, particularly in the interpretation and representation of the intangible dimensions of cultural heritage within the historically neglected Global South. From this, a design methodology was tested which may be of use in the continuous implementation and adaptation of extended reality (XR) for CH technology in the Global South.

Wessels *et al.* (2022, p. 11) present three aspects necessary for the digital representation of CH as meaningful places; multi-vocality, agency and proximity. These guiding aspects were used as a design framework in the development of the Melville Koppies Smelter in AR. Knowledge co-production was led by multi-vocality, knowledge co-curation through the lens of agency, and knowledge consumption through proximity.

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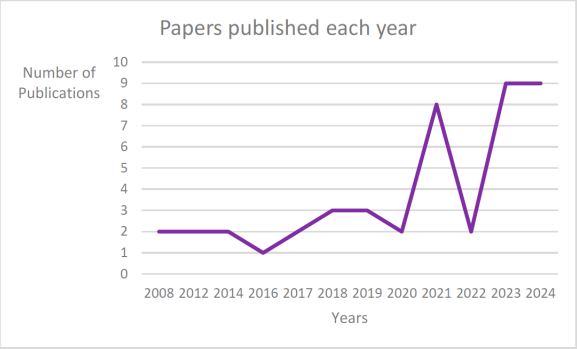


Figure 1: Number of publications about AR applications for cultural heritage in education (2008–2024). (Chatsiopoulou and Michailidis 2025, p. 5)

2 Knowledge Co-Production

The design process followed was that of design thinking, Design thinking is an innovative methodology centred around human needs, technological capabilities and business success criteria (Chatsiopoulou and Michailidis, 2025, p. 13). In short as many different and often conflicting interests are collected and reconciled into a complex design product that through negotiation, trade-offs and group debate attempts to design a cohesive product that cleanly incorporates as many of the key requirements as possible from the multiple stakeholders involved. This approach lends well to Wessels *et al.* (2022, p. 11) principle of multi-vocality as an essential component of digitally representing cultural heritage as place, not merely as a visual artefact. Multi-vocality means that multiple perspectives and worldviews are represented and accommodated in a way that is appropriate and relevant to the present (Wessels *et al.*, 2022, p. 12).

The Melville Koppies was home to several smelters and stone-walled structures (Mason, 1971, p. 38) however, barring a nearby reconstruction of a stone enclosure, this smelter exists without any other remains of the smelting site that may have helped place it in context (Fig. 2). Furthermore, contemporary written records and direct oral accounts on this site's original functions and meanings are lacking. Because of the smelters decontextualization from its original surroundings, a digital representation of the smelter in isolation risks reproducing the smelter as an aesthetic, de-sensualised object detached from its original function, meaning and cultural role within the worldview(s) in which it was originally created.

It is important to note that digital representations of CH are exactly that; representations and not reconstructions as often claimed (Denard, 2012, p. 11). Reconstructions imply that the representation in question is an accurate simulation directly comparable to the original CH site (Schlembach and Clewer, 2021, p. 839). Kreps (2015, p. 10) notes how this attitude comes from archaeology and archaeological visualisation's origins within a Western paradigm in which Items have been methodically arranged and reshaped to conform to Western paradigms of science, culture, art, history, and heritage. This historical idiosyncracy has resulted in a bias towards representing the tangible aspects of CH while neglecting its intangible qualities. However, as Bakka (2015, p. 138) has noted, there is no CH that does not also have intangible aspects to it. CH sites are not mere spaces, but places that carry multiple living spiritual, physical, social and historical facts, practices and worldviews and should be represented as such and in a way that tangibly benefits and helps develop these aspects of place.

Using multi-vocality as a guiding principle for knowledge co-production provides a framework through which some of the shortcomings of the inherited Western paradigm may be superseded. According to Wessels *et al.* (2022, p, 12.) the four pillars of multivocality for knowledge production are;

- "Respect the site and the current users of the place
- Represent the multiple perspectives of the site
- Bring to the centre other uses, past and present, of the site besides its scientific significance
- Create a decolonised visualisation of the place"

Design thinking lends itself well to the use of multivocality as it offers a methodology for synthesising many voices and requests into a single cohesive product. Furthermore, XR is a medium particularly suited to this task, as it can stitch together disparate forms of data and media into a single, unified experience (Potgieter, 2026, p. 21).

