Using New York as a Laboratory for Learning Building Technology

Fig. 1

Abstract

The challenge was placing students and researchers in a digital urban geography that could be examined from macro to micro detail. GIS provided the tool for documenting, analyzing, and particularly storing the geography of building technology, an emerging field of study. GIS driven deep mapping allowed us to examine the process of how New York was built in detail. We found a new way to teach building tech--geographically--and became CUNY's university wide case study in high impact learning.

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Teaching Building Technology

Building Technology is a field that focuses on the way we build. Buildings are amalgamations of many things including ideas, memories, culture, materials, technological innovations, language, tectonics, and climate response to name a few. These things and more are moulded into architectural concepts that can in turn be built. While advanced technology, modern building materials and information on building techniques are all increasing in availability around the globe, there are still important distinct building practices and traditions that are place specific.

Today we are presenting a project focused on exploring and teaching building technology in a way that seeks to answer a few important questions: what is the relationship between place and buildings? How and why does the building culture of a place evolve over time? What factors played a role in the formation of the great buildings of our built environment?[1]

We seek to answer these questions through an educational research project that is integrated into courses of students in fields related to architecture, history, and preservation. This presentation is centered on the work of faculty and students at the New York City College of Technology in the Department of Architectural Technology, City University of New York. In this department, the faculty's task is not merely to focus on disseminating knowledge of how buildings are built, but to engage the students in a process of learning where the students are actively participating in the acquisition of skills and knowledge of building technology past and present, so that they can become creative developers of building technology for the future.

Rote Learning versus Meaningful Learning

Today's students have an ever growing access to virtual information and research sources. This access to virtual sources threatens to weaken or sever students' connection to real experiences and places during their formative educational years. The efficiency the students seek from use of virtual sources can have a limiting effect on their engagement with educational subject matter. The students certainly want to pass their courses, but they can become content with the goal of earning their degree with the least necessary effort. In the study of student learning *How Learning Works* , the authors categorize this approach of the students as the pursuit of a "performance goal" or "work avoidance goals" rather than a learning goal. They cite research that concludes that students who hold performance goals rather than learning goals are less likely to "use study strategies that result in deeper understanding,…"[2] When this occurs, a culture of rote learning can become pervasive.

Richard Mayer, Prof. of Psychology of UC Santa Barbara places learning into two broad categories of retention and transfer. As he points out, students must be able to retain the information presented in the demonstration and lecture, but also process it and be able to apply that information to new situations. He contrasts rote learning and constructivist (meaningful) learning in a useful way. Rote learning is information acquisition. Constructivist learning is

[1] These factors can be broad and diverse, including economics, culture, climate, durability, material, performance, tectonic articulation and craftsmanship.

[2]Ambrose, Susan A. *How Learning Works: Seven Research-based Principles for Smart Teaching.* San Francisco, CA: Jossey-Bass, 2010. 72. Print.

where “students engage in active cognitive processing, such as paying attention to relevant incoming information, mentally organizing incoming information into a coherent representation, and mentally integrating the incoming information with existing knowledge.” [3]

Rote learning, especially where access to information is ubiquitous, is virtual and passive: a student need barely commit information to memory as it is only a click away on a mobile device. Meaningful learning demands active engagement. Rote learning is *by definition* a mechanical process. Meaningful learning requires a cognitive, human relationship to the subject matter where the students are in the act of “constructing meaning” for themselves.[4] Rote learning is most efficient when context is striped away, but context is critical for meaningful learning.

Therefore we must confront the challenge of breaking through barriers that leave a distance between the real world and the students’ education, and to engage students in a way that leads to deeper, more meaningful learning. To face this challenge we build upon two practices that are a growing focus in educational theory: *undergraduate research* and *place-based education.*

Undergraduate Research and Place-Based Education

In his presentation of his research of high impact educational practices, Dr. George Kuh describes undergraduate research as a high impact practice that has the goal “to involve students with actively contested questions, empirical observation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions.”[5] Gregory Smith, an associate professor at Lewis & Clark College explores the important benefits of place based learning. He notes that a “critical characteristic of place-based education is its emphasis on learning experiences that allow students to become the creators of knowledge rather than the consumers of knowledge created by others.”[6] Both these high impact educational practices are a natural part of teaching architecture, but have particular value in the teaching of building technology.

Combining these concepts of undergraduate research and place based learning in the context of teaching building technology, we can see that we can seek answers to our questions above through an investigative, forensic process, rooted in empirical observation of the built environment outside our classroom doors. We can apply cutting edge technologies to the process as tools to help students generate and create knowledge. This combination of participation in undergraduate research and interaction with our own built environment has been shown by Kuh and Smith among others to stir students’ curiosity, generate excitement, and lead to higher levels of engagement and more potential for deep learning.

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[3]Mayer, Richard E. "Rote Versus Meaningful Learning." *Theory Into Practice* 41.4 (2002): 226-32. Aug. 2013. Web. 28 Apr. 2014.

