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Rapid Visualization: Purpose Driven 3D Modeling and Rendering

by Murali Paranandi

"If a picture is not worth a thousand words, the hell with it…"—***Tufte***[1]

One of the virtues of digital computing ought to be the speed – allowing us to accomplish more within less time. While this is largely true, and experienced designers take full advantage, novice student designers often are disadvantaged because they are less discerning about when and how to engage digital media. One of their struggles is coming up with effectual digital model that best supports design process. The best model should help to define, analyze, understand, and express a design solution. More importantly it should be something that is rapidly built, imaged, and revised. Most of the literature in our discipline celebrates the explorative possibilities opened up by the microprocessor (as it should), and very little attention paid studying its meaningfulness the side effects[2, 3, 4]. Our experience shows that most novice students see the sole purpose of building a 3D model to be for generating perspectives of their buildings for final presentation. They lack an understanding of process of modeling and level of detail necessary to represent their ideas. Consequently, they spend an inordinate amount of time building and rendering them, and rarely study iterative variations of their solutions.

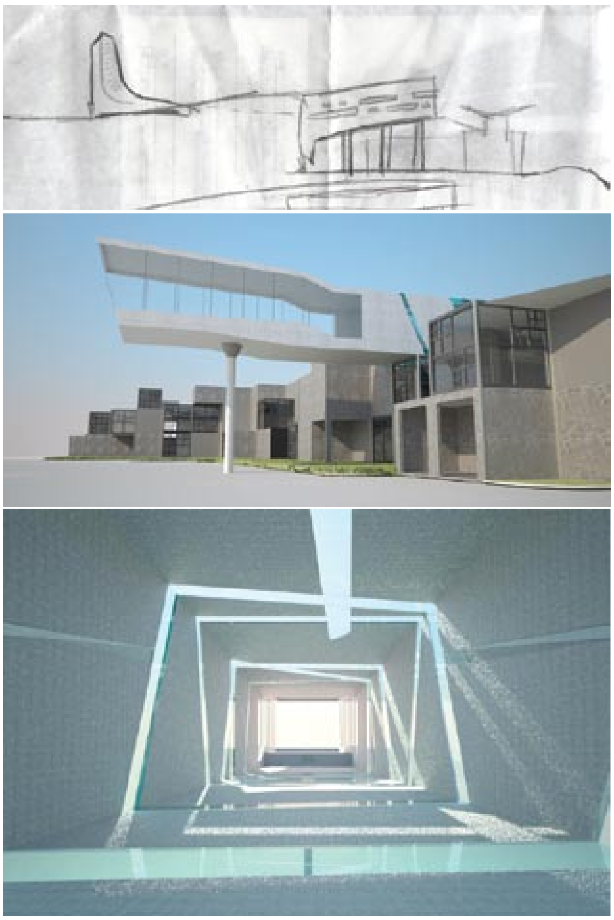
Typically students study their ideas with sketching on paper, refine it further in a CAD package by drafting plans/sections, and then incorporate 3D packages to build a model of their proposed buildings by assembling component geometries; preparing scenes with proper props, textures, lights; rendering to generate photorealistic images. This process increases the time investment in translating the idea into a 3D digital form. Restrictive assumptions made by the underlying modeling algorithms, and excessive render times to generate photorealistic imagery act as two primary obstacles. This slows the pace of design overall, inhibits study of ideas by progressive refinement, and discourages iterative exploration. Consequently, student designers often become less receptive to design feedback because of the effort it takes to revise their models, and the time it takes to re-render their images.

To illustrate this point, I will use the experience of one of my very talented, bright students as an example. Their design solution involved an art gallery space extending out of a subterranean structure, serving as the culmination point for visitors touring the proposed recycling facility. This gallery's purpose was to stage exhibits related to environmental impact of recycling. High concept for this facility was an intervention into a brown field site to heal from years of industrial abuse. The main attraction of the gallery was the experience of this healing of the site. This idea was conceived rather quickly in a sketch form (Figure 1(a)). In the pre final presentation, ten days before the final deadline, they presented images of this modeled in **form•Z** and rendered in Maxwell Render (images not shown in this article). Critics loved the basic idea, but made a suggestion to strengthen it further by unifying the openings into a continuous coil that progressively gets wider as it reaches out such that it provided for more predictable wall display space and also a better forced perspective. The student agreed, and to their credit, invested several hours of modeling and rendering time (14 hours of processing time) to generate one image to study the coiled openings (Figures 1(b) and (c)). At this point, they were reluctant to study its variations any further and abandoned any further development, due to the time it takes to render, which is a perfectly understandable predicament at the end of the semester. Had they made a different choice that allowed generation of images quickly (such as not using glass as a material, or non-photorealistic imagery etc.), they would have been able to refine the idea to their fullest satisfaction.

