Digital Storytelling and Engagement in Exhibitions about Shipping

Digitale fortellinger og engasjement i utstillinger om sjøfart

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ABSTRACT

Museums and Science Centres are informal education environments that intend to engage the visitors with their exhibitions. The installation 'The Highway of the Seas' in the exhibition *Norway is the Sea* is a game that teaches players the roles of people employed in shipping and tasks related to shipping from the perspective of a ship operator. We investigate the narrative elements of this installation, how to characterise these, and their impact on engagement. Using such characteristics, informed modifications that increase engagement can be made. Further, we compare aspects of 'The Highway of the Seas' with two other installations in a study and find that 'The Highway of the Seas' is the most engaging serious game of these three.

Keywords

serious games, digital storytelling, assessment, installation, exhibition, science centres, museums, visitor engagement

SAMMENDRAG

Museer og vitensentre er miljøer hvor uformell læring finner sted og der besøkende skal engasjeres ved at de bruker utstillingen. Installasjonen 'Sjøens Motorvei' i utstillingen *Norge er havet* er et spill som formidler til spillerne hvilke roller ansatte innen sjøfart har og hvilke oppgaver de gjennomfører fra perspektivet til en reder. Vi undersøker de narrative elementene i denne installasjonen, hvordan disse bør beskrives, og den innflytelsen de kan ha på engasjement. Med denne vurderingsmetodikken kan endringer i installasjonene planlegges og gjennomføres slik at engasjement økes. Videre sammenligner vi aspekter fra 'Sjøens Motorvei' med to andre installasjoner, der 'Sjøens Motorvei' er det mest engasjerende av disse tre.

Nøkkelord

læringsspill, digital formidling, vurderingsmetodikk, installasjon, utstilling, vitensenter, museum, besøksengasjement

INTRODUCTION

The Norwegian Maritime Museum (NMM) in Oslo was established in 1914 and relocated to its present premises on the Bygdøy peninsula in the late 1950s. The museum's subject matter and exhibitions are on Norwegian coastal culture, maritime archaeology and international shipping, with a time span ranging from prehistory until current times. The subject matter for this article, the learning game/installation 'The Highway of the Seas'[1], opened to the public in spring 2014. It was part of a new permanent exhibition (*Norway is the Sea*), which was one element in a pervasive restructuring of the museum that started in 2006.

The renewal program for the NMM went through several phases. The plans for new permanent exhibitions were put into action from 2008.[2] By then, the museum had over the

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1. The installation has the Norwegian title 'Sjøens motorvei'. In previous publications, we have also referred to it as 'The Motorway of the Ocean'.
2. *Det nye Sjøfartsmuseum (The New Maritime Museum)* [in Norwegian], Norwegian Maritime Museum Archives: Opplysningsarkiv 069.5 (480), Utkast til sluttrapport fra forprosjektet 20.2.2007 (Norsk Maritimt Museum, 2007); Cathrine Stang et al., *Forandringens vind blåser over Bygdøynes. Nye basisutstillinger på Norsk Sjøfartsmuseum (The wind of change blows over Bygdøynes. New basic exhibitions at the Norwegian Maritime Museum)* [in Norwegian], Norwegian Maritime Museum Archives: Opplysningsarkiv 069.5 (480) (Norsk Maritimt Museum, May 5, 2008).

previous ten to fifteen years lost about half of its annual visitors. The museum management publicly expressed that the museum had suffered a "period of stagnation".[3] A renewal, especially in the shape of more interactive forms of visitor involvement, was the order of the day. The expressed purpose was to attract families and younger audiences, most of whom had scant or non-existing relationships to shipping or the maritime industries. The success of the Norwegian Museum of Science and Technology[4] inspired the renewal process.

The fund raising for the effort, dubbed the NMM Partners, managed to raise about forty million Norwegian kroner from a variety of Norwegian companies in the shipping and off-shore industries. The target year for the renewal was the museum's centennial in 2014. The didactic vision bore influence of the cooperation with people in the maritime industries:

> A strong and interest-provoking national maritime museum is of importance for the recognition and understanding of the economic and cultural significance for Norway of shipping and offshore activities. It will enhance the standing of the maritime businesses, and contribute to a positive assessment of the role played in the Norwegian and international community by sailors, ship owners, brokers, ship builders and other members of the maritime cluster.[5]

The renewal resulted in more than two thousand square meters of new, basic exhibitions.[6] Three large spaces were supplied with new content:[7] a) *The Ship* in 2010, an architect-designed passageway covering technical developments in sea transport, from the oldest boats to current specialised vessels; b) *At Sea!* which opened in late 2014 and focuses on the human aspects of being at sea. The exhibition presents twelve historic persons that are fictional representatives of their respective epochs and places in the society in the form of a ship; and c) *Norway is the Sea*, launched in Spring 2014.

Norway is the Sea is closer in its approach and content to a learning arena or a science centre[8] than to traditional, object-based exhibitions. It comprises several installations, including two developed from actual simulator software from the Norwegian maritime industry. The core of the exhibition is the interactive learning game 'The Highway of the Seas', covering an area of about twenty square meters. We will return to the narrative structure of both the overall exhibition and the installation below.

The installation 'The Highway of the Seas' is typical for science centres and museums that present exhibitions, installations, and educational programmes built to engage visitors for self-education on a subject and to inspire visitors to learn more. A distinguishing feature of 'The Highway of the Seas' is the duration of the game. Depending on the visitors' decisions and the number of participants in the game, it takes between ten to fifteen min-

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3. Bjørn Segrov, «Maritim museumsdugnad (Maritime voluntary work)» [in Norwegian], newspaper article, *Dagens Næringsliv* (September 16, 2009): 52–53.
4. Norsk Teknisk Museum in Oslo, www.tekniskmuseum.no.
5. *Partnerskap for Norsk Sjøfartsmuseum 2010-2014 (Partnership for the Norwegian Maritime Museum 2010-2014)* [in Norwegian], Fundraiser brochure, our translation (Norsk Maritimt Museum, 2010).
6. The renewal also entailed a new library, new visitor centre facilities, a museum shop and a café.
7. Eyvind Bagle, «Nye utstillinger til en hundreåring (New exhibitions for a centenarian)» [in Norwegian], in *Norsk Maritimt Museum Årbok (Yearbook of the Norwegian Maritime Museum) 2014* (Norsk Maritimt Museum, 2015).
8. It is also marketed as such on the museum web site: https://marmuseum.no/en/ exhibitions?kp_id=74:401:4869 (retrieved July 27, 2018).

utes once the player decides to stay on for the whole experience. There is little data showing how well such installations perform in transferring knowledge to the visitors.

Assuming that engagement is an important ingredient in this, our research question is to find the relevant factors that can engage the visitors. Further, we want to find out how to implement these factors, with an emphasis on the role of the narrative or story that is contained in installations.

In the following, we first set the installation into its cultural and historical context, before we describe visitor studies at the NMM. Thereafter, we take a closer look into the narrative of 'The Highway of the Seas' and the factors that might foster increased visitor engagement when they are using the installation. We show how one can characterise installations and their narratives based on our research[9] and methods from the literature. Further, we are interested in how to modify installations in ways that would increase the visitors' engagement. We demonstrate the concepts and characteristics using the installation 'The Highway of the Seas'. We also compare this installation with two other installations in a study, where engagement factors are discussed.

AN 'INVISIBLE INDUSTRY' ON DISPLAY

The preliminary reports in the museum archives and the tender documents for *Norway is the Sea*[10] signpost that this exhibition was expected to make sense of certain complexities and paradoxes. The museum management decided that this space would be designated for the presentation of current themes in (Norwegian) shipping and the maritime world, i.e., the emphasis was on the changes after the 1960s. The museum needed to convert this vast and crucial, but at the same time opaque, subject matter into an engaging and learning experience for new visitor groups.

Even economists working with maritime business, and denoting it as a "key industry" of the global economy, have labelled it an "invisible industry".[11] This alludes to an absence of maritime research in mainstream works on economic growth and globalisation. The academic invisibility reflects a general indifference or unawareness towards maritime affairs. Scaling down to Norway, although its maritime industry in all its permutations is a considerable employer, export revenue earner and cultural force, its economic significance has been relatively diminished by the offshore oil and gas sectors from the 1970s onward.[12]

9.   Wolfgang Leister et al., «Assessing Visitor Engagement in Science Centres and Museums,» *Journal on Advances in Life Sciences* 8, nos. 1&2 (2016): 49–63; Wolfgang Leister et al., «An Evaluation-Driven Design Process for Exhibitions,» *Multimodal Technologies Interact.* 1, no. 4 (2017): 25, ISSN: 2414-4088, DOI: https://doi.org/10.3390/mti1040025.

