Exhibition & Pedagogy: Probing Architecture's Virtual Past in Museum Cast Collections

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This paper describes two educational projects, conducted by the authors in partnership with the Carnegie Museum of Art, in order to illustrate the specific affordances museum exhibition provides in contemporary design practice. We discuss two collaborative and interconnected case studies from our recent work in the context of teaching and design research. The first, an advanced architecture studio, Low-Relief: The virtual and material cultures of architectural deceit, was an experimental course doubling as a museum exhibit. The second project, which ran parallel to the studio, was the development of an augmented reality app: Plaster ReCast. The app was designed to facilitate access to the plaster cast for museum visitors.

Both projects explore architecture's disciplinary history in relation to emerging Augmented Reality Technologies (AR), using plaster cast collections as a rich cultural site to probe architecture's proto-virtual past. These examples also serve as supporting evidence to reclaim AR and the virtual realm at large as a purview of the architect, arguing in favor of a considered application of emerging AR technologies in contemporary design. Ultimately the projects illustrate exhibition design's disciplinary relevance as a unique mechanism to critically engage architectural history with an eye toward future practice.

> [...] the virtual, strictly defined, has little relationship to that which is false, illusory, or imaginary. The virtual is by no means the opposite of the real. On the contrary, it is a fecund and powerful mode of being that expands the process of creation, opens up the future, injects a core of meaning beneath the platitude of immediate physical presence.
>
> —Pierre Levy, *Becoming Virtual*

THE GALLERY AS ALTERNATIVE SITE

This paper will discuss the collaborative work of two faculty members at Carnegie Mellon University (CMU) - one an architectectural educator with expertise in architectural robotics; the other an architectural historian with a focus on 19th and early 20th architecture. Our collective work explores the intersection of emerging design technologies and the deep disciplinary histories of architecture. With an emphasis on making history actionable, we attempt to interrogate design technologies as cultural phenomena and reframe disciplinary strengths in relation to the emerging concerns of contemporary practice.

During the course of our collaboration, museums have emerged as ideal sites to conduct this work. Museums, like all cultural institutions, provide a bracketed context to explore specific modes of knowledge and inquiry. The physical, social, and institutional constraints of museums have long served as an alternative site for architectural discourse, existing in contrast to the dominant environments of professional practice and the academy. In particular, we will discuss how museums provide a unique space for metacognitive reflection on the historical, professional and disciplinary concerns of architecture. This paper describes two educational projects conducted by the authors in museum settings, that illustrate the specific affordances museum exhibition provides in contemporary design practice.

The paper presents two collaborative and interconnected case studies from our recent work in the context of teaching and design research at the Carnegie Museum of Art (CMoA). The first, an Advanced Architecture Studio, Low-Relief: The virtual and material cultures of architectural deceit, was an experimental course doubling as a museum exhibit. The studio was housed in CMoA's Heinz Architectural gallery, where the students' work was on full display to museum visitors, and closely associated with CMoA's Hall of Architecture, an impressive collection of architectural plaster casts dating back to the early 20th century. The second project, which ran parallel to the studio, was the development of an augmented reality app: Plaster ReCast. The app was designed to facilitate access to plaster casts for museum visitors, to conjure up the power of the casts' exciting three-dimensional nature, and to create a rich web of historical associations and allusions embodied in the collection.

Both case studies leverage the museum context to explore architecture's disciplinary history in relation to emerging Augmented Reality Technologies (AR). Plaster cast collections provide an early, and materially intensive, example of pre-digital virtual reality. In addition, plaster as a material is central to many of the techniques architects have traditionally used

to create perceptual illusions in the built environment. These historical plastering techniques parallel many of the operational strategies of contemporary AR. We use these examples as supporting evidence to reclaim AR and the virtual realm at large as a purview of the architect, arguing in favor of a historically considered application of emerging AR technologies in contemporary design.

