



Evaluating Uncertainty Representation in IDNs

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Abstract. Representing uncertain history through Interactive Digital Narratives offers interactors the opportunity to challenge the grand narrative through engagements with the historical record. A gap in the literature exists in the evaluation of IDNs' ability to teach interactors how to navigate historical uncertainty, while a demand for diegetic procedural knowledge learning exists. We propose an evaluation framework that helps determine the effectiveness of an IDN to deliver knowledge in the context of historical uncertainty and seek to evaluate not only the acquisition of declarative knowledge but also procedural knowledge learning needed to handle such conflicting perspectives. This evaluation framework is supported by a VR IDN implementation of a prehistoric complex, presenting alternative interpretations based on published research upon which the interactor is invited to answer questions about the historical site. Validation through cultural heritage experts supports the IDN's ability to empower interactors to question the grand narrative and take an active role in the interpretation of the site.

Keywords: Interactive Digital Narrative · uncertainty · evaluation · procedural learning · cultural heritage · virtual reality

1 Introduction

Interactive Digital Narratives (IDNs) have been presented as “interfaces of dissemination of structured narratives” to serve the need of historiography to represent history's uncertainty [1]. In a post-truth era, the ability to challenge the grand narrative that empathizes with history's victors, particularly about an uncertain history, is a desired attribute of such engagements with the historical record [2]. However, a gap exists in the literature on evaluation techniques to assess IDNs' ability to teach interactors how to navigate historical uncertainty by distinguishing educated interpretations from conspiracy theories.

In this paper, we propose an evaluation technique to help determine the effectiveness of an IDN to deliver knowledge in a context of uncertainty such as when, in the absence of absolute truth, multiple conflicting perspectives exist around an interpretation of an artefact. Furthermore, we seek to evaluate not only the acquisition of knowledge the interactor is exposed to inside the IDN, but also the skills learnt from within the IDN

to handle such conflicting perspectives. Thus, evaluation will consider both declarative and procedural knowledge learning.

We begin by presenting qualitative uncertainty as the source of conflict and multiperspectivity and then present a cultural heritage scenario to ground the theory. We lean on theories of epistemic justification to support multiperspectivity and identify a research gap in IDN evaluation. We then draw on Inoculation Theory, a method to prevent problematic interpretations by means of learning from examples [3], as a model for procedural knowledge learning, and apply it in an IDN representing the complexity of uncertainty. Finally, we present an evaluation framework for this IDN and suggest other areas where it can be applied.

2 IDNs Conveying Complex and Uncertain Information

Uncertainty is traditionally related to data, chance, and prediction in a future quantitative context [4], but is also applicable to the past where, besides measurement uncertainty, retrodiction¹ and interpretation of data are considered as sources of past temporal uncertainty [6]. Sources of uncertainty due to retrodiction include biased history, while lack of external data references, gaps in the archive, and conflicting reports are sources of uncertainty due to data interpretation [6, 7].

A scenario where these issues come to the fore is in the interpretation of prehistoric cultural heritage sites [8], particularly from a critical historiography perspective [9]. A modern understanding of “interpretation” is not only to instruct but also to provoke, as it “aims to reveal meanings and relationships through the use of original objects, by first-hand experience, and by illustrative media, rather than simply to communicate factual information” [10]. This is most challenging when the original objects are of immeasurable value due to their provenance from thousands of years ago. Prehistoric tangible cultural heritage consists of sites and artefacts whose interpretation suffers from a lack of external data references, weathered and damaged evidence, and post-discovery reconstruction, while being developed in parallel with its excavation across recent times [8]. For example, Stroud points to a biased interpretation of the Hal Tarxien Prehistoric Complex due to retrodiction, as an excavation report on the Neolithic site carried out in 1916 immediately claimed the discovery of a “sanctuary” or “temple”, suggesting that the site was “somehow expected to fit into a preconceived concept or idea... that their main purpose was religious” [8] and complains how “misconceptions about these sites remain commonplace, despite the rise of more dynamic interpretations” [8]. Another archaeologist, Grima, interprets the same Neolithic site from a cosmological perspective, where the raised floors of the apses relative to the intervening corridors, and evidence of rainwater retention within them, suggesting a representation of the island’s relationship with the sea [11], while a third archaeologist, Malone, interprets the site using Hertz’ left-right, male-female, fire-water, cleansing-purification schemes [12].