10. Norwegian Maritime Museum, *Norge er havet – Budskap, tema og innhold (Norway is the Sea – Message, theme and content)* [in Norwegian], unpublished tender document for the exhibition, January 30, 2012.

11. Gelina Harlaftis, Stig Tenold, and Jesús M. Valdaliso, «Epilogue: A Key Industry or an Invisible Industry?,» in *The World's Key Industry: History and Economics of International Shipping*, ed. Gelina Harlaftis, Stig Tenold, and Jesús M. Valdaliso (London: Palgrave Macmillan UK, 2012), 263–272, ISBN: 978-1-137-00375-1, DOI: https://doi.org/10.1057/9781137003751_15.

12. Erik W. Jakobsen and Christian Svane Mellbye, *Maritim verdiskapingsbok 2015 (Maritime Value Creation Book 2015)* [in Norwegian] (Maritimt Forum, 2015), accessed August 6, 2018, https://www.menon.no/publication/maritim-verdiskapingsbok-2015/.

Arguably, the maritime world looms larger in the public consciousness on Western, Southern and Northern shores of Norway than its South-eastern region. The latter surrounds the capital of Oslo, where the NMM is situated.

Some of the complexities and invisibilities of the local connection to modern shipping merit some historical perspectives.[13] Norway has had a tradition as one of the world's leading shipping nations since the middle of the 19th century. The capital city Oslo (Kristiania before 1925) has been one of the world's leading shipping centres since the early 1900s. Ships flying the Norwegian flag have been seen in ports all over the world, until the 1980s mostly manned by Norwegian sailors from all parts of Norway, including both coastal and inland regions of Eastern Norway. However, the international shipping crises of the 1970s and 1980s, along with great structural and technological changes in the business, has fundamentally changed this. Container ships have removed port activities from city centres, in Oslo and elsewhere.

Shipbuilding has become globalised and mostly moved out of the country. A considerable number of Norwegian ship owners have registered their fleets abroad, and the number of Norwegian sailors has decreased dramatically. Ships that still fly the Norwegian flag are to a great extent registered in the Norwegian International Ship Register (NIS), which allows the use of foreign sailors on foreign tariffs to the detriment of more expensive Norwegian labour. The typical sailor on Norwegian ships is now recruited from the Philippines, India or Eastern Europe. The only important exception to all these developments is the huge offshore fleet, catering for the gas and oil business on the Norwegian continental shelf and worldwide, owned to a great extent by local companies in small fishing villages and towns in Western Norway. The vessels are still mostly manned by Norwegian sailors, who are often recruited locally.[14]

In the globalised economy of the 21st century, sea transport is even more important than before to industries and consumers in our country, as in most other countries. Norway is still an important player in international shipping, and Oslo is still an important shipping hub, with great ship owners directly or indirectly controlling a large fleet. Further, some of the most important international insurance companies, banks and law firms that serve the shipping business are based in Oslo. However, this is far less visible to the general public now than one or two generations ago, when Oslo was a busy commercial port, and ship yards there built tall ships in the very centre of the city – and when being a sailor was a common occupation, especially as an age-role for young men.

Youngsters growing up in Oslo in the early 21st century are not very likely to have relatives who are or have been sailors, or to have other references to shipping that makes maritime history evidently interesting to them. Making maritime history relevant for new generations of visitors is a major challenge for the museum.

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13. Bagle, «Nye utstillinger til en hundreåring.»

14. See, e.g., Peder Figenbaum et al., «Verdens fraktemenn: Norsk internasjonal skipsfart gjennom 1000 år (The world's carrying men: Norwegian international shipping during 1000 years)» [in Norwegian], *Fortellinger om kyst-Norge* 5 (2009), http://www.kyst-norge.no/?ID=13787&K=2909; Pål Christensen and Ketil Zachariassen, «Det nye kyst-Norge (The new coastal Norway)» [in Norwegian], in *Havet, fisken og oljen 1970-2014: Norges fiskeri-og kysthistorie vol IV*, ed. Pål Christensen (Bergen, Norway: Fagbokforlaget, 2014), 145–153, ISBN: 978-82-321-0427-7; Statistics Norway, *Færre sysselsatt i sjøfart (Fewer employed in shipping)* [in Norwegian], web pages, accessed 6 September, 2018, https://www.ssb.no/transport-og-reiseliv/artikler-og-publikasjoner/faerre-syssel-satte-i-sjofart.

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MAKING A GAME

The installation 'The Highway of the Seas' is a game experience designed to address the kind of complexities treated above. Development started with workshops at the shipbroking company RS Platou.[15] The cooperation with professionals ensured a realistic impression of the multifarious operations behind sea transport between Asia, South America and Europe. The brokers assisted in constructing a suitable system for rewards and penalties, and mapped out the different considerations in modern shipping. The game soon developed into a set of dialogues between the captains of the ships, the shipping agents, and the brokers.
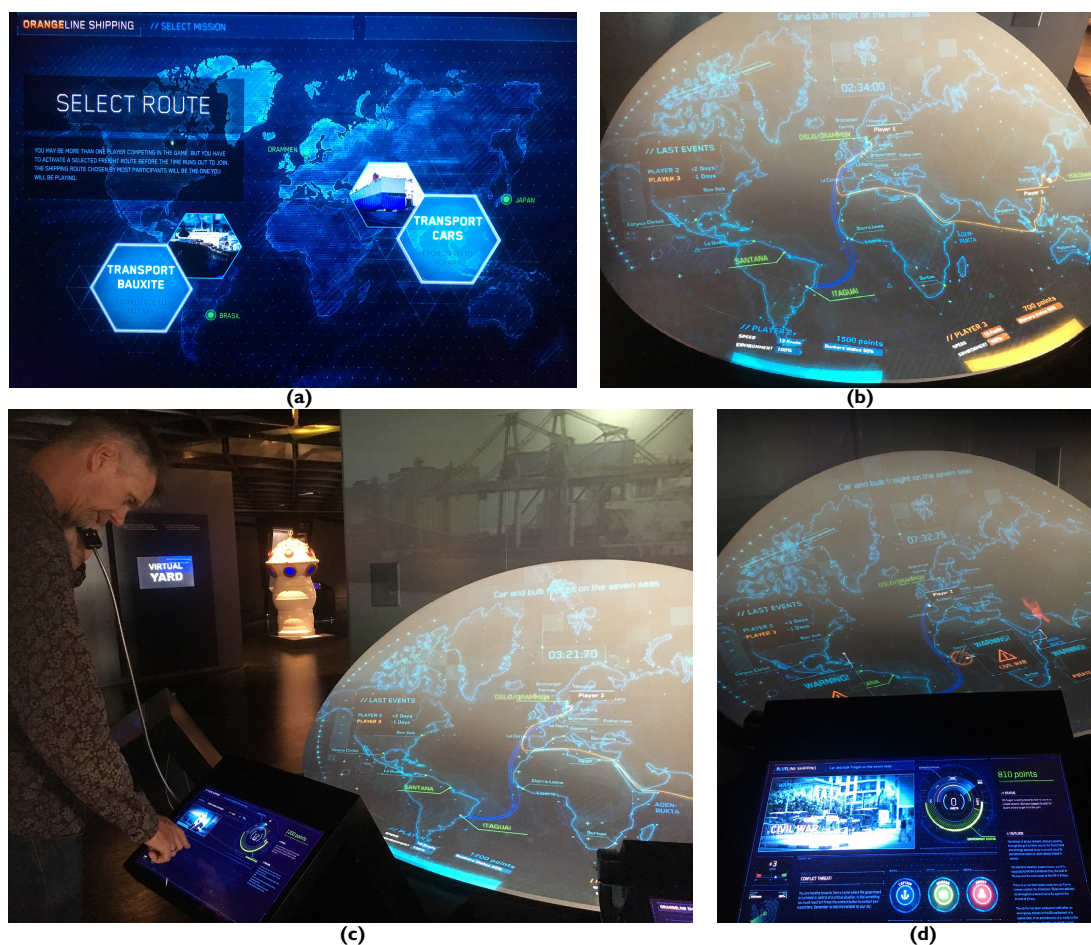
Figure 1: Views of the installation 'The Highway of the Seas'. Images by Göran Joryd.
(a) Selecting a freight task; screen image. (b) The globe showing the game progress. (c) A visitor playing the game and taking informed decisions from information shown on the console and by listening to audio messages. (d) Console and globe during the game; note the alert messages in orange on the globe.