[4]Mayer, Richard E. "Rote Versus Meaningful Learning." *Theory Into Practice* 41.4 (2002): 226-32. Aug. 2013. Web. 28 Apr. 2014.

[5] Kuh, George D. *High-Impact Educational Practices*. Washington DC: Association of American Colleges and Universities, 2008. Print.

[6] Smith, Gregory A. "Place-Based Education: Learning to Be Where We Are." *The Phi Delta Kappan* 83.8 (2002): 584-94. *JSTOR*. Web. 13 June 2014.

The Building History Project

The questions above lie at the heart of the Building History Project, a project established by Jeffrey Burden, PhD, the architectural historian emeritus of the National Trust for Historic Preservation. The Building History Project is built around research that can be used as a teaching tool at local institutions of higher learning. At the core of this project is the *protocol*, a research methodology that guides a process of investigation, data collection, data storage, and analysis.

The protocol guides research through a process of investigation of the macro and micro, zooming in and out as needed to capture both big brush information and as well as highly specific details.[7] All of the data generated by this investigation needs to be stored in such a way that it is easily accessible through an intuitive interface. The conceptual goal of the protocol is to find a way to embed and geo-locate the data within a three dimensional wireframe construction of the general building form or structure of the case study subject. The goal is to allow researchers to navigate through the structure and seek out particular details or building elements to understand the building in increasing levels of detail. The wireframe becomes the armature for the data storage, and data is accessed by clicking on points on the wireframe.

As the protocol emphasizes the cultural and architectural context of the site under examination, information is drawn from a broad array of sources, disciplines, and geographic locations. As this research requires a multidisciplinary approach, this project brings architects, engineers, scientists, conservators, historians and students together in the creation of a digital archive.

A critical goal of the protocol is that it is flexible and nimble enough to be applied to any type of building site from any period. That said, the project seeks out places that have a critical collection of structures and/or a critical culture of building and craftsmanship that makes them ripe for the exploration through this particular approach to research. In the context of the building technology courses at the New York City College of Technology, we have made use of Manhattan, downtown Brooklyn, and New Haven, Connecticut. Each of these places offers the students a case study with a slightly different geographical focal point and building era and the particular technologies emergent in those eras: Brooklyn: 1840s-1880s, New York: 1930s-1940s, New Haven, 1950s-1970s.

GEOGRAPHY OF BUILDING TECHNOLOGY

Each of the case studies revealed a unique contextual geography of building technology. In downtown Brooklyn, a series of interior rooms and exterior facade investigations exhibit the high level of craftsmanship and refinement of 19th century masonry structures. In Manhattan, the Empire State Building stands at a critical, pivotable position in the shift from a pre-modern tectonic that still persisted in New York skyscraper design and the emerging modern tectonics of

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[7] This can include architectural drawings and construction documents from archives, photographs (both of current conditions as well as archival photos of construction and early completion views,) sketches of details, three dimensional models of assemblies and structure, exploded axonometrics to illustrate construction elements and relationships of the parts.

the curtain wall. In New Haven, a powerful collection of mid 20th century modern masterpieces offers a didactic exposition of the development of modern architecture in the United States. All of these places offer opportunities for rich and deep place based research into building technology.

Fig. 2 Brooklyn Historical Society Library

Fig. 3 Empire State Building

Fig. 4 Yale Center for British Art

The Building History Project and the protocol at its core provide a structured approach to the challenge of bringing building technology students into an engaged, deep educational experience. Through the integration of this project into building technology courses, we are achieving our goals of providing opportunities for undergraduate research and place-based education. Further, as recommended by George Kuh, cutting edge technological tools can be applied to the project to further enhance and enrich this process.

Deep Mapping and GIS

GIS today is often used by students in architectural education as a tool to display base information for a design project. Much of this base level research has been part of the site analysis phase of design projects for decades: identification of key site elements, existing site uses, adjacencies, topographic features to name a few. Students today use GIS to quickly deliver much of this site analysis in useful visualizations that tap into the databases provided by

Fig. 5

Fig. 6

local municipalities. But this use of GIS has significant potential to become the mere consumption of knowledge created by others through a rote, virtual process. The educational danger of this use of GIS is that it remains a superficial, prophylactic interaction with data and knowledge. The data is never really touched or reviewed for meaning or accuracy; it is taken *as is* on faith. Especially in the world of education today where digital information is ubiquitous, time pressure is immense, and efficiency highly valued, GIS provides a quick *pro forma* generation of graphics and visualization of data that appears to give depth to the student work. But presentations by the students often reveal the lack of meaningfulness of the data to their work. They are merely producing documents that have become standard accompaniments to project presentations. As information on the built environment that is geo-referenced is critical to the understanding the relationship between place and building technology, we must seek a means of interacting with the information concerning the built environment that more directly engages the students.