Within this framework for knowledge coproduction, the development of the Melville Koppies Smelter in AR involved wide consultation. The project drew on collaborations between the



Figure 2: The Melville Koppies Smelter site. Image taken 2026

University of Johannesburg's (UJ) Metaverse Research Unit, UJ's Department of History, UJ's Language Unit, the Department of Archaeology at the University of Cape Town (UCT, the University of the Witwatersrand (WITS) Department of Architecture, City of Johannesburg Heritage Unit, the Melville Koppies Management Committee and informal conversations with several modern Tswana speakers from varying backgrounds who identify the Batswana smelter as part of their own heritage.

According to Denard (2012, p. 68) "Heritage visualisation is above all, a hypothesis machine" Representations of heritage are, by definition, necessarily not accurate reconstructions or replacements for the original CH (Denard, 2012, p. 11). By embracing a mindset of representation over reconstruction, digital representations of CH should open themselves up to ongoing feedback, new hypotheses, accommodation of diverse heritage practices, worldviews, debates and the integration of ongoing multi-vocal accounts as a living object. To achieve this, the software underlying the Melville Koppies Smelter in AR was set up to be easily updated and altered remotely, without the requirement that any of the sites installed signage and QR codes need to be altered. Additionally, the AR experience was launched on1 May 2026, coinciding with the South African public holiday; Worker's Day. Contractually the university will use this day to annually review the AR experience and incorporate new data or inputs which may present themselves. It is hoped that by annually conducting such a review, that a narrative around XR for CH sites and a n appropriate public commemoration, in this case Worker's Day, may engender ongoing debate, conversation and celebration of the XR for CH experience as a "hypothesis machine" (2012, p. 68).

3 Knowledge Co-Curation

As a framework for the process for knowledge co-curation, Wessels *et al's.* (2022, p. 11) aspect of agency was used to guide the curation process. Agency refers to the agency of the cultural object or site itself to give and receive meaning. According to Wessels et al. (2022, p. 12) A digital representation of CH should treat the CH as a living entity with a biography that stretches from the past into the present and which continues to act and be acted on into the future. A clear line connecting the past to the present should therefore be presented so that the CH does not exist in historical isolation but rather, that it be understood as part of a history and worldview which continues to act on and influence the present day.

Using agency as a guiding principle for knowledge co-curation provides a framework through which CH sites may begin to absorb and disseminate intangible qualities of CH beyond a static representation of tangible heritage in and of itself. According to Wessels *et al.* (2022, p, 12.) the four pillars of agency for knowledge co-curation are;

- "Show the place as a living entity
- Show the place is not static and has a biography from its distant past to the present
- Re-humanise the 3D model
- Enable engagement with the place via its 3D replica"

If production concerns how and from what data sources a representation is built, curation concerns what is chosen to be represented within it, and how that data is represented as easily digestible information. As noted, in the case of representing the Melville Koppies Smelter in AR, the smelter is both without its original surrounding context and lacks contemporary written records and direct oral accounts on the site's original functions and meanings, instead the archaeological and historical record had to provide this data.

To develop a representation of a physically lost/incomplete CH, Potgieter *et al's.* (2025, p. 6) hierarchy of data sources to sequentially consider for the representation of CH (Fig 3) was followed to ensure that the CH representation is systematically represented from the available valid data. The smelter itself was 3D scanned using a LIDAR scanner along with reconstructed artefacts

in the protection of the Melville Koppies management Committee and WITS. After all geomatic sources were exhausted, the archaeological and ethnographic record was consulted which provided a wealth of information on the exact mechanics of the smelter's construction, how it was used, its economic, technical and cultural function as well as the spiritual significance of the smelter and smelting process within the worldviews in which it functioned and continues to function. Finally, the architectural heritage as a valid data source led to the nearby environment being scanned as a near estimation of the environment in which the smelter may have originally been constructed.

While a wealth of diverse and varied valid data was collected though this process, the question of how to curate this data remained. Wessels *et al.* (2022, p. 10) argue that an outcome of the Western worldview's search for objective reconstructions over living representations is that creativity in representations of CH may be rejected as frivolous and subjective. This risks excluding elements, ideas and curatorial practices that fall outside of the scientific worldview, precisely the elements, ideas and practices that may grant agency to the CH representation. The scientific/objective worldview should be seen as one of many worldviews each with its own methodological strengths and weaknesses that may be multiply synthesised and incorporated into a CH representation through the principle of multivocality.

