Personalization and customization in Dutch science museums

How personalization and customization can be utilized to fulfil the functions of science museums in the Netherlands

Janneke Koorn (4140591)

Supervisor: Mark Bos

Second examiner: Liesbeth de Bakker

Science Education & Communication

Freudenthal Institute

Utrecht University

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Abstract

Personalization is often regarded by museums as the holy grail to make a meaningful connection with every single visitor. However, the term personalization (defined as a process in which a system makes adaptations to increase the personal relevance to the visitor) is often used interchangeably with customization (defined as a process in which the visitor him or herself is in control of the adaptations to increase the personal relevance).

Previous research shows that personalization and customization have several strengths and weaknesses. Depending on the context and goals of a museum, the benefits can outweigh the drawbacks. This study aims to make an inventory of the functions of science museums and investigate how personalization and customization can contribute to fulfilling those functions.

First of all, the functions of science museums were assessed by means of a thematic analysis of 32 websites of science museums in the Netherlands. This has resulted in a framework containing 9 meta-functions, 13 organizational functions and 31 public functions.

Secondly, nine interviews were held with Dutch science museum professionals regarding the functions of science museums and the perspectives of the interviewees on the use of personalization and customization in science museums. This has resulted in an overview of perceived strengths and weaknesses of personalization and customization examined through the lens of six themes: Personal relevance, information presentation, social experience, free-choice learning environment, technology and data collection, and costs and effort.

The results suggest that customization is a less complicated and more economical approach to creating an personal experience than personalization. Customization in the physical world is already omnipresent in science museums, but a digital layer can provide more customization possibilities for science museums that are yet to be exploited. Customization shows potential to fulfill various educational, leisure and identity functions. Several implications for design are presented in the discussion.

Contents

Introduction

Products and services tailored to single individuals are becoming increasingly prevailing in our everyday lives: Search engines sort hits by personal relevance, advertisements target specific customers, and we can customize the features of a new car to our own preferences. Personalization and customization are two types of adaptive processes that can create a tailored experience for every single individual. The difference between personalization and customization is determined by who or what is performing the adaption: The user or the system. "Customization gives high priority to user control and involvement, and therefore places users in the *driver's seat*." (Sundar & Marathe, 2010, p. 301). On the other hand, personalization is defined as "a process in which the system changes the functionality, interface, information content, or distinctiveness to increase its personal relevance to an individual" (Blom, 2000, p. 313). The terms personalization and customization are often used interchangeably but they are not identical as the definitions show. Each process can have a different effect on the user (Bowen & Filippini-Fantoni, 2004; Sundar & Marathe, 2010). In the end, the goal of personalization, as well as customization, is to increase the personal relevance of a product, service or experience to the user. The large amounts of personal data that are being collected everywhere have accelerated the use and accuracy of systems that deploy personalization and customization techniques. As a result, personalization and customization have become ubiquitous in industries such as marketing, education and entertainment.

The museum sector has also shown interest in personalization and customization. In the pursuit of museums to become more visitor-oriented, personalization is often regarded as the holy grail to make a more meaningful connection with each visitor. As one of the interviewees in Kranioti (2017) mentioned: "Personalization is the dream." (p. 29). However, there is no consensus about the effectiveness and desirability of personalization and customization in museums and whether the benefits outweigh the drawbacks (Filippini-Fantoni et al., 2005).

Despite the research that has been performed on personalization and

customization in the past 25 years, the techniques have not been widely implemented in museums yet (Not & Petrelli, 2019). Not and Petrelli (2019) pose that "one of the possible explanations for such promising technology not progressing beyond research-led experiments is the lack of attention to the gatekeeper: the museum's curatorial team." (p. 68). This notion has led us to believe that it would be interesting to engage in a conversation with museum professionals about their perspectives regarding personalization and customization. Moreover, the focus of prior research has predominantly been on cultural heritage museums, but not on science museums specifically. Three interviewees in Kranioti (2017) indicate that visitors of museums such as children's museums, zoos and science centres might be more open towards personalization than visitors of cultural heritage museums because the subject matter of zoos and science centres is perceived as "less serious" (Kranioti, 2017, p. 37). It is therefore worthwhile to examine what personalization and customization can entail for science museums in specific. Fantoni (2003) suggests: "Further studies are necessary not only to increase our understanding of the potential of personalization through IT in museums but also to better define which applications and techniques are more likely to succeed in this specific context." (p. 16).

Research questions

The aim of this study is to make an inventory of the functions of science museums and investigate how personalization and customization can play a role in fulfilling those functions. This paper will address the following research questions:

RQ1: Which functions of Dutch science museums can be enhanced with personalization and customization and how?

Sub-questions:

SQ1: What are the functions of Dutch science museums?

SQ2: What do science museum professionals in the Netherlands perceive as advantages and disadvantages of utilizing personalization and customization in science museums?

Theoretical Background

Functions of science museums

The functions of museums, and the way they fulfil those functions, are constantly changing in order for museums to remain relevant to society (Black, 2012). Pedretti and Iannini (2020) have described four generations of science museums. The first generation of science museums was characterized by the look-but-don't-touch principle, with exhibitions that the visitors observed passively. By the twentieth century, the functions of science museums began to shift from merely displaying curiosities to disclosing objects representing scientific and technological progress. The third generation of science museums moves away from the object-based approach and lets the visitor experience scientific phenomena first-hand through interactive exhibits. In the fourth generation, which is still in the future for most museums, Pedretti and Iannini (2020) argue that "science museums can become places for change and transformation, productive struggle, allyship, empathy, and epistemic democracy, and can serve as hybrid third spaces" (p. 13).

Instead of arranging the functions of science museums in generations, Achiam and Sølberg (2017) have made a framework containing nine contemporary meta-functions of science museums: Scientific, cultural, educational, social, network, political, economic, conservational, and symbolic. The meta-functions contain organizational and public sub-functions, such as "sharing expertise" (organizational sub-function of the network function), and "opportunities for learning science" (public sub-function of the educational function). Many functions show resemblance with one of the generations as defined by Pedretti and Iannini (2020). For example, "conserve tangible and intangible heritage" resembles a first and second generation characteristic, whereas "promote civic engagement" rather belongs to the fourth generation of science museums. This shows that contemporary science museums have many functions, ultimately overarching several generations of science museums.

Forms of personalization and customization

There are many different ways in which museums can deploy personalization and customization. It is sensible to make a distinction between the fluid digital world and static physical world to explain the variety of possible applications.

Customization in the physical world includes interactive and hands-on exhibits, which are already prevailing in science museums. Interactivity allows the visitor to construct a personal experience through the adaptations the visitor makes to the exhibits. In the digital world there are examples of customization such as bookmarking items for later use (Fantoni, 2012; Keller & Viennet, 2015) or choosing to view additional information (Wessel, 2010).

Personalization in the physical museum is nearly impossible to achieve because that would require making different adaptations for each visitor in the same space. In the digital world a system maintains a visitor profile that models the visitor's interests, behaviour, and history and uses that information to create a personal experience. Note that *the digital world* does not imply that the personalization or customization is only for at home or online. It is rather a virtual layer that can also be accessed during the museum visit itself. There are examples of personalization such as adapting the displayed information about an object based on personal interest of the visitor (Najbrt & Kapounová, 2014; Stock et al., 2007), constructing personal routes (Alexandridis et al., 2019; Najbrt & Kapounová, 2014), and recommending unseen exhibits (Keller & Viennet, 2015; Wang et al., 2009).

Additionally, the personalized and customized visit can be extended beyond the walls of the museum by making use of online environments such as the museum's website and virtual collections (Fantoni, 2003; Marty et al., 2010; Wang et al., 2009). A connection between the online pre- and post-visit and physical visit can also be made, which Barry (2006) has coined the "virtuous circle". A virtuous circle can for example be created by offering the visitor tools to prepare the visit online at home and sending a summary of the visit afterwards.

Advantages of personalization and customization in science museums

Personalization and customization are of interest to science museums because the techniques have the potential to strengthen two-way communication between the museum and the visitors (Fantoni, 2012). As Bowen and Filippini-Fantoni (2004) argue: "By considering the different necessities of each individual, it is now possible to move from talking *to* the visitor to talking *with* the visitors." (p. 4).

Chang (2006) also argues that museums should "reach out to the public, actively seeking to frame a positive motivation and expectation for the public before they arrive." (p. 183). Online environments, such as the museum's website, can be used before and after the visit to collect data from the visitors and integrate the data into the physical museum experience or extend the physical experience (Barry, 2006; Wang et al., 2009).