PLASTER CASTS: PEDAGOGY THROUGH CRAFT

The Hall of Architecture at the Carnegie Museum of Art in Pittsburgh Pennsylvania boasts a collection of almost 150 plaster casts of architectural pieces. Financed by Andrew Carnegie and assembled under the supervision of John W. Beatty, Director of the Department of Fine Arts at what was then the Carnegie Institute, the Hall opened to the public in 1907.Despite a change of layout, it is still housed in the grand exhibition space expressly added at that time to the original Museum building by the firm Alden and Harlow.

Intentionally created with architectural pieces and fragments, while most of its contemporary plaster collections focused on sculpture the Pittsburgh casts collection was assembled very quickly, for the most part between 1905 and 1906, ahead of a ceremonial rededication of the Carnegie Institute, when the major elements of the new display were expected to be in place. As such, it offers us a fascinating and precise snapshot of the taste of early Twentieth century American elites and their architects. The longevity of the Pittsburgh collection is in part explained by its focus on architecture. Spared by the "Battle of the casts" that raged in Boston and at the MET starting at turn of the century the provincial collection remained untouched - the casts of architectural elements were much more difficult to replace with originals. Today, it is the third largest collection of its kind in the world, following the much more famous collections at the Cast Courts of the Victoria and Albert Museum in London and the Galerie des Moulages at the Cité de l'Architecture et du Patrimoine, in Paris.

From its inception, the Hall of Architecture was conceived as a pedagogical tool to educate the taste of the masses. Carnegie famously expressed the goal of offering an experience of the world to those who could not travel but he also had in mind his own workers, patternmakers and draftsmen as ideal recipients of the educational value of the plaster casts collection. The Pittsburgh cast collection was also an integral part of the infrastructure of architectural education, as offered at the Carnegie Technical Schools where classes began in 1905-1906. The School of Fine and Applied Arts soon defined an Architecture curriculum under the direction of Henry Hornbostel, a Beaux-Arts educated architect, who was also the designer of the new campus. It was clear from the beginning that the Hall of Architecture would function as the Hall of Casts did at Harvard, or the more famous Cour Vitrée at the Ecole des Beaux Arts in Paris. At the Massachusetts Institute of Technology, William Robert Ware's collection in 1868 included 400 casts. In the first brochures for the school of architecture in Pittsburgh, published in 1914, in addition to photos of students drafting from casts, which were a common feature for most architecture schools of this era, the Hall of Architecture is presented as an integral part of the facilities of the school, together with the halls and theaters - thus emphasizing the connection of the new School with the neighboring Museum.

The meaningful educational role of the Hall of Architecture suffered not so much from the debate on the notion of originality and authenticity of the artwork in the Museum environment, but from the effort of architecture to move away from the historicist model, separating history from design, that characterizes the "passage to the modern." The collection did not completely lose its ability to inspire in the visitor an awe of the monumental or an appreciation for the craft of plaster casting. Instead, when architecture education ceased to be based on the imitation of the canon, the collection lost its function and its pedagogical role, and also part of its intended audience. The following case studies explore how and why this unique museum collection might find new meaning in contemporary design practice.

CASE STUDY I: LOW-RELIEF STUDIO

Low-Relief: The virtual and material cultures of architectural deceit was an experimental architecture studio doubling as a museum exhibit. Offered in the spring of 2018 the studio was housed in a public museum gallery where the ongoing activity of the studio was on full display to museum visitors. The studio leveraged the museum as a culturally specific site to interrogate architecture. This provided a uniquely prescribed context - similar to a laboratory or studio setting - where

Figure 1. Students work with a robot installed in the museum gallery to experiment with plaster moulding based on fractal profile geometry.

specific modes of knowledge become actionable. In particular the studio sought to combine hands on making and historical research as primary vehicles for inquiry, exploring contemporary applications in robotic plastering in relation to the museum's large architectural plaster cast collection (figure 1).