Ambala (2020, p. 3) argues that creativity in the representation of CH should embrace digital storytelling at its centre. Digital storytelling has the potential to enable the custodians of a CH site to represent their own experiences and challenge dominant structures of representation. By curating valid data into information presented through the modicum of storytelling, a CH in XR representation may create what Ambala refers to as local heroes (2020, p. 3) Local heroes may be represented when the idea of "the self", is viewed through the "social self rather than the "individual self" (Ambala, 2020, p. 4). The social self is a pivotal element in numerous African philosophies and mythologies. Menkiti (1984, p. 172–173) asserts that personhood within an African episteme is attained by occupying a relational role within a given society and is not merely conferred by virtue of being born. A local hero becomes a proxy for a specific kind of personhood that emerges from the relational role engendered by the CH in question, a relational role often disrupted or erased through the colonial process. Such a local hero then creates a role model and example of a relational role that may be occupied, strived towards and learnt from. In Ambala's (2020, p 2) research the relational role of a local hero was created from interviewing individuals who still occupy the relational role in the present day that seeks to be digitally represented. However, in the case of representing a relational role now lost to us, a local hero may be represented through a process of speculation on this virtual person's life, knowledge and worldview from the valid data acquired around the CH being represented. In this way, a CH site may lend itself to hosting a local hero trained on the knowledge and intangible CH inherent to that site. This local hero, as a representation of the site's intangible CH, should be viewed as a "hypothesis machine" (Denard, 2012, p. 68), left open to continuous scrutiny and adjustment as new information and viewpoints emerge. Just as a CH site's tangible heritage should remain open to revision as new facts come to light, so too should its intangible representation.

By focusing on digital storytelling as a key part the AR experience's knowledge co-curation, this experience hopes to demonstrate how CH in XR representations may go cumulatively beyond the Western/objective approach to representation towards a more inclusive decolonial practice. A storyboard was developed, in consultation with Dr Sechaba Maape, for the Melville Koppies Smelter in AR, (Fig 4). The overarching digital storytelling approach was to personify the smelter as its own narrator, present the story of the smelter starting with its creation right through to the present day Johannesburg, animate and narrate both how the smelter functioned technically along with the cultural role the smelter played within the worldview from which it was created. These points are an attempt to directly implement Wessels *et al's.* (2022, p, 12.) four pillars of agency for knowledge co-curation. The local hero is therefore neither a fictional historical figure nor a real person telling their own story, but a speculative persona of the smelter itself, voiced in each language by a real first-language speaker.

On site, visitors scan a QR code on the signage beside the smelter, which opens the experience in their phone's web browser without an app download, and choose a language (Fig 5). An animated diorama of the Melville Koppies Smelter is placed on the ground in front of them and plays the sto-

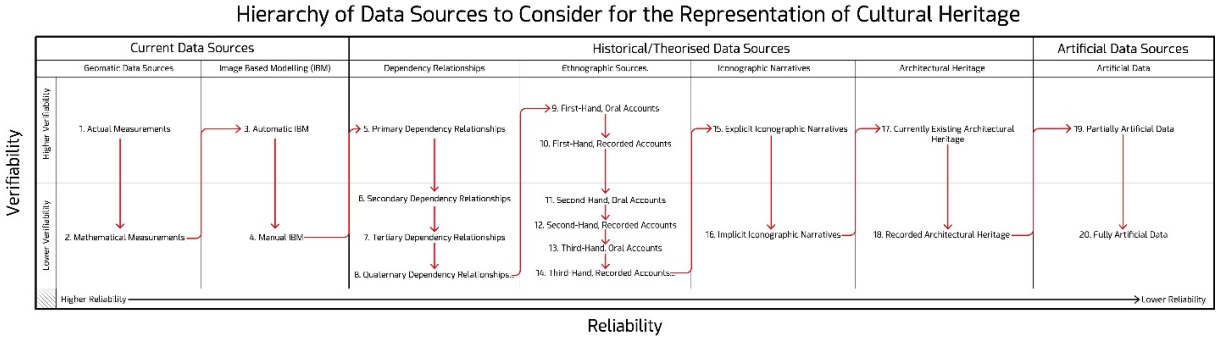


Figure 3: Hierarchy of Data Sources to Consider for the Representation of Cultural Heritage (Potgieter, 2025, p. 266)

ryboarded scenes with the local hero's narration, which can be paused and navigated with an on-screen timeline (Fig 6). A full-scale model of the furnace is also overlaid on the smelter's surviving remains, so that visitors see it reconstructed and in operation where it stands.