Studies show that targeted control of detail supports enhanced understanding of an image[5]. Modeling meaningful elements of the structure/space, rather than all of the building's components should be the priority during the early stages of design. This allows you to focus on things that matter. Such abstract approaches permit the designer to consider the ridiculous and impossible (in real world or within the computer program). An artist must be selective and invest his work with attributes that are essential, discarding much that is superfluous[6], typical computer rendering must come up with an outcome by a process of optimization. The process of optimization can be either driven by realistic or stylistic goals. However, it does not account for awareness of purpose or meaning of the context. Also, there is growing interest even in the scientific community for perceptually motivated stylistic graphics over photorealistic. Hubble's images are touched by Zoltan G. Levay, NASA's artist using Photoshop, to bring out their essential qualities for enhanced understanding[7]. A recent Ph. D. dissertation at Northwestern University is an excellent resource for the interested reader[8].

This essay presents a few projects from my classes that have adapted these strategies successfully.

"*The only way to get good ideas is to get a lot of good ideas.*" ***—Linus Pauling***



a

b

c

Figure 1: Joe Puchala. ARC 302. Spring 2008.
A proposal for a Recycling Center as part of a solution for Mill Creek Restoration Project, Cincinnati, Ohio, by Case Blum, Joe Puchala, and Myles Suer. ARC 302, Spring 2008. Instructor: Murali Paranandi.

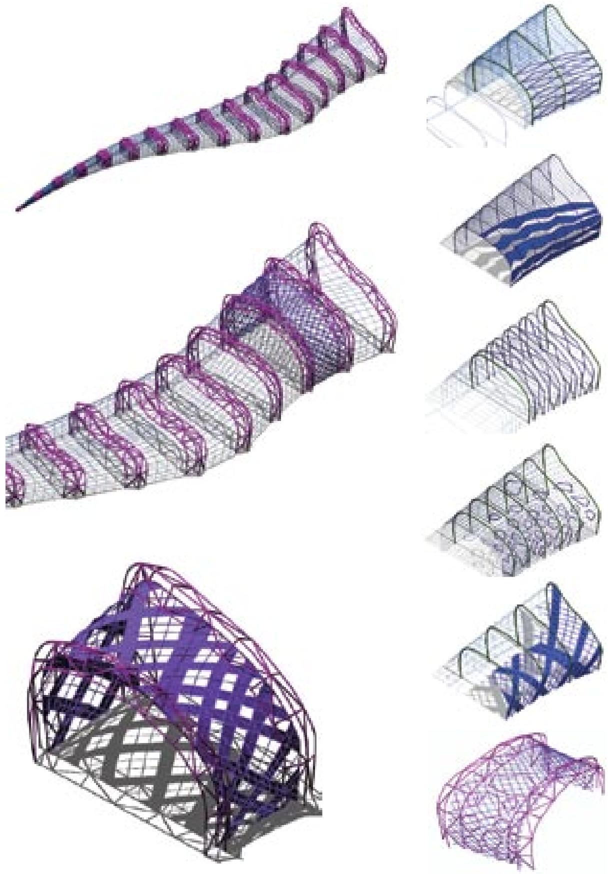


Figure 2: Building exterior envelope studies for Maritime Museum in Chicago, by Adeleh Nejati. ARC 601. Fall 2008. Instructor: Paranandi.

