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Flip-flopping museum objects from physical to digital – and back again

Engaging museum users through 3D scanning, 3D modelling, and 3D printing

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Abstract: *This article focuses on how 3D technology can support visitors' engagement with and interpretation of museum objects by offering a movement between physical and digital experiences – a so-called "flip-flopping" process. The article is based on an observation study conducted by the author at an eight-day 3D workshop organized by the Danish art museum KUNSTEN Museum of Modern Art Aalborg. The museum invited schools and private visitors, children and adults, to 3D scan two sculptures from the museum collection, remix the scans digitally, 3D print the results, and finally share their remixed sculptures online. This was the first workshop of its kind at a Danish museum. The study examines how the 3D workshop, pulling visitors into the digital-physical flip-flop process of observing and remixing, supports deep and engaging acts of interpretation.*

Keywords: 3D printing, 3D scanning, 3D modelling, technology, art museum, sculpture, case study, user participation.

Several museums are beginning to use 3D scanning to make collections available as online 3D files.[1] Also, 3D printed replicas of museum highlights are gaining ground as "please-touch" zones next to a display-case-secured original.[2] The 3D scanning process itself, however, can also be used to support visitors' engagement with the physical collections, and the 3D files subsequently allow for changing, or "re-mixing", the objects digitally. This was the purpose of a 3D workshop organized by the Danish art museum KUNSTEN Museum of Modern Art Aalborg in 2015. The basic idea was to let visitors observe a sculpture carefully through one technology (3D scanning) and then take ownership of it by changing it with another technology (3D modelling). The focus was not on copying sculptures, but to use the digital format to engage users actively in the museum's sculpture collection. Or, as it read in the open invitation from the museum on its website: "Get a different experience of sculptures from

KUNSTEN's collections when we examine the border of the digital and the physical world."[3] The museum got the inspiration for the workshop from one of the hitherto few texts on 3D scanning and printing in museums, which will be introduced in more detail below (Neely & Langer 2013). A main inspiration for the authors, and accordingly for KUNSTEN's workshop, is the term "flip-flop" which describes the process of pushing a work of art or craft from physical to digital and back again (Sloan 2012):

1. Carve a statue out of stone. PHYSICAL.
2. Digitize your statue with a 3D scanner. DIGITAL.
3. Make some edits. Shrink it down. Add wings. STILL DIGITAL.
4. Print the edited sculpture in plastic with a 3D printer. PHYSICAL AGAIN.

Step three is important because it becomes clear that "you aren't aiming for fidelity in these transitions from physical to digital and back" (Sloan 2012). The aim is not to copy an object but to digitize it in order to be able to *do* something with the artefact. When you push an object from physical to digital you inevitably change it in ways you cannot always foresee.

For the present workshop the museum switched level one with a sculpture from the collection. The purpose of the workshop was not just to initiate creativity with new technology but to do so in relation to the sculpture collection. Also, a fifth step was added: Sharing the remixed sculptures online as 3D files.

It has been claimed that this kind of "flip-flopping" museum objects on the borders of the digital and the physical world can "both increase dwell time with the object or its digital surrogate and deepen visitors' emotional relationship with the object" (Neely & Langer 2013).

Through observations of and interviews with workshop participants the present study seeks to qualify these promising advantages of introducing 3D technologies in museums. What does it mean when visitors "deepen their emotional relationship with the object" through 3D technologies, and how can the different steps of the flip-flop process support such interpretative acts for different user groups?

Engaging museum visitors with 3D technology – research overview

Museums have been in the digital age for some time now with great impact on museum practice, with regard to collecting, documenting and exhibiting as well as communication and dissemination (Jones-Garmil 1997, Parry 2007, 2010, Rudloff 2014). Much effort, time, and money have gone into making collections available online in impressive databases. A cross-national example is the Europeana Collections (europeana.eu) that also contain an increasing number of 3D files, mainly of 3D scanned archaeological objects. 3D scanning is also widely used to complement the physical museum galleries with opening hours night and day in virtual pendants like the Google Art Project.[4] The possibilities with digital 3D spaces forming virtual museums have been historicized and discussed (Bandelli 2010, Battro 2010, Huhtamo 2010, Müller 2010) and it has been documented how online access gives rise to remixes and mash-ups of museum content (Parry 2007:102–116). "Variability" is seen as a key quality of new media, especially Web 2.0,[5] which changes the curatorial authorship and authority of the museum because it eases the creation and visibility of more parallel narratives