STUDIO THEMES

In addition to plaster cast collections falling out of fashion, plaster as a building material was rejected by many modern architects because it was considered a "fake" material. Yet despite Modern Architecture's insistence on truthfulness of material, architects before and since have deployed an array of techniques to trick the senses, including the use of faux materials, forced perspective, and media applied to walls and ceilings. Low-Relief explored the material cultures of deceit in architectural design and construction. The studio positioned architectural illusion not just as a visual technique, but as a precise shaping of physical material and the blending of hybrid media forms in three dimensions. The motivation for Low Relief originated from the proliferation of virtual reality in contemporary media, and sought to position the built environment as a proto virtual interface.

In order to address these themes in a museum context, students were charged with curating their own work as it unfolded throughout the semester ,filling the gallery with artifacts and creating a visual identity that spoke equally to the process and final products of architectural design. On the first day of the semester the students walked into an almost empty gallery (it was sparsely furnished with a few tables and chairs). We worked closely with museum staff as the students claimed the gallery in real time. This unique context forced students to think creatively about design communication through the lense of exhibit design for a curious, but uninitiated museum public. The exhibit-oriented constraints of the studio encouraged a level of metacognition about the design process. The students were forced to think more overtly than they would in a traditional studio setting about the underlying motivations and grounding context of their work and the studio themes. Each assignment began with a group exhibition design proposal. It was not enough to simply execute a project, they also needed to explain why their approach might be relevant beyond the insider concerns of the architectural community. All reviews were open to the public, and a portion of the exhibit design involved interactive features to encourage discussion with museum visitors, even when the students were not physically present in the gallery (figure 2).

STUDIO STRUCTURE

The studio was hosted two days a week in the Heinz Architectural Gallery at CMoA as part of the Copy + Paste exhibition. Students worked on three main projects with process work and final products on display in the gallery. Visitors could witness firsthand as we conducted group crits, discussions, and work sessions. CMoA also a hosted a series of public events in connection with the studio including workshops by architect Luc Merx, ceramicist Abigail Murray with

Figure 2. Public reception for final student work in the museum's Hall of Architecture.

Figure 3. Project 1, Atlas of Architectural Deceit Installed on the walls of the museum gallery. Close-up of precedent study for architectural illusion, Teatro Olimpico and view of installed precedent fold-outs.

architect Steven Mankouche; and a lecture by designer Adam Furman. The studio conducted a trip to NYC where we visited the MET (a treasure trove of historical plaster) and two architectural plastering shops steeped in historic craft.

STUDIO PROJECTS

The students worked together in teams to design and install the semester-long exhibit with the three main projects anchoring the exhibition content (figure 3).

PROJECT 1: ATLAS OF ARCHITECTURAL ILLUSION

Students created a visual research compendium exploring the material cultures of deceit in architectural design. The atlas became a shared resource to frame and motivate the material experimentation conducted in Projects Two and Three. The atlas also communicated the studio's three primary themes to museum visitors:

1. *Historic Techniques of Architectural Illusion* - Architects and designers have long been skilled in the techniques of illusion to trick our senses and to augment our experience of physical space with virtual dimensions.
2. *Taxonomy of Architectural Plaster* - Plaster is an ancient building material that is central to many examples of architectural deceit. Plaster can be shaped in multiple physical states and can be used at multiple scales.
3. *Trends in Augmented Reality* - The history of architectural illusion can be re-framed as a precedent of contemporary reality computing such as projection mapping, photogrammetry, and augmented reality.

PROJECT 2: CABINET OF CURIOSITIES

Students explored the physical and virtual techniques of architectural illusion at model scale, by designing and fabricating a furniture-sized artifact for display in the museum gallery. Cabinet of Curiosities provided a site to explore the intersection of the three research themes from Project One. The exercise combined analogue and digital techniques including robotic plastering, projection mapping, and anamorphosis.

Students were asked to explore the potential of model making as a means to explore physical and virtual space. Architectural models are simultaneously objects in and of themselves and abstractions that signify other potential spatial realities. Models are always real and virtual. In this project, Students considered the hybridity of architectural models. How can physical artifacts be both object and interface, physically present and virtually suggestive, true and false? These furniture-scaled objects posed architectural questions to museum visitors by being overtly interactive (figure 4).