Tectonics/Design Development: Surface Rationalization

In this project, the student wanted to explore solutions for the exterior envelope using a double façade principle and with organic expressiveness. She had neither time to learn scripting, nor access to a sophisticated parametric modeler that would automate the study of such forms. However, that did not stop her. She modeled the interior volume as a swept surface. Once the student grasped techniques of using trim with line (to isolate a portion of the exterior skin to study), contouring (to generate structural grids), drawing using snaps (to develop patterns), layer organization (to see options simultaneously, and to set rendering attributes by layer to render wires with thickness, with or without surface to quickly simulate thicknesses for structural members without actually generating geometry), in a desk critique—six variations of cladding the skin of this complex form were explored and constructed within a single studio session. One of these alternatives was integrated into the exterior envelope of her project and the geometry was used for making large-scale physical models using rapid prototyping/laser cutting, to develop drawings for sophisticated double façade section in AutoCAD, and diagrams showing sustainable aspects in illustrator.

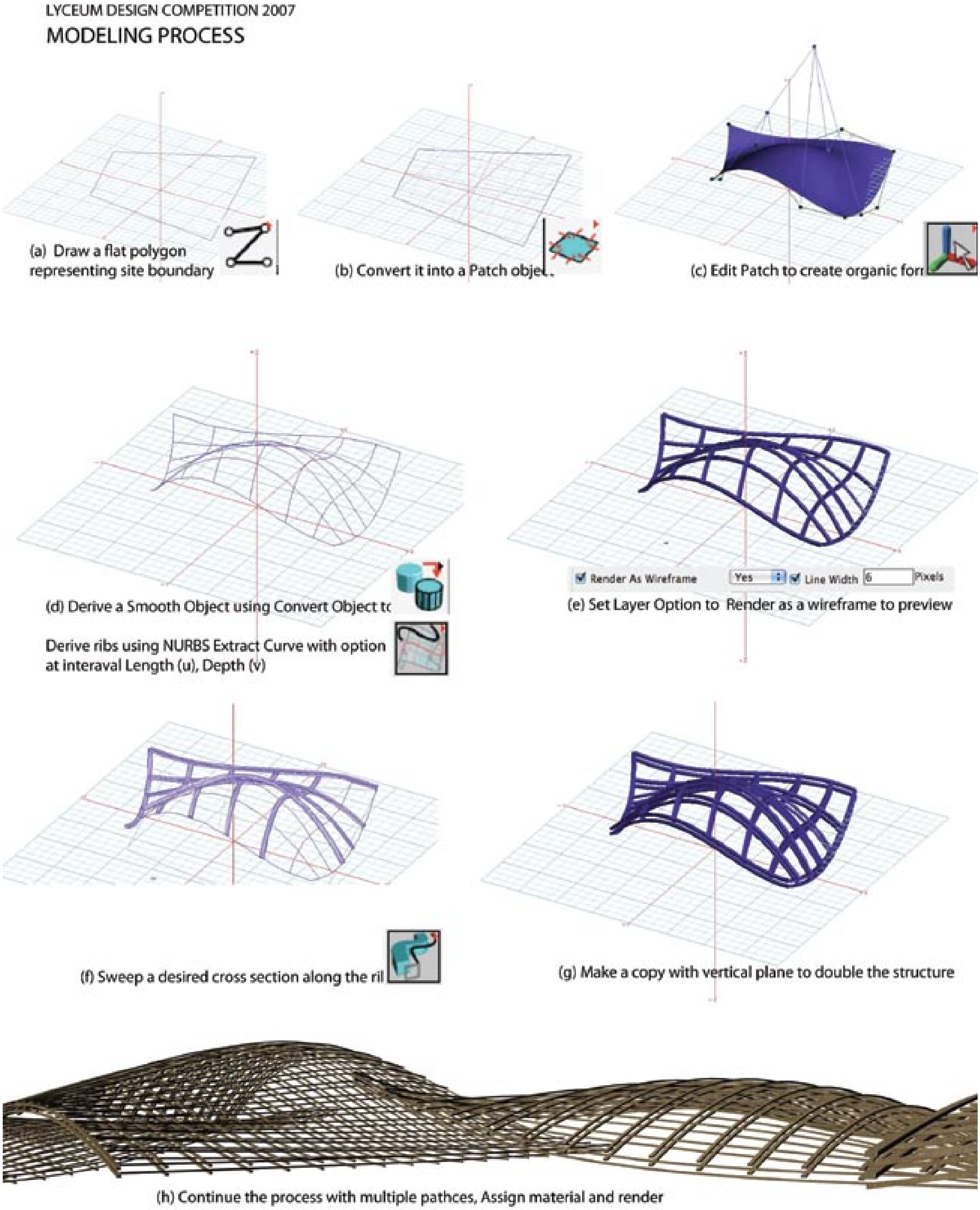


Figure 3: Modeling Process Study by Kyle Coburn. Spring 2007. ARC 404.P. Instructor: Paranandi.