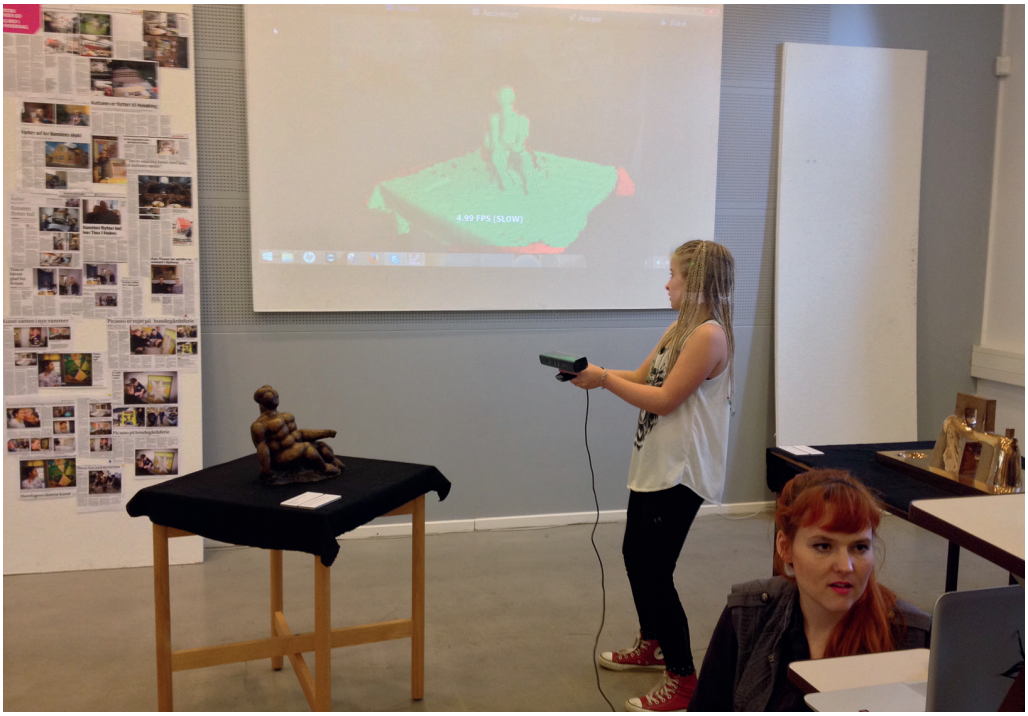

Fig. 1. 3D scanning of Svend Wiig Hansen's sculpture Siddende kvinde [Seated Woman] *(1957). Workshop leader Lina Bergstrøm helps a participant through the process. In the background Wilhelm Freddie's sculpture* Sfinx *(1947). Photo: Lise Skytte Jakobsen.*

(Parry 2007:102). The current condition of the "museum 2.0" also plays a role in the present study, which involves digitization as well as remixing and online sharing. Furthermore, *Museum 2.0* is the title of Nina Simon's widely read blog on how Web 2.0 philosophies can be applied in participatory museum design (Simon).[6]

Specific research on the use and effect of incorporating 3D printing and scanning in museums' dissemination practice is still very limited. An important exception, though, is the conference paper "Please feel the museum: On the emergence of 3D printing and scanning" (Neely & Langer 2013). The authors enthusiastically offer a broad range of reasons why museums should engage with 3D scanning and 3D printing and how the technology can be used to develop different areas of museum practice, from conservation to education and collections access as well as exhibition planning. Neely & Langer's primary focus however, concerns 3D technology's ability to engage museum users in new ways. They emphasize how 3D printing and scanning can add to our experiences hitherto with digital technology in the museum space.

With reference to examples from American museums and an introduction of the technical possibilities Neely & Langer identify three main

areas of opportunities that 3D technology make available to museums. First, the possibility of intensifying the user's experience by introducing full-object scanning, secondly, to use the fascination of the 3D printing process (to watch things come to life), and finally to engage both museum guests and staff in different stages of the flip-flop process. They sum up the advantages of introducing 3D technology in museums in the following way:

> Access to the 3D functions of scanning, designing, manipulation, printing and sharing allows our audiences to engage with our museum collections tangibly and creatively. These participatory actions both increase dwell time with the object or its digital surrogate and deepen visitors' emotional relationship with the object by allowing them to make it their own (Neely & Langer 2013).

The study does not include case studies or interviews but the conclusion is supported by reference to, among other things, a study on artwork tagging that can be applicable in developing both in-gallery and online collection engagement with 3D technologies (Trant & Wyman 2006, Neely & Langer 2013). The central point, much in line with Parry's argument on parallel narratives mentioned above, is that the activity urges visitors to interpret "the works of art by placing them in their personal narrative" (Trant & Wyman 2006). Trant & Wyman's project is based on constructivist educational theory (Hein 1998).

Workshop staff and participants

Planning to let their museum users try out the flip-flop-process, KUNSTEN Museum of Modern Art Aalborg reached out for technology expertise in the local creative community. They engaged a consultant to be in charge of the workshop and prepare the content in collaboration with the museum curator.[7] The workshop took place for eight days during two weeks in March 2015, Thursdays to Sundays from 11 a.m. to 2 p.m. Weekdays were reserved groups that booked in advance on a first come, first served basis whereas weekends were open for anyone who dropped by. In 2015 KUNSTEN was temporarily rehoused in facilities at the city's train station due to a far-reaching restoration of the museum building. With free access but very limited physical exhibition space, placed in the heart of a train station, the total number of visitors during the workshop period was lower than would be expected at the museum, but more diverse than the average museum audience at KUNSTEN.

Altogether four pre-booked groups of 4–10 students and pupils (adults and children) each spent about three hours at the workshop and an approximately 40–50 people visited the workshop during weekends. The groups came with their teacher as a part of a formal creative (design, art) or teaching education or an organized after-school activity. Thus their motivation for coming differs from those of the weekend visitors in terms of not necessarily having chosen to attend the workshop themselves. However, all groups participated eagerly in the workshop. The teachers' motivation for coming was to let their class learn more about 3D technology – and to do so in relation to art. Three out of four teachers explicitly said they felt incompetent in technology and computers in general and wanted to compensate for that by attending the 3D workshop. All four educational institutions had either bought or were considering buying a 3D printer, but felt insecure as to how to use it in relation to their teaching. Two of the

Fig. 2. The 3D printed plastic figures are the physical result of the digital 3D modelling work done at the computers. Photo: Niels Fabæk.

teachers explained that they especially wanted to meet their male students' and pupils' wishes to include more technology. Altogether the four groups consisted of 8 men and 21 women.

Many of the weekend visitors did not do all steps in the flip-flop-process and some only participated as observers, commenting, asking questions, picking up 3D-printed objects, comparing them to the original sculptures and other less time-consuming engagement.