PLACE-BASED CASE STUDIES

To combat this all to real potential for superficial interaction with important data in our classrooms, the protocol is focused on place-based case studies that offer a real experiential laboratory for investigation. This forensic process encourages digging deeply into the case study subject and place, letting the content and context research evolve as new insights are revealed. Careful observation on site is the major mode of the investigation, where new data is generated/created and collected. The students are challenged in the field to use their observational skills to uncover the ordering system, the building materials and the kit of parts, the relationships between parts and details, dimensional and proportional systems as a starting point. Notes, sketches, models, and high resolution photographs document their observations.

Fig. 7

Fig. 8

PRIMARY SOURCES

An important aspect of this examination is the emphasis on information generated from *primary sources*. In addition to the field observations of the structure itself, other primary sources are sought out including contemporary drawings produced prior to and during construction, construction photographs, contemporary maps and atlases, and accounts by the design and construction teams. All of these documents are collected, catalogued, and geo-located with GPS handheld devices or manually through a grid overlay that has a translation of latitude and longitudinal coordinates and references to the elevations coordinated with floor levels.

CONTEXT

This process has parallels in other fields, especially archaeology. Similar to an archaeological project, the Building History Project seeks to reveal a story of how our buildings were built with all of the contextual factors that played an important role in a particular building's development. To do this, we need to use a deep mapping process from which a narrative of the place emerges.

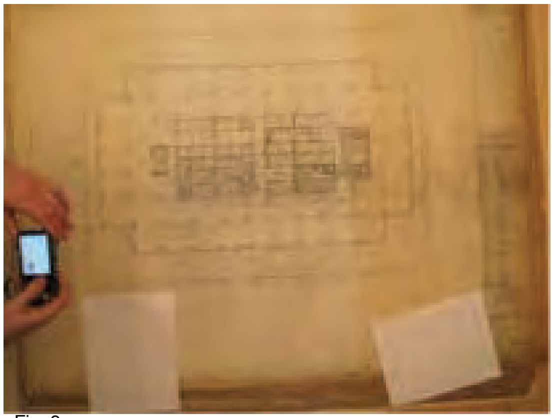

Fig. 9

DEEP MAPS

A deep map can be defined in a number of ways, but insightful definitions are provided in a discussion on the Polis Center blog, where deep mapping is defined as “the act of collecting and the collection of multi varied material and immaterial data/information/knowledge about a particular place…” and “ a way of experiencing a narrative through multiple kinds of content that leads to a well-developed sense of place.”[8] Deep mapping is important to the project research, but especially important to the educational goals of the project. Deep mapping as a method teaches students that the underlying reason for a particular form or detail must by fleshed out by considering all the factors that contributed to the building activity of the case study. These factors are often much broader than the direct parameters of material and construction. An excellent illustration of the application of deep mapping to the Building History Project is provided by our investigation of the Empire State Building.

Fig. 10

[8] Danielson, Laura. "Defining Deep Maps." Web log post. *The Polis Center Blog*. Indiana University - Purdue University Indianapolis, Web. 4 June 2014.

Fig. 11

Fig. 12

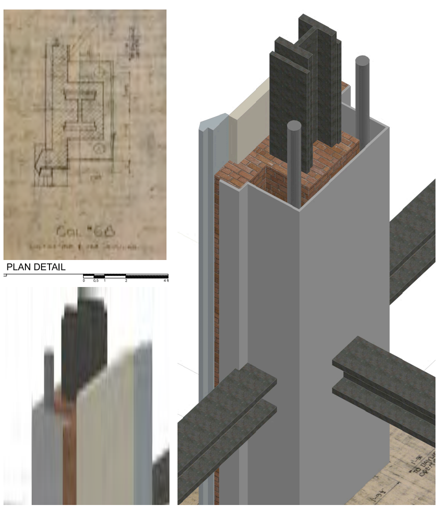

Fig. 13

CASE STUDY: EMPIRE STATE BUILDING

New York City as a place provides a remarkable account of the evolution of craftsmanship, building culture and building technology, especially at the dawn of the modern skyscraper. While Chicago is the epicenter of the American skyscraper, New York is the place where the skyscraper enters the imagination as a new specimen of speculation and urban development.[9] The Empire State Building is the iconic paragon of skyscraper construction. This building changed that way we think about tall buildings and the way we build them. Even so, the Empire State Building is often judged solely as an independent aesthetic object. This mere aesthetic approach to the building results in the usual unfavorable comparison to the Chrysler Building, built one year before and 10 blocks to the northeast. But this superficial judgement belies the critical success of the Empire State Building.[10] In fact, this duality of the two buildings is part of the narrative that emerges from the deep mapping process. These buildings must be considered in the context of time and place and in relation to each other's guiding forces and development intent.

From this examination by the students and faculty, the details and tectonics of the Empire State Building are brought to light in a way that brings new appreciation for the building, its design and craftsmanship. The materials of construction, their prefabrication, sequence of assembly, and critical relationships emerged as a clear tectonic system that has many similarities to modern curtain wall construction. Using GIS to provide a map of potential relationships between buildings around the city built in the subsequent decade, further research reveals a geographic disbursement of the details of the Empire State Building and the impact of the new construction methods on the architectural character of the city. This disbursement is evident in common material pallet, the overall building character and massing, the tectonic organization of the facade materials, commonality of specific construction details, and the links between the various architectural firms executing the work.