Roof Studies Using Patches/Nurbs

In this project by Kyle Coburn, the design responds to the dynamic beauty of the traditional marketplace through the materialization of the ritualistic life of the market in kinetic movement. As vendors come and go, the roof undulates, never being the same as the day before, yet still married to the day to day cycle of what it holds. He had to represent the roof in many configurations to illustrate this intent. Roof form was modeled as a NURBS surface by defining four boundaries (Figures 3(a) through (c)). The Reconstruct NURBS tool was used to regulate and extract gridlines along the surface (Figure 3(d)). Rendering these placed on a separate layer with the option to render "as wireframe with thickness, no shadows" allowed for quick and clearer grasp of the tectonic qualities (Figure 3(e)). Since all of this happens with a single mouse click on the NURBS surface, it was easy to visually study various options. Once a decision was made they simple sweep gave them sectional qualities (Figures 3(f) and (g)). The student was able to generate and study five iterative variations of roof structures before arriving at the final solution presented.

Also notable is the way in which individual vendor stalls (seen in Figure 4) were modeled as symbols with three levels of detail. Given that there are a large number of vendor stalls, those closest to the viewer received highest detail, and those farthest the least. All this combined with the combination of hidden line, and wire frame image exports paired with **RenderZone** images allowed for the generation of non-photorealistic diagrams displaying the operation details of the roof. Notably, in awarding second place in the Lyceum competition, all the jurors agreed that this entry addressed the program in a complete way that demonstrated an understanding of the most important elements. One said that this student had "a fine grasp" of the work[9].

Figure 4: Hybrid marketplace in Mexico City by Kyle Coburn. Spring 2007. ARC 302 and ARC 404.P. Critics: Manoli. Digital strategy: Paranandi.

Site Design/Land Manipulation

Extruding a land form from a set of point data or contour lines works well for modeling existing conditions of the site, but developing it further by sculpting the topography and studying circulation (roads, pathways etc.) in a fluid form is not easily supported by such approaches. The project presented here serves as an example where such investigation took place with ease and success at a rapid pace. The students dealt with a building that was to be located on a man-made 99-acre peninsula along Chicago's lakeshore, which is being developed into an expansive nature habitat for prairie grasses. The design concept called for the building to be weaved into the site such that its rooftop can be occupied to act as amphitheatre-like setting to get the best views of the site. The students started from a given AutoCAD site map and traced the site zones he wanted to develop. Once a simple extrusion of this site outline was made, it was further subdivided into manageable gridded chunks by using trim/stitch with line tool. Meshes of varying densities were applied to each area. Mesh densities were chosen to be fine where land manipulation had to be carefully sculpted, and coarse where it just needed gentle slope. Roads were inscribed into this volume by using trim/stitch with line on double lines drawn in Plan. These were assigned a different color at the face level to read distinctly from the site. Most of this was learned in one studio class session, and by next class the students already made most critical decisions. This crude model was used to refine the design progressively. It was also used in conjunction AutoCAD/Illustrator to generate drawings, and Photoshop to generate perspective imagery.

