2006-07

form·Z

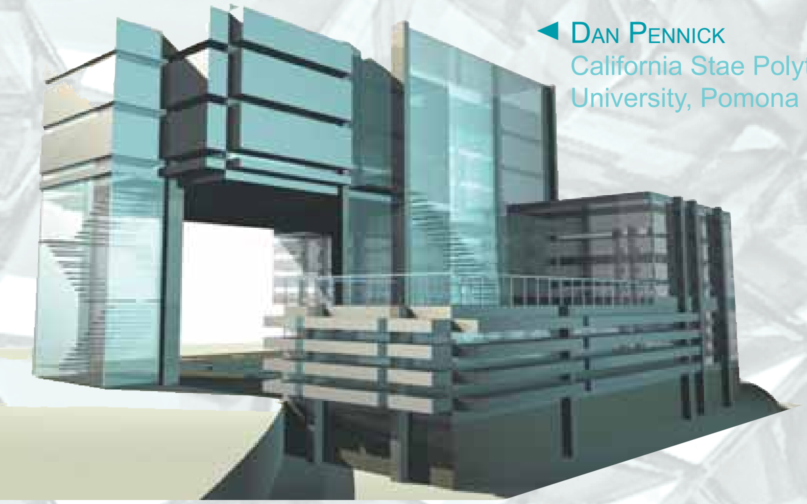
Joint Study JOURNAL 15

Partnerships in Learning

Digital Intentions Explorations and Accidents

Guest Editor: Andrzej Zarzycki

Potpourri



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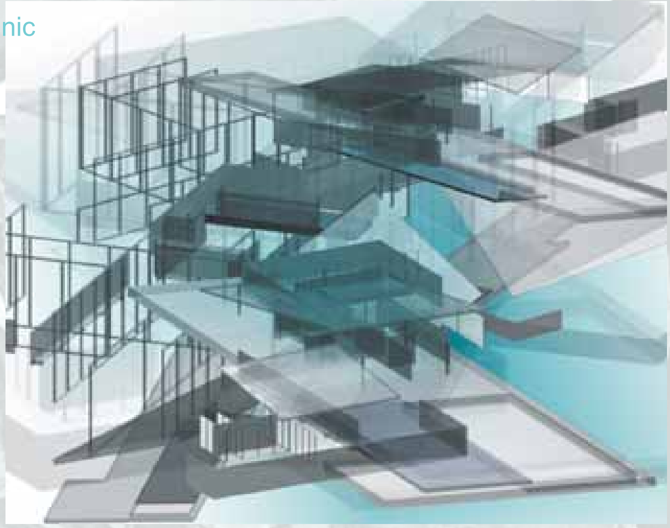

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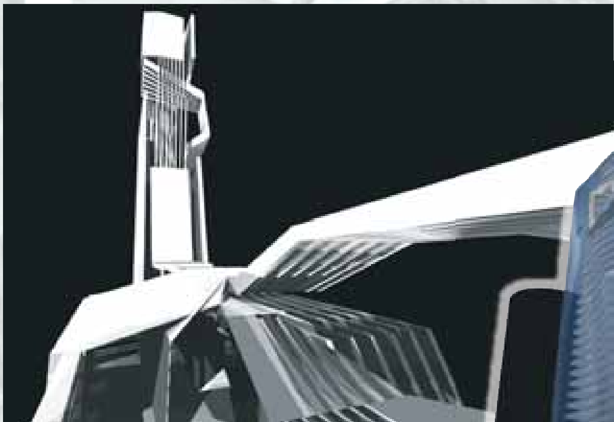

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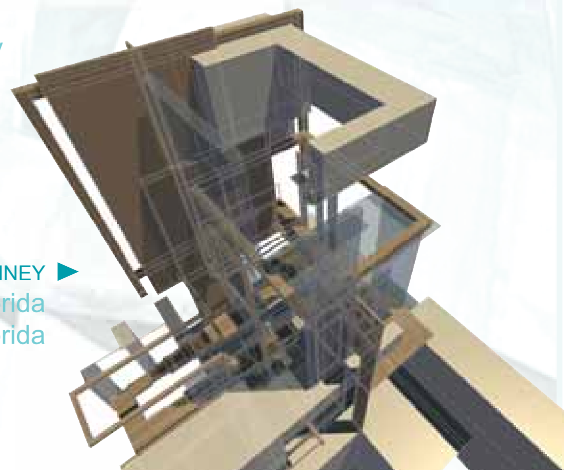

