

Decoding Artifacts for the Museum Viewer:

Case Study of a Virtue from the Cathedral of Notre Dame in the Nasher Museum of Art

by

Jessica Pissini

Program in Historical and Cultural Visualization
Duke University

Date:_____

Approved:

Caroline Bruzelius, Supervisor

Victoria Szabo

Mark Olson

Thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Arts in the
Program in Historical and Cultural Visualization
in the Graduate School of Duke University

2015

ABSTRACT

Decoding Artifacts for the Museum Viewer:

Case Study of a Virtue from the Cathedral of Notre Dame in the Nasher Museum of Art

by

Jessica Pissini

Program in Historical and Cultural Visualization
Duke University

Date: _____

Approved:

Caroline Bruzelius, Supervisor

Victoria Szabo

Mark Olson

An abstract of a thesis submitted in partial fulfillment
of the requirements for the degree of Master of Arts in the
Program in Historical and Cultural Visualization
in the Graduate School of Duke University

2015

Copyright by
Jessica Pissini
2015

Abstract

Decoding Artifacts is a project that explores the ways in which digital technologies, virtual visualizations, and interactive media enhance the museum visitor's learning experience with art. The digital components of the project include a website and a mobile application, both hosting historical content, educational videos, images, 3D models, and an augmented reality experience. These virtual tools offer information to the viewer beyond the museum label, and aim to create a multi-sensory learning environment through an interactive dialogue between the public and the work of art. The thesis paper discusses how and why art museums are adapting to modern technological trends and the affordances of digital tools in museum education and outreach. The Decoding Artifacts project will use the example of medieval sculpture and the process of stone carving as case studies that discuss and demonstrate the effectiveness of virtual technologies in museum experiences.

Contents

Abstract	iv
List of Figures	vi
I. Introduction and Overview of Thesis and Digital Project.	1
II. Technology is Changing the Museum Institution: Creating New Experiences and Ways to Learn.....	3
II.A What Has Changed About the Museum Experience?	7
II.B What Kinds of Works of Art are Best Suited for Virtual Projects?	20
III. Which Museums Have Incorporated Digital Tools?.....	24
III.A The Cleveland Museum of Art, ArtLens: Websites and Apps	24
III.B The Smithsonian Institute, X 3D: Virtual Models.....	27
III.C The Nasher Museum of Art, the Wired! Lab, and the “Lives of Things” Research Theme: Exploring Unconventional Content Within Museum Exhibitions.....	32
IV. Case Study: Decoding Artifacts	35
IV.A Foundation and Gateway: Website and Mobile Applications.....	36
IV.B Visualizations: Images, Videos and 3D Models	41
IV.C The Learning Experience: Historical Content	49
IV.C.1 Historical Context of the Virtue	50
IV.C.2 Stone Carving: History, Tools and Sounds.....	54
IV.C.3 The Process of Making: Drawings and Geometry	58
V. Conclusion and Summary	63
References	82

List of Figures

Figure 1: Pissini, Jessica. "Photo of GalleryOne display in the Cleveland Museum of Art." Digital Image. Decoding Artifacts. July, 2015. www.dukevisualstudies.org/decoding.....	66
Figure 2: Pissini, Jessica. "Photo of ArtLens Application in the Cleveland Museum of Art." Digital Image. Decoding Artifacts. Accessed July, 2015. www.dukevisualstudies.org/decoding.....	67
Figure 3: Pissini, Jessica. "Screenshot of Life Mask of Abraham Lincoln, from the Smithsonian X 3D web-app." Digital Image. Decoding Artifacts. August, 2015. www.dukevisualstudies.org/decoding.....	68
Figure 4: Pissini, Jessica. "Photo of Lives of Things exhibit, with visitors interacting in the Nasher Museum of Art." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.....	69
Figure 5: Pissini, Jessica. "Head of a Virtue in the Nasher Museum of Art." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.	70
Figure 6: Pissini, Jessica. "Screenshot of Decoding Artifacts website homepage." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.	71
Figure 7: Pissini, Jessica. "Simon Verity sculpting the Duke Virtue Copy." Digital Image. Decoding Artifacts. January, 2015. www.dukevisualstudies.org/decoding.....	72
Figure 8: Pissini, Jessica. "Screenshot of SketchFab model, Duke Virtue copy, with annotation." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.....	73
Figure 9: Pissini, Jessica. "Screenshots of PhotoScanPro photogrammetry process." Digital Image. Decoding Artifacts. July, 2015. www.dukevisualstudies.org/decoding. ..	74
Figure 10: Pissini, Jessica. "Screenshot of SketchFab model, Time-lapse Reconstruction camera set-up." Digital Image. Decoding Artifacts. July, 2015. www.dukevisualstudies.org/decoding.....	75
Figure 11: Pissini, Jessica. "Label of the Head of a Virtue, in the Nasher Museum of Art." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.	76

Figure 12: "North transept Portal of the Notre Dame in Paris." Cited in Kimpel, Dieter. "A Parisian Virtue." in <i>The Brummer Collection of Medieval Art</i> . Edited by Caroline Bruzelius with Jill Meredith. Duke University Press, 1991. Page 128.	77
Figure 13: "Allegory of Sculpture by Andrea Pisano." Lib-art.com. Accessed July, 2015. http://www.lib-art.com/artgallery/15219-sculpture-andrea-pisano.html . Cited in Wittkower, Rudolf. <i>Sculpture: Processes and Principles</i> . New York: Harper & Row, 1977. Page 28.	78
Figure 14: "Greek Bronze Chisel." Nasher Museum of Art at Duke University. Accessed July, 2015. http://emuseum.nasher.duke.edu/view/objects/	79
Figure 15: "Drawings with geometric schemata, thirteenth century, by Villard de Honnecourt." Cited in Wittkower, Rudolf. <i>Sculpture: Processes and Principles</i> . New York: Harper & Row, 1977. Page 37.	80
Figure 16: "Pointing Machine." Cited in Wittkower, Rudolf. <i>Sculpture: Processes and Principles</i> . New York: Harper & Row, 1977. Page 31.	81

I. Introduction and Overview of Thesis and Digital Project.

Technology in the last couple of decades has, for the most part, improved the lives of humans and offered new ways to learn, discover, understand and communicate. “Decoding Artifacts” is a project that explores the ways in which technologies and interactive media have changed the traditional museum institution and have offered new ways in which to learn from works of art. The digital component of the project, which incorporates educational visualizations accessed through online and mobile device interfaces, aims to recontextualize the Head of a Virtue, a work of art from the Nasher Museum of Art at Duke University, and also teach viewers about the tools, techniques and process of stone carving.

In an effort to better understand current trends and ideas in digitally enhanced museum exhibition practices, the “Decoding Artifacts” project includes an investigation of institutional projects at the Cleveland Museum of Art, the Smithsonian, and Duke University’s Wired! Lab, all of which incorporate technology in both real and virtual platforms. Certain elements of these projects were highly successful at engaging the public and in offering innovative learning experiences. The “Decoding Artifacts” project adopts approaches and methods

deemed successful as part of a case study for the Nasher Museum. The digital components of the project fall into three categories: (1) The Foundation and Gateway: Website and mobile application, (2) The Visualizations and Educational Tools: Images, videos and 3D models, and (3) The Learning Experience: Historical content. In order to offer an effective and efficient museum learning experience, the implementation of each individual component must exist in a harmonious relationship with the other digital elements. As this investigation of contemporary museum practice reveals, a significant misconception of large-scale digital projects can be that virtual technology is the end solution for everything. Instead of technology being the end or the answer, it should be a mean by which to obtain an answer.¹ The ultimate goal in bringing technology into the museum experience is to enrich the visitor's experience, not control it. Therefore, museums and digital projects must remain open-ended and adaptable as virtual platforms continue to evolve. The case study examples featured here are created with this philosophy of open-ended visitor interaction and adaptability to future innovation and extension in mind.

¹ Wayne G Clough, *Best of Both Worlds : Museums, Libraries, and Archives in a Digital Age* (Washington, D.C.: Smithsonian Institution, 2013), 10. Accessed May 1, 2015.
<http://permanent.access.gpo.gov/gpo41908/BestofBothWorldsSmithsonian.pdf>

II. Technology is Changing the Museum Institution: Creating New Experiences and Ways to Learn.

Museums and learning institutions have made efforts in recent years to better understand the technological shift within museum practice, the changing roles of curators and exhibitions, and the evolving learning experiences within museums. Some educators categorize museum learning as “informal learning” which differs greatly from formal classroom education. However, I think that perhaps a better label would be to classify museum learning as “active,” rather than informal, and traditional classroom type of learning as “passive.” Active learning within a museum offers information as an open-ended presentation that can provide students or visitors the opportunity to formulate questions and seek out the answer at their own pace and in a personalized way. Museums support various learning styles by incorporating text, images, audio, and video, and can be accessed at will by the visitor. Traditional classroom experiences do not foster this type of active learning.

For example, with “passive” or fixed situations and environments like classroom curriculums and tests, some students excel and some struggle. However, it is not fair or accurate to compare learning abilities of individuals, at any age or level through such limited instruments. Every person learns

differently. Therefore, emphasis should be placed on the ways in which students learn, not only upon the end result of the absorbed information. Learning is both “process and product.”¹ Within a free thinking, creative learning environment like museums, students and visitors learn what they want in the ways that work best for them, usually retaining the information for the long term. Hilde Hine, in her article on *The Exploratorium* in San Francisco, California, proposes that “in contrast to classroom routines, museums offer the learner the opportunity to stop at will, to loiter and repeat, to ignore what does not stimulate, and to share what seems interesting.”² The creative learning abilities of any person, young or old, extend past what is done in classrooms, and are in fact integrated into everyday situations and surroundings.

A modern, technological component to active learning in a museum is the inclusion of multisensory interactive displays and visualizations that combine with touch screens and audio, which together can encourage the user to engage with an object or subject matter. Technologies have enhanced and widened the realm of possibilities of creating these types of hands-on experiences in a gallery

¹ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 20.

² Hilde Hein, *The Exploratorium: The Museum as Laboratory*. (Washington, D.C.: Smithsonian Institution Press, 1990). As cited in Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 20.

and online. Technology in all aspects of society has given people the opportunities to become better learners by offering advanced means of active learning, though not all take advantage of the experience.³ Most modern people engage daily in creative, educational opportunities by interacting with technology and personal devices, unconscious that they are learning in the process. In addition to Hine, Mitchel Risnik also suggests that “in the digital age, learning can and must become a daylong and lifelong experience. National education initiatives should aim to improve learning opportunities not only in schools, but also in homes, community centers, museums and workplaces.”⁴

Technology in all aspects of society has given people the opportunities to become better learners by offering advanced means of active learning, though not all take advantage of the experience.⁵ Creative learning through technology in any environment involves balancing the quality of the learning experience with the quantity of what one can absorb in any given situation.⁶ Every person learns differently, but many learn more effectively in a visually enhanced and free

³ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 13.

⁴ Mitchel Risnik, “Rethinking Learning in the Digital Age,” In *The Global Information Technology Report: Readiness for the Networked World*. Edited by Geoffrey Kirkman et al. New York: Oxford University Press, 2002. As cited in Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 13-14

⁵ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 13.

⁶ *Ibid*, 13.

thinking environment, often through digital platforms. It has been theorized that people are essentially “learning to become a better learner” in today’s society, and should actively approach experiences within museums by “learning from objects, rather than learning about objects, and on strategies for discovering information rather than the information itself.”⁷ Therefore, effective learning strategies can encourage the museum visitor to synthesize a better understanding of the object and its meaning.

The willingness to learn or experience new information also varies depending on the age of the person. In a 2002 survey, scholars found that adults “know what they want to learn and they want to learn it in the most direct way.”⁸ On the other hand, children and young students “respond positively to the opportunity for interaction and choice within a goal-based environment.”⁹ This suggests that within the museum environment different visitors may have different kinds of learning preferences. Regardless, within the context of museum education, there is more to creative learning and exhibit interactivity

⁷ Ibid, 13 and 30.

⁸ Ibid, 30

⁹ Ibid, 30. Survey done by Schaller et al, “How Do You Like to Learn? Comparing User Preferences and Visit Length of Educational Websites,” In *Museums and the Web* (2002): 17. Selected Papers from an International Conference, Pittsburgh, PA: Archives and Museums Informatics. Feb 2002. Accessed July 10, 2015. <http://www.eduweb.com/HowDoYouLikeToLearn.pdf>

than just clicking a mouse or watching a graphic on a screen.¹⁰ Digital resources themselves can be structured to support various learning preferences.

Museums by nature provide a creative, active learning experience fueled by the visitors own motivation and willingness to learn and engage with the objects. Technology and interactive displays therefore enhance an already active environment, and offer new ways for the visitor to learn about objects and works of art. The inclusion of digital applications has enhanced almost every aspect of the museum institution, but has also demanded some change to a rigidly structured relationship between the traditional curatorial practice and the public.

II.A What Has Changed About the Museum Experience?

Digital technologies in museum environments are nothing new in today's exhibits and user experiences. There are many museums, science centers and historical sites across the world that have included virtual realms and platforms in their galleries. The long history of art museums has generated formal standards and traditions which exist for art exhibition spaces and the role of the visitor in relation to the art. However, there remains a lack of new standards from a curatorial perspective as museums undergo a technological shift and

¹⁰ Hawkey "Learning with Digital Technologies in Museums, Science Centers and Galleries 24

experiment with virtual platforms. As Clough has observed," the digital revolution offers museums, archives, and libraries a golden age of opportunity, because they are ideally suited for a world in which learning is informal and centered on inspiration and self-motivation."¹¹ Virtual technologies in art exhibits can offer new methods and ways of learning for many different types of audiences as well as new ways to engage with scholarly research. Museums with art collections must find ways to meet the old traditions of curated exhibitions and experiences while at the same time facilitating creative learning environments through digital technologies.

Art museums and exhibitions have remained the same in many aspects yet have changed significantly due to digital tools used within the gallery and as public outreach enterprises of the museum. One of the first technological devices used within an exhibit is the simple audio guide. In some ways this supplemented even older technologies such as the human guide and the printed placard. The handheld device transitioned from cassette tapes to digital mobile apps on phones and tablets, all of which allow the museum public to listen and

¹¹ Clough, *Best of Both Worlds : Museums, Libraries, and Archives in a Digital Age*, 9-10.

learn at their own convenience and pace.¹² Early on, audio guides indeed enhanced learning with curated, recorded “sound bites,” still requiring the viewer to visualize the content or story from the description. Though initially considered groundbreaking technology, by modern standards the audio guide is practically an antique that has been restructured, updated and now accompanied, or replaced completely, by a handful of other virtual platforms and applications. In fact, in a 2012 survey done by *The Learning Museum*, scholars found that about 94% of their participants said that audio guides were no longer in use in their institution.¹³ However, many institutions still have them available, but they are not simply in high demand. The hand-held audio guide has been a great learning tool within the museum gallery space, but since its usage decline, the “guide” experience has been digitized and changed to fit modern expectations and needs.