¹ Retrodiction is defined as “the explanation or interpretation of past actions or events inferred from the laws that are assumed have governed them” [5].

2.1 Conflicting Perspectives and Misinformation

These interpretations give rise to multiple, sometimes conflicting, perspectives, often building upon parts of each other but other times choosing to ignore certain ideas to create a cohesive argument [13]. Such an uncertain field is ripe for problematic speculation, as others may make fantastical claims using what-if scenarios to try and fit the evidence into their story. Hancock, for example, claims that these Neolithic sites are the legacy of an advanced civilization preceding the Ice Age in the Pleistocene Epoch, up to 11,000 years ago [14], with his so-called “documentary” attracting 25 million viewing hours in its first week but also harsh criticism [15–17].

So, how can IDNs help navigate such a space of uncertainty? The interrelationships between multiple perspectives finds its theoretical underpinnings in epistemic justification, which serves the aim of “believ[ing] what is true and to avoid what is false” [18] by “maximizing truth and minimizing falsity in a large body of beliefs” [19]. Each belief formulation has two dimensions: the perspectival dimension and the objective dimension. The objective dimension is determined by the proven facts irrespective of any perspective. The perspectival dimension is determined by the believer’s perspective in the context of their epistemic situation: what the believer knows and what evidence the believer has access to at that point in time [18]. In the prehistoric cultural heritage context, the objective dimension is offered by the evidence found in the archaeological site and its artefacts while the perspectival dimension is provided by the different interpretations that have been offered over the years.

In internalist² approaches to knowledge, epistemic theory is split into two main theories: Foundationalism and Coherentism [20]. Foundationalism favors a linear dependency between justified beliefs, with self-justified basic beliefs at the base supporting a superstructure of layers of justified beliefs where the strength of one depends on those beneath it. Coherentism favors a web-like view of mutually supporting justified beliefs that form a web where the strength of one interpretation depends on the strength of surrounding ones [20]. However, a network of interpretations around an archaeological site cannot be served wholly by any of these two, and instead finds its support in the hybrid theory of Foundherentism, wherein parts of the Coherentist web are self-justified beliefs [21].

Prehistoric cultural sites, denuded of their function and original form, provide evidence for basic assumptions that in turn support networks of beliefs in the form of interpretations, which may be in conflict with each other and give rise to a complex scenario. In such cases, how can these interpretations be presented in the best possible way to the general public when the uncertainty of such interpretations is open to attacks by fantastical claims and conspiracy theories? How can trust-worthy scientifically-backed sources be defended against disinformation, besides reaction in the news [15, 16] and scientific publications [17] which may be out of reach for the public? How can the general public not only be informed through declarative knowledge but also trained in challenging problematic claims through skill acquisition? And how can this knowledge transfer in contexts of uncertainty and multiperspectivity be evaluated?

² Internalism maintains that “justification depends solely on factors internal to the believer’s mind,” as opposed to externalism that maintains that “at least some factors external to the believer’s mind determine their justification” [20].

3 Limitations of Evaluation Methods for IDNs

Evaluation of IDNs has had its fair share of scholarly consideration [22–26]. Building on Murray’s user experience dimensions of Agency, Immersion, and Transformation [27], Roth’s doctoral dissertation and later development with Koenitz provided a toolbox for evaluating a satisfying user experience [22, 23]. Expanding on Roth’s original definition of IDNs as requiring entertainment [22], later work acknowledged IDN’s additional affordance for learning [28] when applying the evaluation toolkit to an interactive documentary about Somali piracy [29] and considering the evaluation of IDNs as representation of complex systems in the White Paper on Evaluation by the COST action INDCOR (Interactive Narrative Design for Complexity Representation) [25]. Other efforts at evaluating IDNs include that of an interactive fiction in cinematic VR prototype [24], and an IDN triad by Koenitz that can be used to map individual narrative instantiations against Murray’s dimensions along an intensity scale [26]. However, the evaluation of IDNs in the above studies, where present, focused its assessment on the user experience of the IDN and not its impact on the interactor outside the experience.