Furthermore, personalization and customization can commit to the societal functions of museums, such as becoming inclusive organizations (Kranioti, 2017). Museums usually choose to display the blockbuster exhibitions to be guaranteed of a certain number of visitors, but this audience often consists of like-minded higher-educated visitors (Chittenden, 2011; Kranioti, 2017). With personalization and customization the museum is able to tailor the exhibits towards the visitor's niche interests, ultimately appealing to more diverse audiences. Anderson and Andersson (2004) describe this phenomenon as the "Long tail theory", which stems from the domain of marketing, but is also applicable to the interests of museum visitors.

Personalization and customization can also improve the visitor experience. The Contextual Model of Learning by Falk and Dierking recognizes the personal, sociocultural and physical context of a museum visit (Falk & Dierking, 2004). This model is famous for describing the components of a successful visit and how learning is facilitated in a museum. Based on Falk and Dierking's proposition, Chang (2006) argues that a museum should "provide opportunities to construct connections between museum experiences and visitors' personal lives." (p. 183). Personalization and customization can make more meaningful connections between the exhibition and visitor by increasing the personal relevance, and are therefore likely to result in a higher

visitor satisfaction and can contribute to the educational goals of a museum.

There is also an argument in favor of personalization that cannot be achieved with customization alone. Personalization systems can reduce an information overload by recommending the most relevant items to the visitor (Fantoni, 2003; Huang et al., 2012). This is especially relevant for museums that have large exhibitions or do not have enough physical space to showcase everything they want from their collection.

Limitations personalization and customization in science museums

In spite of the advantages, there are also arguments that question the usefulness of personalization and customization in museums. Wouter van der Horst, who is a freelance museum consultant, mentioned that most visitors only want to see the highlights and trust the work of the curators for that, suggesting that there is not always a need for a personalized tour (W. van der Horst, interview, December 1, 2020). Furthermore, Loesser (2016) found in a study that visitors may be hesitant to use technologies that collect personal data due to privacy considerations and practical reasons such as mobile applications that drain batteries. Other drawbacks of personalization and customization are the high cost and time investments to provide personalized services (Filippini-Fantoni et al., 2005). Nonetheless, Rey et al. (2020) argue that personalization can be cost-effective if it attracts more visitors or replaces expensive staff.

There are several arguments that only reason against personalization (and may even be solved with customization). First of all, Chang (2006) says that museums should develop "experiences that offer open and free choices and put the learners in control of their own learning." (p. 183). Dierking and Falk (1998a) have coined the term "free-choice learning environments" for places offering informal learning opportunities. Personalization generally decreases the amount of choice that the visitor has, whereas customization actually offers choices and options to the visitor. Secondly, Falk and Dierking (2004) argue that, in accordance with constructivist learning theories, people already construct their own meanings and relations to the museum

exhibits. This makes the added value of personalization questionable. Thirdly, visiting a museum is often a social occasion for groups, such as families, friends or schools. Personalization focuses on the individual and may not be satisfactory to all the members of a group (Van Dijk et al., 2014).

At last, there are many technological challenges such as constructing a good visitor-profile, localizing the visitor inside a building, and determining what a visitor is paying attention to (Kosmopoulos & Styliaras, 2018). Even if those challenges are overcome, it is not always the case that the recommendation "what you will like the most" is also the best recommendation (Kranioti, 2017). One of the goals of fourth generation museums is to include controversy and show exhibits that challenge the visitor's beliefs (Pedretti & Iannini, 2020). With that goal in mind, personalization is not appropriate if it drags the visitor into an information bubble.

It becomes evident from the aforementioned advantages and limitations that some arguments against personalization might actually be in favor of applying customization and vice versa. This is the foremost reason that personalization and customization should not be regarded as an identical process and why this study makes a distinction between the two. Filippini-Fantoni et al. (2005) stress that "personalization should not be implemented for the sake of it but when and because it brings added value to the museum for, if not all, a good percentage of visitors." (p. 19). Consequently, we want to explore how to exploit the advantages of personalization and customization, and how a good implementation can genuinely provide an added value for science museums.

Method

To explore what functions of Dutch science museums can be enhanced with personalization and customization and how, an exploratory qualitative research strategy was followed. The methodology consisted of two parts: A systematic website analysis and semi-structured interviews with experts. The two parts are described below.

Website analysis

In order to answer sub-question 1, the websites of all 40 Dutch science museums connected to the VSC[1] were analyzed regarding their functions by means of a thematic analysis (as described by Braun and Clarke (2006)). Achiam and Sølberg (2017) have presented a framework for understanding and contextualizing the meta-functions of science museums, but they have not presented a detailed inventory of the related sub-functions. Therefore, the aim of the website analysis was to 1) examine whether the functions of Dutch science museums comply with the nine meta-functions as described by Achiam and Sølberg (2017) and 2) reveal a more detailed overview of the sub-functions that are shared by Dutch science museums.

Data collection. For the website analysis, relevant information about the function of the museums was extracted from pages such as "About us", "Mission and Vision" or "Organization" and from documents such as annual reports and policy plans. In addition to the mission and vision, the goals formulated in the ANBI-statutes[2] were included in the dataset.

The overarching term *functions* includes goals, missions and strategies, considering the fact that for example "accommodating fun" was regarded as a means to an end by some museums, whereas for others it was presented as a goal in itself. A rigorous distinction between functions, goals and strategies could therefore only have been made with a substantially literal interpretation of the texts. However, such an analysis would limit the richness of practices by science museums, especially when they are trying to formulate their mission and vision in a captivating statement.

Nine museums provided limited information about their functions on their website.

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[1] The VSC is the sector organisation for Dutch science museums and science centers. In April 2021 the VSC had 40 members of which 39 science museums were located in the Netherlands and 1 in Belgium.

[2] ANBI is an abbreviation for Institution for Public Welfare (Algemeen Nut Beoogde Instelling). Organizations in the Netherlands with an ANBI-status receive fiscal benefits for donations. A requirement to get the ANBI-status is to make the organization's goals and financial reports publicly accessible

Due to the scarce amount of available information they were removed from the dataset. The final dataset consisted of texts derived from the websites of 31 science museums and centers, with addition of the website of the VSC as an overarching organization.

Data analysis. A combination of deductive and inductive coding strategies were applied to analyze the extracted texts. Phrases concerning the functions of science museums were deductively coded into the nine meta-functions as described by Achiam and Sølberg (2017). For example, "Ontdekstation013 acts as a spider in the web between the technical sector and education." was coded into the network meta-function. Phrases that were non-congruent with the framework of Achiam and Sølberg (2017) were reserved and subsequently clustered into novel meta-functions. For example "Oyfo encourages you to discover what art and technology mean to you." was inductively coded into the new identity meta-function.

In the second phase, the phrases in the meta-functions were sorted into sub-functions where possible. The sub-functions in the framework by Achiam and Sølberg (2017) served as sources for inspiration, but were dismissed for the new classification in order to construct a more detailed overview of the sub-functions. The phrases were inductively coded into emergent sub-functions if two or more museums mentioned a similar function. For example "At ARTIS we inspire and encourage a broad public to treat nature responsibly" was coded into the novel sub-functions "inspire" and "make people act more considerate towards science / nature / society". Phrases were not coded into a sub-function if it covered a meta-function in general. For example, "Developing and providing educational projects" was kept in the educational meta-function and not categorized into a sub-function. Functions that were only mentioned by a single museum were not coded into a sub-function.

Semi-structured interviews

To answer the second sub-question, nine semi-structured interviews were held with a total of ten experts. The goal of the interviews was to 1) (dis)confirm the functions as stated on the websites of the museums 2) to elaborate on those functions 3) to uncover

prior applications of personalization and customization by science museums 4) understand the perceived benefits and drawbacks of personalization and customization. Semi-structured interviews were selected as a suitable qualitative method for the purpose of this research because they allow for a deeper understanding of the subject matter and *why* museums have certain perceptions of personalization and customization (Denscombe, 2014, chapter 12).

The interviews were split into two parts: the first part concerned the functions, in order to triangulate the data from the website analysis; the second part was an exploratory conversation about personalization and customization, covering attitudes, examples, and prior experiences (see Appendix A for the interview scheme). The group of participants consisted of a heterogeneous sample of experts, thus the interview schemes were slightly adapted to the expertise of each participant. In the period of 19 April - 3 June 2021, nine separate interviews were held in Dutch which lasted from 45 to 90 minutes. All interviews were held online using MS Teams.

Participants. The interviewed experts were employed by science museums, staff of design bureaus, or otherwise involved in the science museum sector. Table 1 shows an overview of the organizations, participants and their functions.