15. Clarksons PLC acquired RS Platou ASA in February 2015. As a consequence, RS Platou is now renamed to Clarksons Platou AS.

The players can choose between two different sectors of shipping: carrying minerals in bulk from South America, or cars and other vehicles on ro-ro ships[16] from South-East Asia to Europe. In choosing their routes (see Figure 1a), they need to take into consideration economic and environmental issues. Further, they have to take decisions on how to deal with different technical, meteorological, and political problems that may occur at sea, such as machinery that needs to be repaired, fuel supplies that are running out, hurricane alerts in the Caribbean Sea, civil war and closed harbours in Sierra Leone, or pirate threats in the Gulf of Aden. Some of these challenges can be seen on the globe in Figure 1d.

In the game, up to four players compete against each other as ship operators. Each player controls one vessel at a console that is placed in front of a large map of the sea trade routes on the world's oceans (Figure 1b). Throughout the course of the game, players make informed decisions as the ships travel across the oceans to their destinations (Figure 1c). These decisions concern the speed of the vessel, whether or not to take on extra cargo, bunker oil, how to deal with weather or pirates, and so on. The progress of all vessels in the game is displayed on a projection wall showing a globe, visible for all.

VISITOR STUDIES AT THE NORWEGIAN MARITIME MUSEUM

Museums like the NMM present in their exhibitions a variety of exhibits and installations with a variety of characteristics for a variety of target groups. Methodology for visitor studies has been developed since the late 19th century to evaluate exhibits, starting with Higgins,[17] who noted that observations of visitors and asking them for their remarks might result in valuable information. Leister et al.[18] gave an overview of such methods, classified into visitor-centred and installation-centred approaches. To evaluate exhibits, Shettel et al.[19] presented an early installation-centred approach, based on visitor observations and questionnaires using the technology available at that time, such as video tape recordings. They observed how visitors behaved toward installations to determine how effective an exhibit is.

Similar to many museums, the NMM performs traditional questionnaire-based studies on how visitors perceive the museum, in addition to statistics about the visitors. They assess statistical data from ticket sales, collect feedback from visitors, record observations, and perform segmentation of visitor groups into adults, children, students, pensioners, school classes, and, to some degree, of whether visitors are domestic or from abroad. Questionnaires have only been developed in connection with specific projects.

Until recently, studies performed at the NMM have been more visitor-centred than installation-centred, as they are based on observations of the visitors and their interaction

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16. Roll-on/roll-off (ro-ro) ships are vessels designed to carry wheeled cargo, such as cars, trucks, semi-trailers, trailers, and railroad cars, that are driven on and off the ship on their own wheels or using a platform vehicle, such as a self-propelled modular transporter. This is in contrast to lift-on/lift-off (lo-lo) vessels, which use a crane to load and unload cargo. Source: Wikipedia.

17. Henry Hugh Higgins, *Museums of Natural History: Part I. Museum Visitors* (D. Marples, 1884).

18. Leister et al., «Assessing Visitor Engagement in Science Centres and Museums.»

19. Harris H. Shettel et al., *Strategies for determining exhibit effectiveness*, technical report AIR E-95-4/68-FR (Washington, DC: American Institutes for Research, April 1968).

with the installations. These studies focused on the learning aspect, whether the visitors enjoyed their visit, whether an installation worked as intended, and how installations could be changed for a better presentation of their content.

In 2011, the project 'Dialogues in Museum Spaces: examining the boundaries of exhibition practices', in collaboration with Intermedia[20] at the University of Oslo, received funding from the Arts Council Norway. This project compared the communication between visitors and the museum to gain insights into learning in three contexts: a) *The Ship* as representative for a traditional, but rather new and modern exhibition with interactive elements; b) the *Boat Lab*, a partially physical and partially digital exhibition room about the reconstruction of boats; and c) *Modelling of Facts and Things* as an example for the learning-by-doing paradigm.

Results from this project have been published by Dahl and Planke, Dahl and Stuedahl, and Nordal,[21] and as popular science articles about the *Boat Lab*.[22] A major approach is master–apprentice learning as museum pedagogy – that is to say, voluntarism attached to tradition-based knowledge.[23] Further, the project addressed object-based mediation – how can tactile, concrete, and sense-based interaction with the object or a substitute open up for interdisciplinary learning and provide multiple layers of experience and knowledge?

Sandsmark[24] performed field work at the NMM as part of his bachelor degree at the Department of Humanities and Cultural Studies, Telemark University College[25] and in connection with the project 'Dialogues in Museum Spaces: examining the boundaries of exhibition practices'. His work evaluates visitors' movements in and interaction with the exhibition *The Ship* and provided valuable contributions on how to develop both this and future exhibitions. In Sandsmark's study, 556 persons were observed; 96 interviews were given, and 11 visitors answered a written survey to answer the research question: *How do visitors use the exhibition* The Ship*, and how does the exhibition relate to the term 'dialogue' in Norwegian museum policy?*

Surprisingly, the interactive elements did not attract more attention than the more traditional elements in the exhibition, while still objects seemed to create most dialogue between the visitors and the museum.

20. Now: Department of Education.
21. Mette Irene Dahl and Terje Planke, «Man or Vitrine – Investigating Museum Dialogues» in *Norwegian Arts Council conference "Museale praksiser"* (2012); Mette Irene Dahl and Dagny Stuedahl, «Transforming Children's Participation and Learning in Museums: From Singular Dialogues to a Multilayered Explorative Experience,» in *Proc. DREAM Conference: The Transformative Museum* (Roskilde University, May 2012); Snorre Nordal, «Science Centres and Museums as Rooms of Revelation (RoR) in Science Education,» in *Abstracts for seminar on Science Centre Research* (skolelab.no, September 2012), https://skolelab.no/innsendt/skolelab.no/kurs/711/2012-10-08_135131-Nordal_Abstract_DeWitt_seminar.pdf.
22. Terje Planke, «Båt i pølsebua: en av tre artikler om Vaaghals (Boat in a hotdog stand: one of three articles about Vaaghals)» [in Norwegian], *KYSTEN* 2 (2011); Terje Planke, «BåtLab'en ved Norsk Maritimt Museum (The BoatLab at the Norwegian Maritime Museum)» [in Norwegian], *IKONs tidsskrift* sommeren (2011).
23. Mette Irene Dahl, «Master-Apprentice Learning as Museum Pedagogy – Voluntarism Attached to Tradition-Based Knowledge,» *Journal of Lifelong Education* special issue on museum pedagogics (2018).
24. Per Magnus Finnanger Sandsmark, «Mellom opplevelse og læring – En undersøkelse av publikums bevegelse og interaksjon i utstillingen Skipet (Between experience and learning – A study of visitors' movements and interactions in the exhibition The Ship)» [in Norwegian] (bachelor's thesis, Høgskolen i Telemark, 2011).
25. Now: University of South-Eastern Norway.

In a recent publication drawing further on his field work at the NMM, Sandsmark[26] used *The Ship* and an exhibition at the Norwegian Museum of Cultural History[27] to show how visitors behave in museums that exhibit intangible cultural heritage; that is, for example, knowledge about craftsmanship, the use of artefacts and the history behind objects and subjects in the exhibition.

Using observation techniques, Sandsmark finds that artefacts presented in museums are often attractions that foster conversations between visitors, and they discuss intangible cultural heritage from their own experience. He finds that visitors use less time in the exhibition when there is a lot of text. The intangible actions and processes are most understandable for the visitors when they are presented as photos, videos, models and demonstrations.