Spending everything from two minutes to three hours at the workshop, museum users and workshop participants benefited very differently from this initiative. The workshop design was however intended to support a variety in visitor engagement by trying to signal clearly each workshop station (scanning, computer-editing, printing) as a point of interest as compared to the more complex understanding of the interaction between the three technologies. Also, results from the workshop, screen dumps of digital models and 3D prints, were continually displayed to function not only as documentation but very much as opportunities for interested passers-by to examine other users' contributions, perhaps become curious and engage in conversation with staff or users.

The succeeding analysis of the function of the different elements and technologies in the workshop mainly involves experiences from users who spent one to three hours at the workshop. However, it is worth stressing that the workshop activities were experienced

as interesting and valuable to other types of users as well: As information and exhibition experience and as a room within the museum space where the chance to communicate about content and to interact with staff and other guests was enhanced. In this way the 3D workshop corresponded partly with what Nina Simon has described as a change "from me to we design" (Simon 2010:26). Simon's concern is to develop museums' relevance by strengthening their ability to include and engage their users through different participatory practices. As I will demonstrate, the 3D workshop definitely motivated, as Simon puts it, "dialogue and relationship building around the core focus of the institution" (Simon 2010:26). However, it is interesting and relevant for the further development of workshops like this to consider how – rather easily – the workshop design could have supported the integration of the large group of observers more actively. This could, for example, be done by asking them to evaluate the 3D printed objects in a simple visualizing voting system or by handing out printed information about the workshop process with references to the online sharing sites where visitors could re-experience and get an overview of the workshop design.

Fig. 3. A 3D print is removed from the 3D printer. Photo: Lise Skytte Jakobsen.

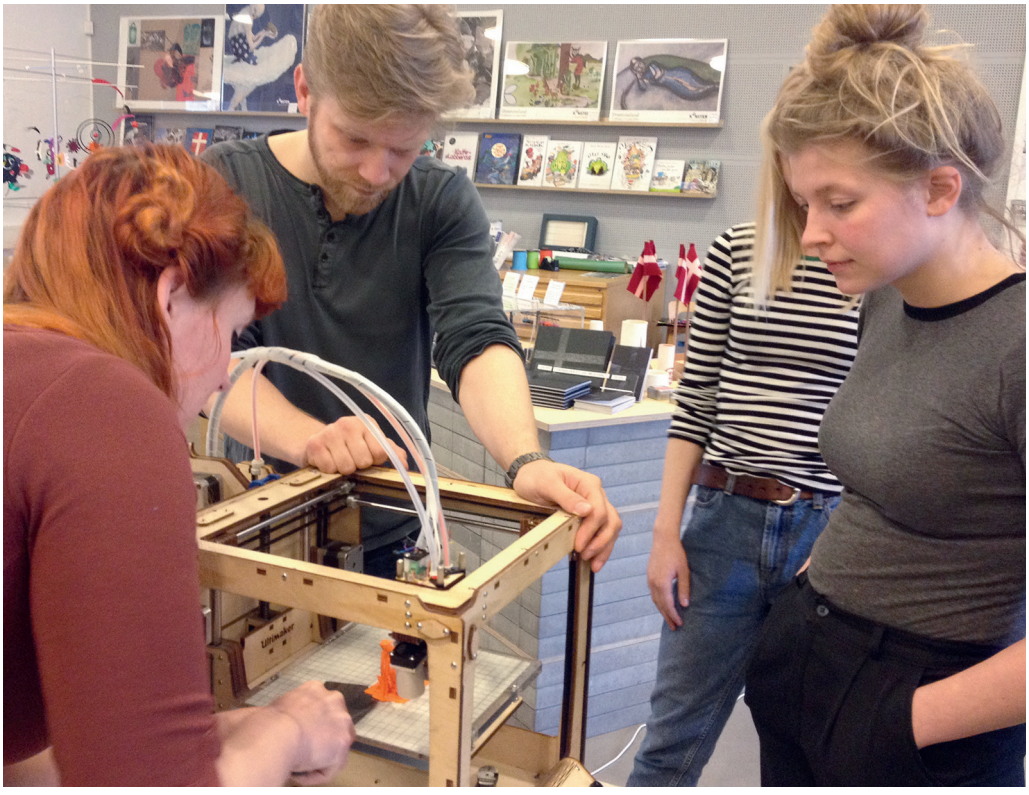

Fig. 4. The 3D printed remixes were used as "tactile eye-opener" to the original sculptures that you were not allowed to touch. Photo: Lise Skytte Jakobsen.

Observation methods

During the eight workshop days I observed the workshop process, conducted small semi-structured interviews with participants and took snapshots and recorded short videos for subsequent analysis and documentation of the workshop. As preparation for the workshop I participated in several meetings between museum staff and the external consultant. Being an art historian with expertise in sculpture analysis and 3D printing (Jakobsen 2015), my role also became to act as an ongoing supplementary discussion partner for the workshop leader. I choose a trailing research method, which alternates between active and passive role performance: "An active role performance means acting as a change agent participating in project activities at stake. Passive role performance means distant and critical observation to an event in order to get and analyse data you hardly can achieve as an active participant" (Olsen & Lindøe 2004:373).

In connection with the semi-structured interviews I introduced myself to the participants as a researcher interested in how 3D technology can be used in museums. The interviews took place at the workshop while the interviewee was working at the computer. I used a small interview guide with four main questions: (1) What is your previous experience with 3D scanning and modelling? (2) How would you describe your experience of 3D scanning the sculpture, what did you notice? (3) What do you emphasize now working with 3D modelling at the computer? (4) What would you like to bring with you from the workshop?