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Guest Editor: **Andrzej Zarzycki**

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2011 Riverside Drive • Columbus, Ohio 43221 • phone: (614) 488-8838 • fax: (614) 488-0848
e-mail: formz@autodessys.com • www.formz.com

Partnerships in Learning 15

2006-07 form•Z Joint Study Journal

Editor: **Chris I. Yessios**

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Preface

It is with pleasure that AutoDesSys presents the 2006-07 **form•Z** Joint Study (JS) Journal, as we extend our sincere thanks to Andrzej Zarzycki, this year's guest editor, for the excellent job he did in soliciting relevant, informative, and even some times provocative papers by members of a new generation of designers and educators that are strong believers in the potential of the digital tools as facilitators in the production of innovative forms and efficient environments.

We have chosen to rename this publication "journal" rather than call it "report," as we did in the past. The latter was sent to you in DVD format a few months ago, as the all-inclusive JS collection of projects and reports. Realizing its importance and relevance in the classroom we decided not to delay its release. The JS Journal continues to be a reflection, as well as a celebration, of how JS member schools are using the digital tools in **form•Z** and other applications, but it also goes a step further. It has evolved into a thoughtful illustration of the combination of practical issues of the past and philosophical explorations of positions for the future.

Our thanks also go to all the reviewers, listed on the right, for assuring that the included articles are of general interest and high quality. And last but not least, we wish to express our appreciation to all the students whose projects enrich the content of both the report and the journal. It all culminates to a celebration of their insightful recognition of the potential in the digital tools and their application to their own future achievements. Congratulations for a job well done!

C.I.Y

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John Cirka, Assistant Professor, Department of Architectural Science, Ryerson University, Canada. *B.Arch. Carleton; M.Sc.Arch. Columbia; MRAIC.*

Modris Dobelis, Professor, Department Head, Department of Computer Aided Engineering Graphics, Riga Technical University, Latvia. *Ph. D., Engineering Sciences, Riga Technical University, Riga, Latvia; Degree of Doctor of Science, Institute of Polymer Mechanics, Riga,Latvia. (Degree in former USSR, informally regarded equivalent to Ph.D. degree).*

Maher S. El-Khaldi, Director of Design Computing division, Shape Architecture, Practice + Research, United Arab Emirates. *Ph.D. student in Design Computing, Georgia Institute of Technology; S.M.Arch. Design and Computation, Massachusetts Institute of Technology; B. Arch. American University of Sharjah, United Arab Emirates (UAE).*

Joy Flanagan, Associate Lecturer, Chelsea College of Art and Design, London, United Kingdom. *B.A. Business Administration University of Iowa. B.A. (hons) Interior and Spatial Design, Chelsea College of Art and Design.*

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Robert Trempe, Assistant Professor of Architecture, Tyler School of Art, Temple University.

form•Z Joint Study Journal

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About . . .

The British anthropologist James Burke described the history of our civilization as a constant shaping of tools by people, and consequentially shaping people and the way we think by the tools we create. This dictum is as true today as it was in the past and equally applies to our thinking about digital tools. In the light of his observation, digital design methodology and tools play a critical role, informing our perception about reality and consequently shape our future. James Burke's dictum is elegantly mirrored by Steve Oles's observation: "The future, it could be argued, is the true medium of the designer," where he discusses the importance of visible media in forming a design proposition.

While Buckminster Fuller would argue that the best way to predict the future is to create it, most designers intuitively recognize that the future is shaped as much by conscious intentions, as it is by creative accidents. The following articles discuss both intentions and accidents through emphasis on careful crafting as well as spontaneous pursuits in design and architecture.