In the context of IDNs for learning, the impact on the interactor may take two forms: declarative learning and procedural learning [30]. Declarative learning is the passing, acquisition, and remembering of knowledge that “we are aware we know and can usually describe to others” while procedural learning is the acquisition of knowledge that we “display in our behavior but that we are not conscious of” [30]. These form the first two of Anderson’s three-phase skill acquisition theory: cognitive skill acquisition is achieved through declarative knowledge, associative skill acquisition is achieved through procedural knowledge, and autonomous skill acquisition is achieved through automatization through practice [30]. While declarative knowledge can be “described to others” and thus affords evaluation through traditional instruments such as questionnaires, procedural knowledge is harder to assess given our unconscious awareness of it. Tellingly, the need for immersion-retaining, intra-diegetic measurement of user experience that evaluates procedural performance learning, rather than just declarative learning, was highlighted in the future outlook section of the COST action INDCOR’s whitepaper on evaluation [25].

3.1 Evaluation of IDNs Conveying Complex and Uncertain Information

Has the ICIDS community addressed the need for such intra-diegetic measurement of procedural performance learning? A scoped literature survey of ICIDS proceedings was carried out to identify any re-search in this community that could shed light on diegetic evaluation of procedural performance learning. A search on the SpringerLink website for papers in the ICIDS proceedings³ using the keyword “evaluation” returned 340 results. A filter by title for papers that deal with evaluation techniques narrowed down the result pool to 19, being further narrowed down to 8 by looking for “diegetic evaluation” and “procedural performance learning” in the abstract. Of these final 8, only Molnar *et al.* present a study in which they evaluate the effectiveness of a game in conveying an educational message targeting a set of 11 learning objectives related to

³ <https://link.springer.com/conference/icids>

health and hygiene by having the interactor take on the role of an investigator solving microbial problems over six puzzles [31]. Each successive puzzle features a suggestion (hypothesis) which the interactor has to prove or reject based on evidence found in the IDN. The non-diegetic evaluation of the IDN, carried out using pen and paper, was reported as not being enjoyed by the participants, leading the researchers to seek ways to integrate the evaluation into the IDN in the future. Molnar *et al.*'s study is relevant in its approach of refuting or accepting a hypothesis based on available evidence, being closest to procedural performance even if not used to evaluate the IDN's effectiveness. One may argue that the distinction between research and evaluation is unclear [32, 33], and embedding the evaluation within the diegetic experience further blurs the lines between the two approaches (see Table 2 in [33] for a good list of differences).

4 Narrative Persuasion and Counterarguments

Providing a sense-making explanation through a narrative has shown to be persuasive and systematically shifts beliefs, particularly in “situations where there exists some public information that can accommodate more than one possible interpretation, potentially allowing some individuals to try to encourage others to adopt their preferred interpretation” [34]. Multiple interpretations of publicly accessible prehistoric cultural heritage such as the Neolithic megalithic buildings of Malta present such a scenario.

Traditional narratives are able to persuade overtly by directing the reader's attention to the storyline and engage the reader in narrative immersion which requires a rudimentary form of agency that Koenitz calls “Interactivity 1” [26]. This gives little opportunity for critical reflection and evaluation of the underlying persuasive message, thus reducing the readers' opportunity for resistance, including counterargument, and amplifying narrative persuasion [35]. This can be seen in a filmed documentary-style series such as *Ancient Apocalypse: Sirius Rising* [14] where challenges to the official archaeological record are in the form of what-if questions as the protagonist tries to find evidence that fits his lost civilization theory, in what presents itself as a biased interpretation of retrodiction.

Here we can learn from Inoculation Theory that against such persuasion techniques, ‘supportive pretreatments’ consisting of one-sided messages that strengthen existing attitudes without mentioning counterpositions were found to be less effective than refutational pretreatment [3]. This approach takes the form of two-sided messages in which persuasive arguments are raised in the form of counterarguments that challenge existing beliefs and are then weakened by refutations [3]. Moreover, such an approach was found to offer resistance to both the same claims, as well as new ones – reinforcing the inoculation model [3].

4.1 IDNs as Inoculation Mechanisms

IDNs by their nature present an interactor with narrative choices, which necessitate pause and reflection upon the presented narrative in order to plan and execute one's actions – what Koenitz calls “Interactivity 2” [26]. Such reflection gives time and space for the interactor to evaluate the actions taken so far and the options currently available:

(cf. Karhulahti's application of Giddens' Double Hermeneutic further developed by Koenitz into a "triple hermeneutic" to account for replay [26]). This double reflection can facilitate the detection of any underlying persuasive messages, particularly when the choices provided seem to channel the interactor into a particular perspective, provoking what Quick *et al.* call 'psychological reactance' [36], which can be further enhanced through replay, and the consequential third reflection, of earlier playthroughs. This makes interactors better primed for resistance [3], willing to manifest their reactance through counter-arguments to the persuasive narrative [36], as was also reported by Grace and Liang when they used Inoculation Theory as a lens through which they analysed a number of research focused games [37].