3D scanning – introducing museum objects through technology

The workshop was physically organized as three "stations": (1) scanning, (2) modelling, and (3) printing. It was a key idea that visitors could join in at whatever level they had the time, energy, and interest for. Taking the "full tour" included a short introduction to the 3D scanning technology. Knowing that the scanner operates by measuring the distance to the object, participants were asked to take a close look at the sculptures in order to consider where it would be difficult for the scanner to "see" the sculpture. The 3D scanner chosen for the workshop was a simple Kinect, which some participants knew from the video game console brand Xbox. It was a point that both hardware and software should be either quite cheap to buy or free to access. Besides being affordable for the museum it was important that the equipment should be mobile and easy to use.

Together with the museum curator the consultant had chosen two sculptures that were both representative for the collection and possible to 3D scan in terms of size, shape, and surface. It should neither be too large nor too

small as participants, had to be able to move around it from all angles with a scanner. The shape should preferably show some diversity, for example being partly figurative, as it is the shape and not the colour or details on the surface which this simple scanner catches. Also, the scanner cannot "read" the surface of materials that are too shiny or transparent, like mirrors or glass. The chosen sculptures were made by two acknowledged Danish artists from the mid twentieth century, *Seated Woman* (1957, bronze) by Svend Wiig Hansen (1922–1997) and *Sphinx* (1947, brass) by Wilhelm Freddie (1909–1995). Most of the workshop participants, however, did not know the sculptures or the artists beforehand.

Encouragement by the workshop leader to look carefully at the sculptures led to close observations and discussions among the participants. These considerations were often of a formal kind about shapes and angles and the modelling techniques of the artists. The next task for workshop participants was to choose between the two sculptures: which one would you like to scan and why? One is a sitting, female figure in organic, round shapes, while the other is defined by sharp edges with features and details like some kind of surrealistic animal.

The participants took this part of the workshop quite seriously and argued very differently for their choices. Some were attracted to the organic shape of Wiig Hansen's sculpture and saw the two art works as sensuous poles – the sharp, male figure versus the soft, female forms. Others tried to determine which one would be easier to 3D scan and thereby enable them to make a successful scan. In the process of choosing, participants were asked to reflect on their choices, encouraged to spend time with their considerations, and offered words and arguments to make them able to share their thoughts with fellow workshop participants. Since the participants knew that they were about *to do* something, with an unfamiliar technology, these works of art clearly motivated both adults and children, both single visitors and groups, to engage intensely with the two rather small and not very spectacular sculptures.

3D scanning – dancing with technology

3D scanning an object is a process that requires full concentration. You must be aware of the device in your hand, the image it produces on the screen – and of course be careful not to trip over the cord of the scanner. One must take into account the correct distance of the scanner from the object, to "sense" which parts of the sculpture have already been "caught" with the scanner and to make sure to move your body in soft slow-motion. If you are proceeding too fast or too abruptly, the scanning sequence breaks off. This type of 3D scanning can be characterized as performing a kind of dance with the sculpture. And this word – dance – was helpful when introducing people to the act of scanning. It is a kind of ritualistic dance where you record every spot of the surface of the sculpture. In a very basic phenomenological way you acknowledge the body of the sculpture by adjusting your own movements, trying to obtain an optimal rhythm and distance dictated to you, not by music, but by the software of the scanner and the shape of the object. One participant described how she was more aware of her own body than of the sculpture and continued: "Lina [workshop leader] said something about ballet – and I spent most time being in control of my movements. Focused on how calm my hands are. Focused on the body somehow." Another participant characterized his scanning

experience as thoughtful and meditative: "The scan is more meditative than the computer, you think more in terms of realization in regard to form. It's more analytical and more abstract to model it. To scan is to observe, to model is to develop."[9]

As these two quotations show, not every participant had the same scanning experience, but it is a general observation from the study that participants were extremely focused and aware of how their movements influenced the 3D scanned image. The "act of scanning" was projected as a large image on the wall for both the person doing the "3D dance" and her fellow participants to see. Performing with the scanner made people hold their breath and a concentrated silence dominated the room.

Recording the sculpture with a 3D scanner structured the time participants spend observing the sculpture. The duration of each participant's observation typically ranged from five to ten minutes, which is a considerable amount of time to spend observing a single artwork. This included choosing a sculpture, considering the challenges of the form, getting familiar with the technology, doing the "3D dance" and finally reflecting on the result of the scan projected on the wall. Furthermore, the 3D scanner structured the space which the participant used to unfold her observation. People often (but not always) walk around a sculpture to see it from more angles. With the scanning device as a handheld "extension" of their senses, participants did not only move around the sculpture but stretched to catch it from above, bent to see it from below and moved back and forth to adjust the scanning result. The 3D scanner clearly structured both the time and the space of each participant's perception, resulting in an explicit bodily focused observation experience.

A 3D scan can also be obtained by "stitching" together digital photographs using the free software called 123d Catch.[10] The 123d app gives visual instructions for photographing an object in the round, making sure to capture every angle. This type of photographing can provide some of the same observation intensity as the 3D scanner (Postrel 2012). In both ways one get to know the object in detail, which is important for the next step down the flip-flop road.

3D modelling

The next phase of the workshop – and of the flip-flop process as described by Robin Sloan – is to "make some edits". In order for people to be able to jump in at whatever level in the process they had the time for and an interest in, scans of both sculptures were made available beforehand at the four computers. Theoretically participants could have used the scans they had just obtained by "dancing" round the sculpture holding the scanner. For the files later to be printable, however, each scan might need sometimes time-consuming digital "cleaning". For the purpose of this workshop it was perfectly satisfying to use the already cleaned scans. The point was not (but could have been) to work with the "mistakes" of the participants' own scans but to remix the shapes and artistic choices made 60–70 years ago by Svend Wiig Hansen and Wilhelm Freddie. Most often the participants chose to remix the sculpture they had scanned beforehand.