Table 1

Interview Participants

Organization	Type	Location	Participant	Function
The Netherlands Institute for Sound and Vision	Media Museum	Hilversum	Corine Lindenbergh	Project Manager
Naturalis	Biodiversity Centre	Leiden	Anonymous	Program Coordinator
NEMO Science Museum	Science Museum	Amsterdam	Esther Hamstra	Senior Program Maker
Museon	Science Museum	Den Haag	Friso Visser	Head of Education and Presentation
De Ontdekfabriek	Science Museum	Eindhoven	Chris Voets	Director
Zuiderzeemuseum	Heritage Museum	Enkhuizen	Martine de Winter	Head of Marketing & Communication
			Femke van Drongelen	Head of Presentation & Education
VSC	Sector Organization	The Netherlands	Marianne Benning	Project-leader Learning Ecosystems & Network Coordinator
Bruns	Design Studio	Bergeijk	Ilone Bloemen	Development Manager
NorthernLight	Design Studio	Amsterdam	Steven Schaeken	Partner

The museums were selected with an expert purposive sampling method (as described by Etikan et al. (2016)). The selection criteria were based on the potential interest that a museum could have in personalization and customization technologies.

This potential was scored by looking at prior experiences with personalization and customization; the use of other technologies by the museum; online activity; number of visitors. These criteria have resulted in the top 10 ranking as shown in Table 2. In order to get a broader perspective from the museum industry, several other experts were approached with a snowball sampling method (as described by Ghaljaie et al. (2017)).

Table 2

Ranking Of Science Museums that are member of the VSC

Ranking	Museum	Location	Participation
1	Netherlands Institute for Sound and Vision	Hilversum	Yes
2	Museon	Den Haag	Yes
3	Technopolis	Mechelen (Belgium)	No
4	Naturalis	Leiden	Yes
5	Zuiderzeemuseum	Enkhuizen	Yes
6	Maritiem Museum	Rotterdam	No
7	Teylers Museum	Haarlem	No
8	NEMO Science Museum	Amsterdam	Yes
9	De Ontdekfabriek	Eindhoven	Yes
10	Space Expo	Noordwijk	No

Data analysis. The interviews were recorded, transcribed and coded. The functions and goals mentioned in the interviews were deductively coded into the functions as identified by the website analysis. The second part about personalization and customization was inductively coded into emergent themes such as “Social experience”, “Free-choice learning environment”, and “Technology and data collection”.

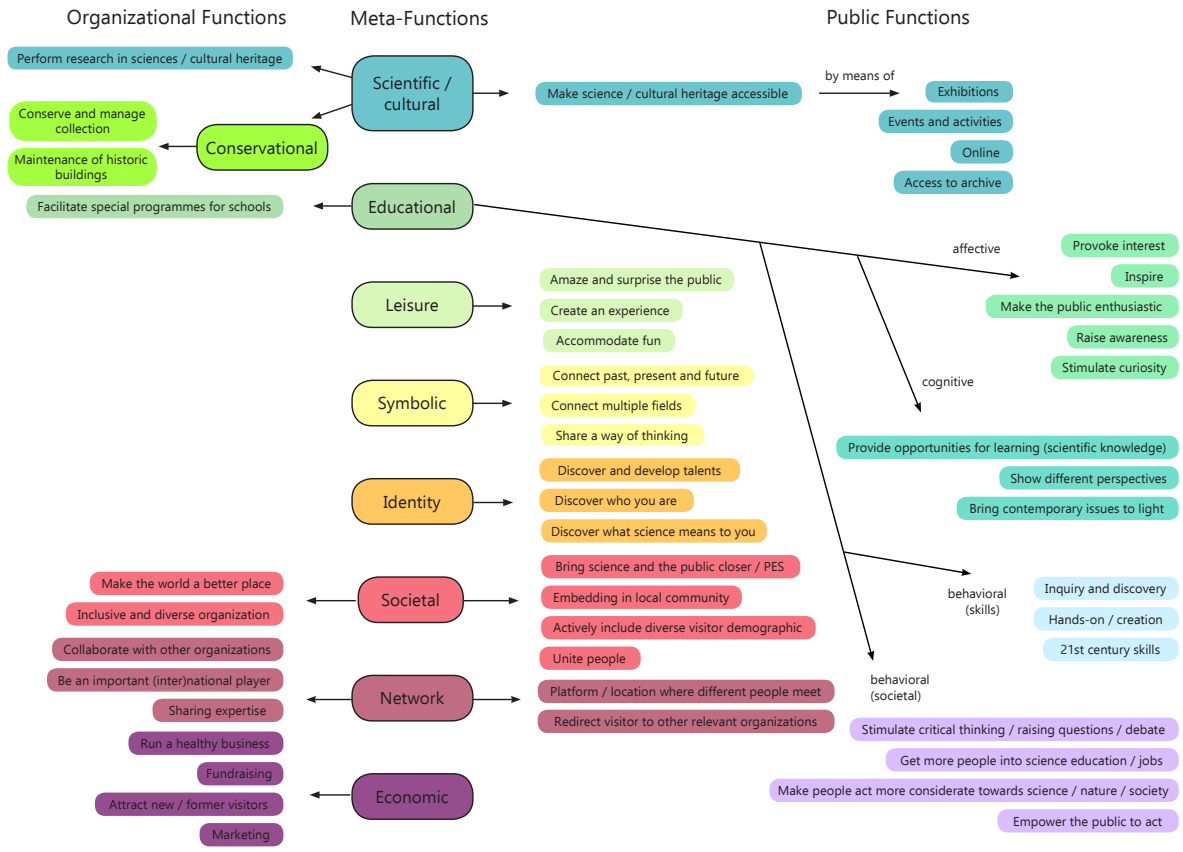
Results

Functions of Dutch science museums

Figure 1 presents an overview of the functions of science museums in the Netherlands as identified by the thematic website analysis and the interviews with museum professionals. It builds on the previous work by Achiam and Sølberg (2017). Ultimately, the framework contains 9 (slightly different) meta-functions, 13 organizational functions and 31 public functions. Figure B1 in Appendix B shows the same framework but includes the percentage of museums that mentioned a certain goal

on their website or in the ANBI-statutes. The discussion elaborates upon the resulting framework.

Figure 1. Functions of Dutch Science Museums



Perceived advantages and drawbacks of personalization and customization

Ten museum professionals were asked about their perspectives on the use of personalization and customization in science museums. The perspectives of the interviewees will be examined through the lens of six themes that recurred in multiple conversations: Personal relevance, information presentation, social experience, free-choice learning environment, technology and data collection, and costs and effort. For each theme the perceived advantages and drawbacks will be reported. The themes are closely connected and occasionally overlap. We conclude with the participant's views on future of personalization and customization in science museums.

Personal relevance. Science museums need to engage with various audiences in order to fulfill their functions. Generally, personal relevance was regarded as being an essential ingredient for good communication and effective public engagement. Current strategies that were mentioned by the interviewees to address diverse audiences in a personally relevant manner were for example offering multiple tours, creating a layered museum and telling stories from different perspectives. Personalization and customization were mostly regarded as ways to improve these existing communication strategies.

Zuiderzeemuseum mentioned that good personalization and customization can result in a more memorable experience:

> What you have experienced becomes more valuable, is more memorable, means more to you, inspires you more. - Zuiderzeemuseum

The Netherlands Institute for Sound and Vision added a leisure and economic outcome to that:

> We thought if it is personalized, and you feel more personally addressed, it will stick better. Then it's more impressive, so that was the goal. To hit even harder. And of course that the visitor likes it very much and comes back more often and remembers the visit. - The Netherlands Institute for Sound and Vision

But perhaps being personally relevant is more dreamlike than reality. As NEMO Science Museum indicated, the technology has its limitations:

> You [a science museum] do want to be in the Zone of Proximal Development with your programs, and then I think it helps to increase the recognizability and increase that relevance for the visitor. That is of course also possible in a personalized manner if the technology were actually that good. - NEMO Science Museum

Even if the technological limitations would be overcome, NorthernLight indicated that humans are complex beings and personalization might not be able to grasp the divergent interests of a visitor:

> People have a lot of choices and it's not really easy to predict the way they choose those things. Many people easily shift from high-culture to low-culture and are harder to put in boxes than we thought. - NorthernLight

Personalization has the drawback that it needs to understand the visitor and model that into a visitor profile, which has been proven to be challenging. On the other hand, customization deals with these issues less and can create an equally personal relevant experience.

Information Presentation. The presentation of information is closely related to personal relevance. By selecting content that is personally relevant, specific information can be presented to the right person at the right time, similar content can be presented in a way that is most suitable for a particular visitor or attention can be directed to interesting parts.