Digital environments are another world with its own logic, emotions, intentions and accidents. We often describe digital technology as an extension of the analog world. In fact, I feel it is closer to being a mirror or a lens that effectively shows us aspects of our creativity, new to our eyes but familiar to us in the ways we are and think. This brings the need for explorations, as we search for hidden possibilities and patterns. The explorative component becomes a central feature of digital design methodology. As a result, digital environments are no longer hideouts for narrowly focused aficionados, but comfortable places for wonderers, artists and dreamers. Words by Tara White crystallize this point: "I was eager to gain experience with digital tools, and interested in exploring the possibilities uniquely afforded by designing in a digital environment (…). I dove with what I hoped would be the kind of clueless-ness that can occasionally lead to unorthodox discoveries."

Digital design, as seen on the following pages, is no longer a discipline with a single visual signature redefining what is visually real, but rather branches into a myriad of visual languages, intellectual pursuits and experiential tones. The frames that used to define digital creativities, even a decade ago, are constantly being re-framed. This can be seen in projects by Bennett Neiman's and Lara Guerra's students, which introduce elements of visual poetics into digital representation and spatial narration. Also, Bennett Neiman and Thomas Fowler explore digital implications of the Space Time Modulator engaging light as a critical form-space maker.

Accordingly, essays in this compilation were divided into four subject categories, directing the reader's attention to various thematic readings. This division reflects the ever-growing richness and diversity of digitally created content. However, any categorization is a simplified convention that provides artificial boundaries. The included projects cover broad conceptual, visual and educational themes. While each paper is internally consistent and coherent, they often cross established boundaries and venture into the unknown.

While the focus of the work in this journal is of a digital nature, the discussed examples are not exclusively framed by it. Individual projects follow their own destinies, often crossing into the analog world of hand-made objects, to reemerge as digital-scapes. These are not the lost wonderers, but rather conscious designers that are able to combine design opportunities that exist in both analog and digital environments. Asterios Agkathidis calls those analog adventures pre-tectonic models that become "spatial prototypes, which then function as abstract machines for architectonic and design solutions." Similarly, David Matthews purses design methodologies that integrate digital and analog objects. Tim Castillo and Chen-Cheng Chen discuss how digital fabrication changes the relationship between digital and physical models. Brad Jirka's students explore the spatial possibilities of digitally generated forms and transform them into elegant physical sculptures. Naomi Crellin relates traditional woodworking to digital design production methods.

While the above essays are great examples of combining traditional (analog) and digital media, there are also strong contributions from authors who charter towards the ever-expanding horizon of digital design. Modris Dobelis and his students explore the spatial implications of three-dimensional fractals. Articles by Kostas Terzidis and Maher El-Khaldi discuss script programming based design pursuing purely computational designs, (not computerized as Terzidis defines them). Thomas Rusher, in addition to myself, addresses other architectural formal aspects in search of dynamic, evolving, perhaps intelligent design agents' based forms. Along similar lines, Robert Trempe sees architecture as a four-dimensional construct, which employs time as a means of articulation.

On the design practice forefronts, Tina Sarawgi and her students test applications of digital tools in professional practice with focus on material and light explorations. Thomas Seebohm's and John Cirka's students use digital tools to discuss the design of structural details. Zachary Meade pursues design challenges and possibilities in the context of a zero-gravity environment.

This broader application of creative digital tools, presented in this compilation of essays, results from a new generation of designers as well as the intuitive ways software programs are implemented. However, the intuitive and creative capacity of software is a quality that has to be earned through a close dialog between the toolmakers and tool users. The Joint Study Program is a critical initiative that facilitates this dialogue and this journal is its physical manifestation.

This Joint Study Program is a unique stage where we can see a consecutive development of ideas, track and compare teaching methodologies, as well as witness the emergence of young artists like Dan Tesene. Once a winner of the **form•Z** Award, Dan is back on the digital scene discussing his recent art. All this would not be possible, without the continued effort of the AutoDesSys team, especially Chris Yessios who is committed to pursuing a critical dialogue between the tools users and toolmakers.

I would like to thank all participants who either critiqued or shared digital narratives.

Andrzej Zarzycki
Guest Editor

2006-2007 Joint Study Award Winners

One of the traditions the **form•Z** Joint Study Program has established is the annual awards presented to deserving students for their exceptional work. This year 6 awards of distinction and 8 honorable mentions were granted. They are in 6 categories and they are displayed on the next 13 pages of this journal.