Developing, or remixing, the digitized sculpture was often conducted in groups by two or three participants. This was partly due to the limited number of computers but also because the remixing process required discussions and peer-to-peer learning of how to use the software and how to alter the sculpture. What features should we keep,

what should we enlarge, what does it remind me of, and what is too silly? Discussing the existing shapes and what they might represent or mean ("Is it a woman?", "Is it soft?", "I had not noticed that" etc.) not only took place as verbal communication but also by sharing a computer mouse that often changed hands continuously during the remodelling phase. It was an eye-opener to most participants that they were not just looking at and remixing an image but a three-dimensional digital model that you need to turn around all the time to be able to consider the implications of your remixing ideas from all angles. Experiencing this supports the understanding the participants gained from capturing the sculpture with the 3D scanner, making sure to "see" every detail. Now, however, it takes place in a digital three-dimensional space as opposed to a physical three-dimensional space.

To emphasize the availability of the editing process the participants were introduced to two different, easy to use software programs, which are both available free: the Autodesk program Meshmixer and a program called Tinkercad.[11] With Meshmixer you can change the shape of the digital model of the sculpture and you can add new shapes. For someone used to working with different 3D modelling software, Meshmixer is a very simple tool. For the rest of us it is fairly easy and intuitive to learn and to play with. Tinkercad is a browser-based 3D design and modelling tool suitable also for small children to work in. With Tinkercad you don't change the shapes of the sculptures, rather you build them into a digital environment.

With these modelling tools it would be fairly easy to almost erase the artistic starting point – the museum objects – to make way for a totally different artistic expression. However, none of the participants chose to do so. Everybody responded more investigatively to this developmental phase of flip-flopping, adding new features or enlarging or diminishing existing features of the sculptures.

A 3D modelling case story – Isabella and her father

During weekends most visitors were families with children between seven and twelve. A nine-year-old girl, Isabella, visiting the workshop with her father, chose to work with the figure of the sitting woman. From the very beginning of the scanning process she was determined to bring the sculpture together with wolves. She got help to find a 3D model of a wolf that somebody had already made available at the file-sharing site youmagine.com. The wolves were then remixed with the Wiig Hansen sculpture in Meshmixer to fit her story of mother wolf, father wolf, and the wolf child living together with the Big Woman out in the wood. As the scene in the wood with lots of trees was a bit too complicated to 3D print, she instead used Tinkercad to visualize this part of her fantasy. The figure itself, without trees, was 3D printed. A screen shot of her Tinkercad visualization was colour-printed in 2D and she displayed it on a board for other guests to see. Isabella also brought a copy of the image home to remember the workshop and her own contribution. She can however also choose to access her Tinkercad account from her home computer and continue the wolf role-playing game later.

Isabella's father was working on his own remixing project. He had chosen the Wilhelm Freddie sculpture with sharp edges, which might resemble a surrealistic dog. He told me that he started out with the digital model of the woman, the Svend Wiig Hansen sculpture, but then changed his mind. By chance he included

Fig. 5. Different remixes of Svend Wiig Hansen's bronze sculpture, seen in the background. Photo: Lise Skytte Jakobsen.

both sculptures in the same Meshmixer file and seeing these two models beside each other made him want to change the hard-edged expression of Wilhelm Freddy's Sphinx by providing it with some of the soft, organic features of Wiig Hansen's *Seated Woman*. He wanted it to reflect the hollows and heights of a mountain-like landscape. It should look like nature. Or as he put it: "I wanted it to be more organic, one should be able to climb on it."[12] He wanted to change the expression of one sculpture to reflect the aesthetic ideal, you could say, of a very different sculpture. And this particular aesthetic expression with organic shapes and deep shadows corresponded to his longing to be out in nature: "I just need to go out there", he said.[13] His daughter came to look at his remixed model on the screen and he told her that this was how he would like their back garden to look like. The daughter replied: "But daddy, we don't have a garden." "No, not at the moment," said her father, and continued, "but some day we will."

The girl and her father used the possibility of remixing sculptures in a rather personal way to visualize and communicate some of their fantasies and also future dreams. This line of thought and dialogue between the two of them could probably have been accomplished in other workshop set-ups, with other

technologies and materials. However, what I do think the digital 3D modelling situation supports is an integration of (1) a widespread familiar technology (computer and mouse) and (2) imagining and building something in three dimensions without being burdened with scale. What you discover very quickly as a newcomer to digital 3D modelling is that you have to turn your object (or 3D image) around all the time to create a satisfying, coherent figure. Doing this means that you move around in a digital three-dimensional space. Moving around in space takes time. This is a very basic human (as well as sculpture analytical) experience. What you cannot do with a figure in, for example, clay is to keep going closer to the surface and even go inside the figure. But this you can do with a digital 3D model. It allows you to zoom in and out and thereby change your perspective dramatically – the scale is not set, it is negotiable. In a 3D modelling program a small-scale sculpture therefore easily becomes a mountain-like landscape or a wolf monument. The physical object transforms from a fixed thing to something where things take place, where stories unfold over time. Including, for example, being a stage for the future, where your private garden dreams come through.