As NorthernLight indicated:

> You can make things more in line with the perception and context of your visitor. So you can actually structure your information on the basis of data or characteristics of the visitor. - NorthernLight

The VSC also pointed out that science museums want to help the visitor to discover new things and then go into depth more if he or she is interested in a specific topic. De Ontdekfabriek was interested in the possibilities that personalization can provide to balance the breadth and depth of the learning experience:

> In an ideal world you can explore very broadly and learn all kinds of things... And if you then have one particular subject like "damn that really touches me", if you can then also go into depth, that's obviously great. - De Ontdekfabriek

Yet, as with most personalization algorithms, there is a chance of channeling too much and spiraling into an information bubble. The VSC mentioned that personalization should not limit the visitor in discovering new things:

> I don't think you should restrict it completely, because the beautiful and inspiring part of visiting a museum is that you also encounter completely new things that you didn't know you were interested in. (. ...) And that might not even have been picked up in such a personalization profile. - VSC

However, if it is known what a visitor already knows, then it is also known what is unfamiliar to the visitor. It is therefore possible to show novel things to the visitor if that is desired. For example, the Netherlands Institute for Sound and Vision uses familiarity as a hook and continues from there:

> We want to grab you by that recognizability and then take you to different worlds in the past, or in the future, or other areas of interest. - The Netherlands Institute for Sound and Vision

Personalization can also help to deal with a information overload. The abundance of information that a museum (potentially) wants to disclose implies that many decisions need to be made that are now usually made by the exhibition designers and curators. But even with a carefully curated exhibition, science museums often showcase more information than can be absorbed by the visitor in a single visit. Bruns indicated that on one hand you can channel information with personalization, and at the same time, you can also disclose more (be it not to everyone):

> You can't give the whole story anymore because it just takes too long, there's too much information. So you have to start channeling. - Bruns

> Because it can be adjusted to your interest, you can reach more people with it. I also think that this gives you a more layered museum. That you can tell more. - Bruns

Bruns also mentioned that the ability to make adaptations in the physical museum is limited, but has more potential in the digital world:

> In the physical world it is very difficult to do both customization and personalization. In the digital world, because it's a fluid world, it's much easier to adapt. - Bruns

Nonetheless, it was mentioned that science museums generally want to limit the amount of screens inside the museum. NorthernLight suggested that a personal digital layer can be efficiently utilized as part of the post-visit, for example with a bookmarking option:

> Adding a layer of depth afterwards can be interesting... Getting in touch afterwards with people or agencies that can take you further... So like a kind of bookmark "oh, I found this interesting". - NorthernLight

An example of a customizable bookmarking method was given by Bruns:

> With your finger scan you could say "well this I think is an interesting story, this is an interesting topic" and then at the end of your visit you could make your own newspaper with those articles of the events that you all said were interesting. - Bruns

Lastly, De Ontdekfabriek mentioned that personal learning experiences may also lead to less collective learning:

> Everybody gets their own truth. So there is less collective learning, so to speak. (. ...) But I think that's actually a good thing (. ...) Let everyone in their own way dig a little deeper in what they are interested in. - De Ontdekfabriek

Although De Ontdekfabriek did not necessarily regard more individuality as problematic, other interviewees have expressed their concerns, which will be discussed in the next section.

Social experience. The interviewees emphasized the importance of the social dimension of a visit to a science museum. Social learning and experiences are a core value for science museums, therefore most exhibitions are designed to facilitate social interactions within the groups that are visiting the museum together. Personalization, but also customization, were regarded as techniques that may interfere with the social experience and are therefore not always desired in science museums.

As NEMO Science Museum and De Ontdekfabriek indicated:

> Personalization and customization assume that you visit an exhibition as an individual, but people don't come as individuals. Better yet, we don't want them to visit as individuals. We want them to come together and experience the museum as a family. - NEMO Science Museum

> We do work a lot with groups, in fact we encourage that. Coming up with something together, building something, that's fun. We like that very much and children like that too. (. ...) If you approach it very individualistically, then you lose the group thing a bit. - De Ontdekfabriek

De Ontdekfabriek also mentioned that one of the characteristics of their museum is that there are the interactions between the visitors and staff. De Ontdekfabriek does not want personalization or customization technologies to replace these interactions.

Despite the seeming contradiction between social and personal, a personal experience does not have to limit the social interactions within a museum per definition. For example, NorthernLight mentioned a solution with personal break-out moments:

> [You can] make the experience social for everyone, and then you have a break-out moment that is personal, so that you can do a personal reflection. - NorthernLight

Additionally, the Netherlands Institute for Sound and Vision gave an example of how they create a personal experience while also respecting the group as a whole:

> If you go to the museum with five friends, and you all take an individual photo and you take a funny photo in front of a green screen as a group, then the camera knows from that moment that you belong together. Precisely we can use that to bring people together or show you at the end all those scores within your group, things like that. We're just linking all those people who are together. - The Netherlands Institute for Sound and Vision

Free-choice learning environment. Science museums are free-choice learning environments that allow the visitor to take control of his or her own experience through customization interactions. By offering a range of choices, the visitor can automatically construct a personal experience, which is even possible without fancy technologies. The free-choice learning environment is often shaped by means of interactive exhibits, hands-on learning, and inquiry and discovery, which are basic offerings of science museums.

> Of course it's a free-choice learning environment, so visitors are allowed to find their own way and decide how they give meaning to what they do and encounter. They are allowed to color their own visit actually. - NEMO Science Museum

> The magic word in museumland used to be "experience", so not just looking at something with your hands behind your back... That used to be the learning experience. But after that, it was more about doing it yourself and pushing buttons, so that you have a kind of experience and it makes a longer lasting impression. You learn more. - The Netherlands Institute for Sound and Vision

But free-choice learning environments have their limitations:

> You have to choose the subject matter, that's already an exclusion. So the fact that I offer something or not to the public, that excludes other things. So you're not totally free in that, that's the first thing. Secondly, you also don't want it to go in all directions. - Museon

Furthermore, Zuiderzeemuseum mentioned that customization and too many choices may lead to choice-stress and a fear of missing out:

> A human being can actually only handle three choices (. ...) Then if there are eight, I'm no longer sure... I'd rather not choose. And that's also how a human being works. So too many choices doesn't work and certainly not choice upon choice. - Zuiderzeemuseum

Museon warns for the fragmentation of knowledge and even pleads for a more activist attitude of science museums:

> I think it is important that people [employees] in science museums realize that we have a certain message and that they [the museums] have to stand for it. So they [the museums] should present themselves in a more activistic way, where customization is probably even more excluded, than that you should necessarily make something for everyone. - Museon

Personalization has characteristics that limit the amount of choices and is therefore less appropriate for creating a free-choice learning environment. NorthernLight also mentioned that humans like to have the feeling that they can choose:

> The current perception and psychology is not far enough that people want [that a system makes choices for him/her]. (. ...) People still think they are free spirits and think they have choices. - NorthernLight

As mentioned in the personal relevance section, personalization may not even add an extra personal dimension to a museum experience because people already attend to what they like and construct their own personal interpretations in a free-choice learning environment:

> So you always make that tour personal because you choose which things to go to or which things to look at or which things to delve into. - NorthernLight

Technology and data collection. For personalization it is necessary to get to know the visitor and construct a visitor-model with collected data. Basic customization, on the other hand, can also be realized without a visitor-profile. Privacy issues related to data storage were of great concern to the interviewees. Not only are privacy laws changing and becoming more strict, collecting data of under-aged visitors, the predominant audience, requires explicit permission from a parent.

NEMO Science Museum contemplated collecting visitor data, but refrained from it:

> Because it was exactly at the time that the General Data Protection Regulation story started and nobody knew what you could and couldn't do with it, so we were very hesitant about that. - NEMO Science Museum

On the other hand, The Netherlands Institute for Sound and Vision indicated that they had surveyed visitors and concluded that their museum was given sufficient credibility and trust to collect data from their visitors.

Secondly, Bruns mentioned the cold-start problem: Every visitor enters with an empty visitor-profile, which results in poor personalization at the beginning of the visit.