PROJECT 3: INSIDE-OUT / OUTSIDE-IN

Students designed and constructed a full-scale prototype of an architectural corner that explored the use of plaster in architectural illusion. Each Corner was to be no larger than 4'x4'x4' and could be elevated off of the floor. Students were encouraged to explore a combination of analogue and robotic techniques for constructing the plaster finish for each prototype.

The corner has historically been a site of material, spatial, and aesthetic richness in architectural design. The corner is a zone of intersection and transition, bringing together wall, ceiling, and floor. As such, corners often negotiate the joining of disparate materials and construction systems. In addition, in the building trades corner mock-ups are often used to train apprentices with the understanding that the most difficult joints and transitions of a building are represented there. Whether exuberantly ornamented or minimally detailed corners are technically challenging and spatially suggestive (figure 5).

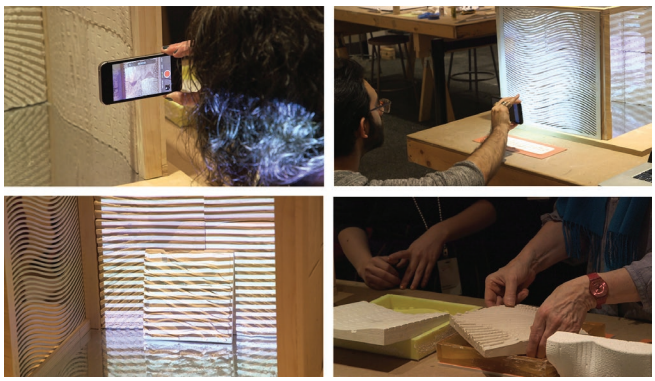

Figure 4. Visitors experiment with Moiré effect combining cast plaster tiles and digital projection mapping.

STUDIO REFLECTION

The physical displacement of the studio, removing ourselves from the CMU studio and robotics lab and establishing an outpost in the museum gallery adjacent to a large plaster cast collection, opened the students' work to new possibilities. Too often emerging technologies are approached by designers in a technocentric vacuum, wherein the particular affordances of the new limit plausibility structure of the creative process. Experimenting in the museum gallery opened the work of the students to a broader field of interests and concern. Emerging technologies were in conversation with historic craft; visitors were constantly asking why; experimental models were treated as artifacts to be curated. It is worth noting that historic plaster cast collections, such as the Hall of Architecture, had multiple intended audiences which included the general public, laborers, students, design professionals, and cultural critics. The broad reach of these collections underscores the reality that craft is not simply an application of technological acumen or an expression of individual talent. Rather craft develops as a cultural expression