3D print

3D printing is a technology which can materialize three-dimensional digital models.[14] It is an additive technology where thin layers of material are applied on top of each other. Like a desktop inkjet or laser printer it can read digital files in specific formats. Instead of the inkjet printers' two dimensions (x and y axes) the 3D printer has a third dimension (z axis). And instead of ink it pours (for example) heated plastic out of the printer nozzle. Much like a computer controlled glue pistol. Due to the amount of time it takes to 3D print even small figures, only one remixed figure was printed each workshop day. An approximately 5×7×5 cm version of Isabella's wolf figure took about 4 hours to print. This meant that only few participants had their remix printed at the workshop and they would have to come back the following day to see the result. This is clearly a disadvantage but participants could share their digital model online and perhaps have it printed later at a private 3D printer service or at the library. The printing process itself fascinated both workshop participants and passers-by and the 3D printer worked as an important vehicle for conversations and discussions. The technology itself and the noises and movements of the 3D printer became a legitimate and easy way to "enter" the workshop. The 3D printer here represented a process, something coming into being over time.

The small printed plastic figures were used during the workshop for people to touch while they were looking at the sculptures. They could "feel the museum" so to speak (Neely & Langer 2013). Or rather, they could feel other people's reflections on a piece from the museum collection. The 3D printed remixed sculptures very concretely invited visitors to reflect and sense the displayed objects through other users' reflections. Even though the size and finish of many of the printed objects are something similar to a Kinder Surprise toy, they actually worked as touchable and eye-opening mediators in relation to the original sculptures. For example, a little boy holding his teddy bear tight with one arm grabbed one of the 3D prints and instead of saying, "please don't touch" the staff could invite him to hold on to the object while showing him the sculpture, which had inspired the remix. He listened carefully, said he thought the sculpture

looked like a big house, and put the 3D print back on the table.

Thus the 3D printer served as a fascinating technology where workshop participants and other visitors could observe matter turning into material form, and also as a producer of "please-touch zones" in an otherwise "don't-touch" institution. When discussing visitor-generated content in museums it has been argued that the process, not the product, is of value to the user (Steinbach 2008). Others have pointed out that a well-handled product can also be of relevance to (other) users (Durbin n.d.). In this workshop the 3D printed objects functioned as relevant "please-touch zones" that were moved around in the workshop area by museum visitors and reflected upon or discussed when visitors studied the sculptures that had inspired the remixes. The objects might not be anything like the original in terms of size and material, but that is rather the point. They differ very much from the museum objects, but still they bear an unmistakable familiarity with them. The remixes served as visitor-generated products that offered a series of relevant, but obviously not authoritative, interpretations of the exhibited artworks.

Online sharing

Some of the remixed models of the sculptures have become available for download at the 3D file sharing site youmagine.com.[15] Isabella's wolf remix of the Svend Wiig Hansen sculpture, for example, has been downloaded more than 200 times. Her interpretation can now be a new starting point in someone else's flip-flop process. At Youmagine.com (or other 3D file sharing sites) it is common to share images and files if you print or remix somebody's design. So far, KUNSTEN has not pursued this aspect of the flip-flopping process's possibilities, but the museum can potentially see (and digitally "collect") new versions of the Svend Wiig Hansen sculpture being made around the world. And Isabella can connect with people who appreciate her design or who just like wolves.

As opposed to the touchable in-gallery 3D prints, it is much more difficult to judge the actual impact of the online shared digital files as visitor-generated content. The files are certainly shared by someone but the connection to the museum objects seems weak. Making the shared files, as Durbin puts it, more "well-handled" by further museum generated information and supporting images could provide online visitors with a better basis for understanding and perhaps remixing the digital user-generated products.

As Neely & Langer point out, the shared files are also potentially an example of what Nina Simon terms "social objects" (Simon 2010). Simon focuses on how participatory strategies can transform a collection object into a social object, "the content around which conversation happens" (Simon 2010). Sharing collection-related material from a 3D workshop is certain to spread museum-relevant content. And, as Henry Jenkins writes, "if it doesn't spread it's dead" (Jenkins 2009). According to Jenkins spreadability supports users "processes of meaning making, as people use tools at their disposal to explain the world around them" (Jenkins 2009). So, if museum content is not at your (digital, online) disposal, something else is. And, this "something" then serves as a process tool instead of for example high quality twentieth-century Danish sculptures. It should be noted, however, that Danish copyright legislation protects all art works done by artists until 70 years after their death, and making these remixes available online requires the approval of the copyright holder. Several

museums have started making 3D scans of copyright-free museum objects available online. This is however, still an area that needs to be extended and discussed (Postrel 2012, Sanderhoff 2013, Wenman 2015, Terras 2015).

Conclusion

This study shows that the 3D workshop, pulling visitors into the digital-physical flip-flop process of observing and remixing, supports deep and engaging acts of interpretation. It was found that participants who joined all steps of the workshop:

- were activated in several different ways in several different phases in relation to a work of art.
- spend much time observing museum objects and their digital replicas.
- entered a multifaceted dialogue with museum staff as well as with each other on account of their workshop experiences.
- gained access to a diverse sculpture experience, aesthetically, bodily and tactile and in terms of scale.

Being supported in spending time with, not just passing by, selected museum content is often a basic workshop condition. However, in this study flip-flopping museum objects was found to have some specific qualities that further encouraged participants' interpreting process. The three main steps of the workshop – scanning, modelling, and printing – visually and in terms of focusing attention, structured a process with specific tasks attached to each step. Encountering the museum object becomes an investigation where each tool (scanner, software, printer) functions as questions: "With this tool at hand how will you address the sculpture? How does the sculpture respond to this technology?" The participant becomes an interpreter not only of a specific artwork but also of this sculpture's reaction to being digitized. The sculpture of course says nothing, but it is present, and the participant is acting as a witness to the transformations of the museum object.

