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Rock, Paper, Chisel, 3D Printer: Teaching Medieval Art with Technology

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Teaching medieval art requires an invocation of students’ imaginations. The majority of the art we study has been decontextualized, removed from the portal, altar, or window for which it was made. Students see it projected on a screen or mounted on the wall of a museum. In these settings, the art is separated from companion pieces in a cycle, often viewed at an unintended angle, and sometimes bears the scars of destruction, cleanings, travel, and time. Simple questions can be hard to answer in a classroom – how did a work of art originally appear? What texture is it? What color was it? What did it look like in the morning? In the afternoon? Digital technology allows us to illustrate and explain the answers to these questions, and when students are the ones illustrating and explaining, they become engaged producers of knowledge. In this short paper, I present a case study, a course that sought to blend art history and digital technology to offer students a deeper, more comprehensive view of medieval art.

Designing a Digital Course

My proposal for a new course, “Rock, Paper, Chisel: The Materiality of Medieval Art,” was awarded a Duke University teaching fellowship for the spring 2015 semester.¹ I had

¹ The course was possible thanks to a Bass Teaching Fellowship for Duke University graduate students. Thanks are also owed to Caroline Bruzelius, Marianne Wardle, Erin Hanas, Mark Olson, Mariano Tepper, Chris Tralie, Lee Nisbet, and Hannah Jacobs, and especially to the students who took the class: Jessica Pissini, Henrietta Myers, Brad Lenz, Hanna Wiegers, Crystal Terry, Chelsea Bright, Victor Del Porto, and Lauren Reuter.
three primary aims for the course: 1: to utilize the medieval collection at Duke’s Nasher Museum of Art to give students training in firsthand analysis of works of art, 2: to use those objects to teach elements of “technical art history,” increasing students’ familiarity with the tools and materials of medieval art-making, and 3: to further their understanding of medieval materials through digital technologies, which they would use to restore works of art to their original appearances and contexts.2 We would try to create biographies for the works we studied, considering the circumstances of their creation, what they looked like when first made, and where they might have been displayed before they made their way to the Nasher.3 Students would gain skills and knowledge not only in art history, but also in software programs and applications.

The success of “Rock, Paper, Chisel” depended on two key resources: Duke’s Wired! program and the Nasher Museum. Wired! was founded in 2009 with the aim of exploring how digital visualization technology could be used in art-historical research and teaching. Wired! projects have focused on urban spaces, architecture, and art objects, and are collaborations between Duke faculty and students, graduate and undergraduate.4 The Wired! Lab, located within the Department of Art, Art History & Visual Studies, offers workshops and tutorials, and access to computers equipped with licenses for numerous visualization software programs for students to use. The Nasher has a remarkable collection of medieval sculpture. In 1966, Duke University purchased around 200 works

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3 “Rock, Paper, Chisel” in some ways expanded upon the 2012 course “The Museum Inside Out,” taught by Professors Caroline Bruzelius and Mark Olson, in which undergraduate and graduate students engaged with works of Romanesque and Gothic sculpture from the Nasher collection and experimented with visualization technologies to re-contextualize them, but focused more extensively on the material and processes of artmaking.

from the estate of Ernest Brummer. Brummer and his brother Joseph had been prominent art dealers who opened galleries first in Paris and later in New York. The initial purchase formed the basis of the Duke University Museum of Art, which became the Nasher in 2005. Subsequent purchases and gifts from Mrs. Ella Brummer, Ernest’s widow, expanded the collection.