> You also don't want to start with a whole questionnaire for your visitor, like "What's your interest?" It has to be very automatic, otherwise it becomes a stumbling block. - Bruns

But even with data, algorithms have their limitations and biases, as NorthernLight and NEMO Science Museum indicated:

> If someone is going to pick something that they think is good for you, you miss a whole bunch, and often they are pretty bad suggestions too (. ...) Then you can hope that with artificial intelligence it works better, but we are still not at the point where we can read people's minds. - NorthernLight

> The algorithm has to be smart enough to read that individual. However, we all know that algorithms are full of biases. - NEMO Science Museum

However, NEMO Science Museum also saw the potential of personalization if the technology gets better:

> On the other hand, algorithms are indeed getting better and better, and if they can really do that, who knows... - NEMO Science Museum

Data collection is essential for rich personalization and that data can also be used for other purposes such as analytics:

> If I know better who is in my museum, then perhaps I can also better specify a product offer on that or an offer for e-services or things like that - NorthernLight

De Ontdekfabriek mentioned that they do not use fancy technologies in their museum, therefore digital customization and personalization are quickly excluded:

> Well it's very simple, those don't apply to us, but still we reach our goals in other ways, so without technology. - De Ontdekfabriek

Costs and effort. Personalization and customization are often an additional layer on top of the regular experience. The word "additional" implies that there are also additional costs. Not only building and maintaining systems such as mobile applications or websites costs money, also the content that can be customized or personalized has to be created and kept up-to-date.

NEMO Science Museum and Museon argued:

> I think also because it is complex and expensive on the one hand. People are already asking you to create a new exhibition and then if you offer something extra, that is of course above the initial budget. - NEMO Science Museum

> I think that in many cases it also has to do with the deployment of manpower and resources. So yes, you are limited in that. It is often the case that you are very happy when you have financed the entire exhibition... So very nice in theory, in practice I think it is difficult. - Museon

However, personalization and customization can also help to generate revenue. As previously mentioned, data collection can give more insight into the visitor behaviour, can be used for the improvement of exhibitions and is useful for marketing purposes. It can also give the visitor a reason to return to the museum to discover new layers.

> I think that for a museum it is of course interesting to know, from a marketing and economic perspective: Who comes to my museum, who is my target group, and how can I adjust the experience to that? - NorthernLight

> I think it also depends on your museum and your goals. I think it doesn't have to be expensive, that you can even achieve a goal in a cheaper way like that. You have to apply everything appropriately. - Bruns

The future of personalization and customization

From the interviews it became evident that *customization* is already inherent characteristic of science museums, but the participants were also asked whether they think we will encounter more *personalization* in science museums in the future. Personalization was regarded as a trend that our society will not go without anymore, but for science museums it is still under debate whether it has relevant applications.

> We think that the added value of the personal tour is becoming less and less because it is already happening in your private life all the time. - NorthernLight

> In my experience, and maybe it really isn't correct at all, but it is something we've tried for years in the museum world and it just didn't really take off and now it's dying a quiet death. - NEMO Science Museum

Others predict that we will see more of it. The Netherlands Institute for Sound and Vision sees a similar trend for personalization as with interactivity:

> You could see that the amount of interactivity only increased, and I think that the same is true for this. (. ...) It's just a trend you see in society,

> everything is getting more and more personalized. So I think that the museums will just do that. - The Netherlands Institute for Sound and Vision

Due to the increasing prediction power of algorithms and other advances in technology the use of personalization in science museums is also expected to increase.

> There are many advantages to it and I think that the technology enables more and more. - De Ontdekfabriek

The overall opinions on using personalization in science museums were divided: Three of the nine participants were generally positive; three were slightly sceptical; three participants could see the benefits of personalization but had some doubts about the feasibility of the implementation or did not see direct applications for their own organizations. Customization, on the other hand, is already omni-present in science museums and is deeply rooted in interactivity, hands-on learning and inquiry and discovery.

Discussion

Functions of science museums

The aim of the website analysis was to identify the functions of science museums in the Netherlands. In this section the main findings as presented in Figure 1 are discussed and compared to the framework by Achiam and Sølberg (2017) and the generations of science museums by Pedretti and Iannini (2020).

Scientific / Cultural and Conservational. Figure 1 shows that the scientific and cultural functions of science museums were united into a single category. This decision was made because many VSC museums do not specialize only in fundamental or natural sciences, but often include historical and cultural themes as well, making it difficult to define a boundary between science and culture in many cases. As was mentioned on the website of the VSC, science museums actually aim to build bridges between science and culture: “Science museums and centers facilitate essential

connections between science, technology, culture and society." The overlap between the two meta-functions was also mentioned by one of the interviewees in Achiam and Sølberg (2017): "Science is culture." (p. 132).

The conservational function was linked to the scientific and cultural function as an organizational function. The conservational function has considerable overlap with the scientific and cultural functions, which was also acknowledged by Achiam and Sølberg (2017).

Educational. At least one educational (sub-)function was mentioned on each website. Even though this can partly be attributed to the many sub-functions that the educational function encompasses, it also shows the significance of education as a function for science museums. The educational function not only involves cognitive learning objectives, affective learning objectives were in fact mentioned more often. The four generations of science museums as described by Pedretti and Iannini (2020) are all reflected in the educational sub-functions. Communicating factual *dry* knowledge, a characteristic of the first and second generation, is connected to the cognitive learning objectives in the framework. *Hands-on learning* and *inquiry and discovery* relate to the third generation of science museums, in which interactivity plays an essential role. The behavioral societal learning objectives have many features of the fourth generation. For example, *empower the public to act* resembles Pedretti and Iannini's "change and transformation" and *stimulate critical thinking, raising questions and debate* can be associated with "productive struggle". These societal functions all aim to stimulate active and good citizenship, for example as the website of Museon stated: "We see it as our task to inspire visitors to take an active attitude as global citizens." The affective learning objectives are relevant to all the generations. The results show that contemporary science museums in the Netherlands combine elements of several generations of science museums and reflect that in the diversity of their educational offerings. Two of the themes that emerged from the interviews - the social (learning) experience and free-choice learning environments - are not included in the framework since those themes are hard to classify as functions, but they are rather key values for

science museums. Due to the connection between learning and education, these values are closest related to the educational function of science museums.

Leisure, Symbolic and Identity. The leisure function was not identified by Achiam and Sølberg (2017), even though it has a high prevalence in the mission and vision statements of the Dutch science museums. Phrases like “edutainment” and “playful learning" show that leisure and educational functions go hand in hand, as was stated on the website of the VSC: “Science museums and science centers offer families, children and other visitors high-quality experiences: substantive and enjoyable at the same time”. Although Shaby et al. (2016) argue that “fun” is part of the affective dimension of the museum learning experience, we have chosen to give leisure a distinctive meta-function to emphasize the significance of leisure for science museums. Leisure is not only reflected in the way science museums approach their visitors, science museums also compete with other leisure activities as a fun day out, such as going to a theme park (Black, 2012).

The symbolic function encompasses similar sub-functions as compared to Achiam and Sølberg (2017) and includes abstract topics that science museums deal with, such as sharing a way of thinking. For example, Batavialand mentioned: “Batavialand disseminates the Dutch pragmatic mentality”.

Also the identity function is a novel meta-function. Almost half of the museums mentioned a function related to identity, for example NEMO Science Museum stated: “The public is invited to discover and explore his/herself and the world around us”. Additionally, the Netherlands Institute for Sound and Vision mentioned in the interview: “We actually want the visitor to undergo a kind of transformation (. ...) coming out as a different person.”. The “transformation” that the Netherlands Institute for Sound and Vision encourages the visitor to undergo is also one of the fourth generation functions as identified by Pedretti and Iannini (2020). The identity function is especially interesting for the purpose of this research as personalization and customization aim to increase the personal relevance to the visitor.

Societal. What Achiam and Sølberg (2017) defined as the *Social* function - which "refers to its value to society" (p. 134) - has been changed to *Societal* to point out that this function concerns what a museum contributes to society. The societal function is such a fundamental value for science museums that it ties together every other function in the framework and may be regarded as a reason for existence. As Rijksmuseum Boerhaave stated: "In a society in which scientific and technological developments are going increasingly faster, we see it as our duty to involve the public.". Inclusion and diversity were also important themes that were identified and classified in the societal function as *actively include a diverse visitor public*.

Network and Economic. The network and economic functions predominantly contain organizational functions, of which *attracting new / former visitors* and *marketing* may benefit most from personalization and customization. One public network sub-function that was not found on the websites of the science museums, but only mentioned by several interviewees was *redirect visitors to other relevant organizations*. The motive for redirecting visitors is to create a larger learning ecosystem in which the visitor gets the opportunity to learn from other organizations with more expertise in their interest. Learning ecosystems show potential for personalization and customization, because personalization and customization can support matching the visitor to the next step in his or her interest.

Other. The political function was not identified in the missions and visions of Dutch science museums. However, the description of the political function by Achiam and Sølberg (2017) resembles the societal function in the new framework. For example, *promote civic engagement* is approximates *bring science and the public closer / public engagement with science* and filed under societal. This decision was made because none of the museums mentioned political involvement as a goal, but bringing science and the public closer was rather put in the perspective of the public's own benefit. It can therefore be argued that the political function is still in the framework, but has been combined with the societal function.