The impact that technology and the internet have on museums is apparent from the number of institutions presenting online or mobile apps and other virtual projects highlighting their collections. Just about every museum and

¹² Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 26.

¹³ Ann Nicholls, ed., et al. “New Trends in Museums in the 21st Century.” LEM: The Learning Museum Project (2013) Accessed March 12, 2015. <http://www.lemproject.eu/WORKING-GROUPS/museums-in-the-21st-century-1/7th-report-new-trends-in-museums-of-the-21st-century>

learning institution have at the very least a website, digital exhibit or online archive of their works of art, which can reach viewers across the globe. As Hawkey has noted, “as early as 2002, the number of virtual visitors to many museums’ websites had already overtaken the number of physical visitors on-site.”¹⁴ In the previously mentioned 2012 report from *The Learning Museum*, the usage of modern learning tools and technologies like websites and virtual interactive displays did not decline like the audio guide type of device within the 185 institutions surveyed.¹⁵ Because of the internet, museums have a competitive, global presence and can make available collections and research in user-friendly platforms. As a result, museums are now reevaluating whether energy should be put toward the viewers in the gallery or the growing virtual audience.¹⁶ The visitor-controlled type of experience that technology creates, whether online or in-gallery, is changing the learning environment, as well as the research process and role of curators in art museums.

Since the 1990s, priorities have slowly shifted the practice of traditional curated exhibits to curating a creative learning experience and environment with

¹⁴ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 1.

¹⁵ Nicholls, et al., “New Trends in Museums in the 21st Century” 62.

¹⁶ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 1.

the help of digital tools and platforms.¹⁷ The curator's vision for an exhibit or theme is not always clear to every museum visitor and consequently may not be effective in reaching audiences and teaching them about art. Therefore, the structure of the curated exhibit has changed in recent years in a more cognitive way by reframing the learning environment as a dialogue between viewers and art. Professor Michelle Tillander indicates in her work on art education that "as communication technologies offer a powerful union with creative and imaginative expression, the breadth of these technologies offers opportunities for creative synthesis and hybrid forms of information representations."¹⁸ She continues by saying "it is easier to enhance creativity by changing conditions in the environment than by trying to make people think more creatively."¹⁹ Therefore, the exhibition itself has been slowly adapting to modern demands of a more free-thinking environment. However, part of the struggle to incorporate technology into museum exhibits results from curators' desire to break away from traditional curatorial practices in order to alter the museum environment, and how that changes their roles within the institution.

¹⁷ Hawkey, "Learning with Digital Technologies in Museums, Science Centers and Galleries," 5-6.

¹⁸ Tillander, "Creativity, Technology, Art, and Pedagogical Practices," 40.

¹⁹ Ibid, 42.

Curators work with a set of art or objects and aim to create an experience through a space that usually builds from a common theme and the relationships of the works of art in the exhibit. However, no two persons understand art in the same way and expect to have their own type of experience. This is especially true of an academic with a specialized degree in that field versus a museum visitor from the general public. In his work "Doing Identity Work in Museums," Curator Jay Rounds states that "visitors come to museums for their own reasons, and those reasons are not necessarily congruent with the goals of the museum."²⁰ In reality, the average museum visitor typically overlooks the curated theme of an exhibit and tends to be drawn toward specific works in no specific order or relation.²¹ And, according to a study from the Cleveland Museum of Art, most museum viewers pass over the large gallery texts and tend to only read or skim some of object labels from the art they are interested in learning more about.²² Therefore, the work spent creating a magnificently curated experience in a gallery is unfortunately often disregarded by the average museum visitor. In the

²⁰ Jay Rounds, "Doing identity work in museums." *Curator* 49.2 (April 2006), 133-50. As cited in J. Alexander, J. Barton and C. Goesser, "Transforming the Art Museum Experience: Gallery One," In *Museums and the Web 2013*, N. Proctor & R. Cherry (eds). Silver Spring, MD: Museums and the Web. Published February 5, 2013. Consulted July 1, 2015. <http://mw2013.museumsandtheweb.com/paper/transforming-the-art-museum-experience-gallery-one-2/>

²¹ Alexander, et al., "Transforming the Art Museum Experience: Gallery One."

²² Ibid.

opinion of the museum or curator, the visitor failed to view and understand the gallery in the way it was intended to be experienced. However, to the visitor, it is no failure, but instead a rewarding and enjoyable opportunity to learn about art on their own terms.²³ As awareness of these preferences on the part of museum visitors grows, the curator's job is continuing to evolve and shift from the traditionally structured curatorial process to a more educational one; he or she takes on the role of facilitator of learning opportunities consistent with modern demands and expectations, and carefully crafted with digital applications and technologies.

If used successfully by curators, digital technologies can bridge the gap between old curatorial standards and new means of learning about art by making curatorial experience accessible when the user wants to retrieve it. Nonetheless, the key to effective technological integration is not by capitalizing on the "wow factor" of the most innovative and newest virtual tool, but rather in considering how the viewer can learn through the technology. If curators make scholarly research available to the public in ways it will understand, the viewer in return will be inspired and more likely to continue the process of learning

²³ Ibid.

after the museum experience. As Hawkey notes, “freed from the constraints, both physical and interpretative, of the curator and exhibition designer, the learner can use appropriate technologies to provide a dedicated and personal mentor.”²⁴ Digital tools can offer an infinite expanse of knowledge, all while creating an active learning environment with more open access and free thinking. However, there still remains a divide between people who expect to have the traditional, curated museum exhibition and the younger generations who demand the technological experiences at every opportunity.

Museums struggle to find a balance that pleases all ages and levels of learning through technology. The larger problem that society faces is the current transition and evolutionary phase of the human-technology relationship. Though only a few decades apart in age, those who were born before the tech-boom of the late 20th century behave, think and adapt very differently to technology than “digital natives.”²⁵ The term “digital natives” refers to anyone born after 1980, and who have grown up with technology integrated into every aspect of life.²⁶ Social media, web-applications, and mobile devices like phones and tablets have

²⁴ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 3.

²⁵ Clough, *Best of Both Worlds : Museums, Libraries, and Archives in a Digital Age*, 37.

²⁶ *Ibid*, 37.

been normalized and are becoming a standard for every institution, though their adoption varies by age groups. Hence, the different levels of visitor expectations create a challenge for museums to find new ways and new technologies with which to share information about art and artifacts and yet, still satisfy everyone.

²⁷ The current divide of technological preferences and acceptances will of course change and adapt in the future, but it is not clear whether all visitors will converge around a single standard for digital resources.

Some scholars and museum educators have expressed concern about this uncertain future. Josef Hargrave and Radha Mistry argue in their book, *Museums in the Digital Age*, that the current struggle of balancing technological enhancements in the museum will never fully satisfy everyone in the future, and museums will still need to concern themselves with older generations that are less inclined to interact with technology.²⁸ However, the older generations of the future that Hargrave and Mistry discuss are the “digital natives” born today, raised with technical advancements that no other generation has had in the past. There is no way to forecast exactly the reaction and outcome of the current technological shift in museums, but in contrast to Hargrave and Mistry’s stance, I

²⁷ Hargrave and Mistry, *Museums in the Digital Age*, 8.

²⁸ Ibid, 23.

think society's struggle to fully adapt to digital platforms in museum exhibitions and the online components will become easier over time for generations already accustomed to technology and virtual interactive experiences. Future generations will increasingly be more accepting of technology, more motivated to interact with digital platforms, and less hesitant to explore new modes of learning. This is reflected in the fact that older generations, the "digital immigrants," are nearly as invested in their social media profiles and smartphones as younger generations.

Another problem to consider in the technological evolution of museums, is the distinction between the effects and importance of real, physical experiences in a museum and the virtual counterpart experiences that are available to anyone around the world through online platforms. An individual's surroundings and learning environments greatly impact the way they engage with art and the information they absorb. Online exhibits and virtual platforms will never fully replace real gallery space and real experiences in museums. They can, however, enrich it. As Knell notes in his work *The Shape of Things to Come: Museums in the Technological Landscape*, "a virtual visitor may understand the thing better and be better prepared to interpret it when they see it but they may receive those

peculiar attributes of real things only through real world engagement.”²⁹

Museum visitors still look for and need the “physical-ness” of real objects, and react differently to digital substitutions.³⁰ Though most humans have become accustomed to interacting with screens and mobile devices, some do not distinguish between the virtual versions of works of art or digital exhibits for the real objects.³¹ This misinterpretation results in completely different experiences than that of the museum gallery with real artifacts and works of art. Thus, as museum exhibitions are currently evolving, and as they integrate technologies into the museum experience, there nonetheless remains a divide between the real and virtual realms. However, that divide will become blurry in the future by removing the “wow factor” of technology and instead by focusing on the learning experience.³² As we move forward into the 21st century, the real, physical museum will not disappear, but instead coexist with virtual

²⁹ Simon Knell, “The Shape of Things to Come: Museums in the Technological Landscape.” *Museum and Society*, Nov 2003, 1(3), 132-146. Accessed July 10, 2015. <https://www2.le.ac.uk/departments/museumstudies/museumsociety/documents/volumes/msknell.pdf>. As cited in Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 19. Knell 23

³⁰ Josef Hargrave and Radha Mistry, *Museums in the Digital Age* (London: ARUP, 2013) 13. Accessed March 12, 2015. http://www.arteducators.org/research/2013_Arup_FRI_MuseumsintheDigitalAge_final_web.pdf

³¹ Hargrave and Mistry, *Museums in the Digital Age*, 13.

³² Hawkey “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 4.

counterparts and high-tech advancements. Technology increasingly provides a new way of learning about art, history and culture.

Although there are many positive outcomes and responses for digital tools within the museum, there are also some potentially negative drawbacks which curators must take into consideration. Digital technologies in a museum exhibition can be viewed as either useful educational tools or as disrupting to the museum experience. While the entertainment value of virtual displays is fun and attractive, such displays may be so engaging that they divert the viewer's attention away from the object or work of art. Also, it is important for museums to find an unobtrusive mode of display that does not confuse or interrupt other viewers who are not participating with the technology. As Boon has indicated, "placing a computer screen in the midst of an artefactual display can be highly distorting of visitor experience, as doing the interactives can tend to overwhelm the slower, more complex, less controllable forms of interaction that occur with visitors' informed, or simply curious, mental interaction with artefacts and display."³³ In addition to maintaining an educational and creative environment,

³³ T Boon, "The Opportunities of Hybridity: Making the Modern World, a New Historical Gallery in a Diverse Institution," Paper Presented at Science Communication, Education, and the History of Science. British Society for the History of Science, London. (July 12-13, 2000). As Cited in Hawkey, "Learning with Digital Technologies in Museums, Science Centers and Galleries," 23.

the process of installation and upkeep of digital technologies within a gallery or online are also new responsibilities that curators and museums must consider.

Many factors and specific questions surface with the integration of digital platforms into museums. First and foremost is the consideration of whether the technology will harm the art or artifacts. Display screens and projectors create light, and therefore may harm light-sensitive objects. In addition to bright distractions, added physical equipment to a gallery space can be an eyesore or disruptive to other surrounding objects. Other factors such as the high cost of the initial equipment and the manpower and energy for every day up-keep, in addition to devices needing system repairs, are some of the main concerns for museums.³⁴ The positive results and engagement with visitors indeed make technology and equipment a good investments for museums, but it is crucial to have a strategy in order to create modern exhibitions that are both “architecturally elegant and maintenance friendly.”³⁵ All of those factors however, must be sustainable for the long run and adaptable to future generations of museums.

³⁴ Clough, *Best of Both Worlds : Museums, Libraries, and Archives in a Digital Age*, 6.

³⁵ Alexander, et al., “Transforming the Art Museum Experience: Gallery One.”

II.B What Kinds of Works of Art are Best Suited for Virtual Projects?

At this point in the paper, it is worth discussing exactly which types of art works are best suited for digital visualizations, and how each piece differs from the next. Technological enhanced experiences in museums will differ depending on the type of artwork, and also on how much information can be understood with or without the help of supplemental visual material. In general, works of art from ancient, medieval or native cultures were typically intended for purposes other than a work of art in a gallery. Many objects or artifacts produced prior to c. 1520 that can now be found in museum collections were created as part of a religious context or as part of a building, like a church façade for example. Their context and historical significance are largely lost when displayed in a museum exhibit. In addition, many ancient or medieval works of art are in fragments that offer little help to visualizing the intact, original work of art. Therefore, to fully understand what the art represents both physically and symbolically is challenging for many museum visitors, especially with sculpted artifacts or objects. Virtual visualizations offer additional ways to learn about art and artifacts, and help to inform the viewer about the historical context and content that may not be obvious by the object itself or the vague labels on the walls. A

major component of this project, and many others, is to emphasize the art's significance and context through the virtual platforms, and how one's knowledge and appreciation of works of art differs once they have a better understanding of the complex objects and origins.

Visual content like photos, videos, reconstructions, or simple illustrations can greatly aid the viewer's understanding of the works of art. If the viewer has no prior knowledge of the cultural context or history surrounding the object, how are they expected to formulate the correct depiction in their head of a label description or a fragmented artifact in a glass case? To be clear, this paper is not suggesting that there needs to be additional content and photos for every single piece of artwork in a museum. That is not logical for a large museum gallery, nor would it be aesthetically pleasing. In fact, contemporary art sometimes uses technology as part of the installation and art itself. For this paper, however, I am concerned specifically with artifacts that have a historical and cultural significance to old world civilizations. Museums therefore, should assess their collections and make efforts to highlight specific works of art that are more difficult for viewers to understand, and implement the technological visualizations where they are needed most.

For example, people view a painting for the story it represents and not so much as a physical object in the sense of sculpture or pottery, although they do have a material presence that adds to their meaning. Also, unlike objects, most paintings tend to be in better condition and usually intact, or restored, when on display in a gallery. Sculptures or cultural artifacts in a museum are in many situations worn from exposure to the elements or damaged from wars and destruction, making it more difficult to fully understand what the piece is as an object or what it may have been in the past. Sometimes artifacts are presented within the context of obvious restorations, but most of the time they are displayed as discrete objects. For ancient or medieval sculpture, specifically, the visitor divides their focus between understanding the subject matter and visualizing the whole, intact physical object. Many museum visitors are not familiar with distant eras of ancient and medieval art, and therefore are sometimes unaware of what they are viewing.

A way to help visitors better understand fragmented works of art is to include virtual, visual aids like images, videos or 3D reconstructions. Auxiliary visual content simplifies the historical and cultural significance of the work of art that is not always clear by the label. Visualizations shared through digital

displays or platforms can help re-create the original context, both historical and physical, as well as the surrounding environment of an object. Digital learning tools can certainly enhance any work of art, but ultimately can be especially effective for the historically and culturally opaque fragments and objects in museum collection.

III. Which Museums Have Incorporated Digital Tools?

This section of the paper will briefly discuss examples of institutions that have integrated technology into museum outreach projects that offer creative learning environments and free-thinking experiences for visitors, both in the physical galleries and virtually. As Hawkey suggests, museums strive to “facilitate lifelong learning by providing a free-choice learning environment that permits a plethora of pathways and possibilities.”¹ After exploring a variety of digital tools and applications, the ones that seem most successful are the discreet, less obvious platforms that generate personal interaction without large distracting displays and interfaces in the exhibit. The next section will discuss several institutions that have made such efforts in their projects and public outreach endeavors, with varying degrees of success.