4 Knowledge Consumption

Finally, as a framework for the process for knowledge consumption, Wessels *et al's*. (2022, p. 11) aspect of proximity was used to design how this experience would be consumed and by whom. Proximity refers to the representations ability to provide a holistic impression of the people who made and interacted with the CH site in question as real people who possessed what Avery Gordon (2008, p. 4) refers to as complex personhood. Gordon describes complex personhood as an understanding that people are not simple and flat, they are not universally victims or perpetrators as often understood through a Western ideological lens.

Using proximity as a guiding principle for knowledge consumption provides a foundation for the representation of CH in XR as a decolonial practice that facilitates the inclusion of people, both past and present, who may have been written out of or placed on the margin of official historical narratives in the past continuing into the present. According to Wessels *et al.* (2022, p, 12.) the four pillars of proximity for knowledge consumption are;

- "3D model of the site and artefacts must be good quality (visually appealing and accurate) to provoke the feeling that the virtual visitor is there at the site
- Mediate the experience to preserve the atmosphere of the place, and communicate its narrative appropriately
- 3D model must be given authority and authenticity
- Facilitate inclusive access to the site"

The AR experience utilised high-quality LIDAR scans of the actual site and site artefacts. This, in conjunction with textured, custom-built 3D models on the blender 3D modelling software later exported and coded in unity, ensured that the AR experience was of a good quality and was as representative of the original as possible. In addition, several 3D models were not created to be photo-realistic but employed abstract shapes and colours to better help communicate the co-developed site narrative (Fig 5).

Regarding the facilitation of inclusive access to the site, three priorities were identified; access to users with disabilities, affordable access and multilingual access. For users with disabilities a collaboration with experts in South African Sign Language is working towards the implementation of SA sign language on the CH in XR experience, while this has not yet been implemented, the annual revision of the experience on Worker's Day provides impetus towards such an implementation. In addition, the Melville Koppies smelter is only accessible after a 10 – 20 minute hike to the top of the koppie. To ensure access to those who may not be able or willing to make this climb, the AR experience was also launched at a nearby museum with infrastructure for universal access.

To ensure that cost of access does not provide a barrier to entry, a concern of particular importance in the Global South, the AR experience was tested and built for older, low-end smartphones, specifically the most affordable android smartphone on the market in 2022 we could find. This was made

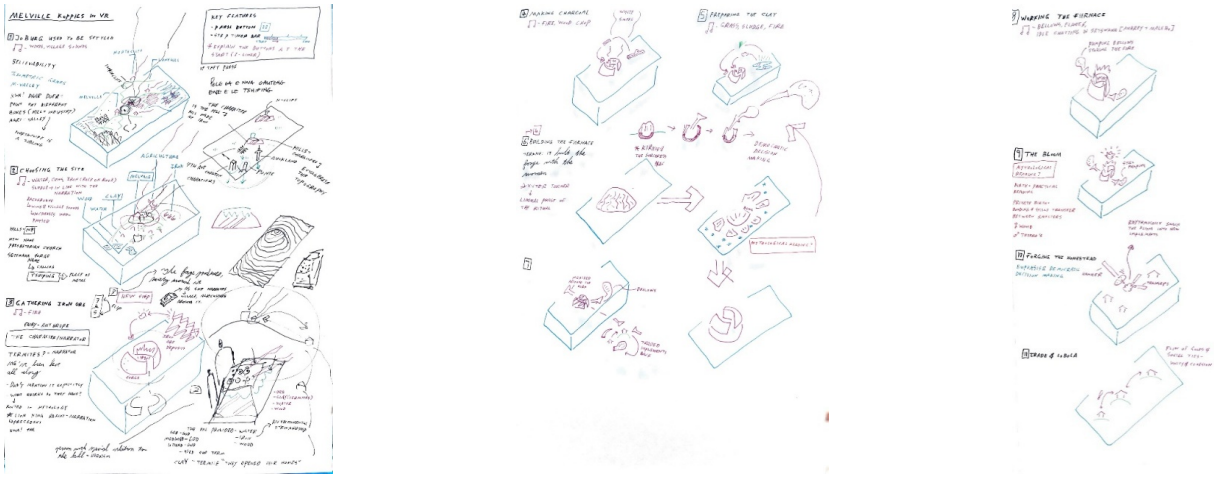


Figure 4: Storyboard for the Meville Koppies Smelter in AR developed in collaboration with Dr Sechaba Maape, 2026