Notably, if you take the first sub-function of each cluster, which is the

sub-function that was mentioned most often, you will also get a good general overview of the functions of Dutch science museums. In this way the framework can be compressed into a more compact version and becomes easier to digest.

Personalization and customization in science museums

Nine interviews were conducted to identify the perspectives of Dutch museum professionals on the use of personalization and customization in science museums. In this section the main findings are discussed and the challenges for each theme are identified. Moreover, several examples of applications and implications for design are presented based on the results and previous literature. Finally, the museum functions that have the highest potential to be enhanced with personalization and customization techniques are listed per theme.

Personal Relevance and Information Presentation. The personal context of a museum visit includes motivation, prior knowledge and interest, and choice and control (Falk & Dierking, 2004). As Falk and Dierking (2004) argue, the personal dimension, as well as the sociocultural and physical context, contribute to the quality of the museum visit. From the interviews it became evident that delivering personally relevant content is desired by many museums. However, understanding the visitor's thoughts and constructing a visitor model is a non-trivial task and it is debatable what the "right" personalization is.

Several systems have been tested in museums in the past. For example, Huang et al. (2012) have proposed a personalized guide recommendation system that suggests exhibits based on the visitor's interests and location to mitigate an information overload. Van Hage et al. (2010) has combined recommendation with a route construction system to help to deal with an information overload and directs the visitor to exhibits in his or her interest. Chatbots, which will also be implemented by the Netherlands Institute for Sound and Vision, can function as a personal assistant, allowing the visitor to ask questions or engage in a conversation. Gaia et al. (2019) have even experimented with a chatbot game in which the chatbot acted as a famous person,

taking the concept of a chatbot beyond the idea of personal assistant.

However, Falk and Dierking (2004) Chang (2006), and Fantoni (2012) also argue that in informal learning situations people already connect their personal experience and prior knowledge to the information that they encounter. This was also mentioned in the interviews and is in accordance with constructivist learning theories. Constructivism is described by Hein (1991) as the "idea that learners construct knowledge for themselves - each learner individually (and socially) constructs meaning - as he or she learns" (p. 1). NorthernLight also mentioned that people already know what they are interested in and do not need a system to direct them towards their interests. These findings suggest that personalization would add little value.

However, for customization this is less problematic. For example, it is possible to add a "Want to know more?" button to create an optional deeper (digital) layer. Wessel (2010) found that "adding a virtual information space on a mobile device on top of the information space of the physical museum can enlarge the interest landscape for the museum visitor and support the visitor in exploring it" (p. 2).

Furthermore, several interviewees mentioned bookmarking as a valuable customization solution in which the visitor can save information him or herself to a visitor profile, for example to return to it later as part of the post-visit. Although Wessel (2010) found that the turnover to the post-visit is low, he suggests that better personalization may increase the number of people that use the post-visit bookmarks, implying that personalization and customization can strengthen each other.

Stock et al. (2007) have experimented with an automatically constructed summary of the visit, in which the report "becomes an entry point for acquiring more information on the themes that appeared of interest for the visitor and for attracting her to subsequent visits." (p. 299). NorthernLight also mentioned that you can include materials in the post-visit that do not fit into a museum visit, such as a documentary of 2 hours.

Table 3 summarizes the main findings and presents several implications for design.

Table 3

Summary Personal Relevance and Information Presentation and Implications for Design

Main challenges	Getting the right information to the right person at the right moment. Modeling the complexity of the visitor's thoughts and interests (from interactions with the museum).
Strengths pers/cus	• Presenting personal relevant information can result in a more positive museum experience and deeper learning. • Digital personalization and customization allow for more depth of content, but can also facilitate a broader offer of information. • Personalization can reduce an information overload by suggesting exhibits, constructing routes or directing attention to relevant details. • Personalization and customization can strengthen each other and thus become more effective.
Weaknesses pers/cus	• The content has to be created in advance, which costs time and money. • Program may become fragmented, causing the museum to have less control over what each visitor sees. • Visitors already connect their own life experiences and prior knowledge to exhibits.
Implications for design	• Create exhibits that make it easy for the visitor to connect the information to his or her own prior interests and knowledge. • Applying personalization to reduce information overload may be worthwhile, but often customization (e.g. using filters and search criteria) is sufficiently effective. • The (physical) exhibition should not be too overwhelming. Additional (digital) layers with deeper information are most useful at home as part of the pre- or post-visit. • When making use of pre- and post-visit opportunities, ensure that the conversion rate is high and genuinely to the physical experience.
Examples	"Want to know more?" (Wessel, 2010), bookmarking (Wessel, 2010), chatbots (Gaia et al., 2019), recommender systems (Huang et al., 2012; Keller & Viennet, 2015), route construction (Van Hage et al., 2010), post-visit summaries (Stock et al., 2007)
Related functions	Identity, Educational, Make science accessible, Leisure

Social experience. As was mentioned by the interviewees, science museums are generally attended in groups, which science museums want to stimulate and cater for. A personal experience was often interpreted as being an individual experience. Therefore, the primary challenge is to maintain the social dimension of a museum visit while also constructing a personal experience. According to Falk and Dierking's contextual model of learning, the social context is an essential component that contributes to learning and meaning making in museums (Falk & Dierking, 2004). This shows that the social context is related to the affective and cognitive educational functions. Moreover, the social experience contributes to making the visit more pleasurable.

A personal experience may interfere with the social context at first sight, but that is not always the case. Good design can even support the social experience as the following examples demonstrate. Van Dijk et al. (2014) have piloted a collaborative tabletop in Museon that allowed visitors to select themes in their interest, after which an unique quest through the museum would be generated, combining the preferences of everyone in the group. Luyten et al. (2006) have described the ARCHIE system which was a digital mobile guide that enabled the visitors to communicate and play collaborative games through a digital interface. Ryding et al. (2021) have described the

mobile application "Gift" that allows visitors to send gifts to each other (or even to people who are not inside the museum). The gifts can contain personal interpretations of exhibits or artifacts in the museum. Ryding et al. (2021) call this strategy *interpersonalization*.

The Netherlands Institute for Sound and Vision mentioned in the interview that they will take the whole group into account during the museum visit. They are also working on a quiz-game in which strangers are dared to play against each other. Such a game will even extend social interaction beyond the groups that visit the museum together. NorthernLight previously mentioned the possibility to combine a social experience with personalized break-out moments. A personalized component may also be added as part of the online pre- or post-visit, so that the visit onsite can be optimized as a social experience.

Table 4 summarizes the main findings and presents several implications for design.

Table 4

Summary Social Experience and Implications for Design

Main challenge	Maintaining or improving the social experience while using personalization and customization.
Strengths pers/cus	• Customization does not necessarily limit the social experience, but can actually support social interactions (e.g. with collaborative quizzes, games). • Interpersonalization can support group dynamics while creating a personal experience. • The social interactions can be alternated with personal reflection moments.
Weaknesses pers/cus	• The more personalized an experience is to a single individual, the less social the experience will become. • Digital customization and personalization often require a device that may limit social interaction (e.g. headsets for audio tours or mobile phone screens for applications). • Group personalization requires making compromises.
Implications for design	• The exhibit should be designed with the social experience as a fundament, with an optional personalized detour (e.g. as break-out moments). • Design with regard to specific group-types (family, friends, couple etc.). • Extend the social experience inside the museum with an individual experience after the visit.
Examples of implementations	Interpersonalization (e.g. Gifting (Fosh et al., 2014; Ryding et al., 2021)), collaborative personalization (Van Dijk et al., 2014), collaborative games (Luyten et al., 2006)
Related functions	Educational (affective, skills), Leisure, Unite people, Platform / location where different people meet

Free-choice learning environment. Free-choice learning was pinpointed by the interviewees as an significant characteristic of science museums. Dierking and Falk (1998a) have coined the term free-choice learning and researched free-choice learning in science museums extensively (e.g. Dierking & Falk, 1998b; Falk, 2001; Falk & Dierking,

2018). They argue that learning is optimal when the visitor "can exercise choice over what and when they learn and feel in control of their own learning." (Falk & Dierking, 2004, p. 141). Additionally, free-choice learning is associated with intrinsic motivation and learning for fun (Dierking & Falk, 1998b).

Bamberger and Tal (2007) have tested three levels of choice in a museum environment and found that activities with scaffolds to make choices (so not a *completely* free-choice environment) resulted in deeper engagement with the learning material. Hence, the main challenge is to optimize the amount and quality of available choices. Essentially customization *is* a form of free-choice learning because it allows the visitor to take charge of their own learning. Personalization may cause the visitor to be less actively involved in the decision-making process, and therefore seems to conflict with a free-choice learning environment. Yet, personalization can provide scaffolds to the visitor by suggesting a selection of choices.