Although the knowledge conveyed to visitors in 'The Highway of the Seas' is intangible as well, it cannot be as easily presented with single artefacts, such as ship models, in the same manner as craftsmanship. Knowledge of shipping is dependent on a narrative that can show the consequences of one's actions; in the case of 'The Highway of the Seas', as a ship owner. For instance, the use of too much bunker oil on a trip, or missing a delivery deadline, cannot be presented visually in a single model. When using narratives as a means of presenting knowledge, we need to examine which are the necessary qualities in installations that present this knowledge.

NARRATIVES IN INSTALLATIONS

In this section, we draw attention to how narratives and stories have traditionally been defined in narrative theories. Against this backdrop, we review digital storytelling. Stokes[28] writes that it is very difficult to come up with a definition of narrative that is more illuminating than "story-like." Aristotle's classic model of a plot and his dichotomy between diegesis (a narrator telling the events, representation) and mimesis (an event not told but enacted) is often referred to, because narration is not only about the content, but about the way the information in a story is distributed. An installation in a museum is a medium conveying a story about a subject.

Genette[29] distinguishes between récit and narration, the latter being statements used to communicate the story – "the producing narrative action and, by extension, the whole of the real or fictional situation in which that action takes place".[30] A narrative is composed of three distinct layers: a) the story consisting of events arranged in the temporal order within the fictional world; b) the discourse consisting of events re-organized in the temporal order in which they are presented to the audience; and c) the narration, which is the act of nar-

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26. Per Magnus Finnanger Sandsmark, «Å stille ut handlingar. Immateriell kulturarv på utstilling (To exhibit actions. Intangible cultural heritage on display)» [in Norwegian], *Norsk museumstidsskrift* 3, no. 2 (2017): 42–59, ISSN: 2464-2525, DOI: https://doi.org/10.18261/ISSN.2464-2525-2017-02-02.

27. Norsk Folkemuseum, https://norskfolkemuseum.no.

28. Patrick Stokes, «Is Narrative Identity Four-Dimensionalist?,» *European Journal of Philosophy* 20, no. S1, E86–E106, DOI: https://doi.org/10.1111/j.1468-0378.2011.00485.x.

29. Gérard Genette, *Narrative Discourse: An Essay in Method* (Cornell University Press, 1983), ISBN: 978-0-8014-9259-4.

30. Ibid., 27.

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rating a story and the concrete situation in which the story is conveyed through a physical medium.[31] Genette separates the medium-independent discourse structure from the medium-dependent narration choices. With this model as the reference, some researchers argue that it is not possible to translate a story from one medium to another medium without changing the story itself. As Jannidis puts it, "narrative should always be treated as something anchored in a medium."[32] There are differences between one medium and another, but also "the 'content' of any medium is always another medium."[33]

'The Highway of the Seas' is about sea transportation, events that might occur as ships sail from one harbour to another, decisions that have to be made, and so on. Digital storytelling is one of many components in installations, often referred to as the narrative component. Here, the medium is digital, or combined with other media or formats. Many authors only discuss digital storytelling. This is not surprising because technology is everywhere and constitutes a key element in many installations and the topic they want to convey. Thus, a digital-analogue dichotomy has become less meaningful. As an example, we mention installations that can be characterised as computer games. Computer games have "all the basic ingredients of a narrative: characters, events, settings and trajectories leading from a beginning state to an end state."[34]

Digital Storytelling

Storytelling consists of several elements, such as the events in the underlying narrative, the plot, timing, dramaturgy, and interactivity. The work of Lambert[35] and his colleagues at the University of California at Berkeley is often cited with regard to digital storytelling.[36] To creatively inspire storytellers, they identified seven elements of effective digital storytelling: 1) point of view (main point of the story and the perspective of the author), 2) a dramatic question, 3) emotional content (connect the audience to the story), 4) the gift of your voice (personalise the story to help the audience understand the content), 5) the power of soundtrack (music and sounds to support and embellish the story), 6) economy (using just enough content), and 7) pacing (the rhythm of the story and its progress). For educational digital stories, further elements are recommended: 8) choice of content, 9) quality of media elements, and 10) good grammar and language use. These elements, and this approach, were taken into consideration when developing 'The Highway of the Seas', but they are not the basis for the engagement profile, because the ele-

31. Rémi Ronfard and Nicolas Szilas, «Where Story and Media Meet: Computer Generation of Narrative Discourse,» in *2014 Workshop on Computational Models of Narrative, CMN 2014, July 31 - August 2, 2014, Quebec City, Canada*, vol. 41, OASICS (Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, 2014), 164–176, ISBN: 978-3-939897-71-2, DOI: https://doi.org/10.4230/OASIcs.CMN.2014.164.

32. Fotis Jannidis, «Narrative and Narratology» in *Handbook of Narratology*, ed. Tom Kindt and Hans Harald Müller (De Gruyter, 2003), p. 50, ISBN: 3-11-017874-5.

33. Marshall McLuhan, «Understanding Media: The Extensions of Man» chap. The Medium is the Message (1964; Cambridge: MIT Press, 1994), 17–36.

34. Marie-Laure Ryan, «Computer Games as Narrative: The Ludology vs. Narrativism Controversy», in Avatars of Story, (University of Minnesota Press, 2006), 181.

35. Joe Lambert, *Digital storytelling: capturing lives, creating community* (Routledge, 2002), ISBN: 0415627036.

36. See, e.g., Sara Kajder, «Visual Ways to Engage Reluctant Readers,» chap. 2 Personal Narrative and Digital Storytelling (Stenhouse Publishers, 2006).

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ments of digital storytelling are – according to their authors – "a framework of the discussion of the aesthetic quality".[37]

Spierling[38] described *interactive digital storytelling* as a hybrid form of game design and cinematic storytelling. She mentioned four disciplines as the most influential: 1) generative computer graphics, animated storytelling for film production;[39] 2) human-computer interaction (HCI); 3) computer game design; and 4) artificial intelligence. Spierling presented graph structures of *dialogue acts* as a means of defining the flow of a conversation. In interactive storytelling (as opposed to linear storytelling), the nodes of the graph contain scripted content as contiguous actions of virtual agents, while transition edges describe conditions and options. Such graph structures can be used to model interactive experiences at various levels of detail.

Shiratuddin and Tenh Hock Kuan[40] made an attempt to merge several models of digital storytelling from the literature into one large model consisting of fifteen interactive and non-interactive elements. While this resulted in a list of what storytelling is comprised of, there is no guidance on how to compose an installation of these elements, nor is it made measurable. However, their list can be valuable as a checklist for which digital storytelling elements are used.

Characterising Installations

An installation-centred methodology can give evidence about characteristics of an installation, e.g., when museums plan and design installations and find suitable narratives. Note that user observations may be part of such an installation-centred methodology as user involvement is generally an important part of evaluations in museums.

Spegel[41] presented the Expogon, which does not involve the user directly. It represents a graphical classification used as a mind map for exhibition planners when evaluators walk through a museum. Note that the purpose of the Expogon is to stimulate and inspire on a subjective (qualitative) basis, rather than to measure. The Expogon breaks down the exhibition medium into six elements: 1) narrative, 2) space, 3) visitor, 4) objects, 5) time, and 6) sender. Each element consists of fifteen hexagons representing categories, ten pre-filled and five empty for additional categories. The researcher wanders through an exhibition and notes observations on the Expogon. Thus, it is a qualitative tool that allows brainstorming when evaluating an exhibition. The Expogon provides hints to an evaluator regarding the design and what to improve in an exhibition. However, it does not reflect to what degree the six elements are fulfilled.

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37. Lambert, *Digital storytelling: capturing lives, creating community*.
38. Ulrike Spierling, «Interactive Digital Storytelling: Towards a Hybrid Conceptual Approach,» in *Digital Games Research Conference 2005, Changing Views: Worlds in Play, June 16-20, 2005, Vancouver, British Columbia, Canada* (2005).
39. See, e.g., Wolfgang Leister, Heinrich Müller, and Achim Stößer, *Fotorealistische Computeranimation (Photorealistic Computer Animation)* [in German] (Springer Verlag, 1991), ISBN: 354053234X.
40. Norshuhada Shiratuddin and Tenh Hock Kuan, «Quality evaluation of a digital storytelling (DST) conceptual model,» in *2014 International Conference on Multimedia Computing and Systems (ICMCS)* (April 2014), 690–695, DOI: https://doi.org/10.1109/ICMCS.2014.6911376.
41. Dan Spegel, *Expogon*, 2014, www.expogon.org.