Being able to transform the object opened up for interpretation and dialogue, as the case of Isabella and her father showed. Moving between physical and digital, and thereby between "frozen" and changeable versions of the sculptural image, worked as stepping-stones for their own fantasies. Robin Sloan (2012) writes about the flip-flop process that "weird things happen on the walls between worlds" – moving between digital and physical. Perhaps what is happening is not weird, but instead schematizes a reopening of the artistic process and situates the exhibited artwork (the museum object) as the dynamic result of artistic choices and considerations (human interaction), supplementary to being an art-historical artefact.

3D printing has been highlighted for its tactile qualities because you can print touchable versions of things you are otherwise not allowed to lay your hands on. These tactile qualities were also observed in this workshop. Importantly, the 3D printed remixes were not just end products for workshop participants but also well-functioning and mobile "please-touch zones" for others museum visitors to benefit from. In addition to the highly engaged participants who spent one hour or more in the workshop, the activity attracted visitors who did not do remixes themselves but engaged in observing others "dancing" with the scanner, modelling digitally, and comparing the printed remixes with the originals. For the very active participants the presence of the workshop leader, giving instructions and being service-

minded, was crucial. For the more observing visitors the tight design of the workshop into three physical stations was very important for them to be able to orient themselves in the process and make connections between the humming 3D printer and the original sculptures on display. For the next museum to experiment with the possibilities of 3D technologies this user group could preferably be included more in the flip-flop process with further elaborated written instructions, a small video of the scanning process, and an extra computer where the online digital remixes could be seen, collected, shared, and evaluated.

For the groups coming as a part of an education and for the weekend visitors, the 3D technology in itself played an important role as motivation for joining the workshop. The study has not collected specific data on potential differences in what motivated men and woman to participate. As a general observation, however, it is worth noticing that the 3D workshop also attracted men of all ages and that men or boys had either organized or initiated several of the groups' and families' participation in the workshop. This is an interesting observation for future 3D technology projects to be aware of, knowing from statistics (Kulturministeriet 2012:67) that the most common museum user in Denmark is an older well-educated woman, while especially young men are underrepresented at museums in general.

Notes

1. The Metropolitan Museum of Art in New York has put objects up for download at the file-sharing site Thingiverse: http://www.thingiverse.com/met/about (accessed 18 March 2016). The British Museum uses the site Sketchfab: https://sketchfab.com/britishmuseum (accessed 18 March 2016). As the current debate on Neues Museum's Nerfertiti sculpture shows, not all museums agree that file-sharing is a task for cultural heritage organizations: http://www.nytimes.com/2016/03/11/arts/design/nefertiti-3-d-scanning-project-in-germany-raises-doubts.html (accessed 18 March 2016).
2. An especially extended version of this is the presentation of Gundestrupkarret in the project "Let Your Fingers Do the Walking" at Moesgaard Museum, Denmark: http://mmex.dk/cases/know-how-book-cultural-heritage.
3. The general invitation to the 3D workshop can be read in Danish at the museum's website: http://kunsten.dk/da/besoeg-museet/arrangementer/3d-workshop.
4. https://www.google.com/culturalinstitute/project/art-project. For a critical discussion of the Google Art Project as an initiative that signals openness and democratic access to fine art and cultural heritage museum buildings but at the same time tends to repeat traditional institutional structures, see Proctor 2011; Bayer 2014.
5. The term "web 1.0" describes content-driven websites where users cannot interact with the interface. "Web 2.0" has been described as "architecture of participation" and "web 3.0", also termed "the semantic web", describes how the Internet currently develops towards computers generating raw data on their own, for example by anticipating what music you want to listen to next (Matusky 2015).
6. In the preface to Nordisk Museologi 2011/1, on digital museology, the expression "museum 3.0" is used with reference to a 1999 Steve Dietz article to term a hybrid museum that is both physical and digital (Hafsteinsson & Hejlskov Larsen 2011). This does not correspond to the prevalent understanding of the term "web 3.0", see note above.
7. The consultant and workshop leader was Lina Bergstrøm, who is today section leader at Coding Pirates, which is a Danish association for the

advancements of children's productive and creative IT skills: https://codingpirates.dk.

8. Interview with workshop participant 20 March 2015: "Man lægger vægt på sine kropsbevægelser mere end på figuren. Lina sagde noget om ballet – og jeg brugte mest tid på at have styr på mine bevægelser. Fokus på hvor rolige mine hænder er. Fokus på kroppen på en eller anden måde."
9. Interview with workshop participant, 20 March 2015: "Scannet er mere eftertænksomt end computeren, du tænker mere erkendelsesmæssigt om form. Det er mere analytisk og mere abstrakt at modellere den. Scanne er at betragte, at modellere er at udvikle."
10. http://www.123dapp.com.
11. www.meshmixer.com, www.tinkercad.com.
12. Interview with workshop participant 28 March 2015.
13. Interview with workshop participant 28 March 2015.
14. The literature on introductions to 3D printing technology is rich; see for example Lipson & Kurman 2013. There are also excellent online descriptions available, e.g. http://www.3ders.org/3d-printing-basics.html
15. www.youmagine.com, search for "KUNSTEN Museum of Modern Art Aalborg".

Literature

Bandelli, Andrea 2010. "Virtual spaces and museum." In Ross Parry (ed.). *Museums in a Digital Age.* London & New York: Routledge, 148–152 .

Battro, Antonio M. 2010. "From Malraux's imaginary museum to the virtual museum." In Ross Parry (ed.). *Museums in a Digital Age.* London & New York: Routledge, 136–147.

Bayer, Alanna 2014. "Evangelizing the 'Gallery of the Future'. A critical analysis of the Google Art Project narrative and its political, cultural and technological stakes." Electronic Thesis and Dissertation Repository. Paper 2239. The University of Western Ontario: http://ir.lib.uwo.ca/etd/2239.