Therefore, we propose that experiences of IDNs can serve as processes of inoculation by presenting the interactor with evidence upon which justified beliefs can be made, and then have these beliefs be challenged by counterarguments. Interactors are then guided on how to use evidence to refute such counterarguments, thus equipping them with the skill to refute future counterarguments [3]. A Virtual Reality IDN in the context of cultural heritage implementing this concept is presented in the next section.

5 Case Study

The subject of the VR IDN is the Hal Tarxien Prehistoric Complex, excavated between 1915 and 1919 by an archaeological team lead by Sir Themistocles Zammit (TZ). It is a complex of four interconnected megalithic structures – described by Zammit as 'temples' – built across some 1200 years and re-used again in the Bronze Age as a cremation cemetery [37]. Supplementary excavations happened again in 1921 by Ashby [39], with subsequent investigations by Evans in the 1950s, and Trump in 1959 [8]. An "intra-site analysis of the animal remains recovered in the Temples and documented by Zammit" was carried out by Attard Mallia and published in 2018 [38]. Further interpretations of the findings of Zammit's and Ashby's excavations at Tarxien but within the wider context of the Maltese Neolithic structures were offered by Grima [11, 40–42] and Malone [12, 43]. As noted by Stroud, Zammit presents a religious interpretation of the site, Grima presents a cosmological interpretation, Malone presents an organization-based interpretation, and Attard Mallia presents an artefact-based interpretation [8]. These different perspectives provide diverse interpretations of the site and its artefacts and what they might have represented to their native communities.

5.1 IDN Design

Koenitz introduced the SPP (System-Process-Product) model of IDNs in 2010 [45] (current version 2023 [26]) to describe the relationship between digital artefact (system), interactive experience (process) and resulting output (objective product – play-trace/subjective product – retelling [46]) as well as the elements of these three aspects. Following the extended SPP by Serbanescu and Koenitz [44], we follow a Non AI design process in developing a narrative design product where the publications of the above-mentioned authors are the source of the traditional narrative (see Fig. 1). They present a network of perspectives about the tangible cultural heritage site which provides the

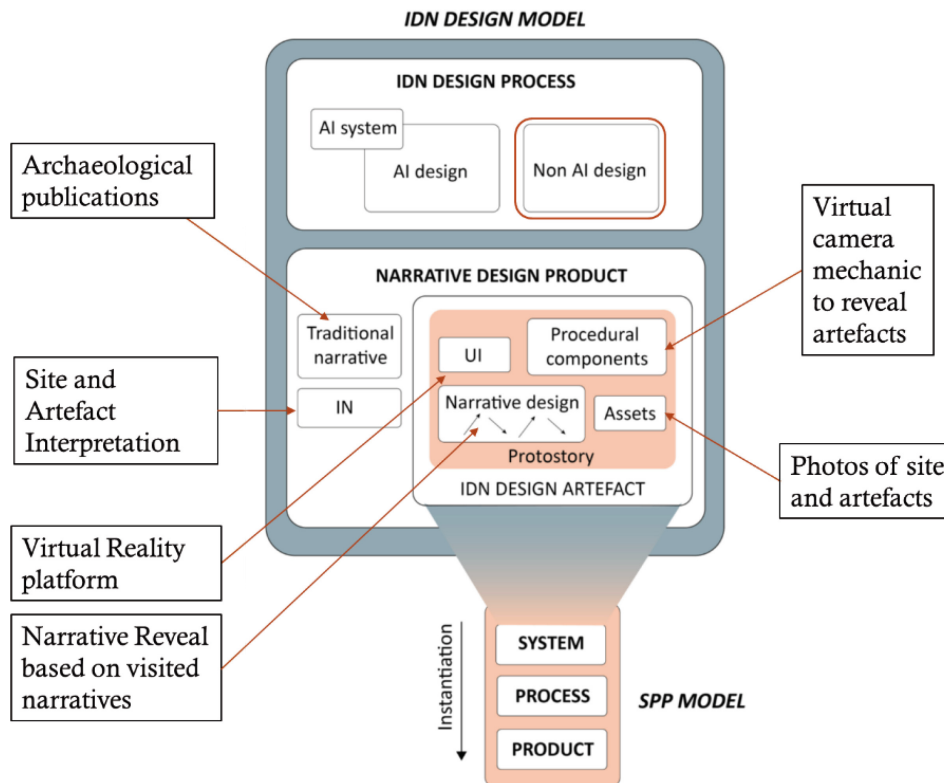


Fig. 1. Mapping the IDN to the IDN Design Process (Serbanescu and Koenitz [44]).