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Schrandt[42] presented a design approach that focuses on the physical characteristics of the exhibits and their impact on visitors. This research studies characteristics, such as layout, atmospherics, ambient conditions, usage of space and media, and social interaction.

Another framework for developing experience-centred exhibits in science centres was recently presented by Ocampo-Agudelo, Maya, and Roldán.[43] They use five building blocks: physical, institutional, personal, relational, and social along with seven interconnected elements (physical environment, interactive exhibit, educational purpose, learning, engagement, interaction, and social context) related to the visitor engagement. Currently, their model is qualitative and focuses on the structural relationships between the elements of exhibits.

To characterise installations, we use the engagement profile[44] that has been developed specifically for installations in science centres and museums. The engagement profile quantifies the properties of installations along eight dimensions, each of which is given a value between 0 and 5 according to a definition table. The dimensions of the engagement profile are Competition (C), Narrative (N), Interaction (I), Physical (P), Visitor [user] control (U), Social (S), Achievements (A), and Explore (E). External influences are not taken into account in the engagement profile since these are not properties of the installation. Thus, physical factors, such as noise, light or smell need to be handled separately. Further, properties that belong to the context, such as social factors, institutional factors, or recent incidents personally or globally, are excluded.

These eight characteristics have a varying impact on the narrative of an installation. Specifically, there is a Narrative dimension (N) that is defined as the degree to which the installation's narrative impacts the visitor. It is characterised by the following values: 0: no narrative elements added; object can only be observed; 1: non-dramatised story, explaining text only; 2: a narrative structure with limited use of narrative or scenographic elements; 3: a narrative structure with rich use of narrative elements in a scenographic setting; 4: a developed dramatised story with a narrative universe in a scenographic setting; 5: a visual, immersive environment with a strongly dramatised narrative story. For a more comprehensive walkthrough of an exhibit, we have designed a chart that is presented in Figure 2.

Schäfer[45] presented the Dimension Star, which characterises narratives into twelve dimensions. It was originally designed for narratives told in stories, films, and so on, but is also applicable for other narratives, such as narratives in educational software.[46] However, while assessing the Dimension Star for installations, we recognised that there are no concrete definitions and criteria for its values. This characteristic makes it somewhat subjective.

42. Bernadette Schrandt, «Designing Experiencescapes» in *poster session: Designing for emotion: impact and evaluation, ECSITE Annual Conference* (Porto, Portugal, June 15-17, 2017).
43. Jose Ocampo-Agudelo, Jorge Maya, and Andrés Roldán, *A Tool for the Design of Experience-Centred Exhibits in Science Centres*, poster at Science Centre World Summit – SCWS2017, 2017, DOI: https://doi.org/10.13140/RG.2.2.22080.43520.
44. Leister et al., «Assessing Visitor Engagement in Science Centres and Museums»; Leister et al., «An Evaluation-Driven Design Process for Exhibitions»
45. Léonie Schäfer, «Models for digital storytelling and interactive narratives» in *COSIGN 2004 Proceedings* (2004), 148–155.
46. Panagiotis Psomos and Maria Kordaki, «Analysis of Educational Digital Storytelling Software Using the "Dimension Star" Model» *Int. J. Knowl. Soc. Res.* (Hershey, PA, USA) 3, no. 4 (October 2012): 22–32, ISSN: 1947-8429, DOI: https://doi.org/10.4018/jksr.2012100103.

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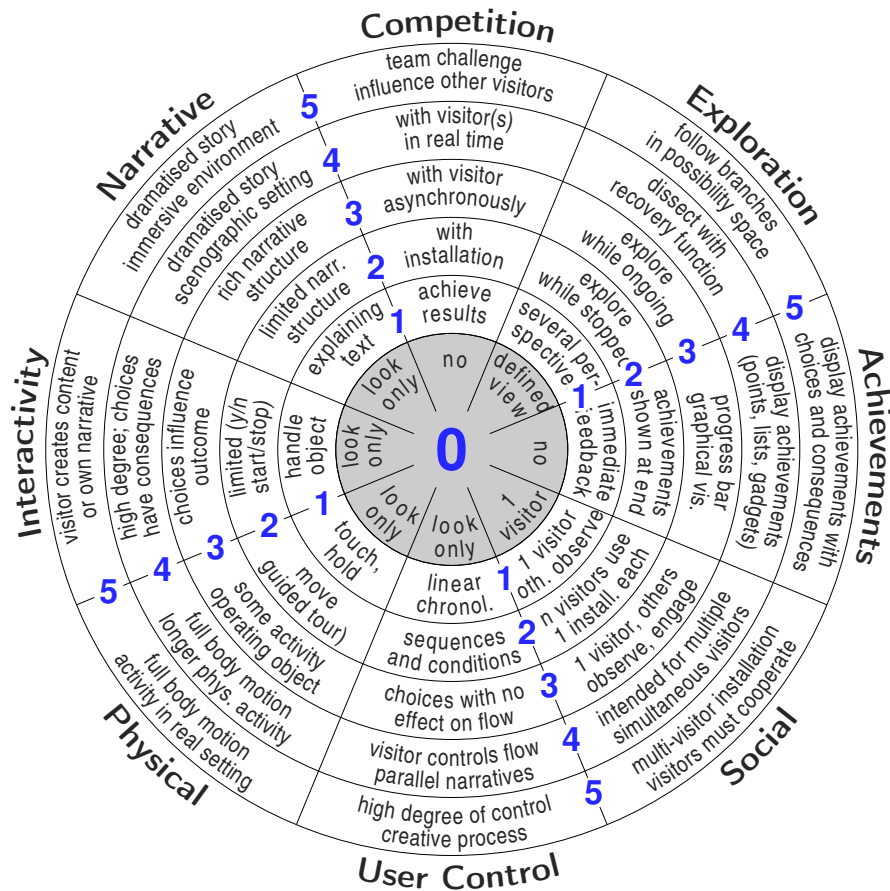
Figure 2: The dimensions of the engagement profile explained with short definitions. To define the value of a property, find the adjacent number of the phrases that fit best.

Relation to Serious Games

A game can be designed for a primary purpose other than pure entertainment. These games are referred to as serious games[47] or game-based learning.[48] In educational programmes offered by science centres to school classes, learning is different from a school setting, and the goal is informal learning. Serious games are used for this purpose. 'The Highway of the Seas' is an example of a serious game that replicates perspectives of international sea transportation and some of the decisions that need to be taken from the port of departure to the final destination.

'The Highway of the Seas' emphasises the use of naturalistic elements. Serious games mimic and simulate an operating model of real life systems. Several meta-analyses have

47. Ute Ritterfeld, Michael J. Cody, and Peter Vorderer, *Serious games: Mechanisms and effects* (Taylor & Francis, 2009); Thomas M. Connolly et al., «A Systematic Literature Review of Empirical Evidence on Computer Games and Serious Games» *Comput. Educ.* (Oxford, UK, UK) 59, no. 2 (September 2012): 661–686, ISSN: 0360-1315, DOI: https://doi.org/10.1016/j.compedu.2012.03.004.

48. Kevin Corty, *Games-based Learning; a serious business application* (PIXELearning Ltd, 2006).

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shown the potential of gamified learning.[49] The most recent review by Ravyse et al.[50] contains a detailed review of 55 serious games. In this review, it is suggested that "serious games should supplement the learning environment, not replace it".[51]

Often, players are seeking enjoyment. Fun is most important to them, but they do not necessarily value the subsequent learning benefit serious games can offer them. Fun and flow[52] – that is, a feeling of full involvement and losing one's sense of space and time – are related to each other. Some researchers, therefore, use the flow theory. Sweetser and Wyeth[53] present an evaluation model for enjoyment in games named GameFlow, which is based on flow theory. The GameFlow model uses eight properties that are related to evoking flow: concentration, challenge, player skills, control, clear goals, feedback, immersion, and social interaction. These properties are related on a scale from 0 to 5 through a total of thirty-six questions.[54] An average of all applicable values is then calculated to receive an overall rating. Recently, Sweetser et al.[55] adapted GameFlow to various game genres and platforms, and they commented that GameFlow is a model of enjoyment rather than of flow, as research has shown that some aspects of flow and enjoyment do not match.