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[9] See Koolhaas, Rem. "The Lives of a Block: The Waldorf-Astoria Hotel and the Empire State Building." *Delirious New York: A Retroactive Manifesto for Manhattan*. New York: Monacelli, 1994. Print.

[10] Its critical success can be judged by its innovative use of materials and construction systems, its high level of craftsmanship and execution, the coordination and efficiency of its construction, and its aesthetic sophistication and iconic status. The success of the tectonics of the Empire State Building did not go unnoticed by contemporary architects and builders as evidenced by a number of subsequent structures that follow its tectonic logic.

From the principle examination of the case study building, the context of the development of the primary subject begins to emerge and grow richer through continued research. The ever expanding context then defines a series of related sites that reveal a geography of building culture and building technology. With an emphasis on the significance of place for all this research, GIS is the natural tool for continued research and discovery, to store this research, and leverage the visualization of the software.

GIS AS THE VEHICLE FOR STORAGE OF RESEARCH

Our application of GIS tools in this case study is an iterative process moving back and forth between examination of existing databases and development of new information to integrate into the database. For example, New York City's ongoing release of data into the public realm is providing a base level of support for our research. The MapPluto database facilitates queries based on building period and massing to establish the consortium of tall buildings executed in the contextual timeframe of the development of the Empire State Building. (see fig. 10) In using this database however, we are discovering new data fields that need to be added to enhance our study. As the current data is broad brush, including use group, year built, number of stories, our process is leading to the development of a richer database at a more detailed level that includes structural typologies, exterior wall systems, architects and builders, construction drawings and details, and high quality photographs. Our deep mapping process requires this rich database in order to help us examine, judge, and visualize the relationships between buildings and sites so that we can map the evolution of building technology across the city.