III.A The Cleveland Museum of Art, ArtLens: Websites and Apps

The Cleveland Museum of Art in northeast Ohio has been one of the pioneering institutions among major American museums of art that is exploring the enhancements of technologies in exhibitions and online, while also maintaining the traditions of curatorial standards. The physical museum in

¹ Hawkey, “Learning with Digital Technologies in Museums, Science Centers and Galleries,” 2.

Cleveland underwent a heavy renovation several years ago that made way for their newest exhibit space called Gallery One, the foundation and hub for their museum-wide ArtLens application. The mobile app and new gallery officially opened to the public on January 31st, 2013.² Like many of the leading museums around the world, the CMA also has an extensive online archive of their collection that can be viewed at home, around the world or within the Gallery One space in the museum. The digital platforms offer images and information on thousands of objects in the CMA collection on view and in storage.³ The Gallery One is a very unique exhibit of selected artworks that inspire game-like interaction with large touchscreen displays and works of art. (See Figure 1.) Interactive platforms and mobile applications within a gallery are a way in which to bridge the physical collections to the virtual counterparts. (See Figure 2)

According to Jane Alexander, Chief Information officer of the CMA, "Gallery One is organized in three sections, each asking visitors a question to engage them in their experience: (1) What is it, and what do you see? (2) How is it made? (3) Why was it made?"⁴ By encouraging visitors to ask new questions

² Alexander, et al., "Transforming the Art Museum Experience: Gallery One."

³ Visit to CMA in July 2015 by Jessica Pissini. The author experienced and explored Gallery One and uses the ArtLens app on a personal iPad.

⁴ Alexander, et al., "Transforming the Art Museum Experience: Gallery One."

and actively engage with the artwork on virtual platforms, the CMA is pushing boundaries and standards for technology in the museum gallery by using digital visualizations that produce an “environment for creative investigation.”⁵ Like many other museums, the CMA has taken advantage of all that the internet and mobile apps can offer to the museum visitor. The core of their project online and within the gallery relies on the virtual platform of the museum’s website and custom app that have become the gateways to interacting and viewing their collection.

Websites and applications can function as foundations and hosting platforms for content and visualizations that help the viewer better understand the works of art. In today’s society, websites and mobile apps are the fastest and easiest way to share data and media. Most visitors have personal mobile devices and expect that institutions have online components readily available for public viewing. However, the creation of websites and apps is a simple or cheap investment, and therefore institutions are still exploring capabilities of online interfaces. Some museum websites and apps are virtual counterparts to the collection, and others offer more advanced and educational types of visual

⁵ Center for Advanced Spatial Technologies, University of Arkansas, “Visualization/Animation.” Accessed January 20, 2015. <http://cast.uark.edu/home/research/visualizationanimation.html>

content. The most basic types of visualizations presented within a website or app are two dimensional images and educational videos. As evident from the Cleveland Museum of Art, so much information and visual content can be shared within a gallery space and online through websites and innovative mobile applications.

III.B The Smithsonian Institute, X 3D: Virtual Models

In a slightly different approach from the CMA, the Smithsonian Institution has set the bar high for its work on the Smithsonian X 3D Explorer web-app that utilizes an online platform and application to share 3D models of various historical objects from the institution's collections. The models are available for viewing on any type of device, for downloading to a computer, and for 3D printing for creative educational purposes. The web-app is also available worldwide, generating a global learning environment and enhancing learning experiences outside of the museum. Joseph Henry, one of Lincoln's advisors during the Civil War and the first secretary of the Smithsonian Institution, notes that "the worth and importance of the institution are not to be estimated by what it accumulates within the walls of the building, but by what it sends forth to the

world.”⁶ In unexpected ways, the X 3D web-app can now fulfil Henry’s vision for museum outreach world-wide through the virtual 3D models.

The X 3D web-app presents multi-cultural works of art and objects from all periods of history, including archaeological artifacts, and natural and scientific objects and specimens. Second to the original, a virtual three dimensional replica is the closest and most accurate visualization with which a viewer can interact. For example, one of the most popular models available on the web app is the life mask of Abraham Lincoln which is so realistic that it is almost chilling to view. (See Figure 3.) Many artifacts in the Smithsonian collection are fragile objects that need protection in glass cases or may not be on display. Therefore, the X 3D models offer the viewer an opportunity to engage with the works of art and objects. Though the models are virtual replicas and cannot replace the value of seeing the original, they become another way in which to learn about the work of art or artifact. Three dimensional models enhance the viewer’s perspective of the object and generate interaction not available in other platforms.

⁶ Clough, *Best of Both Worlds : Museums, Libraries, and Archives in a Digital Age*, 21.

Virtual models, whether on a website or mobile app, offer different viewpoints and perspectives that people cannot get in person by the nature of the object not being accessible. Many objects on display are in a fixed position, sometimes under glass or up against a wall, which limits the view and interaction of the object and visitor. Three dimensional models on mobile devices or displays also create a type of physical interaction between the artwork and the viewer that would never exist with the original object due to the “no touching” rule of artifacts in museums. However, as a viewer, it is important to remember that a model is only a virtual representation and interpretation of the object.⁷ As noted earlier, virtual replicas will never fully replace the real object or the experience with the real object. Instead, they create an open-ended dialogue between the visitor and works of art, inspiring new ideas questions about the object, its original context and its creation.⁸ Models are an interactive and creative type of visualization that offers many opportunities to learn and engage with works of art and objects in so many new ways. However, some concerns still remain about the effectiveness and usage of models as educational tools.

⁷ Diane Favro, “In the Eyes of the Beholder: Virtual Reality Re-creations and Academia,” In *Imaging Ancient Rome: Documentation, Visualization, Imagination*; Proceedings of the Third Williams Symposium on Classical. Edited by Lothar Haselberger and John Humphrey, (2006) 326. Accessed May 1, 2015. <http://sitemaker.umich.edu/cah/files/favorreading.pdf>

⁸ Center for Advanced Spatial Technologies, University of Arkansas, “Visualization/Animation.”

Digital visualizations, especially 3D reconstructions, are sometimes too artistically abstracted and not accurate enough to warrant credit at scholarly work. In the case of the Smithsonian's X 3D project, the models were taken directly from the objects and serve as virtual copies, with little artistic design or modification. Currently there are not sets of standards for digital reproductions or how to access them. In specific cases such as virtual reconstructions of sculptural fragments or architectural remains that are in pieces or no longer exist, there will exist some level of interpretation. Visualizations and 3D reconstructions are a form of art themselves created by some digital medium and behave as a beacon of information and visual expression. Diane Favor states in her article that a visual representation "no matter how scientific or abstracted, is imbued with an aesthetic shaped by the artist, tool, and period."⁹ Sometimes, a fine line exists between an accurate model and exaggerated visualization. Hyper-realistic models and reconstructions, and the "wow-factor" of 3D displays easily distract audiences into experiencing the model itself instead of learning from the model as an educational tool. Nonetheless, accurate three dimensional models are useful, educational tools for humanities research and for enhancing museum

⁹ Favro, "In the Eyes of the Beholder: Virtual Reality Re-creations and Academia," 328.

education through online platforms. The outcome of the Smithsonian's X 3D project is a confirmation of the creative learning experiences visitors have when viewing and interacting with virtual models through an app. However, as technology evolves, so does the software and equipment, which presents issues and concerns for museums and exhibition designers.

In research labs at Duke University and many other institutions, viewers can either walk or fly through a 3D environments with the controller in hand, or watch a virtual object rotate in real space inches in front of their face. The equipment used for these 3D experiences is expensive and not exactly the easiest type to integrate within a gallery space, although that is begin to change with more discrete web-apps and platforms that run off of small devices. Researchers and institutions have used many different types of equipment, software and methods to create these models within their scholarly projects. Each type of technology has both advantages and disadvantages, and has proven to be useful for certain types of documentation and work. Two common methods of producing accurate 3D models of objects and works of arts are laser scanning and photogrammetry. Both present challenges depending on the object, but are

becoming popular ways in which museums create virtual models for educational experiences within and outside of the gallery.

III.C The Nasher Museum of Art, the Wired! Lab, and the “Lives of Things” Research Theme: Exploring Unconventional Content Within Museum Exhibitions

A third example of an organization experimenting with innovative display technologies is the “Lives of Things” research theme that forms part of Duke University’s Wired! Lab. Many teams of professors and students have generated innovative and educational projects in the Art History department in collaboration with other university departments, specifically Engineering and Computer Science, and also with the Nasher Museum of Art. One of the Wired! Lab’s goals is to present scholarly research in virtual platforms that document, display and tell the story of art and architecture around the world. The “Lives of Things” project recently installed within the Nasher Museum an interactive in-gallery exhibit which offers an in-depth application for paint and color on medieval sculpture. Not only does the project present historical information about four apostle reliefs from medieval France, it also educates the public about the fact that ancient and medieval sculptures once had brightly painted surfaces. The topic of paint on sculpture is not a new subject for academics or within the discipline of Art History. However, the majority of museum viewers do not

know that ancient and medieval sculpture was once colorful and vibrant, as many objects in museums no longer preserve remnants of paint. And, if they do, in most cases the surviving colors are faded and hard to detect, especially if one is not aware or looking for it.

So how exactly does the “Lives of Things” project teach the public about a broad and unconventional topic within the museum exhibit? Similar to the interactive displays found in the CMA Gallery One, the Nasher Museum and Wired! Lab have created a simple, yet engaging platform that utilizes iPads and a controlled color projection onto the medieval sculpture to create the illusion of a colored surface. (See Figure 4.) The technology does not harm the objects, and the digital equipment visible to the visitors in the gallery is minimalized to a fixed iPad station with an overhead projector that is out of sight. This type of in-gallery experience opens the doors to new information not typically available in traditional exhibits. However, a way that the “Lives of Things” virtual display differs from the other two previous projects is in the approach of presenting scholarly research and topics that are typically not discussed in museum exhibitions.

The Wired! Lab team has used the technological interfaces of mobile applications and devices differently from the guided tours of the CMA's ArtLens app and the interactive models from the Smithsonian's X 3D, but have still been effective in creative learning experiences with the museum audience. So much research and work has gone into understanding complex topics like surface painting on sculptures, but the majority of the work was conducted for academics and for academics. The "Lives of Things" project aims to present that information to the museum public through the digital display which ignites new questions and observations that the visitors can apply to other works of art in and outside of the gallery. Although users may color the statues in ways that are not actually true to the original context of the Apostles, the project as a whole focuses more with the larger learning experience of color on sculpture, rather than a completely accurate representation of what the Apostle statues originally looked like with painted surfaces.

IV. Case Study: Decoding Artifacts

As seen within all of the examples from the CMA, Smithsonian and Duke University Wired! Lab, technology clearly enhances the way people learn from and about art, history and culture, and offers new ways to engage with the works of art. The major digital projects differ greatly in their approach and outreach, but all make use of a website or application platform to share information and visual content. The virtual component of the website and app seem to be creating a general standard for museum outreach, but still vary in design, layout and effectiveness. The “Decoding Artifacts” website and mobile app are small-scale examples and test cases of how virtual content enhances the museum learning experience and how scholarly research is shared through digital visualizations.

In the next few sections, this paper will describe the digital tools used in the “Decoding Artifacts” project and what kind of information the project offers to the museum public. “Decoding Artifacts” combines the strengths and successful elements of the larger digital projects from the CMA, Smithsonian and “Lives of Things” to create learning opportunities about the process of stone carving and one medieval sculpture: the Head of a Virtue from Notre Dame in Paris, a fragment now in the Nasher Museum of Art. (See Figure 5.) The project

emphasizes the importance and effectiveness of visual content and storytelling through multi-sensory visualizations in the gallery and online, and has highlighted certain elements successfully applied in other projects. In general, the remaining sections of this paper will break down the “Decoding Artifacts” project into three sections: (1) The Foundation and Gateway: website and mobile application, (2) The Visualizations: Images, videos and 3D models, and (3) The learning experience: Historical content. Each section will highlight the specific tools and methods used, what has works and not worked well, and how certain project components are successful and effective for museum education about the Virtue and the process of stone carving.

IV.A Foundation and Gateway: Website and Mobile Applications

The “Decoding Artifacts” project tested a handful of website and application building programs, some being more successful than others. The project’s website hosts of all the content, images, videos and models, and was made through the popular WordPress content manage system. (See Figure 6.) With a program like WordPress, there are some options to customize the structural code for specific design and aesthetic purposes. But in general, it is a simple, clean platform that has a library of already made themes or designs to choose from for website building beginners, with the possibilities for editing CSS

and creating child themes or even creating entirely new themes available. Most large museums or institutions have teams or specialists to create their online galleries and websites which are customized for looks and exhibition purposes. But for the timeframe and purpose of the “Decoding Artifacts” project, a website building program was logical and suitable for the project’s needs. This platform choice reflects an important decision for any prospective digital project: when to create a site from scratch, and when to build upon existing resources. For this project it, was important to divide efforts and energy between the website and mobile application since the app presented slightly more challenges than its counterpart website due to the unknown nature of new programs and interface capabilities.

Three different types of app building programs were tested for the project: AppInventer2, Metaio and Wikitude. The first, AppInventer2, is a beginner’s app building program, which was made by MIT and runs off of Google accounts. The final app product runs on Android devices only, which limited the use for potential museum visitors. However, AppInventer2 is overall a good starter program for learning the basics of app building, but for the “Decoding Artifacts” project and other larger institutional projects, a more customized platform is

more effective and worth the time and investment. AppInventer2 could not sustain a large collection or database of museum of objects. As a result, efforts were directed to augmented reality application programs like Metaio and Wikitude.

The second types of applications involve an augmented reality platform and app experience that integrates a trackable image in real space with and virtual media on the same screen and at the same time, through a scanning type of function. The mobile devices responds to and scans images in the same way that phones scan URL codes. When first creating test examples through Metaio, the large images, videos and links placed directly over top of the trackable image seemed a bit distracting and jumbled. To create a more organized viewing screen, buttons were used to link the images and videos to the app with minimal clutter on the screen. However, over the course of this project, the Metaio program and company were bought by Apple and would no longer be available in the current format after December of 2015. This setback reflects a reality of the digital landscape. Tech companies and products evolve and change quickly which presents challenges for the users, and potentially museums. Luckily,

another competitor augmented reality program called Wikitude is available and similar in structure, capabilities and effectiveness.

Wikitude has options for both beginners and skilled programmers who can create very detailed and high-tech app experiences. For a long term project involving Wikitude and augmented reality platforms, fully custom software development kits (SDK's) are available but they require experience in coding and involve more sophisticated constructions. Wikitude is also developing a 3D trackable engine through a SDK plugin. In theory, the 3D engine will allow the viewer to scan a 3D object instead of a 2D image. Since this technology is not available yet, the "Decoding Artifacts" project utilized the 2D creator Studio through the Wikitude app.