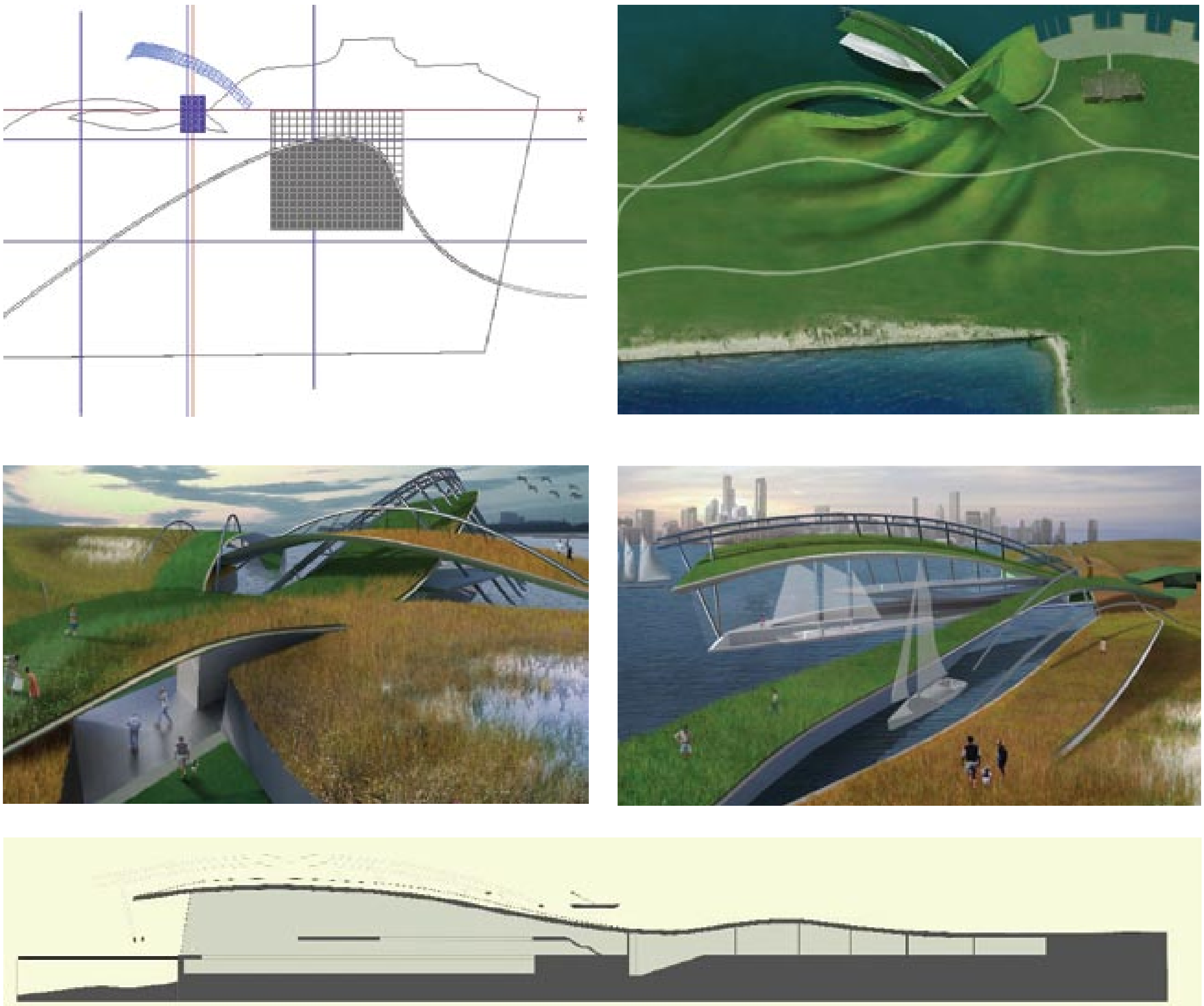


Figure 5: Maritime Museum and History Center at Northerly Island, Chicago, by MatiAlex Hogrefe and Jeff Kruth. ARC 601. Instructor: Paranandi.

Expressive Rendering

Modeling an idea: This student's (Todd Spangler) concept was to express the forging activity (in the design of the school for metals on a college campus) using photo chromatic materials and nano-technologies. Modeling strategy was setup accordingly. Only essential elements were chosen purposefully for modeling to study their organization and integration. Images were constructed by rendering in layers. This was accomplished quickly. This process demonstrates the effectiveness of non-photo-realistic rendering in facilitating iterative design development. The student was very receptive to the critical feedback provided at reviews, and was able to revise his models, images, and drawings with great agility.

Stylistic/Caricature Approach

This student (Augustine Fernando), although had a good design solution, built an accurate model that was used to generate drawings (plans, sections, elevations). However, he was having a hard time with rendering imagery that conveyed his design intentions. Consequently, his design reviews did not go well. He was encouraged to shift his investigation into non-photorealistic caricature realm. This allowed him not only to enjoy the process, but also to produce images of his ideas fluently.