The Jury

The selection of the awards was made by four jurors outside of AutoDesSys, all experts or theorists of computer aided design. They are listed below, in alphabetical order.

- **Ruth M. Gless**, AIA, Principal, Lincoln Street Studio, Columbus, Ohio
- **John Staerk Hansen**, MikroGraph, as, Abyhoj, Denmark
- **Gregory McCambley**, Technical Illustrator and Graphic Designer, President, Pelican Graphic Limited, Calgary, Alberta, Canada
- **Mahesh Senagala**, Associate Dean for Academic Affairs and Research, College of Architecture, University of Texas, San Antonio, Texas

The Process

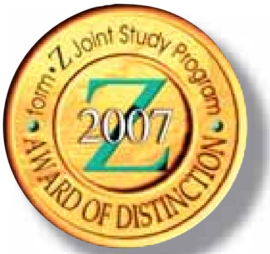
The nominated projects were sent to the jurors as Acrobat documents on DVDs. Names and school affiliations were not included. The jurors returned their selections for the awards and grades (0 to 10) for each of the other projects. Selection of a project for an award was considered equivalent to a grade of 15. The grades were averaged and the project from each category receiving the highest grade was selected for the award. Projects receiving a score of at least 8.5 were selected for the honorable mentions.

The Prizes

All Awards of Distinction received a **form•Z RenderZone Plus** license with one year technical support and updates. They were also invited, expenses paid, to attend ACADIA 2007, where the awards were officially announced. In addition, AutoDesSys, Inc. waved the costs of a 10-seat JS license for the school they attend, for next academic year. Honorable Mentions received one year licenses and diplomas acknowledging their distinction. This year's happy award winners that attended Acadia are pictured below:

From left to right are: **Arturo Nunez**, Award of Distinction in Fabrication, University of New Mexico; **Pawel Ostrokowski**, Award of Distinction in Visualization and Illustration, Temple University; **Julie Barghout**, Award of Distinction in Interior Design, University of North Carolina at Greensboro; **Juan Calderón**, Award of Distinction in Architecture Design, Universidad San Francisco de Quito; **Ming-Chieh Chen**, Award of Distinction in Product and Industrial Design, Tamkang University; **Bridget Hyde**, Honorable Mention in Animation, Ohio University; **Natalie Dibenedetto**, Award of Distinction in Animation, Ohio University.

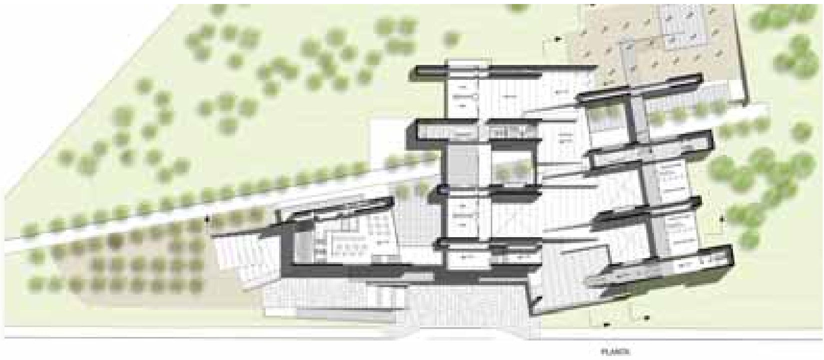
Architectural Design



"Ocho Muros"

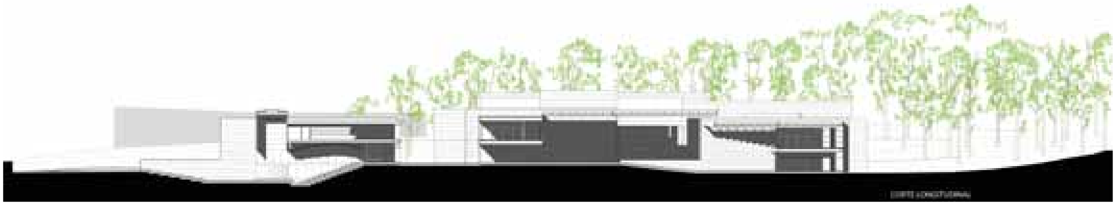
Juan Calderón : Fifth year, Thesis
Advisor/Principal Investigator: **Marcelo Banderas/ Marco Villegas/ Jose Atiaga**