Similar to the approaches made with the Metaio program, hyperlinked buttons worked best to organize and bridge the website content to the mobile application. However, augmented interactive platforms can offer many of other educational experiences that utilize the possibilities of augmented experiences. For example, a museum visitor using the "Decoding Artifacts" app can scan an image of a Claw Chisel and immediately view a superimposed video of that tool in action. In addition, since the Head of a Virtue is just a head with no body, an

augmented reconstruction of a body appears when the devices hovers over an image of the Virtue. Both types of AR experiences are quick and engaging learning opportunities that can be done in a gallery with a mobile app or through the website. These are just a few of the many ways in which augmented reality applications can be useful and successfully applied to museum exhibition and outreach projects.

Similar to the other three larger institutional projects previously discussed, “Decoding Artifacts” has found a simple, yet fun way to create a foundation and gateway to scholarly research and visual content. Both digital platforms, websites and mobile apps, offer a way for the museum to integrate historical information and media into a gallery experience without implementing ridiculously large technical equipment into the exhibit space. Websites and apps also give the visitor a choice to interact or not with the technology, offering a more personalized and visitor-guided experience. The museum public can navigate virtual information quickly while viewing an object in real space galleries, while virtual visitors can engage with the digital collections and learn from the art without ever stepping foot in the museum. Mobile versions of museum apps are curated to highlight the collection and correspond to the

physical exhibit space, but rely on media and content that enhance and offer something new to the experience. Digital images, videos and 3D models are the core educational visualizations presented in the “Decoding Artifacts” project that enhance the visitor’s experience in the Nasher Museum.

IV.B Visualizations: Images, Videos and 3D Models

Images, videos and 3D models are significant visual media types that help all ages and knowledge levels understand works of art more effectively beyond the descriptions presented on the museum label. Although it might seem redundant to use supplemental visual content to educate about works of art, people learn the best through digital and interactive visualizations. For example, when a viewer reads a work of art’s label on a wall or display case, their brain must formulate a depiction of what the text describes, and then try to make sense of their intellectual version of the text. A typical museum label for a work of art provides a few sentences. In some cases only the date, origin (if known), and the material data are available. (See Figure 7., the label for the Head of a Virtue) A label rarely provides enough information the normal viewer to fully comprehend the work or art. Therefore, incorporating visual content in a museum website or mobile application enhances the learning experience and ensures that the viewer has a better foundation and understanding of the work of art.

On the “Decoding Artifacts” website, the viewer can find both historical imagery and modern photos taken during sculptor Simon Verity’s visit to Duke. By interacting with these materials, scholars, students and the museum public better understand the Head of a Virtue and the process of making sculpture.¹ (See Figure 7.) The images appear in gallery formats on the website for individual photo viewing, and also as slide-show videos with narration. Educational videos are powerful learning tools because they are multi-sensory experiences that synchronize visual content with narrated stories. A downfall to videos is that their sounds that may interrupt museum gallery visitors. However, for museum outreach and virtual visitors, videos are one of the most efficient ways in which to share visual content and historical information, and also among the simplest visualizations to make. The videos for this project were shot by a collaborator and then edited for inclusion in the digital resources.

For the “Decoding Artifacts” project, the majority of videos were edited on Windows Movie Maker, which is a free program and very user friendly for beginners. In similar ways to creating a PowerPoint presentation, the user simply

¹ Description from the Decoding Artifacts Website: A Duke University team of students and professors joined with master stonecarver Simon Verity in January of 2015 in a 10 day endeavor to better understand the tools, techniques and overall process of stone carving. Verity has worked on many large sculpting projects over the years, including work for Elton John; he was also Director of carving on the West Portal of the Cathedral of St. John the Divine in New York.

uploads images, video clips and audio files to the program, then aligns and synchronizes the visuals to the sound. The narrated stories in the “Decoding Artifacts” videos describe general historical information while images and short movie clips appear, creating a multi-sensory learning experience that connects stone carving tools, techniques and history to the Head of a Virtue and other sculpted works of art in the Nasher Museum’s gallery.

In addition to the images, and videos presented in the website and application, the “Decoding Artifacts” project has also incorporated two interactive models and platforms for additional perspectives and learning experiences. As the project creator, I tested out several types of modeling programs and methods to create virtual copies; laser scanning, photogrammetry, and time-lapse reconstruction. The three-dimensional models of the Virtue and the Duke Virtue Copy created with laser scanners or by photogrammetry software, and are now available through an embedded link from Sketchfab, an online hosting platform for models. Several years ago, scholars and students of the Duke Wired! Lab used laser scanners to create 3D models of the Head of a Virtue and several other medieval artifacts in the Nasher Museum’s collection. The final model of the Virtue has been borrowed for this project and made

available through the website and app. The other available model displays the Duke Virtue Copy, carved by master sculptor Simon Verity in January, 2015, and was completed using photogrammetry methods. (See Figure 8.)

Both laser scanning and photogrammetry were tested on the Duke Virtue Copy, but in the end, photogrammetry proved to be the most successful method for this part of the project. Though I did not use laser scanning as part of the final product, it is worth discussing the struggles I had as part of the learning process.

Laser scanning is a very useful and accurate method for creating models for art and architecture, but it simply did not work for this project, mostly due to equipment technicalities. When the laser device scans an object, it not only captures the surface shape with the laser and creates what is called a “point cloud”, but also photographs the surface to create a texture or skin for the model. Eight sectioned scans around the Duke Virtue Copy were taken which required a manual stitch or alignment. In other words, each scan needed to be matched to the neighboring scan similar to how photo editing software stitches together panoramic photos. There were a handful of equipment malfunctions and bad scans taken resulted in a failure to create a final laser scanned model for this project. However, many other art historians, archeologists and computer

scientists have found great success and results from laser scanning technologies in labs and museums. The overall experience was a good teaching moment that showed how sometimes technology simply will not do what is needed or expected, and therefore other methods should be explored.

As a result, the “Decoding Artifacts” project shifted its focus to photogrammetry methods, which also came with some challenges, but resulted in a useful model of the Duke Virtue Copy. The process of photogrammetry is a technique that has evolved alongside modern photography and digital technologies in the last half century. Typically it has been used in mapping projects or for excavations, among other similar fields, and has now become a useful method for creating models of artifacts and works of art in museums. With photogrammetry software, institutions and museums produce accurate models of objects that can parallel the preciseness of laser scanned models.

To create a photogrammetric model, the user first takes photographs of an object from every angle possible, in most cases 360 degrees around the object. The “Decoding Artifacts” project captured about 80 to 100 photos of the Duke Virtue Copy for each attempt. The sharp details of images taken by high resolution digital cameras transfer easily to the model shape and texture within

the software. The photos were uploaded to a software program called PhotoScan Pro, which then aligned and stitched the images together to create a model shape from the outline of the object and also a texture. (See Figure 9.) As easy as the process sounds, some issues still occurred due to lighting and the object's surface. Shadows create additional geometry on the models that appear as facial growths which was not easy to delete. The texture of a model relies on the geometric shape, and therefore would become distorted if the model was altered. After several attempts, a model was finally created that is not perfect, but a good working model. Like the failures with the laser scanning attempts, these occurrences were useful teaching moments. Sometimes sophisticated technology does not produce what one would hope for or expect, and requires the user to adapt or try again. Eventually with time and effort, the issues were solved with the photogrammetric model. However, in the case of the time-lapse reconstruction model, many of the problems were not anticipated and beyond the creators control.

In addition to the Virtue and Duke Copy models, an experimental method for creating a time-lapse 3D model was also tested during Simon Verity's visit by Carlo Tomasi, a computer scientist at Duke University. Tomasi's goal was to

produce a virtual model of the Duke Virtue Copy, changing over time from a new block of limestone to the final carved copy. Within the studio space where Verity worked, Tomasi set up four tripods with four cameras on each, 16 total, around the carving space. (See Figure 10.) Each camera was focused on the stone and programmed to take a photo every 8 seconds for 19 hours a day, over a span of 11 days, which resulted in 1,504,800 images and 1.75 terabytes of data.²

In theory, the idea was to combine the useful photos into an algorithmic program that would align the photos similar to the photogrammetry software, and show the block change. For this concept to work, the limestone block would need to remain in a fixed position with consistent lighting and limited barriers or human bodies blocking the camera view. Plus, the cameras were very sensitive and would need to remain perfectly still and untouched. Everything that was needed for a potential successful completion, in fact did not happen by nature of the busy, messy and somewhat chaotic process of stone carving. The working space was at many times filled with extra people in addition to Verity because many students and scholars were interested in observing the work and at times tested out the tools themselves on scrap pieces of blocks. Therefore, many of the

² Personal email correspondence with Dr. Carlo Tomasi. July, 2015.

cameras were capturing people's backs and in some situations were bumped and thrown out of focus. Also, the block itself did not remain fixed. Verity naturally moved, tilted and flipped the stone as he progressed with each layer and side of the head. The movement of the sculpture presented an initial problem for Tomasi who is now reworking the program to account for the moving block. Overall, it was a good trial attempt resulting in a lot of captured data. However, for future endeavors, many factors would need to be reconsidered for a successful completion of a time-lapse model.

Despite the challenges that arise while creating 3D models, they are still very important and useful for the museum education and humanities research. The final products of the "Decoding Artifacts" 3D models are still works in progress, but have proven to be successful visualizations and educational tools for sharing historical information about the Head of a Virtue and about the process of stone carving. Through the process of making the models and the websites, there were many challenges that resulted in learning experiences themselves. With any digital project, the creator must be willing to fail, many times, in order to be successful in the end.

IV.C The Learning Experience: Historical Content

Thus far, this paper has discussed the importance of informal, creative learning experiences in museum galleries and the projects, tools and technology used to create such experiences. But what about the content? Some museum projects simply copy the description directly from the object label and paste the text right into the website or app. While this method presents the basic information about the work of art to the public, it offers nothing new or supplemental, and therefore does not generate a creative learning experience. A web-app serves no purpose if the content does not teach anything new to the viewer. In addition, by not including visual components such as photographs, videos or models, the creative visual learning experience and dialogue between the art and viewer does not exist either. The core of the learning experience stems from the educational content mined from the visualizations available through the application and technology. Within the “Decoding Artifacts” project, different topics and areas of content are available on the website and app that are not available from the gallery installation or object labels. The content of the projects aims to recontextualize the historical significance of the Head of a Virtue, and also teach the public about history of stone carving tools and techniques, and

how to identify evidence of tool marks on other sculpted works of art in the collection.

IV.C.1 Historical Context of the Virtue

Decoding Artifacts has focused all of the content and visual materials around one object, the Head of a Virtue from the Notre Dame Cathedral at the Nasher Museum of Art. I have produced several videos with images and narrated audio that describe the object, its historical background, and also the tools and techniques of stone carving. For museum fragments like the Head of a Virtue, understanding the historical context is difficult, time-consuming and requires years of scholarly research. How is it possible for museum visitors to understand the complex life story of this work of art, and others in the gallery, but just a few sentences on the label? As an example, the following description is a slightly shortened version of the content available on the Decoding Artifacts' webpage about the Virtue's history. It is only a brief overview and summary of the known history and origin of this work of art:

The Virtue has been identified as one of three theological virtues from Notre Dame Cathedral in Paris, possibly from the west jamb of the north transept

portal, and dates as far back as 1245.³ The Virtue came to Duke University as part of the larger Brummer Collection with some questions regarding its provenance. Scientists have since turned to a scientific method called neutron activation analysis, to test the virtue head's limestone composition in an attempt to unveil more information about its origins. The process allows scientists to categorize within a given sample, an elemental identity as a "fingerprint" for the material, potentially revealing its provenance, or origin. According to the Limestone Sculpture Provenance Project, "small samples of stone removed from a sculpture, monument or quarry are irradiated in a nuclear reactor to produce radioactive isotopes of elements present in the stone."⁴ It is a useful technique that only requires a very small amount of the material (at least 1 gram) to obtain reliable results. Similar compositions compared to other tested samples would suggest similar origins, perhaps from the same quarry or two quarries that are located in the same region. Overall, "some twenty five samples created the compositional profile of the limestone used at Notre Dame in the twelfth and

³ Dieter Kimpel, "A Parisian Virtue." in *The Brummer Collection of Medieval Art*, edited by Caroline Bruzelius with Jill Meredith. (Durham: Duke University Press, 1991) 136.

⁴ Limestone Sculpture Provenance Project, "Applying Science to Art History." Accessed July 15, 2015. <http://www.limestonesculptureanalysis.com/>

thirteenth centuries.”⁵ Scholars believe that the Nasher Virtue relates to another female head traced to the Notre Dame Cathedral, possibly one of the other Theological Virtues, which is found in the Musee de Cluny, Paris, France. Both of the Virtue heads, and many other sculptures, artworks and fragments of architecture were torn down during the French Revolution and have since ended up in museum collections.

The Nasher’s Head of a Virtue hides in her hair various holes running along the back of her head and an indentation that may have held a metal halo, crown or diadem of some kind, which is typically a decorative element of a virtue. In terms of Christian philosophy, there are three theological virtues: faith, hope, and charity. In order to determine which of the three a sculpture represents, scholars study certain features like posture, symbols, actions, accessories, and setting to name a few. For example, the Virtue of faith is usually depicted with a cross and chalice, hope may hold a flaming brand or torch, and charity is often gathering fruit and may have small children at her sides. In the case of Nasher’s Virtue, all that remains of the statue is the head so it is difficult to determine exactly which virtue she may have been.

⁵ Charles Little, “Searching for the Provenances of Medieval Stone Sculpture: Possibilities and Limitations,” University of Chicago Press, International Center of Medieval Art, 33:1 (1994).

The current Virtue label in the Nasher gallery simply states the estimated date, location, and a couple of sentences, while the previous web description is just shy of 500 words. (See Figure 11.) There have been multi-page articles and chapters dedicated to just this one Virtue Head from the Nasher's collection. It is impossible to understand and appreciate the Virtue by a brief label. However, it is not logical to have such long descriptions on object labels or gallery texts. Most museum viewers will not read them. And, if by chance a visitor reads every word, it cannot be assumed that they will comprehend or be familiar with every term, location and concept in the description.

For example, the Virtue is thought to be from the Notre Dame Cathedral in Paris. Of course scholars and students of art history would immediately form an image in their mind of the cathedral. But not all people know what the cathedral looks like or its significance in French history. And with children, their understanding of Notre Dame may come from the Disney movie about the tale of the hunchback. Furthermore, if the viewer is unaware of what the cathedral looks like in general, there is probably no further connection made with the indication of the Virtue's possible position in the "west jamb of north transept portal", or what those terms indicate within architecture, or the religious and

symbolic meaning of a virtue. (See Figure 12.) Museums have created a closed-off experience that assumes every viewer is aware or understands art, its history and its context to a degree of what the curator or scholar knows. The problem is how museums share information in ways not realistic to everyone's level of familiarity. Digital tools and displays are some of the ways to present the extra information needed to better understand a work of art. Well-researched and accurately presented historical content is one of the keys to understanding and appreciating medieval works of art like the Head of a Virtue. The project website and the mobile app aim to re-contextualize the Virtue by the use of images, videos and models as education tools and virtual visualizations. The "Decoding Artifacts" project offers to museum visitors several ways to interact, view, listen, and read about the Virtue at their own pace, and continue the learning experience when they leave the museum.