**Teaching with Technology**

Eight students enrolled in “Rock, Paper, Chisel,” which met twice a week in the Nasher classroom. The students and I spent substantial time in the galleries and storage space, honing observational skills and discussing the physical properties and materials of the art produced in the Middle Ages. We studied primary and secondary texts related to various medieval media, including stone, stained glass, paintings, manuscripts, and textiles, as well as canonical and lesser-known works of medieval art. In addition to the Nasher galleries, we visited the North Carolina Museum of Art to view its collection of early Italian paintings, and Duke’s David M. Rubenstein Rare Book and Manuscript Library. Wanting all students to gain exposure to the digital visualization technologies that could help them approach and present medieval art in new ways, I arranged tutorials in the Wired Lab, taught by multimedia analyst Hannah Jacobs, to give them basic capabilities in tools such as Photoshop, SketchUp, and Google Maps. My goal was to emphasize active, experiential learning that would make the medieval world more real to students than textbooks or slides could.

In consultation with Nasher staff, I selected works from the Brummer collection that might make especially fruitful student projects. As we had only a few weeks, and the students had limited language abilities and background in medieval art, the works needed to be accessible and reasonably well-researched and published. I didn’t expect the students to engage with heady issues of provenance research, or to be able to conduct primary source research – I needed them to have enough available information about the
objects’ histories and contexts so that they could focus on the issues of materiality and digital recreations. The three works were: a segment of stained glass depicting God instructing Adam and Eve in the Garden of Eden from Troyes Cathedral (fig. 1), the limestone Head of a Virtue, from the Cathedral of Notre Dame, Paris (fig. 2), and a Head of a King from the Abbey of Saint-Germain-des-Prés, also in Paris (fig. 3). The eight students were divided into two teams, one to work on the stained glass, the other on the sculptures. Students came to the course with different sets of skills. Some were more interested in art history, others in technical issues. Working in teams, we could divide and conquer the components of the projects, allowing students to play to their strengths.

Digital Stained Glass
I was extremely excited to see the group of students work with the stained glass. Earlier projects in the Wired! Lab had focused on sculpture and architecture, but we had yet to work with glass. I was especially interested to see how we could use technology to revitalize it. The piece from Troyes was in particularly bad condition. It had never been mounted and displayed at the Nasher, and could not be removed from its storage box, even to be viewed on a light box (fig. 4). The cloudy glass and decaying, loose caming precluded an understanding of the true colors of the piece, and the painted details of the figure’s facial features were nearly invisible; even if we had been able to hold the glass against a light, it would have been almost completely opaque. Complicating matters, the only lit photograph of the panel that we could access was at least 50 years old, and black and white.

In class we had studied the process of medieval glass-making, in particular reading the 12th-century On divers ars by the monk Theophilus to understand the process and to

5 The image included in this article was made against a light box by conservator Mary Clerkin Higgins in 2016, just prior to its restoration.
Figure 1 French, God and the Tree of Knowledge, c. 1250. Stained glass and lead, 26 x 17 7/8 x 1/4 inches (66 x 45.4 x 0.6 cm). Collection of the Nasher Museum of Art at Duke University. Gift of Mrs. Ella Brummer in memory of her husband, Ernest Brummer, 1978.20.9. Photo: after conservation by Peter Paul Geoffrion.
Figure 2 French, Head of a virtue from Notre-Dame Cathedral, c. 1245. Limestone, 13 x 12 1/4 x 9 1/2 inches (33 x 31.1 x 24.1 cm). Nasher Museum of Art at Duke University. The Brummer Collection, 1966.179.1. Photo: Peter Paul Geoffrion.
Figure 3 French, Head of a King, c. 1175 – 1200. Limestone, 9 7/8 x 8 x 7 1/2 inches (25.1 x 20.3 x 19.1 cm). Nasher Museum of Art at Duke University. The Brummer Collection, 1966.125.1. Photo: Peter Paul Geoffrion.
learn about the pigments used to produce colored glass. This information, coupled with a visit to the Duke Chapel (where the glass is admittedly not medieval) and comparisons to images of other glassworks, both in museums and in situ, gave the students a frame of reference for the vivacity of the colors that the piece should have, and the way that artists painted intricate details on the glass. Using Photoshop, students edited a photograph of the work, cleaning the lines of the caming, and hypothesizing what the colors of the glass

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would look like with light streaming through, as if it were placed in a widow (fig. 5). This was a challenge for the students – they learned the difficulties of balancing color and texture with opacity to create a final product that was realistic, a struggle that can be seen in the varying shades of blue in the pieces of glass next to the figure of God.