foundational beliefs. This network of narratives builds upon, or counters each other's observations, providing a Coherentism approach to belief construction that completes the Foundherentism approach mentioned earlier. A set of questions about the site are presented to the interactor as narrative goals to seeks answers to.

From the above publications, statements are extracted as evidence to support particular perspectives attributed to these authors. Narrations are then adapted to create a conversation between the different perspectives. As assets for the IDN design artefact, a 3D model of the site was acquired from SketchFab⁴ while photos of points of interest (POIs) were taken on site or in the National Museum of Archaeology where the originals have been conserved. The procedural component of the IDN design artefact is implemented as a virtual camera interface provided within the experience: POIs are hidden from the virtual site but can be seen through the camera and are revealed when a virtual photo of them is taken. This triggers the different perspectives to be made available by accessing the respective author's field notebooks in which they share their opinions on the meaning or use of the revealed artefact. The narrative design is such that reading each narration triggers further narrations by the same author but also by other authors, giving life to a conversation among archaeologists and historians across time and space, each presenting justifications for their argument. When reviewing these narratives, the interactor is presented with the corresponding paragraph from the author's publication that supports that narrative, shown diegetically on the large virtual screen (see Fig. 2).

⁴ <https://sketchfab.com/3d-models/tarxien-temple-f8c1e7518f1641c1b77f4ab66a9fe13f>.