IV.C.2 Stone Carving: History, Tools and Sounds

The next section and pages of the Decoding Artifacts website contain historical information focusing on the process of stone carving, and visual content in the form of images, videos, and models that help teach viewers about the tools and techniques. Stone carving is a craft and creative process, and best understood by observing a sculptor at work. However, as the "Decoding

Artifacts” team learned during Simon Verity’s visit, the process of stone carving is a messy and somewhat chaotic process, and certainly not suitable for a museum gallery. The next best option is to include video clips of the tools at work and images to show the stages of carving, the change over time of the stone, and the overall technique of the sculptor. While at Duke, Verity used traditional tools to produce a facsimile of the Virtue Head from the Nasher Museum of Art’s collection, and also a copy of the Head of a King from Bowdoin College. The Wired! Lab team documented Verity’s progress and approach, in addition to conducting historical research on stone carving techniques. All of the project’s visualizations and content surrounding the process of stone carving are available through the project site and app.

Modern stone carving can be traced to ancient civilizations, and had changed very little through the middle ages.⁶ During the medieval era and into the Renaissance, the rise of guilds and masons revived the craft of stone carving from ancient times. Much of what scholars know about stone carving has survived in a few 15th and 16th century manuscripts, in the remains of sculptures and sculpted architecture, and in a few of other artworks like stained glass or

⁶ Rudolf Wittkower, *Sculpture: Processes and Principles* (New York: Harper & Row, 1977) 15.

drawings.⁷ One example, a work of art by Andrea Pisano, circa 1340, called the *Allegory of Sculpture*, shows a sculptor at work, referencing the techniques and tools of that age. (See Figure 13.) Throughout the different eras of sculpture, many aesthetic trends and tastes created popularity of specific artistic styles and the use of certain tools that left marks distinctive to that age.⁸ However, a handful of standard chisel types have remained a constant over the years and are still in use today.

The four basic types of chisels, Point, Claw, Flat and Roundel, all have a distinctive end shape, vary in sizes and widths, and result in a unique mark cut into the stone. The Nasher has in its collection an ancient Greek bronze chisel, perhaps a worn down flat chisel or maybe a roundel type that is comparable to medieval tools and even the modern ones Simon Verity used during his time at Duke. (See Figure14.) Throughout the many centuries of stone carving history, not much has changed with the standard chisel types. Each tool, whether ancient, medieval or modern, has its own purpose and is used for different stages of sculpting. To highlight the four main chisel types, the website's "Tools" page organizes videos and images of each kind that show the distinct shape of the tool

⁷ Wittkower, *Sculpture: Processes and Principles*, 35.

⁸ Ibid, 15.

and the tool in action. Also on the page and app is a model of the Duke Virtue copy that directs the viewer's attention to specific marks left in the stone and how to identify the use of different chisels.

Another concept discussed along with tools is the relationship of pitch, or sound with the artist's technique. Of course no recorded sounds or proof exist from the Middle Ages. However, during Verity's visit, it became clear how important it is to recognize the high sounding pitch of the chisel and how to adapt the applied hand pressure. If the viewer listens carefully, they will recognize different pitches and tool sounds from the videos of the working tools. When a pitch becomes too high, pressure is lessened from the sculptor's hand the angle of the tool is slightly changed.⁹ Likewise, if the pitch is too low sounding, the sculptor adapts his hand or may switch tools. Sometimes, a low pitch is a result of an unintended crack through a section of the block. The concept of sound and pitch is a unique type of engaging information and should be part of the creative learning experience.

Understanding the craft of stone carving, the tools and techniques used to make works of art in the gallery, and how sculptures came to be in their current

⁹ Notes and discussion with Simon Verity, with Jessica Pissini. January, 2015.

condition are all significant components to the history of art, specifically for the Head of a Virtue and similar fragments. Ideally, after engaging with the “Decoding Artifacts” app and learning about the process of stone carving, a visitor can apply their knowledge to other objects or artifacts, and perhaps better understand the context or history surrounding complex works of art in other galleries.

IV.C.3 The Process of Making: Drawings and Geometry

The final area of research and content that is presented through the website and app is the inter-relationship of shapes and drawings with the process of stone carving. Both medieval and modern sculptors approach stone carving by first visualizing geometry through two-dimensional shapes and next by transferring those shapes into the three-dimensional stone. (See Figure 15.) Today there are many great tools and materials available to help the modern sculptor visualize his work, like computers and 3D printed copies, and even the simplest form of paper and pencil. However, medieval sculptors did not have the luxury of virtual 3D models, and at times they may not even have had paper because of the scarcity and high price.¹⁰ Parchment was typically used early on

¹⁰ Wittkower, *Sculpture: Processes and Principles*, 36.

for architectural drawings and blueprints, and later became more relevant and available for artists in the 14th century.¹¹ It may never occur to some people that paper would have been scarce and expensive for early medieval artists. This topic is not one typically discussed within galleries of stone sculptures. But it is an important concept to consider while learning about stone carving. Stone sculpture is not a forgiving medium to mistakes and is difficult to measure estimates of shapes and sizes within the large block. So how exactly did medieval sculptors conceptualize their ideas without paper and preliminary drawings?

At the very least, early medieval sculptors sketched shapes on other pieces of stone or directly onto the surface of their working block after careful measuring.¹² One account for this idea was made by Theophilus, a pseudonym for a 15th century Benedictine monk, in his work manuscript called *De Diversis Artibus*.¹³ Though Theophilus worked with bones as his medium of choice, the preparatory work of stone sculpture can be viewed as a similar process. In his description, he suggests to “try out the design you wish to make on a piece of slate,”¹⁴ and continues with directions on how to mark and score the working

¹¹ Ibid, 38.

¹² Ibid, 36.

¹³ Ibid, 35

¹⁴ Ibid, 36.

surface. Theophilus instructs the artist to “draw the figures with lead (pencil) according to your wishes, and score the outlines with a sharp tracers so that they are quite clear. Then with various chisels, cut the grounds as deeply as you wish.”¹⁵

The concept of marking the stone in some way with scratches from tools was a technique passed down from ancient sculptors. Some artists may have had real-life models or perhaps even clay models as reference, while others went as far as using a contraption called a “Pointing Machine.”¹⁶ (See Figure 16.) The pointing apparatus was an ancient mechanism used to align and mark cuts into the block of stone and was another way for the artists to visualize their work.¹⁷ Most museum visitors are more familiar with the smaller versions of marking and measuring tools like the caliper, divider, and the compass, which itself became a recognizable symbol of stone masonry and still used today by craftsmen and artists like Simon Verity. The “Decoding Artifacts” team who observed Verity at work on the Duke Virtue Copy saw just how important the preparatory work and drawing stages are to the entire process of stone carving.

¹⁵ Ibid, 36.

¹⁶ Ibid 30.

¹⁷ Ibid, 30.

During many discussions about the importance of drawings, the use of sacred geometry and relationship of 2D shapes were also popular topics and features of the stone carving process.

The visualization of basic geometry within the human body, and interrelationships of drawings, shapes and nature, form what is known as sacred geometry, which has been a fundamental concept of ancient and medieval stone carving for many centuries. Shapes identify as numbers and have potential deeper meanings and purposes in everyday life, nature, religion and in art.¹⁸ For example, a circle is viewed as the number 1, because it is whole and seen as having no beginning or end. A line identifies as the number 2, a triangle is 3, a square is 4, and so forth. Most viewers of sculpture can typically identify basic geometrical shapes like the natural round circle or spheres within body parts.¹⁹ And, within the Head of a Virtue, Simon Verity saw a unique shape and devised a theory surrounding sacred geometry.

While closely examining the Virtue, Verity identified a pentagonal, five-sided shape around the exterior of the Virtue: its nose and ears as three of the

¹⁸ Michael S. Schneider. *A Beginner's Guide to Constructing the Universe: Mathematical Archetypes of Nature, Art, and Science* (New York: Harper, 1995).

¹⁹ Schneider. *A Beginner's Guide to Constructing the Universe: Mathematical Archetypes of Nature, Art, and Science*.

points, while the back of the head touches a plane and creates the remaining two points. Verity's theory is that medieval sculptors may have carved the heads of figures from a roughed out pentagonal shaped block and not a cube or cylinder shape. The pentagon is both the interior shape and the exterior perimeter of the connected five points and lines of a pentagram, or star, which is typically seen as a religious symbol in art. Medieval stone carvers may have used this five-sided shape as a divine reference, but also as a practical starting guide and mental alignment to carve the face and head within the stone. It is difficult to prove his theory because not many (if any) sculptures remain in their working condition. Most remaining fragments of medieval sculptures are so damaged, that is impossible to visualize the original working shape. However, the concept of sacred geometry is way in which to understand shapes and symbols within works of art from all ages and civilizations.

In general, the discussions of tools, techniques and methods of stone carving are unconventional topics and subject matter for museum galleries and object labels, and therefore are better expressed through digital visualizations. Museum visitors can greatly enhance their understanding of stone sculpture from any era or culture by learning about basic carving techniques and chisels.

V. Conclusion and Summary

The “Decoding Artifacts” endeavor aims to present scholarly research and content to the public and enhance the overall learning environment of museum galleries and virtual platforms. As more educational institutions make efforts to shift to more free-thinking environments and visitor-driven experiences, this project and the others from the Cleveland Museum of Art, The Smithsonian, and the Duke Wired! Lab, have begun to generate standards for creative human-technology interaction with works of art. Museum exhibits and public outreach endeavors have and will continue to greatly benefit from virtual technologies, especially through website and applications.¹ Visual components, such as images, videos and models, are the tools to understanding art and its historical context more precisely and effectively in museum spaces.

Throughout the entire project, the goal was to maintain an opened-ended type of outcome that would perhaps be adopted by future students and endeavors. In many ways, successful museum projects that incorporate digital technologies have no specific end or cut-off to the experience. I feel that the effectiveness of websites and mobile apps, and different types of visualizations

¹ Tillander, “Creativity, Technology, Art, and Pedagogical Practices,” 40.

like 3D models, greatly enhance the museum experience with little distraction from the original artworks. Interacting on small devices eliminates large displays and equipment in galleries, and is the most efficient way in which to share information. Digital platforms and displays should in no way replace the real works of art, but rather complement the existing museum experience and offer new ideas, perspectives, and visual content to the public.

The demands and expectations of modern society continually challenge curators of art to produce content and exhibits that please all levels of learning, in addition to creating experiences that are both traditional and innovative. Many past and current museum projects have begun to set standards for virtual technologies in the galleries. However, much work and research remains to be considered and developed as the tools and technology evolve and the digital-native generation matures. There is no doubt that virtual museum projects offer new ways to ask questions about art and artifacts, new ways to view and interact with the objects, and new ways to create a dialogue between the artwork and the viewer. It is important to remember that digital tools and technology are not the final experience themselves, but rather the means in which a creative learning

experience shares knowledge in museum galleries and inspires lifelong learning about art.

Figures



Figure 1: Pissini, Jessica. "Photo of GalleryOne display in the Cleveland Museum of Art." Digital Image. Decoding Artifacts. July, 2015.
www.dukevisualstudies.org/decoding



Figure 2: Pissini, Jessica. "Photo of ArtLens Application in the Cleveland Museum of Art." Digital Image. Decoding Artifacts. Accessed July, 2015. www.dukevisualstudies.org/decoding.

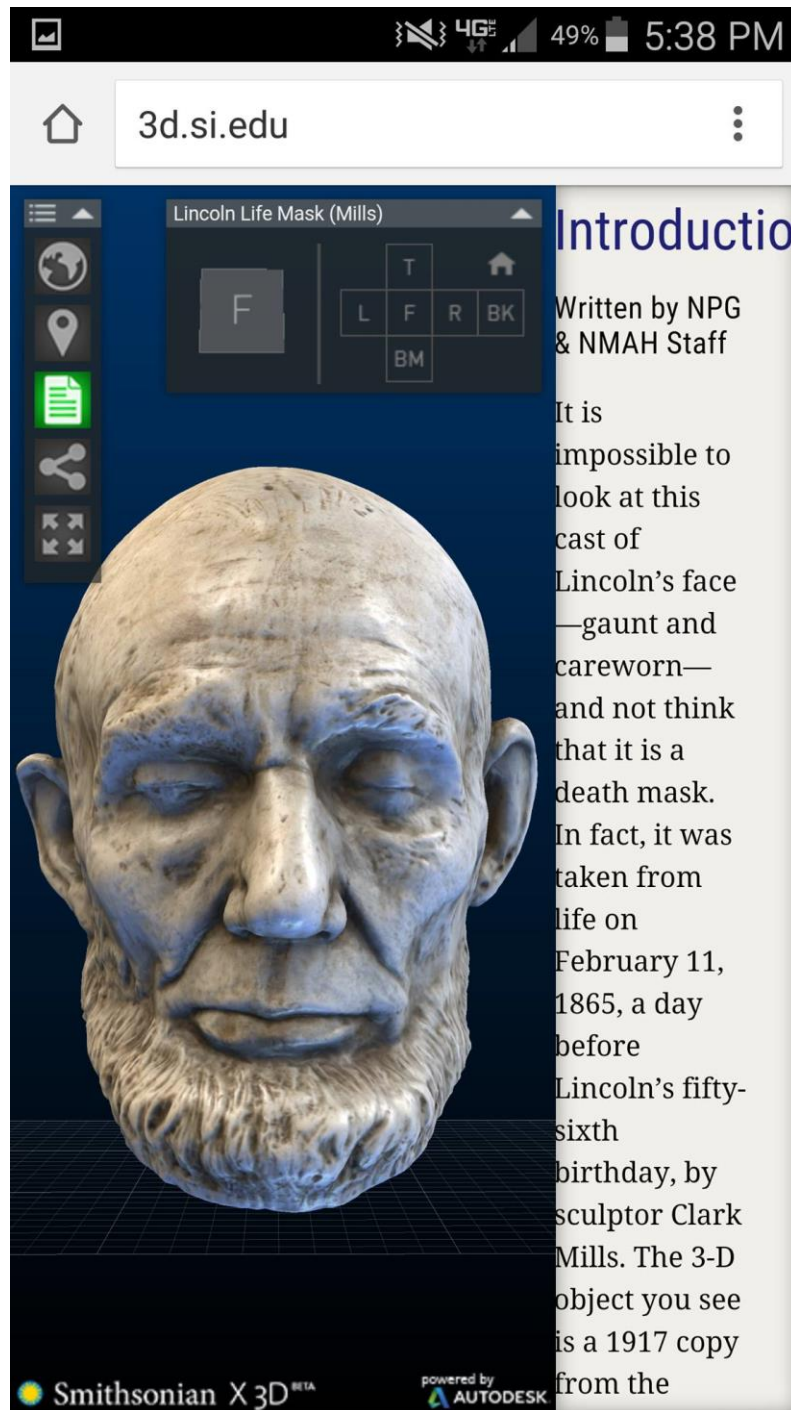


Figure 3: Pissini, Jessica. "Screenshot of Life Mask of Abraham Lincoln, from the Smithsonian X 3D web-app." Digital Image. Decoding Artifacts. August, 2015. www.dukevisualstudies.org/decoding.