Other students in the group focused their work on the original context of the piece, convincingly argued to be an apsidal chapel within the Cathedral of Troyes on stylistic, documentary, and iconographic grounds. The students used the architectural program SketchUp to create a 3D digital model of the cathedral as it may have appeared in the 13th century, and then inserted the image of the Nasher stained glass into the chapel in which it was described in the 19th century (figs. 6, 7). Thanks to the students’ work, this piece of stained glass, which had spent decades in a drawer, was visualized as it may have originally appeared.

The Virtual Virtue

The second group of students worked on two pieces of sculpture: the Head of a Virtue, from the north transept portal of the Cathedral of Notre Dame, Paris, and the Head of a King, from Saint-Germain-des-Prés (figs. 2, 3). Both of these sculptures were removed from their original contexts (and bodies) during the French Revolution, and had suffered substantial damage including missing noses and ornamentation, such as crowns, and

7 For this panel, see Bruzelius, The Brummer Collection, 179, and Elizabeth Carson Pastan, The Early Stained Glass of Troyes Cathedral, c. 1200-1240 (Ph.D. diss., Brown University, 1986). An 1837 description of the church made by artist Anne-Francois Arnaud recorded a glazed image of God admonishing Adam inside a chapel dedicated to St. Margaret. This scene does not appear, however, in an 1864 study of the church. See A. F. Arnaud, Voyage Archéologique et Pitttoresque dans le Département de l’Aube et dans l’Ancien Diocèse de Troyes (Troyes: Imprimerie de L.C. Cardon, 1837).

8 The focus of this class was not to develop a precise architectural history of Troyes. Students based their model on an existing floor plan and built their model to reflect the cathedral’s state of incompletion in the 13th century.
Figure 6 SketchUp model of Troyes Cathedral in the 13th century with God and the Tree of Knowledge inserted into a window in the chapel of St. Margaret. Model: Brad Lenz, Henrietta Myers, Crystal Terry, and Hanna Wiegers.

Figure 7 Detail of SketchUp model. Model: Brad Lenz, Henrietta Myers, Crystal Terry, and Hanna Wiegers.
their original polychromy had worn off, or been scrubbed away.⁹ The students set out to digitally restore them—a task that would require knowledge of stone carving techniques.

Early in the semester, the class had spent substantial time discussing the tools and techniques of medieval stone carving. We talked about the varying properties of different types of stone found in different regions and conducive to different settings, and discussed the use of neutron activation analysis to match sculptures to the quarries or regions from which their stone originated. We also learned about sculpting tools, from point chisels to claw chisels to rasps, and were fortunate to do this in a decidedly non-digital way.

Sculptor Simon Verity is known for his work on sites including Exeter Cathedral and the Cathedral of St. John the Divine in New York. He uses manual tools, rather than the electric ones favored by modern stonecutters, and works in a manner probably not dissimilar to medieval craftsmen. Simon had previously visited Duke and the Nasher in 2013, but returned in 2015 to work with the Wired! Lab and our class. “Rock, Paper, Chisel” students attended demonstrations with Simon, in which they learned to use stone-carving tools. While initially hesitant to follow his instructions to split blocks of stone and to chisel into them, the students quickly gained an appreciation for the intense physicality required of sculptors, as well as the required visual gifts to conceptualize a figure from within a block of stone (figs. 8, 9).

The Wired! group and my students had a specific project in mind for Simon. He was commissioned to create a copy of the Notre Dame Virtue out of a soft French limestone. Members of the Wired! team had made photogrammetry and laser models of the Virtue and the Head of a King several years ago, but we could not frequently uninstall the pieces

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Figure 8 Students learning sculpting techniques from Simon Verity. Photo: Alexandra Dodson.