THE NARRATIVE IN 'THE HIGHWAY OF THE SEAS'

The narrative in the game 'The Highway of the Seas' takes strong leads from the overall narrative in *Norway is the Sea*. It follows the intention to create an arena for experiences and dialogue and to inspire for learning and discussion. In practice, this task was solved by creating an immersive room. The immersion effect should create a tension between the as-yet hidden events and the activation of events via sensors by the players.

Norway is the Sea is about maritime business in recent time, between 1960 until the present day, as experienced in 2014. In this timeframe, the world population has doubled while the world's shipping trade tonnage has grown by factor of six. Shipping and the maritime business, as the bearers of the world's trade, have grown in volume and complexity. This growth has triggered large changes specifically tied to an increased specialisation and complexity in the technological, economic, and organisational dimensions. We posit that

49. Tracy Sitzmann, «A meta-analytic examination of the instructional effectiveness of computer-based simulation games», *Personnel Psychology* 64, no. 2 (2011): 489–528; Katherine A. Wilson et al., «Relationships Between Game Attributes and Learning Outcomes,» *Simul. Gaming* (Thousand Oaks, CA, USA) 40, no. 2 (April 2009): 217–266, ISSN: 1046-8781, DOI: https://doi.org/10.1177/1046878108321866; Pieter Wouters et al., «A meta-analysis of the cognitive and motivational effects of serious games,» *Journal of Educational Psychology* 105, no. 2 (May 2013): 249–265, DOI: https://doi.org/10.1037/a0031311.

50. Werner Siegfried Ravyse et al., «Success factors for serious games to enhance learning: a systematic review,» *Virtual Reality* 21, no. 1 (March 1, 2017): 31–58, ISSN: 1434-9957, DOI: https://doi.org/10.1007/s10055-016-0298-4.

51. Ibid., p.52.

52. Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York: Harper / Row, 1990), ISBN: 0-06-092043-2.

53. Penelope Sweetser and Peta Wyeth, «GameFlow: A Model for Evaluating Player Enjoyment in Games» *Comput. Entertain.* (New York, NY, USA) 3, no. 3 (July 2005): 3–3, ISSN: 1544-3574, DOI: https://doi.org/10.1145/1077246.1077253.

54. The following scale is used in GameFlow: 0=n/a; 1=not at all; 2=below average; 3=average; 4=above average; and 5=well done.

55. Penelope Sweetser et al., «GameFlow in Different Game Genres and Platforms» *Comput. Entertain.* (New York, NY, USA) 15, no. 3 (April 2017): 1:1–1:24, ISSN: 1544-3574, DOI: https://doi.org/10.1145/3034780.

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these changes have neither the visibility in the public debate that they deserve, nor are they communicated through exhibitions in maritime museums in general.

Norwegian shipping interests have had the world as their arena for a long time, since even before 1960. Further, globalisation has accelerated during recent decades. The exhibition wished to spark an interest in the global importance of Norwegian shipping; in fact, the importance of Norwegian shipping is disproportional in size in relation to the country's population.[56]

Under the headline *Shipping drives world trade*, a project group elaborated the learning goals for the above target groups: to *experience the factors that make ship freight profitable and to get a picture of actors that optimise the highway*. The latter can be described as giving the participants an introduction into the functions of modern shipping logistics. Professions such as shipping brokers and agents act on-shore while the captain is the most important communicator at sea.[57]

The installation 'The Highway of the Seas' is designed to convey the message that shipping is an important driver of world trade, and a very complex business involving a variety of people and skills, with decision making dependent on the processing of diverse and extensive information. The installation is intended to create a meaningful mix of this complexity for the primary target groups described as 1) youth and young adults, 2) tourists from abroad, 3) adult Norwegian visitors, and 4) families visiting the museum.

Mastering is a central element in the pedagogic concept; to master the quest, the visitor must understand the challenge and what to do at all times. Learning from one's own mistakes is part of the principle; experimenting and making the wrong decisions is rather easily done.[58] Lundgren et al.[59] call this style *learning by burning*, in the sense of "[. . .] being burnt by making mistakes, but also being on fire; to passionately engage oneself in projects and course work. As any other approach it has its pros and cons; stress being one of the downsides, the insight that one actually can conquer, manage and master new technologies one of the advantages."

Implementing the Narrative

The installation 'The Highway of the Seas' uses a variety of narrative elements: virtual persons in their roles as captain, agent, and broker, virtual phone calls, and the progression of events occurring on the sea charts, to mention a few of them. While the game is underway, the players are asked to make decisions about, for example, freight, bunkering, and speed. Furthermore, decisions need to be made in relation to events such as storms, pirate attacks, and strikes. There are elements in the installation that are meant to be immersive, such as the sound of the sea and dimmed lights. Although there are elements of immersion, we classify the narrative as follows: *a narrative structure with rich use of narrative elements in a*

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56. Norwegian Maritime Museum, *Norge er havet – Budskap, tema og innhold*.
57. Norwegian Maritime Museum and Expology, *Sjøens motorvei programskisse (Sketch of 'The Highway of the Seas')* [in Norwegian], internal working document, July 13, 2013.
58. Dahl, «Master-Apprentice Learning as Museum Pedagogy»
59. Sus Lundgren et al., «Teaching Interaction Design: Matters, Materials and Means» in *Proc. DRS Wonderground conference* (Lisbon, January 2006).

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scenographic setting which results in a narrative level of N=3, according to the engagement profile definition presented by Leister et al.[60]

The installation 'The Highway of the Seas' can be considered a serious game with the purpose of facilitating education in issues around freight transport at sea. Observations show that players from secondary school classes often have no insight into the roles of the figures in the narrative. If designed well, serious games should be able to educate the players.

Competition is an important element that contributes to increased engagement. In the installation, up to four players compete against each other. In addition, the game is designed so that the participant can compete against him/herself by trying to increase his/her score over several rounds of play. We observed that when school classes visit the exhibition, students are often interested in playing the game several times.

The overall narrative consists of three parts: a) a start sequence, in which players choose a vessel and task to perform; i.e., which freight is to be transported, and to where; b) the main sequence, in which the sea transport is underway, including events occurring and the players' subsequent decision-making; and c) the final sequence, in which the results are presented.

The start sequence and the final sequence have a linear structure. During the main sequence, the narrative is a story with branches where the structure cannot be changed by the player. Players make decisions that have an effect on the final score, but these decisions have only limited impact on the narrative. Each decision consists of selecting a branch of a tree-like structure that gives access to content adequate to the chosen branch. Thus, the interactive behaviour of 'The Highway of the Seas' is defined by a graph network.

Analysing the Narrative

We show the engagement profile for two versions of the game in Figure 3. In a previous version of the installation, shown with the blue hatches, the achievements were shown to the visitor only at the end, when the winners are announced. We observed that visitors understood neither why they were appointed the number of points they received, nor which of their decisions they could have made differently. To fix this, the game was changed to show the achievements during the entire game as points in two dimensions. The engagement profile for the altered installation is shown with the red hatches. Note that this solely changes the values of the A-dimension (Achievements), while the others are unaltered.

The values for the engagement profile are quite high. This may explain why 'The Highway of the Seas' evokes a higher degree of engagement than other installations we have studied, as we will see in Section 6. As a note, 'The Highway of the Seas' shares a rather low physical (P) dimension with many other installations.