An example of free-choice learning mediated by personalization and customization is the CHESS project which uses the concept of interactive digital storytelling (Roussou & Katifori, 2018). Instead of merely picking an interesting tour at the beginning of the visit, the visitor is actively involved in the construction of a narrative throughout the museum, resulting in a personalized and adaptive experience. The Atlantic Wall exhibition in Museon was based on a similar concept in which personalization and customization were combined to construct a narrative in the visitor's interest (Not & Petrelli, 2019). The visitor was able to interact with the system with a tangible object that functioned as a bridge between the digital layer and physical museum.

Furthermore, as mentioned by the interviewees, adding digital customizable features to the physical experience can open up more possibilities for free-choice learning. Previously mentioned examples are applications such as bookmarking and a "Want to know more?" button (Wessel, 2010). Most science museums are already familiar with free choice and customization options in the physical world, such as hands-on activities, workshops and experiments, but many opportunities remain to extend free-choice learning to a digital customizable layer.

The educational and leisure functions are closest related to free-choice learning mediated by personalization and customization because the intention of free choice is to make the learning process more meaningful and pleasurable. Furthermore, because choices allow for more recognition with the lived experience of a visitor, it can also elevate the identity function.

Table 5 summarizes the main findings and presents several implications for design.

Table 5

Summary Free-Choice Learning Environment and Implications for Design

Main challenge	Optimizing the amount and quality of choices.
Strengths of pers/cus	• Customization implicitly has characteristics of free-choice learning. • Free choices make it easier for the visitor to connect the experience to personal interests.
Weaknesses of pers/cus	• Personalization limits the amount of choice (but can be applied to construct a smaller set of more relevant choices). • Too many choices may result in choice-stress or fear of missing out. • Fragmentation of program and less control over what the visitor sees. • A completely free-choice environment results in less depth of learning.
Implications for design	• Allow visitor to make his/her own choices, but provide scaffolds. • Extend free-choice learning to a customizable digital environment.
Examples	Interactive storytelling (Roussou & Katifori, 2018), Hands-on activities, Experiments, see also first three examples in Table 3
Related functions	Educational (affective, cognitive, skills), Leisure, Identity

Technology & Data Collection and Costs & Effort. Concerns about the capability of the current technologies and associated costs were raised by the interviewees. Modeling the complexity of a visitor's thoughts into a robust visitor profile and keeping the personalization and customization interventions low cost were identified as the main challenges.

A visitor model can be based on data gathered from interactions with the museum, but also on visitor styles. Falk (2016) has identified five visitor styles based on motivation: Explorer, Facilitator, Experience Seeker, Professional/Hobbyist and Recharger. Almeshari et al. (2019) found that it is possible to reliably identify the visitor style using only two multiple choice questions about visit motivation and perceived success criteria. Initializing a visitor profile with a visitor style can be useful to overcome the cold-start problem (Almeshari et al., 2020). After that it is recommended to collect additional data, for example through customization interactions to create a more nuanced visitor profile. Serrell (1996) already argued in the nineties

that dividing visitors in visitor styles is insufficient to get to know the visitor thoroughly because not every visitor checks off all the characteristics of the five visitor styles as identified by Falk (2016). Therefore, gathering *some* information is better than *none*. Serrell (1996) suggests that this does not have to be sensitive personal data, but for example interest can also be measured by the time that a visitor spends at an exhibit.

When data is collected, it needs to be stored carefully and abide privacy laws. Sundar and Marathe (2010) found that most users assume that they have little privacy in online environments. However, as the Netherlands Institute for Sound and Vision has concluded from their survey, visitors trust the museum for carefully handling their data, which shows that privacy may be considered less of a public concern in the context of science museums.

To implement a virtual personalization and customization layer inside the museum, the visit is often augmented with a digital device. There are several arguments for an against the use of handhelds. Wessel (2010) provides a comprehensive overview of potential benefits and drawbacks of mobile media technologies found in literature on p. 40 and p. 41. Gammon and Burch (2008) conclude: "While some studies indicate that digital technology can be a distraction, there is considerable counter-evidence that when it is properly designed, it can actually increase visitors' engagement with other exhibits." (p.39).

There are also less intrusive technologies, such as RFID-tags, or finger scans and face recognition as was mentioned in the interviews. Hsi and Fait (2005) summarize various uses of RFID technologies in science museums such as providing additional information in the post-visit, collecting personal information during the visit, or creating an avatar. They say: "Wireless RFID technologies are appealing to museums not only because of their relatively low cost compared to alternative technologies like barcode readers, but also because of their potential for improving each and every visitors' learning experience, as well as their personal sense of belonging to the museum community." (Hsi & Fait, 2005, p. 63).

In the interviews it was argued that personalization and customization, especially

as an additional digital layer, bring about additional costs. Keeping the costs low can be accomplished by using low-tech solutions or existing software. In fact, interactive and hands-on exhibits that most science museums already offer fall into the category of low-tech customization.

Furthermore, the costs of content creation can partially be put into the hands of the visitor, for example through contribution, collaboration, and co-creation as Simon (2010) advocates for in her book *The Participatory Museum*. This not only reduces the costs, but also increases active participation and can make a museum more relevant to the public.

Lastly, data collection can give insight into the visitors and quality of the exhibition. For example, Huang et al. (2008) have demonstrated what the possibilities are with collected data. In their study, Huang et al. (2008) have even assessed the quality of learning by checking the number of right answers to mini-quizzes.

Table 6 summarizes the main findings and presents several implications for design.

Table 6

Summary Technology, Data Collection, Costs and Effort and Implications for Design

Main challenges	Getting the maximum amount of information out of minimum personal data. Reducing the costs and optimizing the return on investments.
Strengths of pers/cus	• Modern technologies are increasingly providing more possibilities. • Most people carry a smartphone, so the museum does not need to maintain a fleet of handhelds. • Customization allows the visitor to create his or her own things, reducing the costs of content creation. • The collected data can also be used for analytics and improving the museum experience.
Weaknesses of pers/cus	• Collecting data requires careful data management and abiding privacy laws. • Cold-start problem: a visitor has a blank visitor profile upon entering. • Algorithms are not sufficiently nuanced to make extremely accurate predictions or read people's minds. • It can be frustrating for the user if the technology does not work as desired. • Personalization and customization in the digital world are like an additional layer that also requires additional costs.
Implications for design	• Start with low-tech solutions such as contribution, collaboration, and co-creation not only reducing the costs, but also stimulating interactivity and creativity. • Use existing software and digital infrastructures. • Do not collect more data than strictly necessary and anonymize the data. • Communicate clearly with the visitor what data is being collected and provide an easy opt-out. • Consult an expert company for visitor data management. • If using technology, ensure that it works in all circumstances to prevent frustration. • Use non-intrusive technologies (such as RFID-tags and face recognition) for a seamless interaction. • Include nuances in the visitor model instead of categorizing only into visitor-styles (by learning from the interactions during the visit).
Examples	Mobile applications (Almeshari et al., 2020; Wessel, 2010), RFID (Hsi & Fait, 2005; Huang et al., 2008), face recognition, fingerscans, data analysis (Huang et al., 2008), participatory museum (Simon, 2010)
Related functions	Economic, Educational

Conclusion

We have discussed the strengths and weaknesses of personalization and customization for science museums through the lens of six themes. In many cases we have seen that *customization* is a less complicated and more economical approach to creating an personal experience than *personalization*. It became evident that customization in the physical world is already omnipresent in science museums. Bruns noted that in a digital environment, which is more fluid than the physical world, it is easier to make adaptations. This suggests that a digital layer can provide more customization possibilities for science museums that are yet to be exploited. Personalization in the physical world was barely discussed since it is nearly impossible to adapt the physical museum to individual visitors. Personalization in the digital world sounds promising but poses many challenges, for example trying to comprehend the

visitor's thoughts. Nonetheless, there is one situation in which personalization can be a very effective strategy, which has not been discussed so far, and that is when the topic of the exhibition is related to personalization. Since science museums often include technological topics such as data collection and artificial intelligence, implementing these techniques as part of the exhibition is a very efficient strategy to convey the message. In this way science museums can also show the limitations of personalization and be transparent about data collection instead of trying to hide the weaknesses of personalization. At last, we have observed that personalization and customization can strengthen each other, for example by collecting data from customization interactions to enrich the visitor profile. Figure 2 shows an overview of personalization and customization in the physical and digital world and includes the themes and functions are closest related.