Figure 9 Students learning sculpting techniques from Simon Verity. Photo: Alexandra Dodson.

Figure 10 Sculptor Simon Verity’s work process, sketching on limestone. Photo: Jessica Pissini.

Figure 11 Simon Verity at work on the Virtue, with 3D printed model in background. Photo: Jessica Pissini.
from the Nasher gallery to examine them or to make new scans as technology improved. If we had a stone copy that was neither 700 years old nor mounted on a wall, we could allow students to handle, measure, and scan it—it would be a valuable teaching tool.

Because the dust and mess of stone carving was not appropriate for a museum gallery, Simon could not carve the sculpture in the Nasher, using the head as a direct model for his copy. Instead, he worked both from sketches and from a 3D print made from the earlier digital model. He worked for about a week, as students documented his progress (figs. 10, 11).

When his copy was completed, students used photogrammetry to make a digital 3D model (fig. 12). A frequent question when working with digital models has been this: how can we share them? While static images of models can be shared via JPEGs, challenges persist in sharing 3D versions that can be manipulated, as most viewers are unlikely to have adequate software to load and view program-specific files. A solution is SketchFab, an online embedded 3D model server, which presents models in a platform that does not require anything more than a web browser to manipulate them. Student Jessica Pissini annotated the models, both the original and Simon’s copy. The annotations draw viewers’ attentions to valuable components such as visible chisel
marks. These annotations also allow for the positioning of the model in SketchFab to the hypothetical angle at which the sculpture would have been viewed in its original context (above the north transept portal at Notre Dame).\(^\text{10}\)

Jessica also used the modeling program *Sculptris* to digitally restore the *Head of a King*. With the laser scan as a base, she modeled missing pieces such as the figure’s nose and other chunks of stone, restoring it to an approximation of its original appearance.\(^\text{11}\) Using this restored model, and the model of Simon Verity’s copy of the Notre Dame *Virtue*, students now had a canvas for restoring the original polychromy of the sculptures. While white limestone against a white museum wall may appeal to our contemporary sensibilities, they are a far cry from the brightly colored sculptures that peppered the facades and portals of medieval churches.\(^\text{12}\) By analyzing painted wooden and stone sculptures from other sites, students gained an understanding of the pigments most commonly used on medieval works of sculpture, and then used Photoshop to envision what the sculptures might have looked like. Their model of the *Head of a King* envisioned a gilded crown on a mostly unpainted figure, while the *Head of a Virtue* was given rosy

\(^\text{10}\) An additional, larger consideration that all scholars who work with the digital humanities grapple with is how to maintain and preserve these projects both as technology advances and as project creators move between institutions, funding agencies, and servers. The case of this class is an excellent example – I asked each student team to create a WordPress page for their project, which would contain images of their work, in addition to written explanations of their research and their bibliographies. The WordPress pages were hosted through Duke, and it has been a challenge to keep them live and functional as the students (and I) have graduated and lost access to campus accounts. While the “Rock, Paper, Chisel” pages remain online at the time of writing, I have not linked to them in this article as they may be removed at any time. I hope to transfer them to a platform not affiliated with campus accounts in the near future.


\(^\text{12}\) At this time, I and other members of the Wired! Lab were working on a different project, known as *The Lives of Things*. This was a collaboration between faculty and students from the department of Art, Art History & Visual Studies, as well as the department of Electrical and Computer Engineering. The project ultimately resulted in an installation in the Nasher in which visitors use an iPad to select colors to be projected onto medieval sculptures.
skin and blond curls (figs 13, 14). While the student research into pigment accuracy was not extensive, the process of coloring these works still helped them to develop an understanding of how the works might have originally appeared, and how our modern biases have colored our expectations and appreciation of the appearance of premodern sculptures.