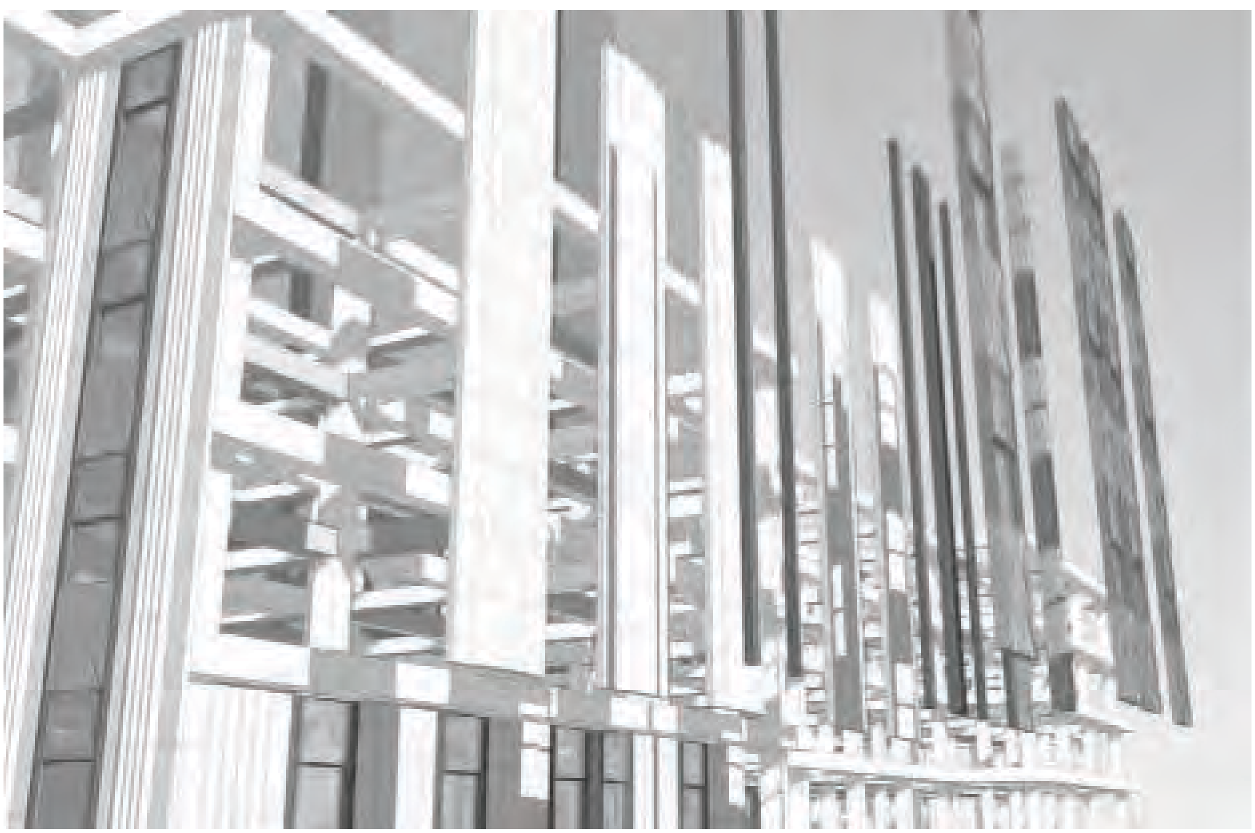

Fig. 14

Visualization of the Building History Project & GIS

Fig. 15

This mapping process and database construction are first and foremost a scholarly pursuit, and the visualization and aesthetic vision for the project are closely linked to this goal.[11] This has been a key aspect of the evolution of the protocol. As other projects also recognize, three dimensional investigation is critical to the depth and sophistication of the research. The richness of the information sought through deep mapping requires a holistic three dimensional examination. Two dimensional representations are abstract and fail to capture the full story of spatial relationships, material assemblies, structural conditions, form, and spatial quality. Certainly diagrams and other graphics may be useful reduced to two dimensions; that said the default mode of operation for this project is three dimensional. Naturally then, ArcScene is a preferred environment for the GIS work, were building lots and masses can be extruded and three dimensional wireframes generated in Sketchup or Revit can be imported.

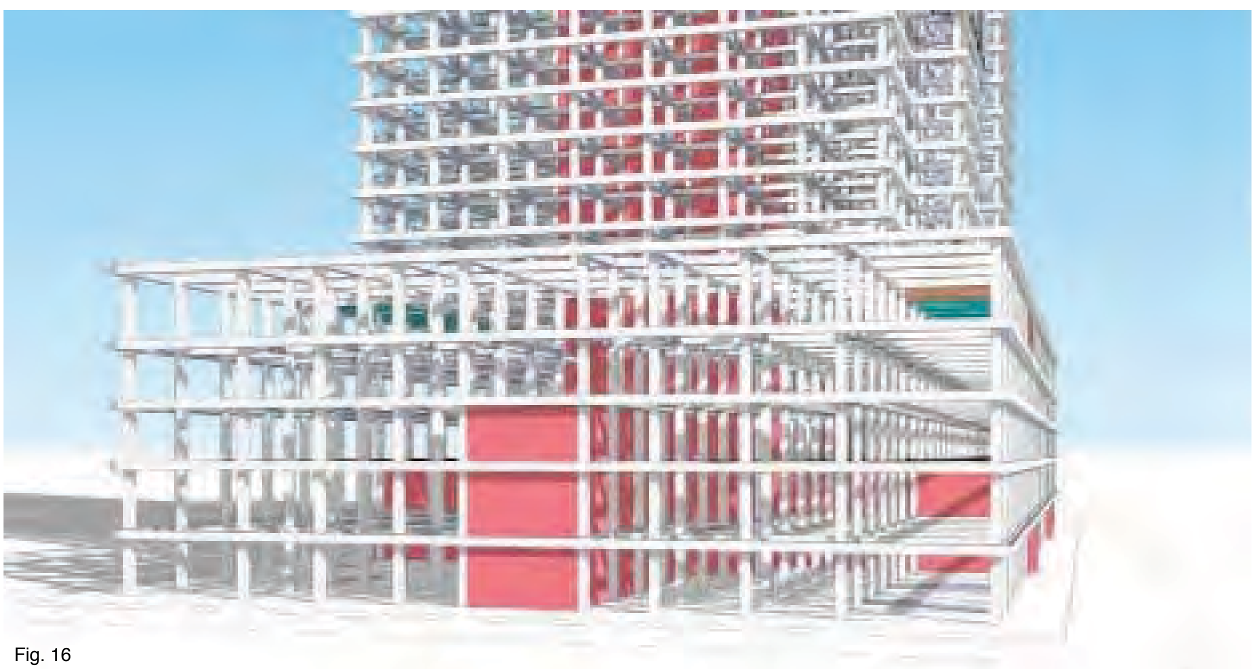

Fig. 16

[11] For more discussion of visualizing data see: Yau, Nathan. *Data Points: Visualization That Means Something.* Indianapolis: Wiley, 2013. Print.

While three dimensional models and mapping are a critical mode of operation, it is important to be conscious of the difference between our goals and those of other projects. Most significantly, we are not striving to create a virtual reality visualization of the city or of particular buildings. Our goal is to develop a nuanced and nimble methodology for scholarly investigation, documentation, and storage of our data and findings. Therefore the three dimensional models used in this project are intentionally depicted as wire frames, keeping the focus on the three dimensional armature as a spatial reference for the geo-referenced, embedded information. The abstraction of the wireframe avoids the reading of a simulated reality, and lets the eye read the relationship of the structure to the context map in GIS as well as other wireframes or masses of related structures. Interior space and exterior mass are simultaneously apparent in the wireframe. Texture and detail are consequently reserved for the data points within the wireframe.