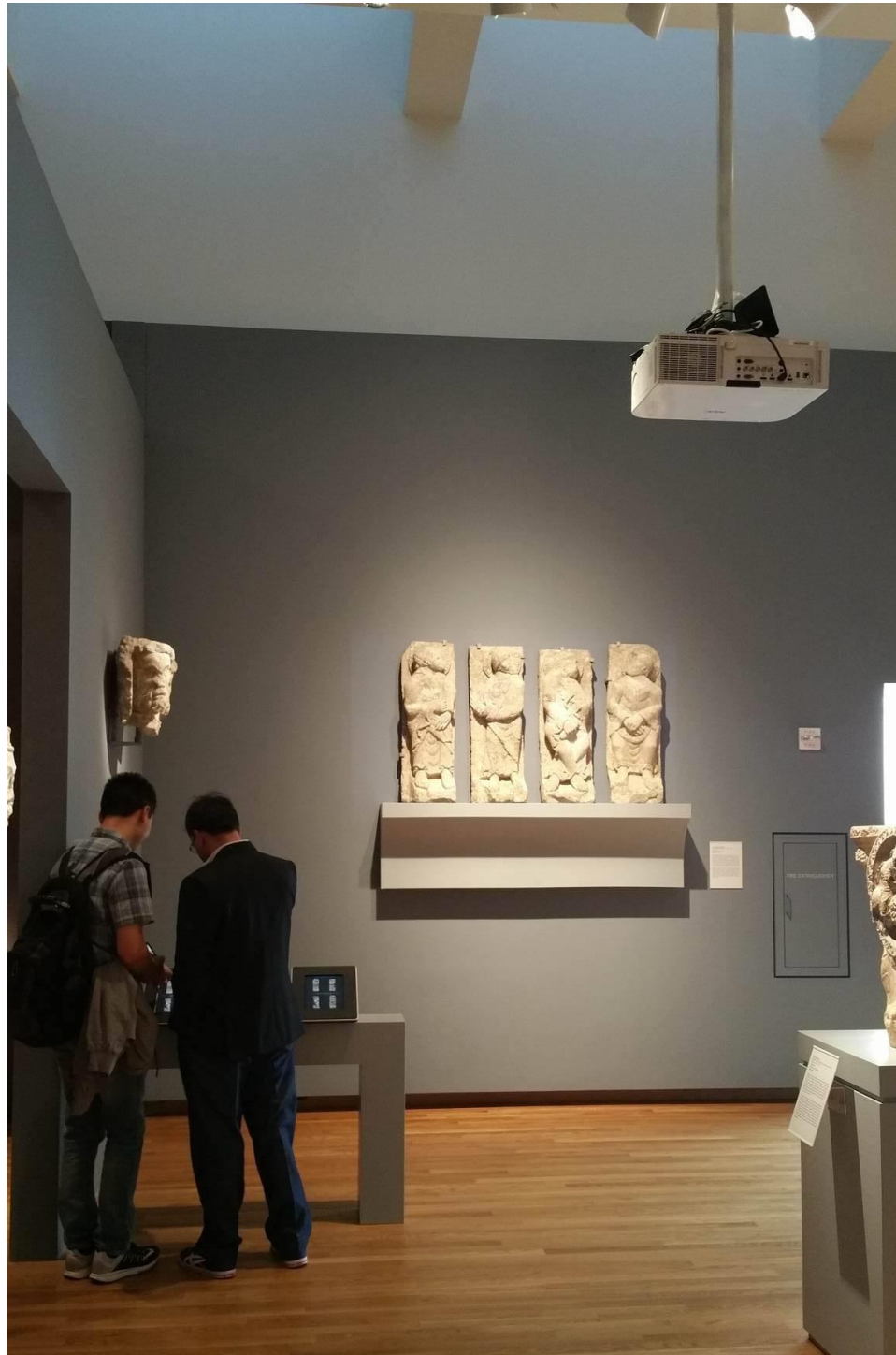


Figure 4: Pissini, Jessica. "Photo of Lives of Things exhibit, with visitors interacting in the Nasher Museum of Art." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.

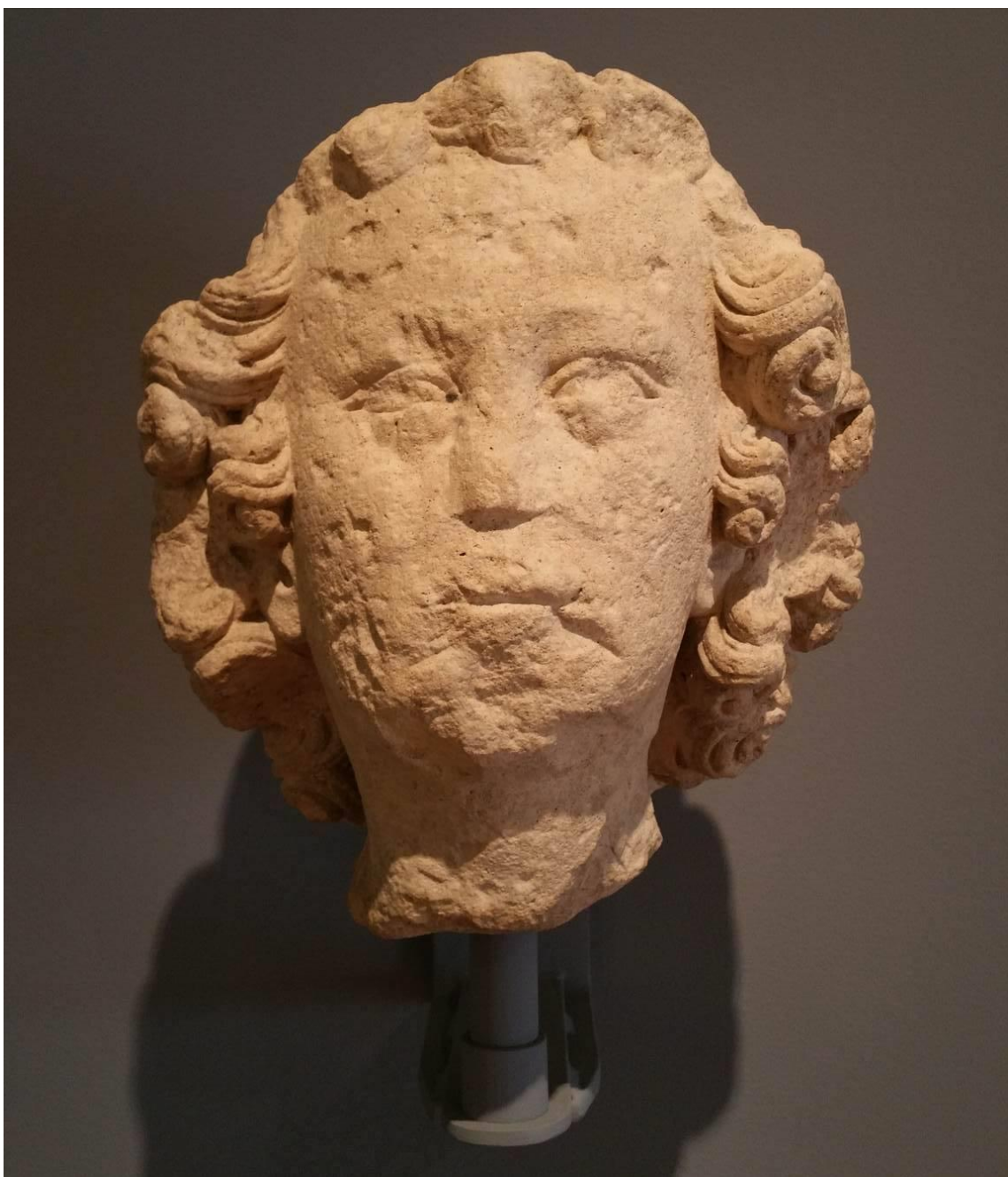


Figure 5: Pissini, Jessica. "Head of a Virtue in the Nasher Museum of Art."
Digital Image. Decoding Artifacts. October, 2015.
www.dukevisualstudies.org/decoding.

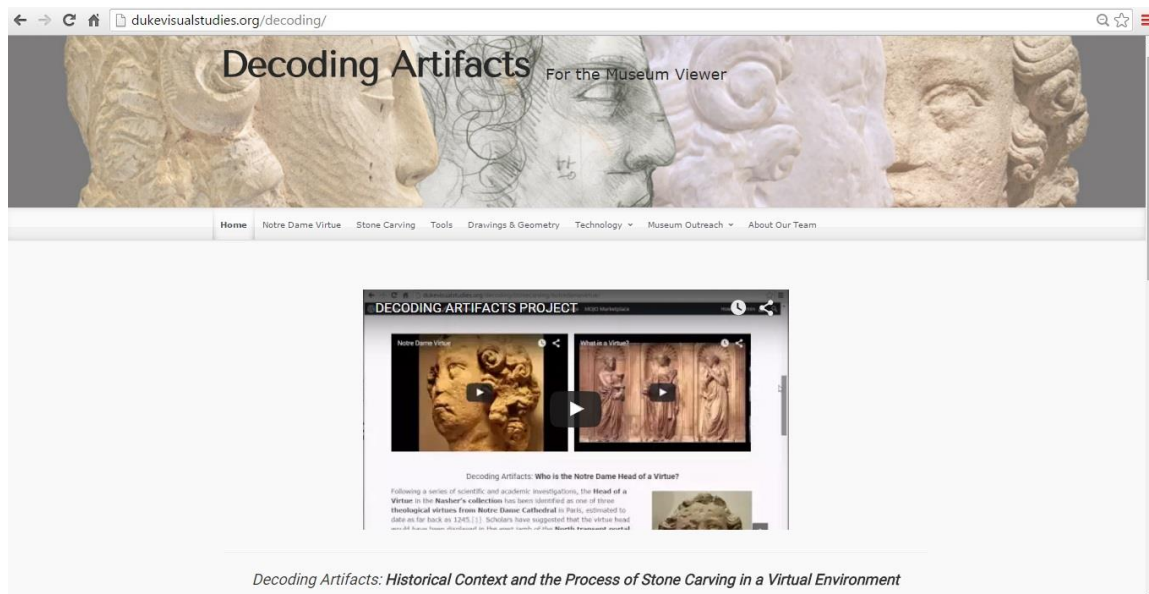


Figure 6: Pissini, Jessica. "Screenshot of Decoding Artifacts website homepage." Digital Image. Decoding Artifacts. October, 2015.
www.dukevisualstudies.org/decoding.



**Figure 7: Pissini, Jessica. "Simon Verity sculpting the Duke Virtue Copy."
Digital Image. Decoding Artifacts. January, 2015.
www.dukevisualstudies.org/decoding.**

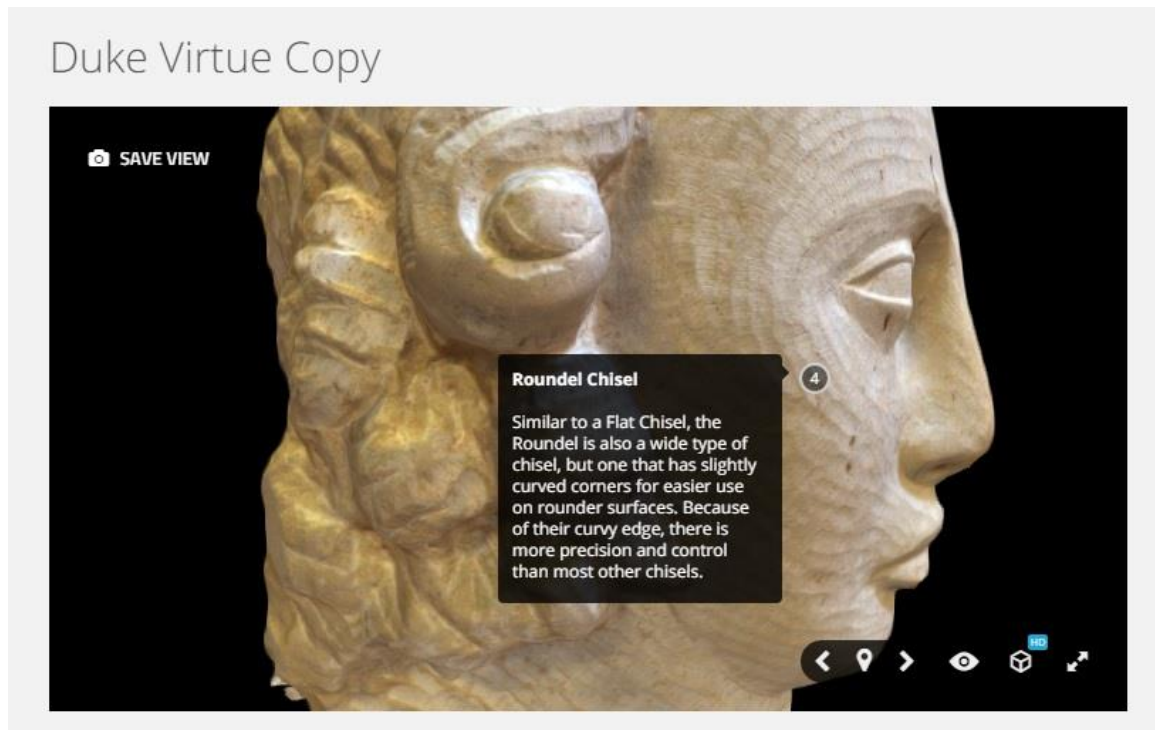


Figure 8: Pissini, Jessica. "Screenshot of SketchFab model, Duke Virtue copy, with annotation." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.

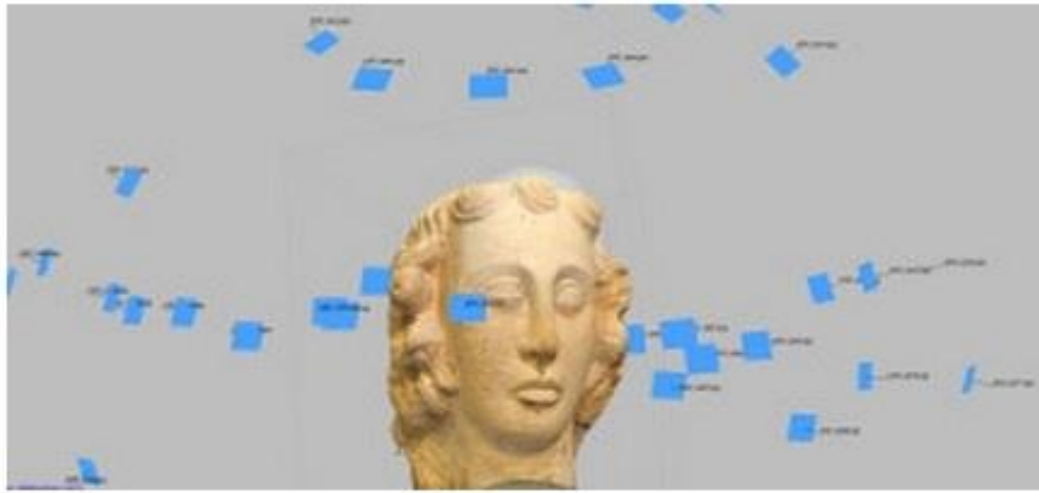


Figure 9: Pissini, Jessica. "Screenshots of PhotoScanPro photogrammetry process." Digital Image. Decoding Artifacts. July, 2015.
www.dukevisualstudies.org/decoding.