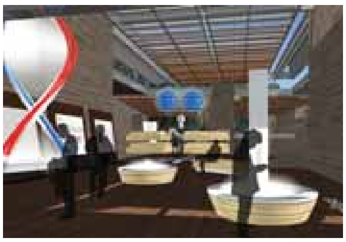
Colegio de Arquitectura y Diseño
Universidad San Francisco de Quito, Ecuador



Summary description of project:

Ocho Muros (Eight Walls) is an architectural design project for an interactive museum in the Metropolitan Park at Quito. The investigation begins by setting a theoretical background based upon the notion of active learning and its possible implications in Architecture. Next, it analyzes the main programmatic and contextual conditions that will be considered during the process of design. Once these initial decisions are taken, it is possible to state a hypothesis and to establish a 'parti' for the project.





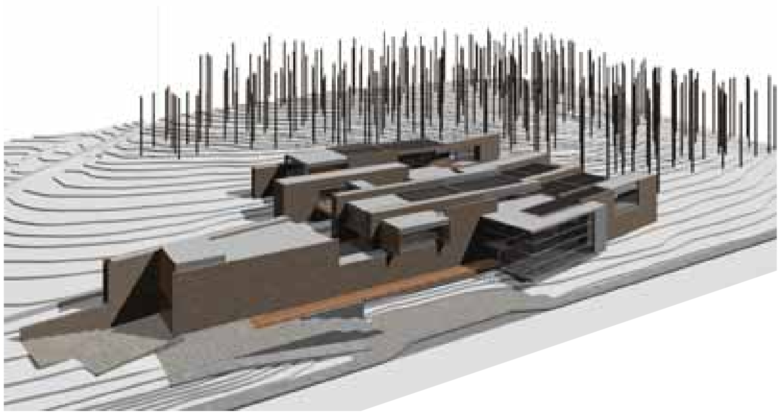
Reasons for the nomination:

In addition to the architectural resolution of the project, and its urban qualities, the design process emphasized the use of **form•Z** to test and visualize several design decisions. Although the final renderings express a clear control over **form•Z**, the software was constantly used in the process.

Jury comments:

Ocho Muros is a deceptively simple project with fascinating spatial complexity. Through an intelligent amalgamation of gently skewed and interlocked cuboidal spaces and contextual considerations, the project frames poetic spatial experiences. Effective use of digital media has been demonstrated in the sensuous portrayal of materiality, movement, light, and scale. Moreover, the project seems to successfully engage the site in a matrix of relationships at all levels. The project demonstrates that formal exuberance is not a necessary attribute to achieve spatial and experiential complexity. **–Mahesh Senagala**

A convincing exploration of a simple idea turns this project into an inspiring visual experience. **–John S. Hansen**



Architectural Design

"A Satellite Automobile Production Facility"

Jeff Hammerquist

Advisor/Principal Investigator: **Thomas Fowler, IV**

Department of Architecture

California Polytechnic State University, San Luis Obispo, California

Summary description of project:

The satellite auto facility was designed to showcase and expose the production process of a 21st Century car. By focusing an audience on these transformations, it will help them quantify the volume of resources that go into the fabrication of a car. The formal vocabulary of the project evolved from an honest expression of programmatic requirements for car production, site considerations, and how to best express this in the structure and skin of building.

Reasons for the nomination:

Even though this student's use of **form•Z** was from two years ago, he did an excellent job using the software to provide spatial insights into his project that would have not been possible if he would have worked only with physical models. What I believe is most impressive about his project in the convincing qualities to the immersive views of space and the believability regarding the functional aspects of project along with the seamless integration of building into the context of the surrounding industrial environment of the site.