CASE STUDY: YALE UNIVERSITY ART GALLERY AND YALE CENTER FOR BRITISH ART

Fig. 17

New Haven CT presents one of the greatest collections of modern architectural masterpieces in the United States. In particular, the two seminal museums of Louis Kahn offer a didactic exposition of the use of concrete, exterior detailing, integration of building systems, and crafting of space. Nearby, other masterworks are a continuing essay on the themes established by Kahn: concrete as a major building material providing mass, weight, texture, surface, and the frame/bearing walls providing an ordering of space and form. Our starting point is the two Louis

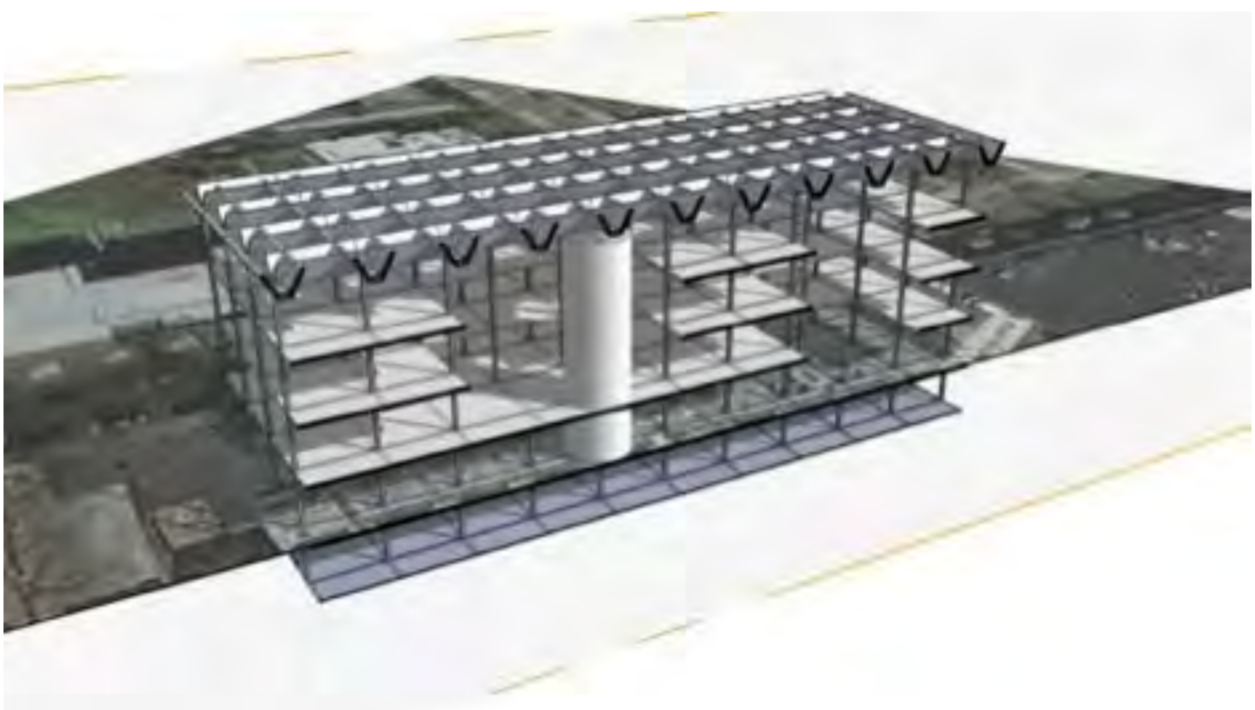

Fig. 18

Fig. 19

Kahn museums: The Yale Center for British Art and and the Yale University Art Gallery, which sit across the street from each other. Each building exhibits features and details unique to Louis Kahn's approach to modern architecture. With these buildings and the subsequent works, New Haven is an exemplification of a laboratory for place-based education.

Here the visualization approach is made clear: the wireframes of the buildings in ArcScene work in tandem, showing Louis Kahn's evolution of architectural space in relation to structural organization and frame. The poignant repetition of the cylinder form for the primary public stair of each building is revealed in the dueling wireframes. The data points link to the on-site sketches, detailed three dimensional model studies and high resolution photographs of the existing conditions. The navigation of the data points itself is an exploration of the structure and its context. The wireframes offers unique spatial viewpoints across the two structures.

This case study reveals the benefit of ArcScene to the process. ArcScene is an integrative environment that achieves the goal of a tool for storage and visualization that is: three dimensional, places the case study structures in context, facilitates the storage of geo-referenced information and data, makes the data accessible through an intuitive and visually striking interface, and connects the data to the position (both horizontal and vertical location) within the structure. ArcScene allows us stay true to our vision to house our placed based research with accurate positioning and to stay consistent with our scholarly aesthetic.

OTHER TOOLS

Certainly Sketchup has played an important role in this project, and will continue to do so. Sketchup's virtues of simple modeling and visualization, as well as its own abilities for geolocation offer functionality to our project. The GIS wireframes are generated in Sketchup and then imported to ArcScene. Building Information Modeling tools are also being explored as a means of data storage and visualization. A powerful development we hope to see is the integration of BIM and ArcScene, where detailed building information can be queried and analyzed through GIS.