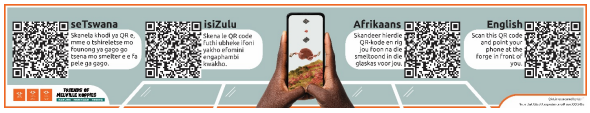


Figure 5: Signage with QR Codes installed on site. (By the Author, 2026)

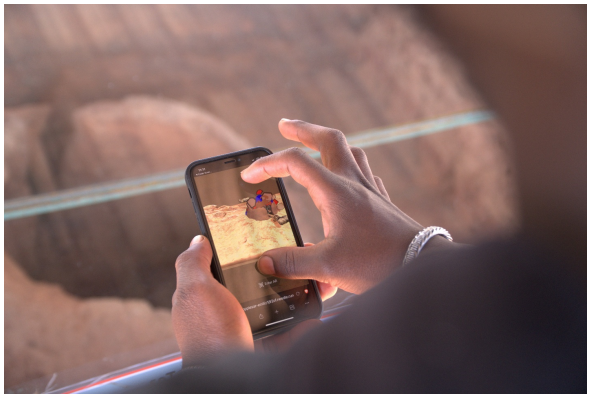


Figure 6: The Melville Koppies Smelter in AR in use. Image taken 2026

possible by Needle AR, a Unity plugin that hosts, compresses, and renders AR experiences online. While this reduces the computational demands on less powerful smartphones, it shifts the burden onto data bandwidth. This risks excluding users who cannot afford substantial data, as well as limiting deployment at sites with poor signal, a common constraint in cultural heritage environments. To alleviate this, the AR experience was modelled and textured at a very high fidelity and tested in AR. The size and resolution of the model and its textures were then halved sequentially each time testing the AR experience on a smartphone to see how/if the experience was affected. Through this process the size of the experience could be reduced drastically. By the end the entire experience used less than 10mbs of data per playthrough.

Multilingual narration was incorporated in the experience with a focus on South African languages. The experience was narrated and made available in Setswana, isiZulu, Afrikaans and English with South African Sign Language under development. Three benefits were identified from doing this. Firstly, while the majority of South Africans are fluent in English, listening to a story from a culture you may identify with in your own language helps users to personally identify with the history being presented, an identification which for many, may have been denied in the past. Secondly, multiple studies (Clayton, 2024, p. 1; Malindi, Ndebele and Gobingca, 2023, p. 9) have shown that mother tongue education consistently leads to better learning outcomes. Theodoropoulos and Antoniou (2022, p. 1) have also found that visual learning through XR can support greater user engagement, interpretation and reflection. Including multilingual access in an XR experience. Multilingualism was therefore essential for the representations efficacy as an educational tool for visiting school groups who frequent the site for school tours.

Finally, by providing multilingual narrations, it becomes possible to directly address specific groups. Ambala's (2020, p. 3) concept of the local hero may now become one of local heroes. While the script for the narration was largely the same for each translation. Some nuance could be inserted to accommodate the different groups viewpoint. For example the English and Afrikaans translations re-

ceived additional explanations regarding common cultural terms that would be obvious to Setswana and isiZulu speakers. Early user data collected on the first four months of the AR experience shows that out of 1283 users who have engaged with experience so far, 944 used the experience in English, 150 in Setswana, 97 in Afrikaans and 92 in isiZulu. It is not unexpected that the majority of users would prefer an English narration in a Global city such as Johannesburg. However, these early findings do point to clear engagement across language versions.

5 Conclusion

This paper has examined the Melville Koppies Smelter in AR through the lens of knowledge co-production, co-curation and consumption. Knowledge co-production was guided by multi-vocality, drawing on wide consultation across university departments, heritage bodies and modern Tswana speakers to shape a design-thinking process capable of synthesising these varied voices into a single, cohesive AR experience.