Durbin, Gail (n.d.). "User-generated content on museum websites." *MuseumID*, Ideas: http://www.museum-id.com/idea-detail.asp?id=352.

Hafsteinsson, Sigurjón Baldur & Ane Hejlskov Larsen 2011. "Forord." *Nordisk Museologi* 1, 1–2.

Hein, George, E. 1998. *Learning in the Museum*. New York: Routledge.

Huhtamo, Erkki 2010. "On the origins of the virtual museum." In Ross Parry (ed.). *Museums in a Digital Age.* London & New York: Routledge, 121–135.

Jakobsen, Lise Skytte 2015. "Holding your scream in your hand. 3D-printing as inter-dimensional experience in artworks by Alicia Framis, Martin Erik Andersen and Hito Steyerl." *Acta Universitatis Sapientiae. Film & Media Studies* 10, 25–45. http://www.acta.sapientia.ro/acta-film/C10/film10_02.pdf.

Jenkins, Henry 2009. "If it doesn't spread, it's dead (part one). Media viruses and memes." *Confessions of an Aca-Fan:* The Official Weblog of Henry Jenkins. 11 February 2009. http://henryjenkins.org/2009/02/if_it_doesnt_spread_its_dead_p.html.

Jones-Garmil, Kathrine (ed.) 1997. *The Wired Museum. Emerging Technology and Changing Paradigms.* Washington, D.C.: American Association of Museums.

Kjær, Birgitte 2015. "Print Solvognen eller Guldhornene i 3D" [Print the Sun Chariot or the Golden Horns in 3D]. *Politiken,* 24 April 2015.

Kulturministeriet 2012. *Danskernes kulturvaner* [Danes' cultural habits]. http://kum.dk/uploads/tx_templavoila/endelig_danskernes_kulturvaner_pdfa.pdf.

Lipson, Hod & Melba Kurman 2013. *Fabricated. The New World of 3D Printing. The Promise and Peril of a Machine that Can Make (Almost) Anything.* Indianapolis: John Wiley & Sons.

Matusky, Randy 2015. "Web 2.0 vs. Web 3.0 – What really is the difference?" Blogpost: http://

randymatusky.com/2015/04/03/web-2-0-vs-web-3-0-what-really-is-the-difference/.

Müller, Klaus 2010. "Museums and virtuality." In Ross Parry (ed.). *Museums in a Digital Age.* London & New York: Routledge, 295–305.

Neely, Liz & Miriam Langer 2013. "Please feel the museum. The emergence of 3D printing and scanning." In Nancy Proctor & Rich Cherry (eds.). *Museums and the Web 2013*. Silver Spring, MD: Museums and the Web. Published 31 January 2013. http://mw2013.museumsandtheweb.com/paper/please-feel-the-museum-the-emergence-of-3d-printing-and-scanning/

Olsen, Odd Einar & Preben Lindøe 2004. "Trailing research based evaluation; phases and roles." *Evaluation and Program Planning* 27: 371–380.

Parry, Ross 2007. *Recoding the Museum. Digital Heritage and the Technologies of Change.* London: Routledge.

Parry, Ross 2010. *Museums in a Digital Age.* London & New York: Routledge.

Postrel, Virginia 2012. "3-D copying makes Michelangelos of the masses." *Bloomberg View.* http://www.bloombergview.com/articles/2012-06-14/3-d-copying-makes-michelangelos-of-the-masses.

Proctor, Nancy 2011. "The Google Art Project: A new generation of museums on the web?" Curator: *The Museum Journal,* March 2. curatorjournal.org/the-google-art-project/

Rudloff, Maja 2014. "Formidlingsbegrebets digitalisering i Danmark. Diskursive implikationer og praktiske konsekvenser." *Nordisk Museologi* 2, 21–36.

Sanderhoff, Merete 2013. "Open images. Risk or opportunity for art collections in the digital age?" *Nordisk Museologi* 2, 131–146.

Simon, Nina. *Museum 2.0*, online blog: http://museumtwo.blogspot.dk.

Simon, Nina 2010. *The Participatory Museum*. Santa Cruz: Museum 2.0. Available online at www.participatorymuseum.org.

Sloan, Robin 2012. "Dancing the flip-flop." Blogpost: http://www.robinsloan.com/notes/flip-flop/.

Steinbach, Leonard 2008. "User-generated content." http://tatehandheldconference.pbworks.com/User-Generated+Content.

Terras, Melissa 2015. Keynote lecture at the conference Sharing is Caring 2015: http://sharecare.nu/keynote-melissa-terras/ Lecture builds on Terras' blogposts: http://melissaterras.blogspot.dk/2014/10/reuse-of-digitised-content-1-so-you.html.

Trant, Jennifer & Bruce Wyman 2006. "Investigating social tagging and folksonomy in art museums with steve.museum." http://www.ra.ethz.ch/cdstore/www2006/www.rawsugar.com/www2006/4.pdf.

Warberg Løssing, Anne-Sophie 2015. "Når publikum bliver en vigtig medspiller" [When the audience become an important co-player]. In Ane Hejlskov Larsen, Rune Gade & André Wang Hansen (eds.). *Cybermuseologi. Kunst, museer og formidling i et digitalt perspektiv.* Aarhus: Aarhus Universitetsforlag, 190–217.

Wenman, Cosmo 2015. "3D scanning and museum access." Adapted from a presentation by Cosmo Wenman to the California Association of Museums' 2015 Conference panel on access" https://medium.com/@CosmoWenman/3d-scanning-and-museum-access-9bfbad410d46#.d0vdmpvmd.

All weblinks accessed 13 January 2016.

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