Jury comments:

The notion of transparency has been explored in this project in an intriguing fashion. Transparency in this project goes beyond the merely visual and embraces the conceptual, the procedural, and the programmatic aspects. Deep layering, spatial interlocking, and a commitment to restrained architectural dialectic make this project a compelling proposition. The project is driven primarily by a combination of programmatic concerns that aim to expose the process of production of the automobile "in the skin." **form•Z** seems to have been utilized quite effectively. The animation drives the designer's point home by revealing the inner spatial and programmatic complexity. **–Mahesh Senagala**

Architectural Design

"A Zero-Gravity Habitat"

Zachary Meade : Graduate, Thesis
Advisor/Principal Investigator: **Kurt Hunker/ Gil Cooke**

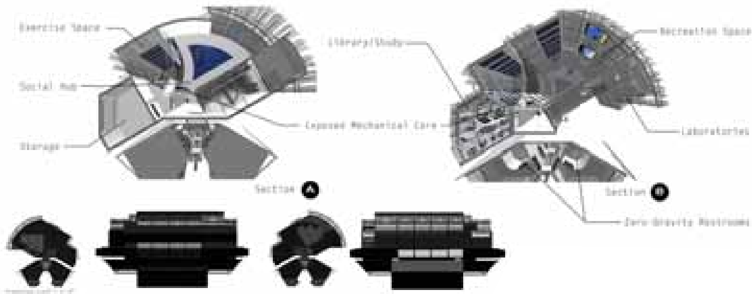
Department of Architecture
New School of Architecture and Design, San Diego, California

Summary description of project:

The project is a conceptual 20-person habitat that orbits the Earth. The design merges realistic limitations and conceptual ideals in order to produce an attainable organizational strategy. The form of the habitat is based on the shielding and filtering of light, the implementation of structure, and the projectile movement of users as they maneuver through the environment. The design process began with many physical experiments, drawings, and models. The final design was produced entirely in **form•Z**. This allowed for a thorough design analysis of the interiors of the habitat, as well as the creation of details such as furnishings, lighting fixtures, and structural members. Interior renderings explore the actual dimensions and quality of the habitat. The integration of background imagery allowed for the illustration of view corridors. The habitat is one of many possible design strategies of this type that may be explored. It successfully illustrates that realistic concepts for zero-gravity spaces are within reach.

Reasons for the nomination:

This project is an outstanding introduction for architects in a field hitherto yielded to engineers and industrial designers. The execution was superior in every area in the eyes of the faculty and exterior reviewers. The project could not have been fully appreciated were it not for the outstanding computer modeling in **form•Z**. This proved the right program to delineate the very complex elements that created both the total imagery and details required to "tell the story" of a rich and artful thesis.



Jury comments:

The project premise is utterly captivating. The notion of architecture without gravity, and as the designer proposes, without technological or logistical limitations, would have been very interesting. However, despite the claims made in the project narrative and nomination statements, the project falls short on some accounts. The notion that there is an "ideal case" without limitations of any sort other than the absence of gravity would have been interesting if the designer took a Stanley Kubrik-esque stance. There can be no architecture without constraints. Choosing the right set of constraints would have led to a better design project.. **–Mahesh Senagala**

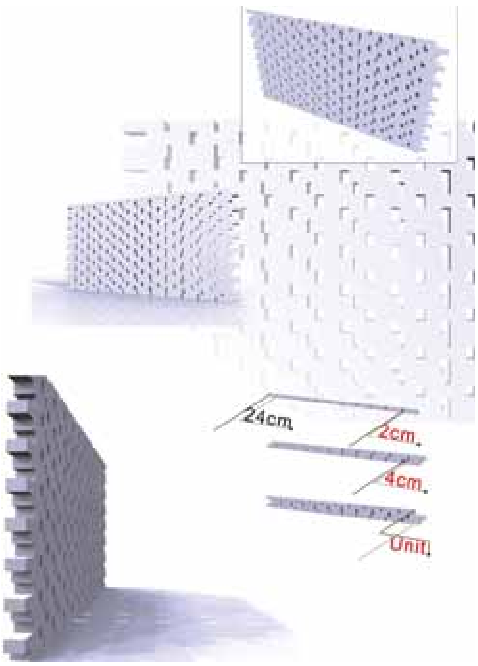
A thoroughly detailed design—well thought out, and beautifully presented. **–Ruth Gless**