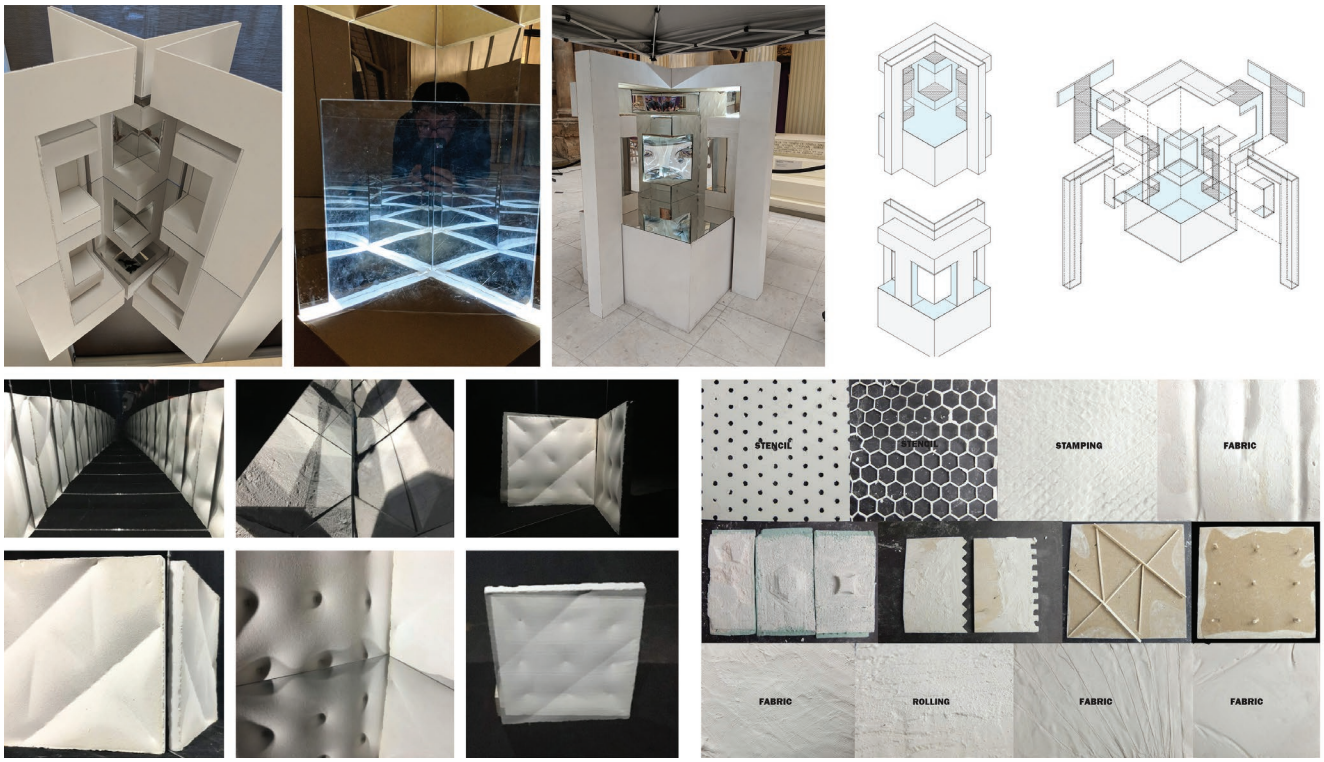

Figure 5: Student project exploring texture, reflection, and light to confuse perceived and physical space in the architectural corner.

that is nurtured by institutions, organizations, and the dissemination of knowledge. The work produced in the museum internalized the lessons of this environment and added a layer of criticality to the students' design process.

CASE STUDY II: PLASTER RECAST AUGMENTED REALITY APP

Any exploration of the contemporary relevance of cast collections must contend with the dual nature of plaster casts. They are compelling artistic objects themselves, providing visitors a rich visual tapestry of juxtapositions, but they also contain complex associations, a dense web of historical and cultural references that are not typically accessible to visitors today. In addition to this, architectural casts have traditionally addressed the role of three-dimensionality in experiencing, teaching and exhibiting architecture. Plaster was an ideal material to obtain high-fidelity replicas of pieces, whose originals were out of reach for American museums at the time, making revered artifacts more accessible to the visiting public and able to fulfill their function of educating the taste of the masses. The collection of the Carnegie Museum of Art in Pittsburgh includes over one hundred full scale architectural casts, tightly packed into a single gallery. The juxtaposition of forms from disparate geographic regions and time periods is striking and is emphasized by the uniformity of plaster. Despite the stigma attached to these objects because of being copies, their tactile and spatial qualities, are re-emerging as central facets of contemporary design due to the possibilities afforded by reality capture, 3D modeling, and GIS.

The Hall provides a virtual tour within its walls. Similar to VR experiences, the Hall collapses space and time, encouraging unexpected adjacencies and the ability to curate and organize fragments to form new structures of understanding. The fact that this experience is achieved starting from massive physical artifacts raises interesting questions about the materiality of the collection and plaster in general. At the same time that plaster collections were being destroyed as worthless reproductions, plaster as a building material was being jettisoned by modern architecture as a "fake" product used to copy on the cheap "authentic" materials like stone and wood. In the United States, the Chicago Columbian Exposition of 1893 and and its White City sparked enthusiasms, such as Andrew Carnegie's, but also a reaction of disdain.