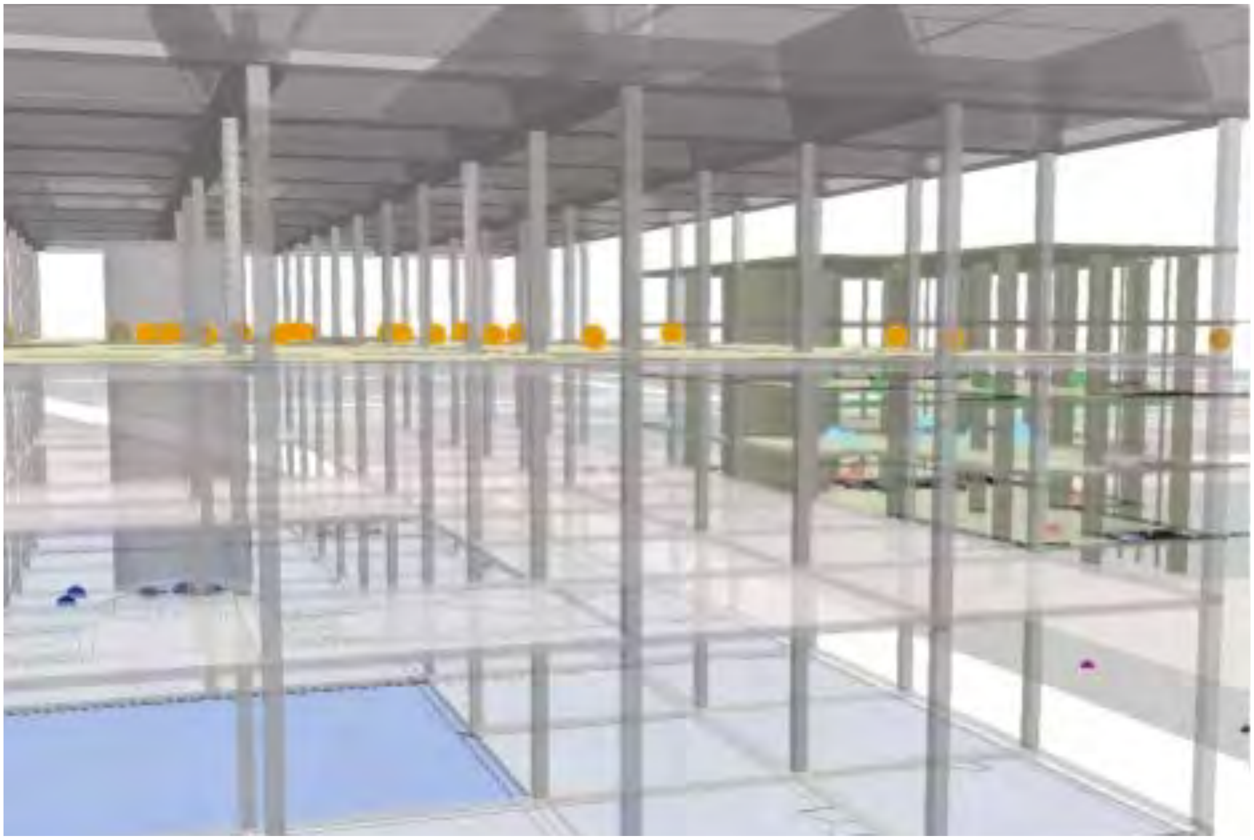

Fig. 20

Fig. 21

Conclusion

The application of the Building History Project to the education of students today is a direct attempt to counter a virtual, rote education culture. Place-based education, with careful observation at its core, offers a real experience and interaction with the built environment. It offers a gateway into undergraduate research and moments of genuine discovery, sparking students interest to dig deeper. The Building History Project seeks to build a foundation for life long learning.

The approach to the research, the protocol, is developed specifically to engage the students with information and knowledge that they are generating and creating. The storage and organization of this generated place based knowledge in GIS format is a natural link and application of cutting edge technology to undergraduate education. GIS demands linking information and place. In addition, GIS provides the very format sought in protocol for the storage of data. The visualization aesthetic purposely avoids any hint of virtual reality experiences to keep the focus on the scholarly investigation. The stored data inhabits the wireframe and the students see their work growing and densifying, always in the context of the City as a Laboratory.