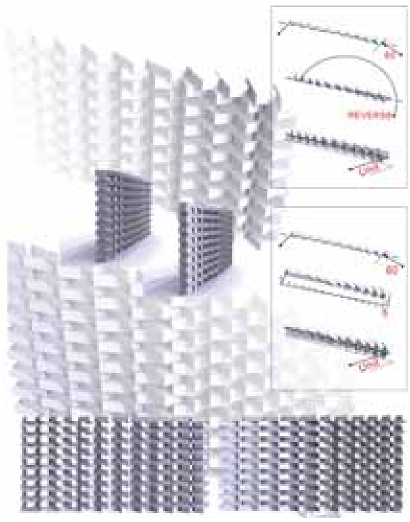
Architectural Design

"A Study of Brick Walls"

Ching-Hang Lee : Graduate, Thesis
Advisor/Principal Investigator: **Chen-Cheng Chen**

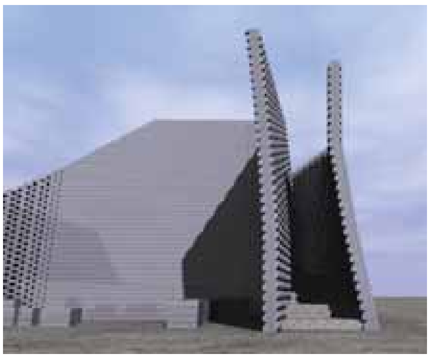
Department of Architecture
Tamkang University, Tanshui, Taiwan

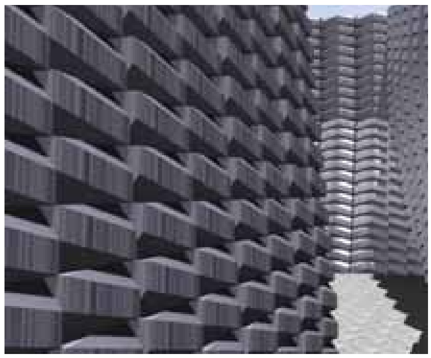




Summary description of project:

This student studies different possibilities for laying brick walls, which use methods other than plain texture mapping. The actual methods explored and discussed are based on the geometry or physical shape of bricks and the different ways in which they can be laid out and picked. These explorations produced some very interesting results. At the end of the project, these brick pavilions are designed near the ocean. They function as places from where one can observe the rain, the ocean, and the sky.





Reasons for the nomination:

Instead of applying texture mapping to describe brick walls, this project inserts the brick element one by one in the **form•Z** environment. Through simple manipulations on geometries and transformations, this project produces interesting patterns for brick walls.

Jury comments:

Here we see the intrinsic role of digital media in exploring what is essentially a shape grammar approach. Clearly, the explorations would have been onerous or downright dangerous if done with the actual bricks. Thus, the use of digital medium to conceptualize, develop, and concretize a material-based exploration is indispensable. The project pitches a plausible design proposition if we set aside the questions of structural stability, robustness of the system and the system of actual construction with or without mortar joints. I would have liked to see the project actually built either in a model form or as a proof-of-concept construction. It appears that the designer onerously built the digital models literally brick-by-brick, row-by-row, and operation-by-operation, which is ironic! A truly computational and algorithmic approach would have allowed the designer to generate and test far more number and types of possibilities.
–Mahesh Senagala

Interior Design

"Mullen Advertising Agency"

Julie Barghout : Fourth year, Interior Architecture III
Advisor/Principal Investigator: **Tina Sarawgi**

Department of Interior Architecture
University of North Carolina at Greensboro, North Carolina

Summary description of project:

Project Outline: The task of this project was to design a workplace environment for Mullen Advertising Agency that would reflect its core values and principles, encourage creativity and teamwork, and be impressive to its clients and visitors. The project involved designing workspaces for the five distinct areas in an ad agency, namely, the creative department, account services, media, accounting and human resources. Other spaces included reception, waiting area, large and small conference rooms, team rooms, media library, edit room and tape storage and mail/ copy/ print rooms.

Student's conceptual statement: As an advertising agency, Mullen's key role is to 'see' (observe) and create a visual identity for its clients. The inspiration for the design evolved from the desire to reverse the role of Mullen from 'seeing' to 'be seen', hence challenging the conventional notions of a commercial workspace environment. The proposed space puts the Mullen facility on display by enclosing all the departments in Mullen in a glass 'box', thus providing opportunities to the prospective clients, employees, and visitors to see and visually experience Mullen and all its unique qualities.