60. Leister et al., «Assessing Visitor Engagement in Science Centres and Museums»
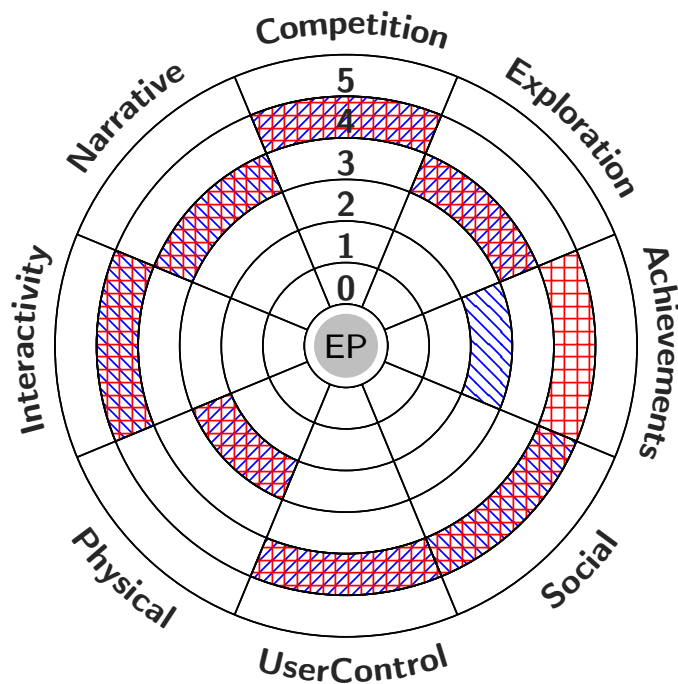
Figure 3: The engagement profile of 'The Highway of the Seas' in two variations: The blue hatches show the installation as designed originally; the red grid lines show the installation where achievements are shown to the visitors. This change has an impact on engagement.
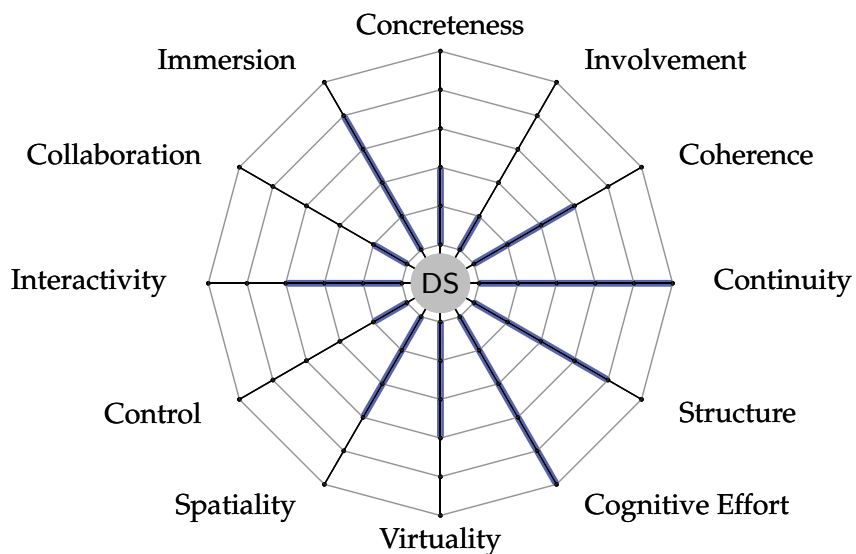
Figure 4: The Dimension Star for the narrative of the installation "The Highway of the Seas"

We created the Dimension Star for the installation 'The Highway of the Seas', as shown in Figure 4. For this, we used the definitions and examples presented by Schäfer[61] and com-

61. Schäfer, «Models for digital storytelling and interactive narratives»

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pared values for 'The Highway of the Seas' with those examples. In our opinion, 'The Highway of the Seas' scores highly on cognitive effect, structure, continuity, and immersion. Coherence, virtuality, spatiality, and interactivity are mid-range, while concreteness, involvement, control, and collaboration are quite low. Note that the values for the engagement profile and the Dimension Star might be defined differently, even if the same label is used.

For instance, while one would expect that the values of both diagrams are related, in the engagement profile the Social factor is high, while the Collaboration factor in the Dimension Star is low. Similarly, the factors User Control in the engagement profile and Control in the Dimension Star differ.

In our work, we do not consider flow as the main factor for engagement in installations in science centres and museums. Commonly, the experience is too short for flow to be invoked. However, since 'The Highway of the Seas' is a game of considerable length, and GameFlow is considered more a model of enjoyment,[62] we made an attempt to assess the degree of game enjoyment according to the GameFlow model.

Table 1: Assessment of 'The Highway of the Seas' using GameFlow

criteria	average	detailed values
concentration	4.3	(5, 5, 5, 3, 4, 4)
challenge	2.0	(3, 1, 1, 3)
player skills	4.6	(5, 5, 0, 0, 4, 4, 5)
control	2.8	(3, 4, 3, 0, 2, 2)
clear goals	5.0	(5, 5)
feedback	5.0	(5, 5, 5)
immersion	2.4	(3, 3, 2, 2, 2)
social interaction	3.0	(3, 0, 0)
average	3.6	

To assess the GameFlow for 'The Highway of the Seas', we answered all thirty-six questions of the GameFlow questionnaire.[63] The result is shown in Table 1. We observed that some of the criteria were difficult to assess since the questions are tailored for a different genre and type of games. Specifically, the criteria in the category Social Interaction did not fit. Further, the category of Player Skills and Control contained questions that we were unable to answer.

According to our assessment, 'The Highway of the Seas' is just above average with a value of 3.6. Instead of suggesting that GameFlow is not suited, we examine the criteria where the installation scores below average. We already mentioned that the criterion for social interaction is not suited for installations without alterations. Regarding Challenge,

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62. Sweetser et al., «GameFlow in Different Game Genres and Platforms»
63. Ibid.

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the installation is created in a manner so that one size fits all. The only choice relevant for Challenge is at the beginning of the game, when the quest is defined.[64]

Regarding Control, the game has some potential to give the player more control as we observe that the impact of an action is not always obvious. On the other hand, the questions for this criterion are tailored for a different genre, and it is not always obvious how to answer them in the context of an installation.

The design of 'The Highway of the Seas' is informed by many efforts to achieve high immersion, but the museum setting sets some limits. Furthermore, the quest is rather abstract, which might restrict the level of immersion according to the GameFlow.

Comparison of Three Installations

We performed a survey-based study on how engaging the installation 'The Highway of the Seas' is. We compared the findings of this study with those of two other installations, on which we performed similar earlier studies. Besides 'The Highway of the Seas', we performed studies with 'eQuiz' at Engineerium[65], a science centre outside Oslo, and 'Solar Cell', a game at the Norwegian Museum for Science and Technology.

'eQuiz' is a quiz game about the oil and gas industry, where one or two players are presented ten questions with two alternatives each that they answer as fast as possible. At the end, a total score is presented. The game lasts about three minutes. In the game 'Solar Cell', players toss small balls representing photons at a wall on which electrons are depicted. The players receive scores when they hit the representation of the electrons. One round lasts typically less than a minute.

To test the installations, we chose to involve students from upper secondary school as this made it easier to obtain the necessary consent from the participants (or their parents) to observe their interaction with the installations. At the same time, this age group is an important target group for the exhibitions in question. The students were recruited from school classes that were visiting the respective museum or science centre. The experiments were performed in a variety of sessions between Autumn 2014 and Autumn 2017.

In each of the three studies, the students played the respective game during an organised visit with their school classes at the museum. Immediately after they played the game, they were asked to fill out the questionnaires given in Table 2.

We used a questionnaire about factors for engagement for all three installations. We asked students from upper secondary schools to rate the claims presented in Table 2 on a Likert scale ranging from 1 to 7. Note that the questions for the three installations are slightly different due to the nature of the respective installation. For instance, question C_3 for *Solar Cell* did not contain the phrase "listened carefully", as there is nothing to listen to.

Although we had observers at the sites during parts of the experiments, the results of this study are derived solely from the questionnaires. The observers were present to conduct other experiments, such as those described by Leister et al.[66] In the experiments,

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64. At the beginning of each round, the players choose which type of cargo to transport from which harbour to Drammen harbour in Norway. Currently, four selections are available where these parameters are combined.
65. www.engineerium.no.
66. Leister et al., «An Evaluation-Driven Design Process for Exhibitions»

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video cameras were present for a feasibility study on whether facial expressions can be extracted automatically using these cameras.

Table 2: Formulation of the questions for the variables F_i, C_i, A_i, R_i, L_i, D_i, and E, tailored for the installation 'The Highway of the Seas'. All questions are on a scale from 1 (low) to 7 (high). Note that questions for the other installations may vary slightly since they are about different subjects.