Because plaster was used as a primary material of architectural illusion in building construction it was cast aside as fake. Yet it is precisely this capacity for deceit that makes plaster relevant in a contemporary context. Margaret Wertheim, in her article The illusionistic Magic of Geometric Figuring, argues that the architectural techniques of illusion developed in antiquity - and celebrated in plaster cast collections - prefigured virtual reality and gaming. For example she observes, "Contemporary architects of computer-generated virtual worlds have added the element of motion, but the psycho-spatial transport aimed at in Grand Theft Auto remains the one that Giotto enacted in the Arena Chapel." In fact, if the wealth of historical examples are taken seriously, the use of illusion to create virtual space is one of architecture's core disciplinary strengths.

Plaster has an amazing ability to mimic other materials through casting and the skilled application of faux finishes. The casts at the Carnegie Museum, all made from the same material, look so convincingly real that one is tempted to touch them to confirm that this is not actual stone, or wood, or bronze before your eyes. The ancient craft of scagliola, a technique that uses plaster and mixed dyes to imitate other materials, principally marble, became so convincing that many architects preferred using it in place of natural stone. When observing the chameleon-like qualities of plaster one is reminded of the Stanford Bunny, the standard polygon mesh used to test rendering techniques in computer graphics. As rendered in the cast collection plaster serves as an analogue texture map (figure 6).

Figure 6. Side by side detail of plaster cast at CMoA and polygon mesh converted from 3D scan of cast. Plaster cast of column capital from Tower of the Winds.

PLASTER RECAST DEVELOPMENT

In the fall of 2017 our team piloted a mixed reality app called Plaster ReCast, created with the goal of enhancing visitor experience of plaster cast collections of architecture. The app is based on the interplay between the virtual and physical dimensions of the cast collection - the required mental effort of imagining the original building in its complete state; the collection's didactic connections to history, geography, and archeology; and the physical experience of observing highly crafted artifacts in spatial juxtaposition to each other. Using contemporary reality computing technologies, the app also explores new didactic possibilities for the collection.

Plaster Recast is a mobile app built on the Google Tango Developer Platform. At the time of the app's development Project Tango offered advanced positional tracking and mapping functionalities that were ideal for mixed reality applications. In addition to the standard camera, accelerometer, and gyroscope found in most mobile devices, a suite of

onboard sensors including an IR projector, RGB-IR camera, and depth sensor, could enable area learning and real-time motion tracking of the tablet's position in a scene. Tango's positional tracking affords real-time interaction with location aware information mapped in the space of the collection.

While the visitors explore the collection, the app runs a full screen, live camera view of the plaster collection, allowing them to remain visually connected with the physical artifacts in the gallery. When a cast is captured in the camera's field of view, interactive features are overlaid on top of the camera feed (figure 7).

THREE PRIMARY INTERACTION MODES

1. 3D Scan of Cast Fragment - In the first interaction mode users can explore a 3D scan of the plaster cast up close. Many of the casts are positioned high on the gallery walls, far from their observer. The scans provide a detailed reading of the fidelity of the plaster, including markings from the craftspeople making the cast. Hotspots on the scans also allow for architectural details to be called out and explained.
2. 3D CAD Model of Building - In the second interaction mode, users can place a virtual 3D model of the entire building represented by the cast fragment on the floor of the museum. Physically moving the camera allows users to rotate, zoom, and pan to actively explore the building. Users can also toggle to see a ghosted view of the model with the location(s) of the cast fragment highlighted in the overall building.
3. History notes and Archival Documents - In the third interaction mode users can explore the rich historical narratives associated with the casts and see historical source documents.