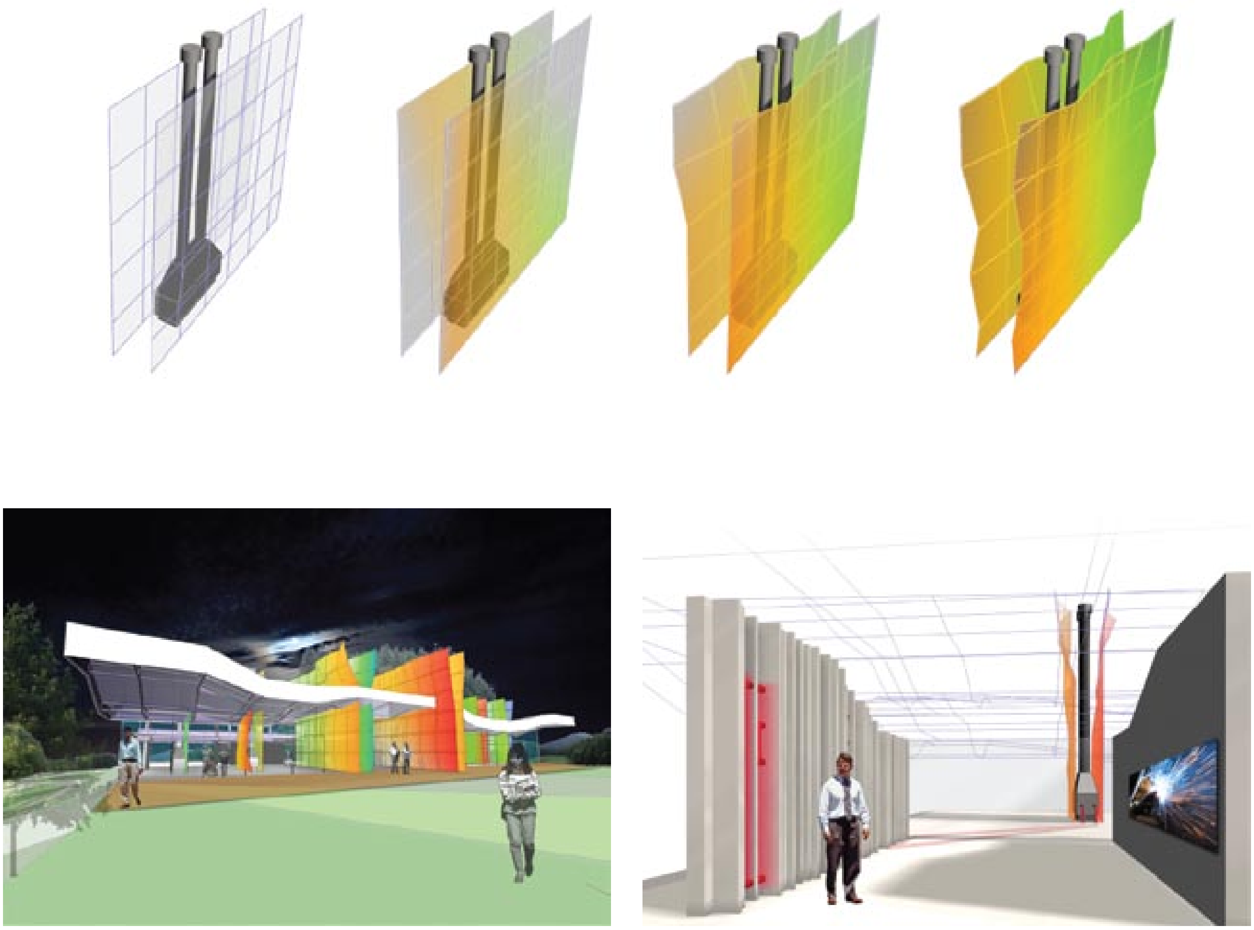


Figure 6: Todd Spangler. Arc 401. Fall 2008. Critics: Elliot, Paranandi.

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Figure 7: A proposal for a Recycling Center as part of Mill Creek Restoration Project next to I-75 in Cincinnati. Augustine Fernando. ARC 402. Spring 2008. Instructor: Paranandi.

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