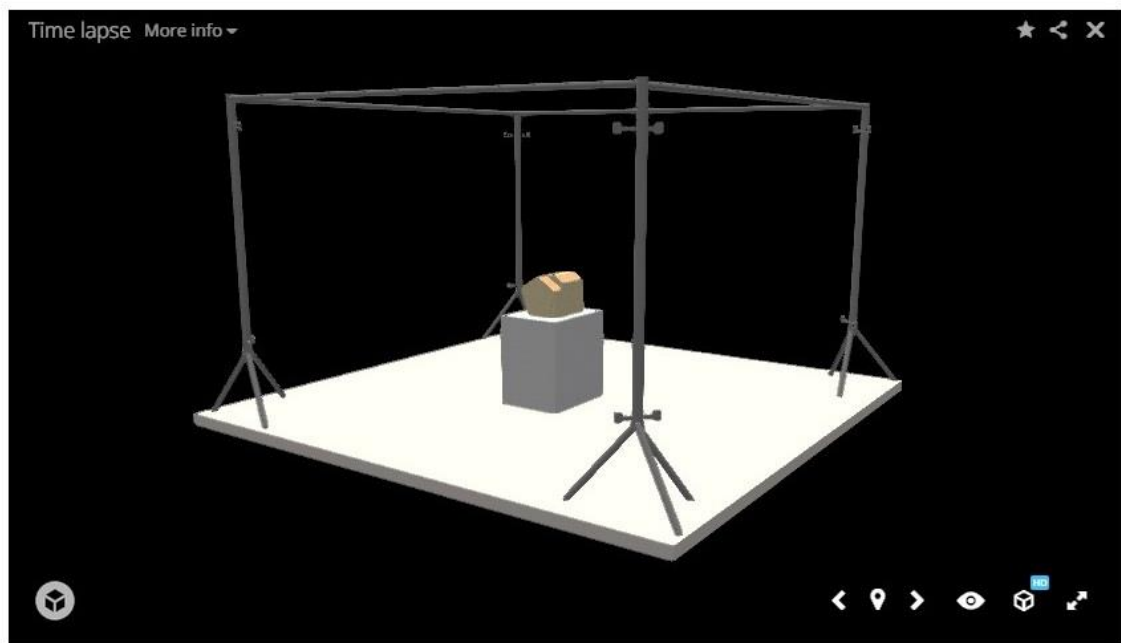


Figure 10: Pissini, Jessica. "Screenshot of SketchFab model, Time-lapse Reconstruction camera set-up." Digital Image. Decoding Artifacts. July, 2015. www.dukevisualstudies.org/decoding.

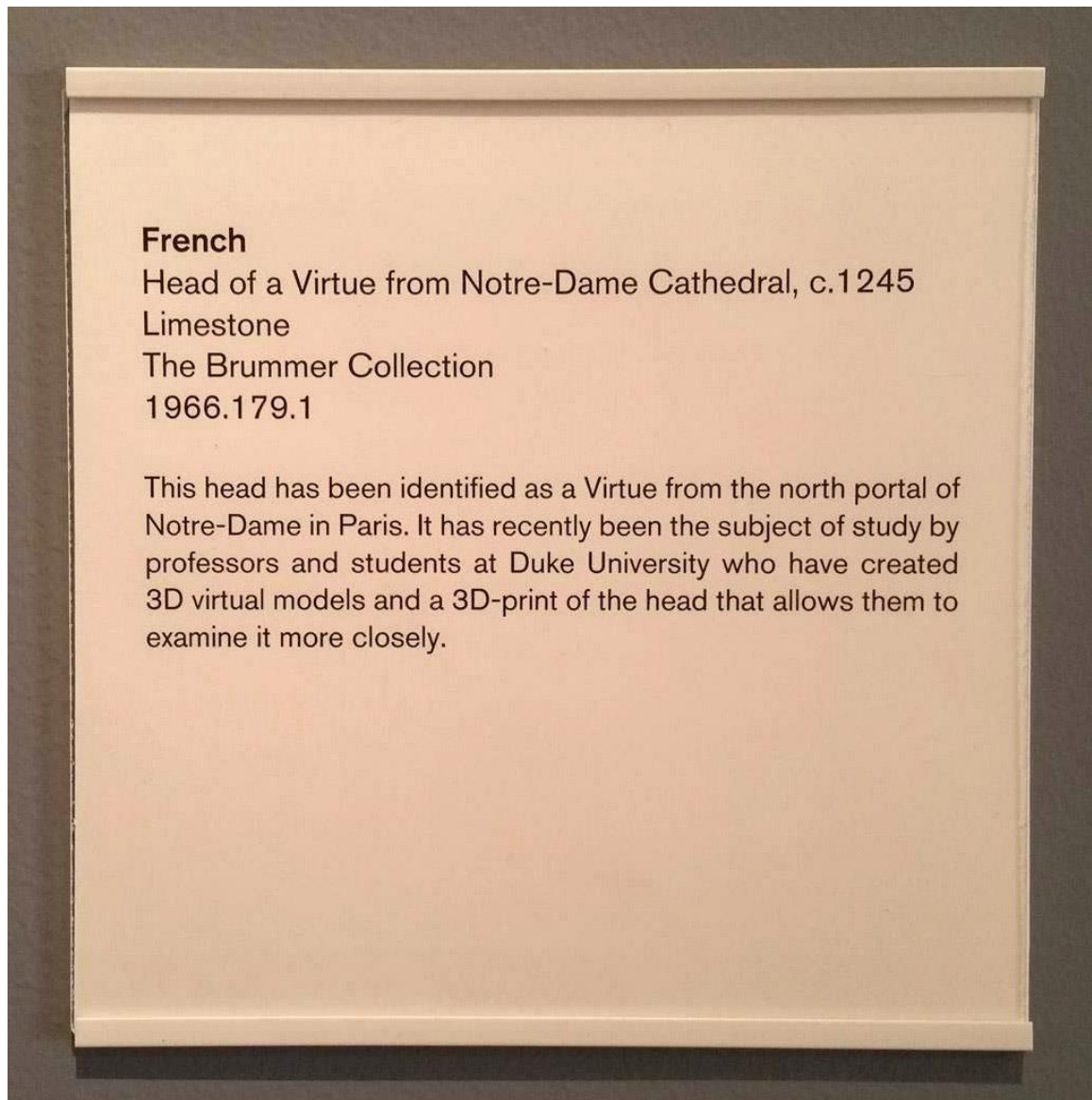


Figure 11: Pissini, Jessica. "Label of the Head of a Virtue, in the Nasher Museum of Art." Digital Image. Decoding Artifacts. October, 2015. www.dukevisualstudies.org/decoding.

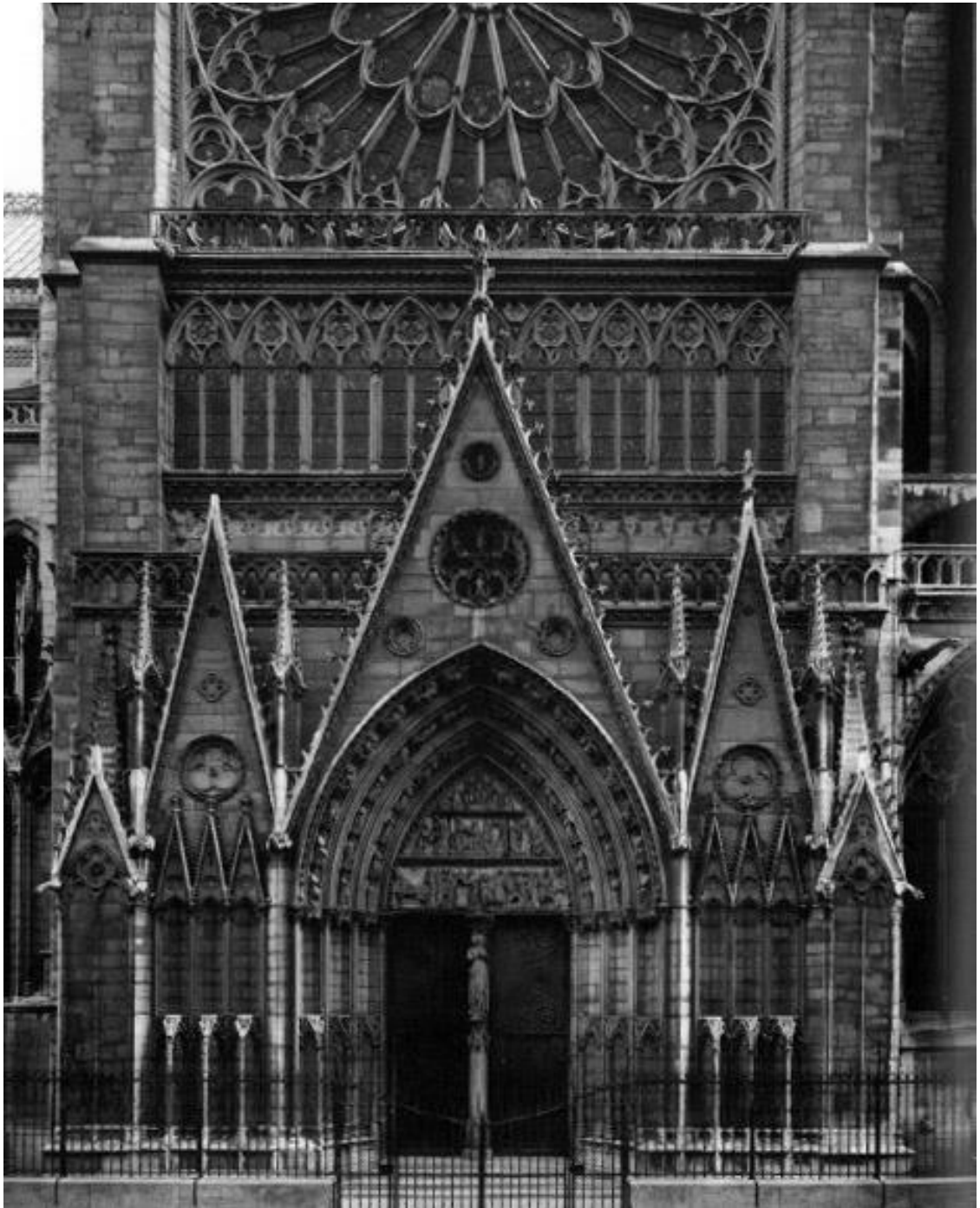


Figure 12: "North transept Portal of the Notre Dame in Paris." Cited in Kimpel, Dieter. "A Parisian Virtue." in *The Brummer Collection of Medieval Art*. Edited by Caroline Bruzelius with Jill Meredith. Duke University Press, 1991. Page 128.

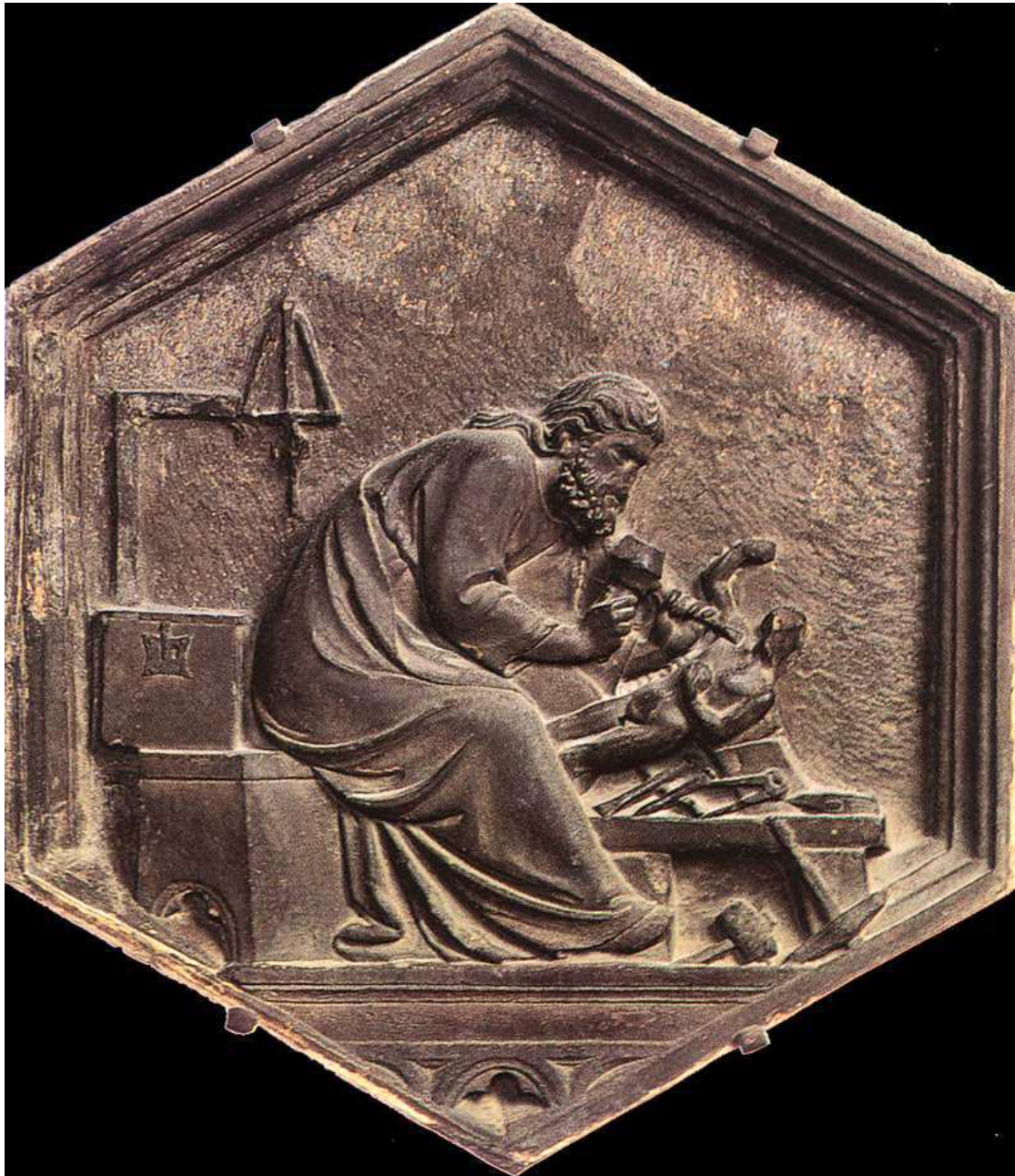


Figure 13: "Allegory of Sculpture by Andrea Pisano." Lib-art.com. Accessed July, 2015. <http://www.lib-art.com/artgallery/15219-sculpture-andrea-pisano.html>. Cited in Wittkower, Rudolf. *Sculpture: Processes and Principles*. New York: Harper & Row, 1977. Page 28.