F_1	Did you have fun playing the game?
F_2	How much did you like the installation?
F_3	The installation was entertaining.
C_1	I concentrated so that I could choose the most appropriate answer.
C_2	When I did not fully pay attention or were not pleased with a choice, I intended to be more focused the next time I am playing.
C_3	I was focused and listened carefully before I answered a question.
A_1	Do you want to use the installation one more time?
A_2	Do you want to use the installation a second time to improve your score?
A_3	At your next visit to the museum, do you think you will use this installation?
R_1	Would you recommend the installation to others who are with you today?
R_2	I would like to recommend the installation to someone I know.
R_3	I will recommend the installation to other visitors to the museum.
L_1	Sometimes I did not know the right answer, but I would like to learn more about what the game is about.
L_2	Is your interest in the matter the game is about increased or decreased because you played the game?
L_3	The installation triggered my interest to learn more about shipping.
D_1	During the game, did you find it easy or difficult to make choices?
D_2	Did you find it difficult to understand why you were given choices in the game, or what the consequences of these choices were?
E	How engaging was the installation?

So far, these experiments are inconclusive as placement of the cameras and lighting conditions need to be improved to receive better results. Note that these experiments are beyond the scope of the current paper.

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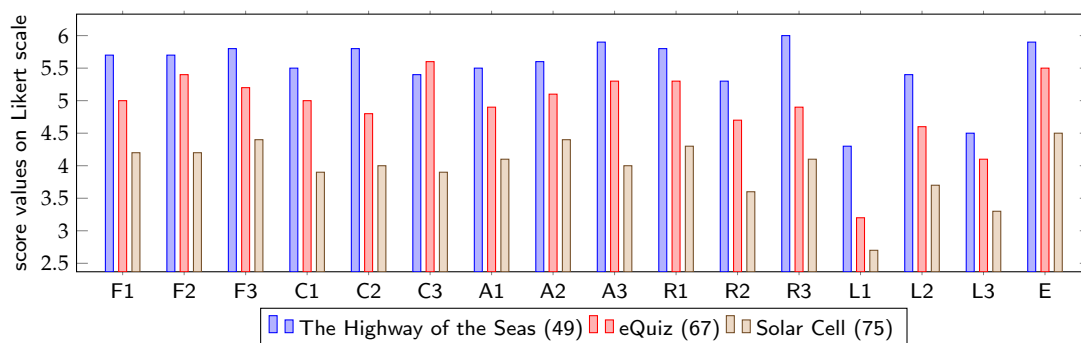
Figure 5: Response scores for tests with three installations on a Likert scale for the independent variables for *fun* F and *concentrate* C and the dependent variables for *play again* A, *recommend* R, and *intention to learn* L. Each variable occurs in three different questions. We also show the results for the variable *engaging* E.

In the study, we received 49 responses for 'The Highway of the Seas', 67 for 'eQuiz', and 75 for 'Solar Cell'. According to the results of the study that are shown in Figure 5, 'The Highway of the Seas' scores highest of these three installations for almost all factors, including engagement, while 'eQuiz' is ranged second.

In comparison, 'The Highway of the Seas' is the most complex and has also the longest play duration of these installations. We observed that once the visitors stay with the game, they play it in an engaged manner. However, due to length of the game, many visitors start the game and abandon it after a short while. We note that in our study, the participating students were not given the option to leave before the game was finished.

As these three games are quite different in many respects, their engagement profiles differ significantly, as can be seen in Figure 6. For instance, 'The Highway of the Seas' has the most elaborated narrative of the three games and, thus, scores much higher for the narrative dimension than the other two games. Further, when using the Dimension Star or GameFlow, the two other installations score significantly lower, or the respective dimension is not applicable.
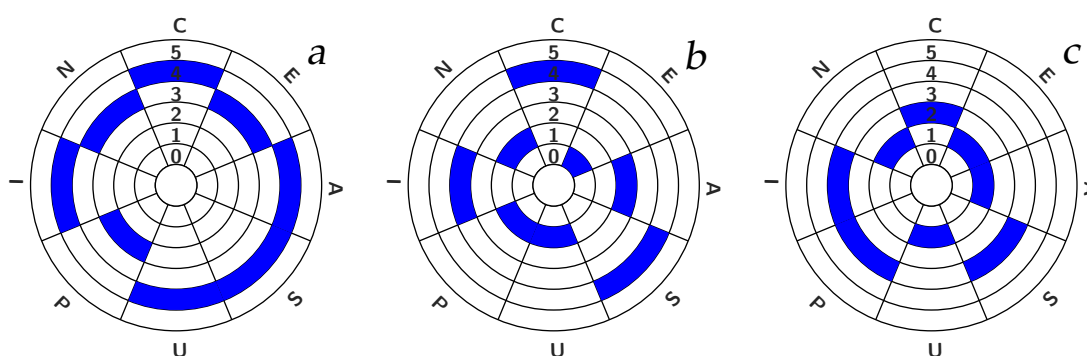
Figure 6: Engagement profiles of three installations: a) 'The Highway of the Seas' (altered version), b) eQuiz at Engineerium, and c) Solar Cell at the Norwegian Museum of Science and Technology.

CONCLUSION

With 'The Highway of the Seas', the NMM has installed an engaging serious game that conveys knowledge about shipping to the visitors of the museum. In comparison with two other installations, it scores much higher on engagement parameters, although it tries to convey insight that is not common knowledge to most of the visitors.

We did not perform an assessment of the learning effect, as this would require a much larger, long-term study. From a game such as 'The Highway of the Seas', one can only expect that it provides insights into the roles (e.g., captain, broker, ship owner), procedures (such as bunkering, charging, lighting, increasing or reducing speed), and threats to shipping (such as weather conditions, strikes, and pirates). Evoking interest in shipping is the goal of the installation. Therefore, instead of assessing increased knowledge, we looked for engagement as an expression of increased interest.

We have looked into three measures to characterise 'The Highway of the Seas': a) the engagement profile, which is developed for characterising installations; b) the Dimension Star, which is developed for characterising narratives; and c) GameFlow, which is developed for games in other genres. All three of these measures gave reasonable results that can be used to reflect on the qualities of the installation. In our study, we achieved quite different values for items that are characterised with a similar keyword. This can be explained by different definitions and semantics behind keywords that seem alike.

These measures can be used to identify characteristics that could be changed in further development of installations. For instance, using the engagement profile, we identified that there were issues with showing achievements to the visitor in an earlier version of 'The Highway of the Seas', and the designers could address this in subsequent versions. Another use could be comparing these measures to two versions of an installation under development in order to make informed decisions about which version to choose.

Further, these measures can also be used to compare several installations to each other, or to characterise an ensemble of installations in an exhibition that consists of several exhibited items. A good mix of installations with different characteristics is often desirable. However, which selection of characteristics to choose might depend on the target group an exhibition is designed for.

In our research, we intended to measure expression of engagement more directly using sensors and cameras. We performed several experiments, but despite progress with these methodologies,[67] there are still obstacles to installing advanced assessment technologies that recognise emotions of visitors in exhibitions. In our studies, we found out that with current technology, lighting conditions could have a negative impact; moreover, the placement of cameras and sensors so that they do not have a negative effect on the experience remains an unsolved problem. However, progress moves rapidly, and we expect that technologies such as affective computing will soon be available to provide evidence of how engaging installations and exhibitions are. Knowing this is important for the increased relevance of science centres and museums.

67. See, e.g., Ingvar Tjøstheim et al., «The Role of Emotion and Enjoyment for QoE – a Case Study of a Science Centre Installation,» in *Proc. QoMeX 2015, The 7th Intl. Workshop on Quality of Multimedia Experience* (IEEE, 2015), 1–6, DOI: https://doi.org/10.1109/QoMEX.2015.7148112.

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ACKNOWLEDGEMENT

AUTHOR CONTRIBUTIONS

The authors conceived and designed the concept and the experiment as joint work in the context of the VISITORENGAGEMENT project.

P.G.N. and E.B. provided the cultural and historical background presented in Sections 1 to 3. I.T. contributed with the narrative theories in Section 5, while W.L., I.T., and G.J. surveyed how to analyse narratives in installations. G.J. and I.T. designed and performed the experiments, supported by E.B. and H.T.S., W.L. and I.T. analysed the data, developed the engagement profile, applied the engagement profile to the installations, analysed the narratives, and compared the three exhibits described in Section 6. W.L. acted as editor for the paper and integrated the contributions written by all co-authors.

CONFLICT OF INTEREST

Some of the experiments were performed at the NMM where three of the authors are affiliated (P.G.N., E.B., H.T.S.). The installations used in the experiments were developed by Expology, where one of the authors (G.J.) is affiliated. Beyond these facts, the authors declare no conflict of interest.

LIST OF FIGURES

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