Knowledge co-curation was guided by agency, using a hierarchy of data sources and digital storytelling to represent the smelter as a living entity rather than a static reconstruction. This allowed the site's disrupted intangible heritage to be approached through a speculative local hero, framed as a "hypothesis machine" open to ongoing revision. Knowledge consumption was guided by proximity, ensuring the experience remained accessible through low-bandwidth optimisation and multilingual narration in Setswana, isiZulu, Afrikaans and English.

The Melville Koppies Smelter in AR experience presents a practical first step towards the implementation of this underrepresented technology, particularly in the interpretation and representation of the intangible dimensions of cultural heritage within the historically neglected Global South. From this, a design methodology was tested which may be of use in the continuous implementation and adaptation of extended reality (XR) for CH technology in the Global South.

References

Bakka, E. (2015) 'Safeguarding of intangible cultural heritage – the spirit and the letter of the law', *Musikk og Tradisjon*, 29.

Chatsiopoulou, A. and Michailidis, P.D. (2025) "Augmented Reality in Cultural Heritage: A Narrative Review of Design, Development and Evaluation Approaches," Heritage, 8(10), 421.

Clayton, R., 2024. *Linguistic interdependence? Foundation Phase mastery in home language as a predictor of grade 4 repetition and EFAL marks*. RESEP Working Paper No. 02/25. Stellenbosch: Stellenbosch University, Research on Socio-Economic Policy.

Denard, H. (2012) 'A New Introduction to the London Charter' in A. Bentkowska-Kafel, D. Baker. and H. Denard. (eds.) Paradata and Transparency in Virtual Heritage, pp. 7-71. Routledge.

European Commission (2020) Decision C(2020)6320 of 17 September 2020.

Gordon, A. (2008) Ghostly Matters: Haunting and the Sociological Imagination. University of Minnesota Press.

Kreps, C. (2015) "Appropriate museology and the 'new museum ethics'. Honoring diversity," *Nordisk Museologi*, (2), pp. 4-16.

Malindi, Z., Ndebele, C. and Gobingca, B.Z., 2023. Examining teachers' views on the adoption of mother tongue-based bilingual education in mathematics teaching and learning: a South African context. *South African Journal of Education*, 43(Supplement 2), a2242.

Mason, R.J. (1971) Prehistoric Man at Melville Koppies, Johannesburg. Occasional Paper 6. Johannesburg: Department of Archaeology, University of the Witwatersrand.

Menkiti, I.A. 1984. "Person and community in African traditional thought". African Philosophy: An Introduction 3: 171–182.

Motumi, M. (2026) 'Melville Koppies smelter gets tech upgrade as UJ launches augmented reality experience', UJ News, 4 May. Available at: https://news.uj.ac.za/news/melville-koppies-smelter-gets-tech-upgrade-as-uj-launches-augmented-reality-experience/ (Accessed: 21 August 2026).

Potgieter, I.F., (2026) Embodying Sophiatown: Mediating Multivocal Representations of Cultural Heritages in Virtual Reality. PhD thesis. University of Johannesburg.

Potgieter, I. F., Hendricks, D. M., & Ntshona, M. (2025). Using a Hierarchy of Data Sources to Represent Cultural Heritage Sites a Case Study of Sophiatown, Johannesburg in Virtual Reality.In Gaming Media and Social Effects (hal. 263–279). Springer Nature Singapore.

Schlembach, R. and Clewer, N. (2021) '"Forced empathy": Manipulation, trauma and affect in virtual reality film', *International Journal of Cultural Studies*, 24(5), pp. 827–843. https://doi.org/10.1177/13678779211007863

Terah Ambala, A. (2020) 'Adapting Digital Storytelling Methods to African Contexts: Insights from the Utaifa Project', African Journalism Studies, 41(4), pp. 22–34.

Theodoropoulos, A. and Antoniou, A. (2022) 'VR Games in Cultural Heritage: A Systematic Review of the Emerging Fields of Virtual Reality and Culture Games', *Applied Sciences*, 12(17), 8476. https://doi.org/10.3390/app12178476

UNESCO. (2003) 'Basic texts of the 2003 Convention for the Safeguarding of the intangible cultural heritage'. Paris, France: UNESCO.

Wessels, S., Maape, S., Schoville, B.J. and Wilkins, J. (2022) 'The Drone, the Snake, and the Crystal: Manifesting Potency in 3D Digital Replicas of Living Heritage and Archaeological Places', *Archaeologies*, 18(2), pp. 395–429. https://doi.org/10.1007/s11759-022-09460-3