REFLECTION

At the center of the recent rediscovery of plaster casts lies an interest in seriality, copying, and multiplicity. These concerns are connected with the issues raised by reproduction techniques such as 3D scanning and 3D printing and their impact on curation, museums and the ownership of originals. From our point of view, though, one of the most promising aspects of the Plaster ReCast experience and its connection to the historical precedent of plaster cast collections is the prominence of three dimensional media and artifacts. Plaster casts of architecture are not complete copies of originals, as is the case for statuary. They are copies of pieces, fragments or portions of buildings. As such, they require a very interesting mental process, in which the visitor, looking at an architectural fragment in the Museum gallery, has to conjure up and mentally visualize the entire building, which cannot be present in the gallery space. In both cases the object in the Museum, whether a physical or digital copy, is an alias which also represents the entry point into a larger, virtual and three-dimensional space that the visitor can explore and learn about. This process makes historic

Figure 7: Live playtest of Plaster ReCast app at the Carnegie Museum of Art's Hall of Architecture.

collections of plaster casts of architecture a precedent of contemporary virtual reality, once more supporting the argument that architects should harness the design opportunities offered by the bridging of physical and virtual. Claiming this virtual space implies a shift from 2D to 3D media in the design and representation of architecture. Inundated as we are with a proliferation of images, we could reclaim architecture's special skill of thinking and operating tri-dimensionally. This could have serious implications for architectural pedagogy and practice.

CONCLUSION

Architectural exhibitions have become an important disciplinary agent and the last few years have seen a rise in the status and specialization of curators, as well as dedicated courses in curating, specific to the field of architecture. The multiplication of events and their growing public though have not solved the age old conundrums intrinsic to exhibiting architecture - the tension between showing and communicating, and that between the comprehension and appreciation of an architecture, the experience of it, and the physical limits of what can be shown in the galleries.

Museums provide an alternative site to interrogate the disciplinary extents of architecture. This unique context allows for work that is distinct from studio, office, and lab-based learning environments. Using exhibition design as a vehicle for discourse provides a distinct exploratory mode of operation relative to the museum. Our experiments in teaching and design research started by investigating plaster casts, with models and drawings one of the most traditional tools for exhibiting architecture. Then they proceeded to consider the implications of digital tools and immersive spatial experiences on one side, and the possibility of "curating the process" as a new response to the architectural exhibition dilemma. The projects described in this paper stand in contrast to, but certainly do not diminish, the prevalence of architectural installations as a primary approach to interacting with museums. Many designers use installation work to push the boundaries of creative practice and seed the slow work of building design. The shift between exhibiting work and exhibit design represents a layer of abstraction, a curatorial moment where the discipline can be critical of its own practice. It is precisely this critical distance that is needed when incorporating emerging technologies into design practice.

ENDNOTES

1 Pierre Lévy, *Becoming Virtual: Reality in the Digital Age* (New York: Plenum Trade, 1998), 16

2 A sculpture collection, also planned and begun at the same time, was never completed.

3 On the history of architecture plaster casts collections, see Mari Lending, *Plaster Monuments. Architecture and the Power of Reproduction* (Princeton, NJ: Princeton University Press, 2017). For the history of the Pittsburgh collection and the involvement of the architecture community in its creation see Francesca Torello, "Exhibiting Architecture: Plaster Casts in Pittsburgh between Instruction and Professional Debate," paper presented at the Annual Southeastern College Art Conference Meeting, Pittsburgh, PA, October 21 - 24.

4 Alan Wallach, *Exhibiting Contradiction* (Amherst, MA: University of Massachusetts Press, 1998), 49.

5 Mattie Schloetzer, "Andrew Carnegie's Original Reproductions. The Hall of Architecture at 100," *Western Pennsylvania History* (Fall 2007): 36-47.