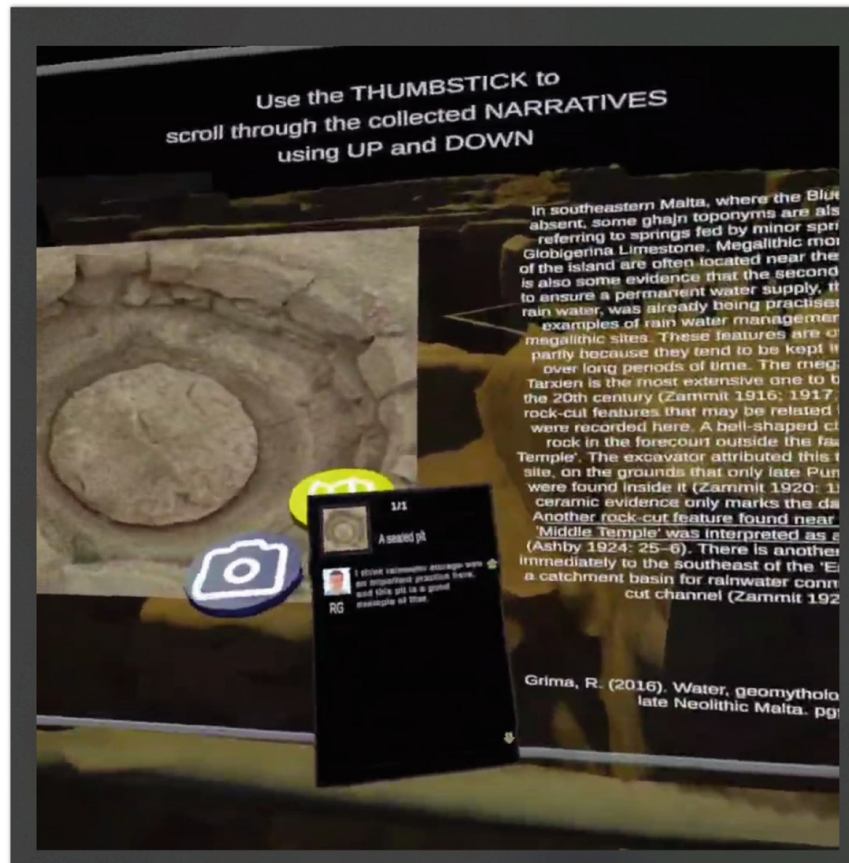


Fig. 2. Supporting the narrative with publication extracts

The result is an IDN system in which the interactor decides when, and which, perspectives to engage with, while forming their own interpretation of the site and artefacts based on, or in spite of, the presented information. The product of their interaction manifests itself when they decide to answer the questions set in the outset as their goal. Each one asks a typical question about some artefact found on site, or the relationship between site features and artefacts. Subjects include the use of the sealed pit in the ground, the identification of the animal(s) represented on the bas relief on the wall, and the relationship between the bas relief and the bone deposits discovered in the same room. To answer the questions, the interactor is asked to choose a discovered narrative upon which they base their answer and then voice record their own response to the question. In this way, interactors are prompted to make their own interpretation based upon published research, in line with Foundherentism [20].

It may happen that not all narratives relative to a question are discovered before the interactor attempts to answer it, and that additional narratives are discovered later on while looking for information to answer other questions. In this case, the interactor always has the opportunity to re-visit a previously answered question, citing the newly discovered narrative as they provide an alternative interpretation. This is in line with the perspectival dimension of belief [18].

5.2 Measuring Uncertainty in IDN

Van der Bles *et al.* explored the representation of epistemic uncertainty around basic facts and numbers and its impact on trust, and showed a slight decrease in public trust and perceived reliability of the data representation, particularly when uncertainty was made explicitly verbal (i.e., “could be somewhat higher or lower”) [47]. These authors’ instrument consisted of a questionnaire that first measured participants’ feeling (positive or negative) after having read the account, then the perceived uncertainty and trustworthiness of the figures presented, the trustworthiness and competence of the statisticians responsible for producing the figures, and the trustworthiness of the journalist writing the story in which the figures were presented [47].

We used this as a model for measuring uncertainty in our IDN by asking how certain the interactor is of their voiced response and how much trust they put into the narrative chosen to support their answer, thus having the interactor reflecting upon, and evaluating, their choices in the IDN. In addition, we let the interactor rate the trustworthiness and competence of the author of the chosen narrative, as well as the trustworthiness of the IDN designer(s). This questionnaire (see Table 1) is presented diegetically in the VR experience and immediately after each registered vocal response to minimize the time between decision-making and reporting upon it. Each criterion is rated using sliders to provide a Likert scale rating.

Table 1. Diegetic questionnaire items

Question	Likert Scale
1. How does the information you just read make you feel?	0 - negative/unhappy to 10- positive/happy
2. How certain are you of your response?	1 (very certain) to 7 (very uncertain)
3. How trustworthy do you think is the narrative you chose to support your answer?	1 (not trustworthy) to 7 (very trustworthy)
4. How trustworthy do you think is the author of the narrative you chose to support your answer?	1 (not trustworthy) to 7 (very trustworthy)
5. How competent do you think the author of the narrative you chose to support your answer?	1 (not competent) to 7 (very trustworthy)
6. How trustworthy do you think the experience designers responsible for writing this VR experience are?	1 (not trustworthy) to 7 (very trustworthy)

5.3 IDN as a Process of Inoculation

The instrument described above helps the interactor to reflect upon their procedural knowledge: in choosing a narrative to base their response upon, how certain were they of their response? However, the questionnaire does not measure the interactor’s understanding of how to counter arguments that challenge their understanding. Thus, we propose to augment the above with a non-diegetic evaluation process (to minimise cybersickness

or tiredness from VR) wherein the interactor is presented with a number of claims, some of which are coherent with the perspectives presented in the experience and some of which are counter to said perspectives, and the interactor is invited to choose a claim to challenge by presenting a counter-argument. This can be recorded in text or voice recorded. Their ability to choose a claim to counter and justify their choice with information gathered from the experience would indicate a successful inoculation process within the IDN.

5.4 Validation

An expert review of the IDN and the diegetic questionnaire (but not of the inoculation test exercise at this stage) was carried out with three cultural heritage experts (a senior curator, a coordinator, and a curator for prehistoric sites, including Hal Tarxien Prehistoric Complex) using heuristic evaluation. The heuristics were based upon criteria set out during a preliminary meeting with the senior curator prior to the project's commencement, and are presented below:

1. The experience empowers the visitors with the ability to question what they are being shown
2. The experience empowers the visitors with the ability to ask for the evidence for the interpretation
3. The following message is being conveyed to the visitor: Uncertainty is not a bad thing - open to reinterpretation and experimentation
4. The following message is being conveyed to the visitor: There is no hard truth
5. The experience allows the visitor to tell their own story
6. The experience allows the visitor to take an active role in the past

After each expert tried out the VR IDN experience and answered at least one question, they were presented with a questionnaire, measuring the above heuristics using a 5-point Likert scale. All criteria attracted a response of Agree, except for (3) and (5) which attracted a Strongly Agree from the Co-ordinator and Senior Curator respectively, the latter remaining Neutral on item (6).