Figure 14: "Greek Bronze Chisel." Nasher Museum of Art at Duke University. Accessed July, 2015. <http://emuseum.nasher.duke.edu/view/objects/>.



2. Drawings with geometric schemata, thirteenth century. Villard de Honnecourt

Figure 15: "Drawings with geometric schemata, thirteenth century, by Villard de Honnecourt." Cited in Wittkower, Rudolf. *Sculpture: Processes and Principles*. New York: Harper & Row, 1977. Page 37.

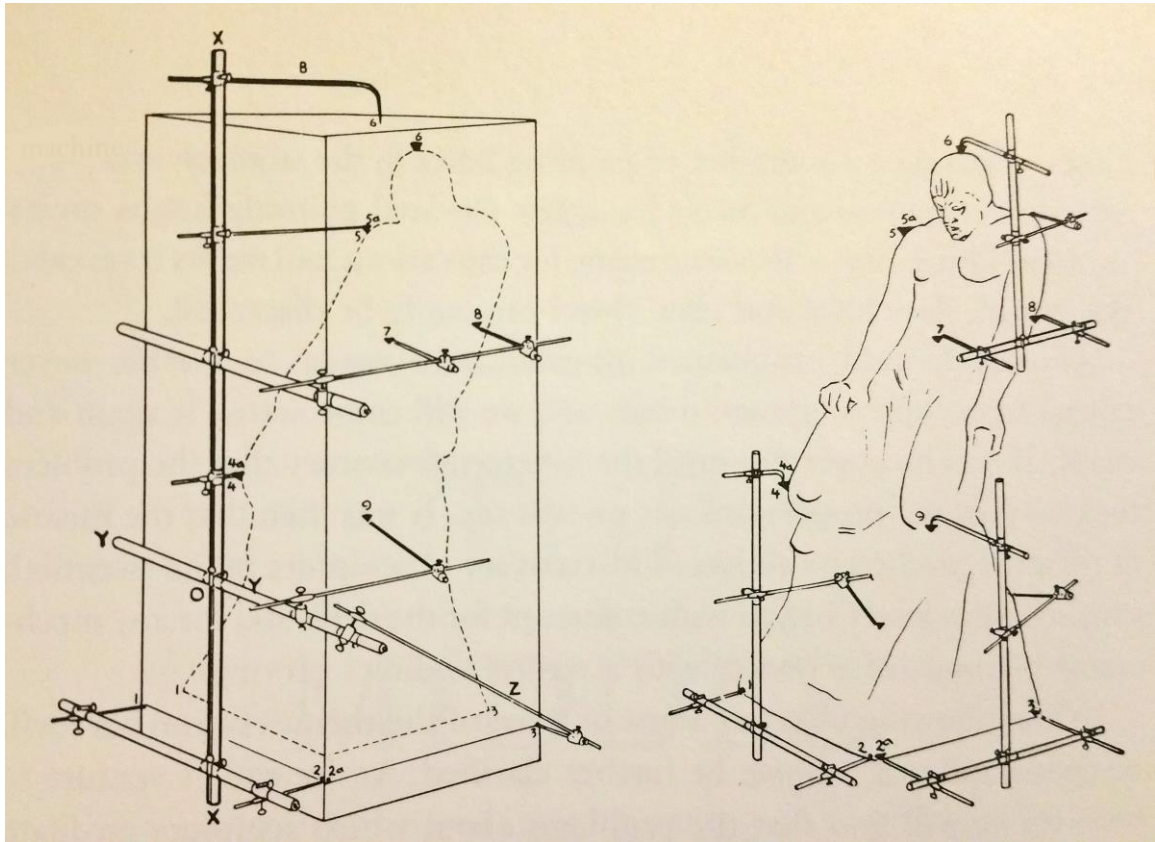


Figure 16: "Pointing Machine." Cited in Wittkower, Rudolf. *Sculpture: Processes and Principles*. New York: Harper & Row, 1977. Page 31.

References

- Alexander, Jane. "Gallery One, the First Year: Sustainability, Evaluation Process, and a New Smart Phone App." MW2014: Museums and the Web 2014. Published March 7, 2014. Consulted July 1, 2015.
<http://mw2014.museumsandtheweb.com/paper/gallery-one-the-first-year-sustainability-evaluation-process-and-a-new-smart-phone-app/>
- Alexander, J., J. Barton and C. Goeser, Transforming the Art Museum Experience: Gallery One. In Museums and the Web 2013, N. Proctor & R. Cherry (eds). Silver Spring, MD: Museums and the Web. Published February 5, 2013. Consulted July 1, 2015. <http://mw2013.museumsandtheweb.com/paper/transforming-the-art-museum-experience-gallery-one-2/>
- Ames-Lewis, Francis. Tuscan Marble-Carving: 1250-1350: Sculpture and Civic Pride. Aldershot, England: Ashgate Publishing, 1997.
- "The Art of Making in Antiquity: Stone Working in the Roman World." Accessed Jan 10, 2015. <http://www.artofmaking.ac.uk/>
- Bartscherer, Jordan and Roderick Coover, Eds. Switching Codes: Thinking Through Digital Technology in the Humanities and the Arts. Chicago: University of Chicago Press, 2011
- Boon, T. "The Opportunities of Hybridity: Making the Modern World, a New Historical Gallery in a Diverse Institution." Paper Presented at Science Communication, Education, and the History of Science. British Society for the History of Science, London. July 12-13, 2000. Bruno, Fabio, et al. "From 3D reconstruction to virtual reality: A complete methodology for Digital Archaeological Exhibition." Journal of Cultural Heritage 11, no. 1 (2010): 42-49. Accessed January 20, 2015.
- Bruzelius, Caroline, and Jill Meredith. The Brummer Collection of Medieval Art. Durham: Duke University Press, 1991.
- Callieri, Marco, et al. "Visualization and 3D data processing in the David restoration." Computer Graphics and Applications, IEEE 24:2 (2004): 16-21. Accessed January 20, 2015.
http://vcg.isti.cnr.it/Publications/2004/CCGIMPPS04/david_rest_cg&a.pdf

- Center for Advanced Spatial Technologies. University of Arkansas.
 "Visualization/Animation." Accessed January 20, 2015.
<http://cast.uark.edu/home/research/visualizationanimation.html>
- Cleveland Art Museum, Gallery One. Accessed May 1, 2015.
<http://www.clevelandart.org/gallery-one>
- Clough, Wayne G. *Best of Both Worlds : Museums, Libraries, and Archives in a Digital Age*. Washington, D.C. : Smithsonian Institution, 2013. Accessed May 1, 2015.
<http://permanent.access.gpo.gov/gpo41908/BestofBothWorldsSmithsonian.pdf>
- Cultural Research Imaging. "Reflectance Transformation Imaging (RTI)." Copyright 2002-2013. Accessed January 20, 2015.
<http://culturalheritageimaging.org/Technologies/RTI/>
- Favro, Diane (2006). "In the Eyes of the Beholder: Virtual Reality Re-creations and Academia." In *Imaging Ancient Rome: Documentation, Visualization, Imagination; Proceedings of the Third Williams Symposium on Classical*. Edited by Lothar Haselberger and John Humphrey. Accessed May 1, 2015.
<http://sitemaker.umich.edu/cah/files/favorreading.pdf>
- Frischer, B., F. Niccolucci, N. Ryan, and J. Barceló, *From CVR To CVRO: The Past, Present, and Future of Cultural Virtual Reality*. CAA 1997.
- Hargrave, Josef, and Radha Mistry. *Museums in the Digital Age*. London: ARUP, 2013. Accessed March 12, 2015.
http://www.arteducators.org/research/2013_Arup_FRI_MuseumsintheDigitalAge_final_web.pdf
- Hawkey, Roy. "Learning with Digital Technologies in Museums, Science Centres and Galleries" *Future Lab*, 2004. Accessed March 12, 2015.
<https://www.nfer.ac.uk/publications/FUTL70/FUTL70.pdf>
- Hein, Hilde. *The Exploratorium: The Museum as Laboratory*. Washington, D.C.: Smithsonian Institution Press, 1990.
- Kimpel, Dieter. "A Parisian Virtue," in *The Brummer Collection of Medieval Art*, Caroline Bruzelius with Jill Meredith, 124-140. Durham, NC: Duke University Press, 1991.
- Knell, Simon. "The Shape of Things to Come: Museums in the Technological Landscape." *Museum and Society*, Nov 2003, 1(3), 132-146. Accessed July 10,

2015.
<https://www2.le.ac.uk/departments/museumstudies/museumsociety/documents/volumes/msknell.pdf>
- Levoy, Marc, et al. "The Digital Michelangelo Project: 3D Scanning of Large Statues." In *Proceedings of the 27th annual Conference on Computer Graphics and Interactive Techniques*, 131-144. ACM Press/Addison-Wesley Publishing, 2000. Accessed Jan 20, 2015. <http://graphics.stanford.edu/papers/dmich-sig00/>
- Limestone Sculpture Provenance Project, "Applying Science to Art History". Accessed July 15, 2015. <http://www.limestonesculptureanalysis.com/>
- Little, Charles T. Ed. *Set in Stone: The Face in Medieval Sculpture*. New Haven: Yale University Press, 2006.
- Meredith, Jill. "Romancing the Stone: Resolving Some Provenance Mysteries of the Brummer Collection at Duke University." *Gesta*, 33:1. University of Chicago Press, International Center of Medieval Art, 1994.
- Museum Association. "Technology and Digital." Accessed March 20, 2015.
<http://www.museumsassociation.org/museum-practice/technology-and-digital>
- Nicholls, Ann, ed., et al. "New Trends in Museums in the 21st Century." *LEM: The Learning Museum Project* (2013). Accessed March 12, 2015.
<http://www.lemproject.eu/WORKING-GROUPS/museums-in-the-21st-century-1/7th-report-new-trends-in-museums-of-the-21st-century>
- Olsen, Sandra, Ashley Brickman, and Yang Cai. "Discovery by Reconstruction: Exploring Digital Archeology." In *SIGCHI Workshop (Ambient Intelligence for Scientific Discovery (AISD))*. 2004. Accessed January 20, 2015.
<https://www.andrew.cmu.edu/course/60-427/aisd/Museum.pdf>
- Olsen, Vibeke. Ed. *Working with Limestone: The Science, Technology and Art of Medieval Limestone Monuments*. Burlington, VT: Ashgate, 2011.
- Palagia, Olga, and John Steven. "Who Invented the Claw Chisel?" *Oxford Journal of Archaeology* 13:2 (1994). 184-197. Accessed February 10, 2015.
<http://uoa.academia.edu/OlgaPalagia/Papers>
- Palagia, Olga. "Marble Carving Techniques." In *Greek Sculpture: Function, Materials, and Techniques in the Archaic and Classical Periods*. Edited by Olga Palagia.

- Cambridge: Cambridge University Press, 2006. Accessed February 10, 2015.
https://www.academia.edu/2292766/Marble_carving_techniques
- Payne, Emma Marie. "Imaging Techniques in Conservation." *Journal of Conservation and Museum Studies* 10:2 (2013): 17-29. Accessed January 20, 2015.
<http://www.jcms-journal.com/article/view/jcms.102120>
- Penny, Nicholas. *The Materials of Sculpture*. New Haven: Yale University Press, 1993.
- Perkinson, Stephen. "Sculpting Identity," in *Set in Stone: The Face in Medieval Sculpture*, edited by Charles T. Little, 120-123. New Haven: Yale, 2006.
- Perry, R. "The Secret Life of 3D Models" Shot SIGCSI 2012. Accessed January 20, 2015.
<http://www.sigcis.org/files/Dissertation%20Section%C3%B1%20The%20History%20of%203D%20Modeling.pdf>
- Pospíšil, Jan. "Digital Reconstruction of Archaeological Finds." 2012. Accessed Jan 20, 2015. http://is.muni.cz/th/172435/fi_m/diplomovaPraceJanPospisil.pdf
- Risnik, Mitchel. "Rethinking Learning in the Digital Age." In *The Global Information Technology Report: Readiness for the Networked World*. Edited by Geoffrey Kirkman et al. New York: Oxford University Press, 2002.
- Ronchi, Alfredo M. *eCulture: Cultural Content in the Digital Age*. London: Springer, 2009.
- Schaller, David T. et al. "How Do You Like to Learn? Comparing User Preferences and Visit Length of Educational Websites." In *Museums and the Web 2002: Selected Papers from an International Conference*, Pittsburgh, PA: Archives and Museums Informatics. Feb 2002. Accessed July 10, 2015.
<http://www.eduweb.com/HowDoYouLikeToLearn.pdf>
- Scher, Stephen K. "Iconoclasm: A Legacy of Violence," in *Set in Stone: The Face in Medieval Sculpture*, edited by Charles T. Little, 18-45. New Haven: Yale, 2006.
- Schneider Michael S.. *A Beginner's Guide to Constructing the Universe: Mathematical Archetypes of Nature, Art, and Science*. New York: Harper, 1995.
- Smith Bautista, Susana. *Museums in the Digital Age: Changing Meanings of Place, Community, and Culture*. Lanham, Maryland: Altamira Press, a division of Rowman & Littlefield, 2014.
- Smithsonian X 3D. Accessed March 15, 2015. <http://3d.si.edu/>

- Stokstad, Marilyn. *Medieval Art*. Boulder, CO: Westview Press, 2004.
- Tallon, Loïc, and Kevin Walker. Eds. *Digital Technologies and the Museum Experience: Handheld Guides and Other Media*. Lanham: Alta Mira Press, 2008.
- Tillander, Michelle. *Creativity, Technology, Art, and Pedagogical Practices*. *Art Education* 64.1 (Jan 2011): 40-46. Accessed May 1, 2015.
<http://proxy.lib.duke.edu/login?url=http://search.proquest.com.proxy.lib.duke.edu/docview/847386915?accountid=10598>
- Trusted, Marjorie. Ed. *The Making of Sculpture: The Materials and Techniques of European Sculpture*. London: V & A Publications, 2007.
- Tucci, G. et al. "Effective 3D Digitization of Archaeological Artifacts for Interactive Virtual Museum." *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2011. Accessed January 20, 2015.
<http://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XXXVIII-5-W16/413/2011/isprsarchives-XXXVIII-5-W16-413-2011.pdf>
- Vasari, Giorgio. *Vasari on Technique*. Translated by Louisa S. Maclo hose; ed. with introduction and notes by Professor G. Baldwin Brown. New York: E.P. Dutton and Company, 1907.
- Wittkower, Rudolf. *Sculpture: Processes and Principles*. New York: Harper & Row, 1977.