6 "We are a raw and noisy and obtrusive people; but place one generation of us under the influence of the past, let us see something grand and beautiful, not made by our hands . . . and perhaps we shall feel the sweet flower of humility break through our pride, and diffuse its gracious influence over us. Eugene Benson, "Museums of Art as a Means of Instruction," *Appleton's Journal of Literature, Science, and Art* 3, (January 15, 1870), cited in Allen Wallach, *Exhibiting Contradiction* (Amherst, MA: University of Massachusetts Press, 1998), p. 47 and note 16.

7 The name changed to Carnegie Institute of Technology in 1912 and Carnegie Mellon in 1967

8 On the use of plaster casts collections in architectural education see Mark Wigley, "Prosthetic Theory: The Disciplining of Architecture," *Assemblage* 15 (August 1991): 6-29; and Katherine Wheeler, "A Tangible Past: Casts in British Architectural Education," *ARRIS: The Journal of the Southeast Chapter of the Society of Architectural Historians* 23 (2012).

9 Photograph captioned "Hall of Architectural Casts, Carnegie Institute," Bulletin of the Carnegie Institute of Technology - Department of Architecture, Pittsburgh, PA, Series 10 Number 1, (September 1914): 7. Carnegie Mellon University Archives, Architecture, box 1, folder 11.

10 It is impossible to give here a complete list of references, but a few exhibition catalogues, such as Anna Maria Giusti and Fondazione Palazzo Strozzi, *Art and Illusions: Masterpieces of Trompe l'eil from Antiquity to the Present Day* (Florence: Mandragora, 2009); Celestine Dars, *Images of Deception: The Art of Trompe-l'oeil* (New York: Phaidon, 1979) can help situate illusion in architecture in the broader framework of the history of visual and material illusion in art.

11 The use of illusion in the first generation of modernists can sometimes seem surprising or contradictory. In fact, it has deep roots in their own schooling and in the traditions and practices of work that were widespread in their era. It seems only natural that they would still use and appreciate the possibilities offered by the mastery of these techniques, while at the same time advocating for stylistic change. It is also important to note that the concept of "Truth," which was at the center of the debate at the time, had in reality a different meaning and variable implications for each one of the architects considering it. About this, see Leslie Topp, *Architecture and Truth in Fin de Siecle Vienna* (Cambridge, UK: Cambridge University Press, 2004).

12 Jonathan Gaugler, "Architecture, Technology Collide in *Copy + Paste*," Carnegie Museum of Art official website, September 13, 2017. http://press.cmoa.org/2017/09/13/copy-paste/.

13 Luc Merx event announcement, "Gallery Conversation with Luc Merx," Carnegie Museum of Art official website, February 15, 2018. https://cmoa.org/event/gallery-conversation-with-luc-merx/.

14 Abigail Murray and Steven Mankouche event announcement, "Workshop: Texture + Plaster," Carnegie Museum of Art official website, March 18, 2018. https://cmoa.org/event/workshop-texture-plaster/.

15 Adam Furman event announcement, "Designer Adam Nathaniel Furman Talk and Discussion," Carnegie Museum of Art official website, April 7, 2018. https://cmoa.org/event/adam-furman/.

16 Louis Sullivan is famous for his criticism of the White City and its effect on American architecture. See Louis Sullivan, *The Autobiography of an Idea* (New York: Press of the American Institute of Architects, 1924).

17 Margaret Wertheim, "The Illusionistic Magic of Geometric Figuring," *Cabinet* 26 (Summer 2007). http://www.cabinetmagazine.org/issues/26/wertheim.php.

18 The Stanford 3D Scanning Repository, the Stanford Computer Graphics Laboratory official website, August 19, 2014. http://graphics.stanford.edu/data/3Dscanrep/.

19 The app was developed by faculty at Carnegie Mellon University in collaboration with the CMU Entertainment Technology Center and Carnegie Museum of Art. See CMU School of Architecture, "ReCast," Vimeo video, 05:46, December 8, 2017. https://vimeo.com/246512552.

20 See Lea-Catherine Szaka, *Exhibiting the Postmodern: The 1980 Venice Architecture Biennale*, (Venice: Marsilio, 2017).