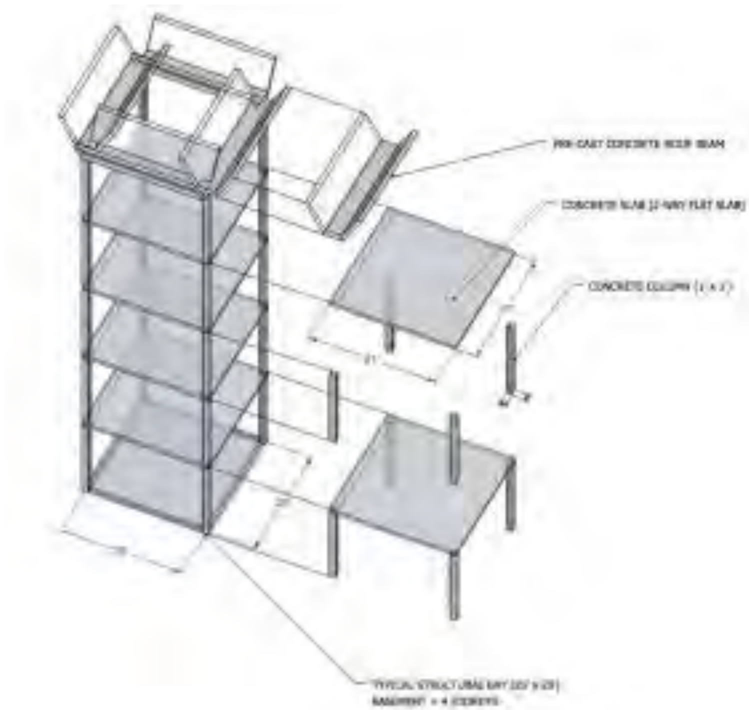

Fig. 22

FIGURES

Fig. 1 "History New York 20th Century." *Wired New York*. N.p., n.d. Web. 24 June 2014. <http://wirednewyork.com/forum/showthread.php?t=21249&page=5>.

Fig. 2 Brooklyn Historical Society Library Interior, Brooklyn, New York. Personal photograph by author. 2013.

Fig. 3 Empire State Building, New York. Personal photography by author. 2013.

Fig. 4 Yale Center for British Art, New Haven, Connecticut. Personal photography by author. 2013.

Fig. 5 Montgomery, Jason. Land Use Map Lower Manhattan. Digital Image. 2014.

Fig. 6 Montgomery, Jason. Figure Ground Map Lower Manhattan. Digital Image. 2014.

Fig. 7 Sketchbook Review at the Empire State Building, New York. Personal photography by author. 2013. *This image shows a group review of on site observations recorded in the students' sketchbooks.*

Fig. 8 Brooklyn Historical Society Library Interior, Brooklyn, New York. Personal photograph by author. 2013. *This image shows the field investigation by students in Building Technology I. The students are reviewing the design drawings by the office of George Post for the building.*

Fig. 9 LambF, William F. *Construction Document Set.* 1930. MS. Avery Architecture and Fine Arts Library, New York.

Fig. 10 Montgomery, Jason. Highrise Construction of Manhattan 1930-1940. Digital Image. 2014. *This map is based on the MapPluto database and was generated in ArcScene.*

Fig. 11 Hines, Lewis W. *Empire State Building Construction*. 1930. Avery Architecture and Fine Arts Library, New York. *This photo shows a group of masons installing a limestone ashlar block at the exterior wall.*

Fig. 12 Hines, Lewis W. *Empire State Building Construction*. 1930. Avery Architecture and Fine Arts Library, New York. *This photo shows a mason preparing to lay up a brick back up wall behind the limestone exterior wall already installed.*

Fig. 13 Montgomery, Jason. Student Guide for Reconstruction Assignment at Exterior Wall Detail. Digital Image. 2013.

Fig. 14 Smith, Joe. Exploded Axon Exterior Wall Empire State Building. Digital Image. 2011.

Fig. 15 Montgomery, Jason. Exterior Wall Wireframe, Empire State Building. Digital Image. 2012.

*note: Base plan provided by the City of New Haven City Plan Department.

Bibliography

"Courses in Spatial Data in Design." *Geographic Information Systems in the Design Curriculum*. Harvard University Graduate School of Design. Web. 07 May 2014.

Danielson, Laura. "Defining Deep Maps." Web log post. The Polis Center Blog. Indiana University Purdue University Indianapolis. Web. 4 June 2014.

Hines, Lewis W. Empire State Building Construction. 1930. Avery Architecture and Fine Arts Library, New York.

Koolhaas, Rem. "The Lives of a Block: The WaldorfAstoria Hotel and the Empire State Building." Delirious New York: A Retroactive Manifesto for Manhattan. New York: Monacelli, 1994. Print.

Kuh, George D. HighImpact Educational Practices. Washington DC: Association of American Colleges and Universities, 2008. Print.

Lamb, William F. Construction Document Set. 1930. MS. Avery Architecture and Fine Arts Library, New York.

"PbcGIS: Geographic Information Services." PbcGIS: Cultivating Spatial Intelligence [tm]. Web. 07 May 2014.

Research Plan and Research Cluster: Cluster 2: Innovations: Technological, Social. German Archaeological Institute. Web. 11 June 2014.

Smith, Gregory A. “Place Based Education: Learning to Be Where We Are." The Phi Delta Kappan 83.8 (2002): 58494. JSTOR. Web. 13 June 2014. <http://www.jstor.org/stable/10.2307/20440205?ref=searchgateway:c435de7ddf f41eb0fe56d0755b4d23b7>.

Wheatley, David, and Mark Gillings. Spatial Technology and Archaeology: The Archaeological Applications of GIS. New York: Taylor & Francis, 2002. Print.

Yau, Nathan. Data Points: Visualization That Means Something. Indianapolis: Wiley, 2013. Print.