Figure 2. Personalization and Customization in the Physical and Digital World

	Physical World	**Hybrid**	**Digital World**
Customization	*Inherent characteristic of science museums* Edcational (skills), Leisure, Unite people, Location / platform where different people meet Social Experience	*Ability to enhance physical and digital experience* Combination of customization functions Free-Choice Learning Environment	*Opportunities for science museums:* *1) Breadth and depth of information* *2) Extension of physical experience* *3) Bookmarking for post-visit* Educational (affective, cognitive), Leisure, Identity
Hybrid		*Integrate physical and digital personal experience and pre- and post-visit (virtuous circle)* Combination of all functions + Redirect visitors, Attract new/former visitors Personal Relevance Costs and Effort	*Optimize systems by combining personalization and customization* Combination of digital functions Technology and Data Collection Information Presentation
Personalization	*Almost impossible to realize in the physical world*		*Useful for:* *1) Recommendations* *2) Marketing* *3) If the exhibition is about personalization* Make science accessible, Marketing

Limitations and suggestions for further research

This study has identified several advantages and drawbacks of personalization and customization, but has not given a horizontal comparison with other strategies to engage with visitors of science museums. Possibly there are easier or more effective approaches to get a message across, such as gamification, storytelling, and good interaction design in general. On top of that, personalization and customization are often applied in combination with other communication strategies, making it hard to assess the added effect of the personalization and customization interventions.

Also the comparison with other types of museums has not been made. Personalization may have more potential for other museums such as art museums, in which personal taste and emotion play a bigger role. Also the potential of customization may be less significant for other types of museums.

Furthermore, the attitude of the visitors towards a personalized visit has not been elaborated upon in this study, but should not be overlooked. If the public is not willing to use the tools that create a personal experience, there is no point in offering those tools, for example as is now often the case with using bookmarks after the museum visit. Keller and Viennet (2015) have also suggested to include the perceptions of the audience more. Moreover, with increasing attention to privacy and data security, it is important to bear in mind the stance of the public on personalization. We suggest to focus more on the perspectives of the visitors in further research.

Lastly, we have not discussed learning ecosystems and the redirection of the visitor to other relevant organisations in depth. This function shows a lot of potential for digital personalization and customization and deserves more attention to explore what personalization and customization can entail to contribute to the construction of learning ecosystems.

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Appendix

Appendix A

Interview scheme

Museum:

Naam:

Functie:

Ik ben aan het onderzoeken wat personalisatie en customization kunnen betekenen voor wetenschapsmusea bij het vervullen van hun functies. Dat doe ik door te achterhalen wat de doelen zijn van wetenschapsmusea. Daarnaast maak ik onderscheid tussen personalisatie en customization en ga ik op zoek naar innovatieve manieren om personalisatie of customization in te zetten om de doelen te bereiken. Het interview is verdeeld in twee delen: eerst gaan we praten over de functies van [het museum] en daarna over jouw visie over personalisatie en customization in wetenschapsmusea. Deze begrippen zal ik dan verder toelichten. Voorafgaand aan dit interview heb ik literatuur over toepassingen van personalisatie en customization in musea bestudeerd en gekeken naar wat de voor- en nadelen kunnen zijn. Ik heb ook alle websites van de musea die bij de VSC aangesloten zijn geanalyseerd voor de functies die benoemd worden op de missie visie pagina en in de ANBI-statuten.

Deel 1: Functies

1. Kan je in het kort vertellen wat de belangrijkste functies zijn van [het museum] volgens jou?

    (a) Op jullie website kwam ik het volgende tegen []. Kan je je daar in vinden? Heb je het idee dat de organisatie zich actief inzet om dit te bereiken?

2. Ik heb een aantal hoofd- en sub-categorieën geïdentificeerd op basis van een website-analyse van alle VSC partners [framework laten zien].

    (a) Komen deze hoofdcategorieën overeen met jullie bezigheden?

    (b) Zijn er hoofdcategorieën waar jullie eigenlijk niks mee doen?

    (c) Heb je nog wat toe te voegen aan dit framework?

3. Zijn er nog andere thema's of kernwaardes die belangrijk zijn voor [het museum]? [Denk aan inclusie, interactie, inquiry, integriteit, actualiteit, publieke betrokkenheid etc.]

4. Wat zijn jullie huidige strategieën/aanpak om de doelen te bereiken?

5. Zetten jullie wel eens technologie in om de doelen te bereiken? Zo ja, kan je een voorbeeld noemen?

6. Meten jullie ook of de doelen bereikt worden?

   (a) Zo ja, worden die ook bereikt?

   (b) Hoe meten jullie dat?

7. Hoe gaan jullie om met de verschillende doelen en wensen die de bezoekers kunnen hebben?

Deel 2: Personalisatie en customization

8. Waar denk je aan bij personalisatie?

9. Waar denk je aan bij customization?

Voor mijn onderzoek maak ik onderscheid tussen personalisatie en customization. Dat komt omdat ik bij mijn vooronderzoek erachter kwam dat van personalisatie vaak wordt gedacht dat het dé manier is om een bezoeker op een relevante manier aan te spreken, maar meestal werd er eigenlijk customization wordt bedoeld. Dit komt omdat je bij customization als gebruiker veel meer controle en autonomie hebt, en dat is één van de factoren die de kwaliteit van het museumbezoek kan verbeteren volgens de literatuur. **Customization** is gedefinieerd als een proces waarbij de gebruiker zelf aanpassingen maakt waardoor hij of zij zelf een persoonlijke ervaring creëert. Denk hierbij bijvoorbeeld aan dat een bezoeker zelf objecten kan opslaan in een persoonlijk profiel terwijl hij of zij door het museum loopt.

Personalisatie is gedefinieerd als proces waarbij een systeem zich aanpast naar de wensen van een bezoeker op een manier waarvan het denkt dat het passend is. Denk hierbij bijvoorbeeld aan het suggereren van een object dat de bezoeker nog niet gezien heeft op basis van interesse.

Andere voorbeelden zijn route constructie, chatbots, adaptief informatie laten zien, een persoonlijk item om mee naar huis te nemen en personalisatie en customization op de website.

Personalisatie en customization gaan soms ook hand in hand. Een voorbeeld van een tentoonstelling die gebruik maakte van beide is the Great Black Music exhibition in Parijs. Bezoekers kregen daar een Android telefoon met een app erop die muziek aanraadde op basis van beluisterde nummers en likes. De bezoeker had ook de mogelijkheid om nummers op te slaan en die later terug te bekijken op een persoonlijke webpagina.

Van beide begrippen bedoel ik wel de variant waarbij technologie aan de pas komt. Dus niet een vorm van personalisatie zoals bijvoorbeeld door een tourguide mogelijk gemaakt kan worden. Ik gebruik de term individualisatie voor de begrippen customization en personalisatie samen.

10. Is deze definitie duidelijk?

11. Ben je het eens met deze definitie? Zou je aan deze definitie, in de context van een museum, nog iets veranderen?

12. Heeft [het museum] wel eens een vorm van personalisatie of customization toegepast in een tentoonstelling of daaraan gedacht? [Hier ook voorbeelden noemen waarvan ik weet dat het museum personalisatie en/of customization heeft toegepast]

    (a) Hoe heeft dat uitgepakt?

    (b) Waarom hebben jullie toen gekozen voor deze aanpak?

    (c) Welke obstakels kwamen jullie tegen bij de implementatie?

(d) Zijn er andere musea waarvan je weet dat ze op een innovatieve manier personalisatie of customization hebben ingezet?

13. Wat denk jij dat personalisatie en/of customization kunnen betekenen voor wetenschapsmusea? Geldt dat ook voor jullie museum? [Veel genoemde voordelen zijn maximale public engagement, informatie overload beperken, beter leren etc.]

14. Wat zijn volgens jou beperkingen van personalisatie? [Veel genoemde problemen zijn de kosten, dat het niet sociaal is, wat is goede personalisatie?, weinig autonomie etc.] En van customization? [Veel genoemde problemen zijn de kosten, dat het niet sociaal is etc.]

15. Verleent een wetenschapsmuseum zich wel voor personalisatie en customization? Is dat niet meer iets voor bijvoorbeeld kunstmusea?

16. Denk je dat personalisatie en/of customization kunnen bijdragen om de publieke doelen van het museum te behalen?

17. En is dat een slimme aanpak ten opzichte van andere manieren en technologieën?

18. Hebben jullie wel eens onderzoek bij de bezoekers gedaan om te vragen hoe zij tegenover personalisatie en/of customization staan?

19. Denk je dat er in de toekomst meer personalisatie en/of customization toegepast gaat worden door wetenschapsmusea?

20. Zijn personalisatie en customization technologieën die we moeten omarmen of juist sceptisch over moeten zijn?

Appendix B

Framework functions of science museums

Figure B1. Framework Functions Of Science Museums Including Percentages