6 Discussion

While the heuristics used during the validation process do not relate directly to the measurement of uncertainty, they reflect properties of the IDN that facilitate the representation of uncertainty and the agency afforded to the interactor to navigate through the multiple perspectives leading to this uncertainty.

The first heuristic was about empowering the visitor with the ability to question what they are being shown. This reflects upon the IDN's affordance of narrative interaction compared to a static information panel representing the curator's perspective. In the IDN, the interactor is presented with the ability to consult with archaeologists and historians upon whose research interpretations can be made, to answer questions about a cultural heritage site. The experts' unanimous agreement with this statement reflects a positive acknowledgement of this affordance in IDNs.

Empowering the visitors with the ability to ask for the supporting evidence for an interpretation reflects upon the ‘drilldown ability’ of IDNs where interactors can trace each narrative’s source to the author’s publication rather than accept the curator’s interpretation at face value. The experts’ unanimous agreement with this statement reflects a positive acknowledgement of this affordance in IDNs.

Conveying the message that “Uncertainty is not a bad thing – open to reinterpretation and experimentation” to the visitor is a reflection on the IDN’s ability to represent uncertainty. The coordinator claimed that, rather than being uncertain, they are “certain that we cannot know,” which reflects a level of competence beyond what is attributed to science when presenting uncertainty [47]. The coordinator strongly agreed with this statement when evaluating the IDN, a mark of quality on the IDNs ability to represent uncertainty. This sentiment is also reflected in the experts’ unanimous agreement that the message “there is no hard truth” is being conveyed to the visitor.

The IDN’s ability to allow the interactor to choose which narratives to read, and in which order once they are made available, and which one to consider for its response to the question with their own interpretation was acknowledged by the experts’ unanimous agreement with the heuristic of allowing the visitor to tell their own story.

Lastly, whether the interactor was able to take an active role in the past was a divisive issue between the experts and the senior curator. Certainly, the present work provides the interactor with the ability to take an active role in the interpretation of the past, but not a re-enactment of the actual past.

7 Evaluation Framework

We now abstract the above approach into an evaluation framework made up of two components: a reflective component and a procedural component.

The first component of the evaluation framework uses a questionnaire to provide a reflective analysis of the interactor’s encounter with uncertainty and its impact on perceived trust and competence. The subjects of these questions are the uncertain data itself, the trustworthiness and competence of the authors of the data, and the trustworthiness of the VR experience designers presenting this data in. The rationale being that data presentation may skew the author’s original data in favour of the designers’ own bias.

The second component is a challenge to the information acquired from the IDN experience, in the form of claims that the interactor is invited to accept, or refute by drawing on their recently justified beliefs, using procedural knowledge skills of refuting counter-arguments learnt from the IDN’s archaeologist statement as dialogue.

8 Conclusion

IDNs have a role to play in the representation of uncertain history, giving interactors the ability to challenge a grand narrative through engagements with the historical record. Evaluation techniques to assess IDNs’ ability to teach interactors how to navigate historical uncertainty are missing in the literature. While evaluation emphasis focused on user experience [23] and declarative knowledge learning, a demand for diegetic procedural knowledge learning was made manifest [25].

In this paper, we proposed an evaluation framework that helps determine the effectiveness of an IDN to deliver knowledge in a context of historical uncertainty and sought to evaluate not only the acquisition of declarative knowledge but also procedural knowledge learning to handle such conflicting perspectives. This evaluation framework was supported by a VR IDN implementation of a prehistoric complex, presenting alternative interpretations based on published research upon which the interactor was invited to answer questions about the historical site. Cultural heritage experts validated this IDN and its ability to empower interactors to question the grand narrative and take an active role in the interpretation of the site.

Future work should develop this IDN further by covering more areas within the site as well as validate the framework's second component that qualifies IDNs as an inoculation process.

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