![Figure 13 Head of a Virtue, digitally colored. Image: Chelsea Bright, Victor Del Porto, Jessica Pissini, and Lauren Reuter.](image)

![Figure 14 Head of a King, digitally restored using Sculptris and gilded. Image: Chelsea Bright, Victor Del Porto, Jessica Pissini, and Lauren Reuter.](image)

**Digitizing the Middle Ages**

Teaching Rock, Paper, Chisel, was immensely rewarding on many levels, as well as challenging. A consideration when incorporating sophisticated digital technologies into content-heavy courses is how to balance training in digital programs with the teaching of art history. I had to limit the scope of my syllabus to accommodate in-class tutorials and

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13 An additional initial aim for the project was to animate the digital models of the heads, in collaboration with faculty and students from the Department of Electrical and Computer Engineering. My students wrote narrative scripts from the point of view of the sculptures, explaining their creation, location, and journey from France to the Nasher, and hoped to match recordings of the scripts with animations of the heads speaking, in a sense, allowing the sculptures to narrate their own histories.
site visits – we simply couldn’t do a comprehensive survey of medieval art and materials while designating substantial time for learning digital tools. I also had a range of student interests to consider. Some students came with a strong art history background, while others had greater experience with the digital humanities, and others were simply trying to fill a general education requirement before graduation. Though student group projects can be tricky to navigate (for students and instructor!), they allowed for a division of labor that permitted students to play to their strengths, whether rooted in history or technology. All students completed graded tutorials on select digital technologies, however, within the scope of their projects, they could focus on research, digital visualizations, or both.\textsuperscript{14}

Another consideration is finding the resources to teach a course like this. At Duke, I was extraordinarily fortunate to have extensive access to the Nasher Museum, and to the Wired! Lab. Marianne Wardle, Andrew W. Mellon Curator of Academic Programs, and the Nasher staff gave my students and I regular access to the museum’s galleries, storage area, library, and curatorial files, access that gave my students training in detailed observation, object analysis, and scholarly research. We also benefited from funding. Simon Verity’s residency was supported by “The Lives of Things,” an initiative supported by Duke’s Bass Connections program, supporting interdisciplinary collaborations. The Wired! Lab offered my students the ability to use an extensive range of software and, critically, tutorials.\textsuperscript{15} While I have a baseline of skills in the digital tools we used, as an art historian I do not have the mastery to teach them to full capacity and troubleshoot student questions. As the instructor, I gave the students the background art-

\textsuperscript{14} All students also completed a written assignment early in the semester, a “thick description” of a work of their choice in the Nasher Collection. They were also expected to complete readings in advance of each class session and come prepared to discuss them.

\textsuperscript{15} A full list of the technologies used by the students: Photoshop, Photogrammetry, SketchUp, Video editing, Sculptris, SketchFab, NextEngine (3D Laser Scanner), MeshLab, PhotoScanPro, and Cheetah 3D.
historical knowledge and the tools to successfully engage with the works of art, provided feedback as their hypotheses and models developed, and negotiated resources for them. It takes a village to teach like this.

And teaching like this is extremely worthwhile. The object-based, technology-based pedagogy I practiced fostered high levels of student engagement. Students also gained experience in primary and secondary source research, as they analyzed scholarly articles, curatorial files, and conservation reports to gain as much information as possible about their projects. They were able to see a practical function to their work, gaining an understanding of what art conservators and curators do, trying to learn how to restore works of art to their original appearances and learning to present them in engaging ways grounded in scholarly research. Cementing this is that, after the completion of the semester, the Nasher decided to send God Instructing Adam and Eve for conservation. After cleaning, reparation of came, and replacement of pieces of glass inserted in an earlier repair, the piece is today lit and hanging in the Nasher galleries (fig. 1). The students’ work literally shed new light on a stunning piece. Their virtual reconstruction became reality.