Reasons for the nomination:

This student's project is noteworthy due to the following reasons:

1. The project is conceptually strong and thought-provoking.
2. **form•Z** has been used convincingly to express the underlying design elements.
3. The project is thorough in its exploration of light, materials and colors.

Jury comments:

The project undoubtedly demonstrates the designer's mastery of the rendering medium. However, I am unsure if the digital medium played any significant role in the design of the space itself. The drawings that accompany the renderings show a more or less cookie-cutter approach to design that is driven more by two-dimensional design-thinking. **–Mahesh Senagala**

Excellent use of color, reflection and viewpoints to present a realistic, well informed concept to the client. All the design information required to deliver a solid presentation. **–Gregory McCambley**

An impressive total design of a workspace for creative professionals and an inspiring showroom for clients and prospects. Provoking in colors and forms, but on the right side of the edge to chaos. **–John S. Hansen**

Interior Design

"Escher's Relativity"

Sophia Chan : Graduate
Advisor/Principal Investigator: **Andrzej Zarzycki**

Department of Interior Architecture
Rhode Island School of Design, Providence, Rhode Island

Summary description of project:

The inspiration for the project was to take Escher's two-dimensional etching, "Relativity." My goal was to generate a three-dimensional space reminiscent of the limitless quality of Escher's spaces. I started by extrapolating measurements from the graphics to calculate the size of the interior space and then constructed the tectonic elements and generated the three gravities of the space. Consequently I constructed the space with realistic dimensions and applied materials to create the photorealistic environment. I then investigated the interior relationships between the gravitational orientations of the space and explored the connections between the building elements by rendering a series of light studies. Finally, I explored the seemingly impossible aspects of this space through animations and narrative tools.

Jury comments:

At first blush, the interior exploration based on Escher's etchings looks simplistic. However, the challenge of translating a masterly two-dimensional world into a measurable three-dimensional one is daunting at the least. Although the renderings do not even approach the visual and intellectual mastery of Escher's works, they are interesting enough to draw the viewer into the designer's mind. A commendable effort!
–Mahesh Senagala

Reasons for the nomination:

Some designs may look complex and imaginative (involving NURB surfaces, morphed objects or metaball **form•Z**), however, their appeal is often based on visual novelty rather than on intellectual innovation. In contrast, there are other designs that look relatively straightforward but contain sophisticated ideas that are intellectually persistent. I propose that the visual space of the Escher's Relativity etching is an example of this: a simple but expressive design. This student in the Interior Architecture Department, undertook the challenge of delineating it in three dimensions. She was able not only to produce a three-dimensional model for the space, but also used various narration techniques to successfully express through her imagery and animations the main theme in Escher's etching: relativity. She took her explorations a step further and explored what is outside Escher's Space. Her imagery visually speaks for itself…

Interior Design

"Vernissage: A Guide to the Culinary Avant-Garde"

Katie Longenecker
Advisor/Principal Investigator: **Murali Paranandi**

Department of Architecture and Interior Design
Miami University, Oxford, Ohio

Summary description of project:

Vernissage is a magazine publication for the culinary avant-garde, each month showcasing the latest and greatest chef from around the world. In addition to highlighting this selected chef in each new issue, the company invites the chef to come and showcase his work in a specially designed culinary exhibition space.

Situated in the center of the United States greatest culinary hub, San Francisco, the design program consists of the company's studio headquarters on the upper floors and below, a restaurant exhibition space open to the public. To emphasize the idea of cuisine presented as an exhibition in the same way as artwork, individual structures are designed to convey three different interpretations of a "frame." The design of the main staircase exaggerates a perspective frame, the show kitchen is displayed through a picture frame, and the office is developed through a flexible frame and panel system for the evolving working space. The restaurant features space for traditional dining with an open show kitchen, as well as tasting galleries featuring bars of appetizers, desserts, and wine and cheese. As one way to connect all six floors of the program, natural light filters down from a skylight on the top floor all the way to the ground level to highlight a vertical cable system running the entire length of the building. Colorful cupboards and shelves move along the cable system as functional artwork that can be visible from all locations within the space.

Jury comments:

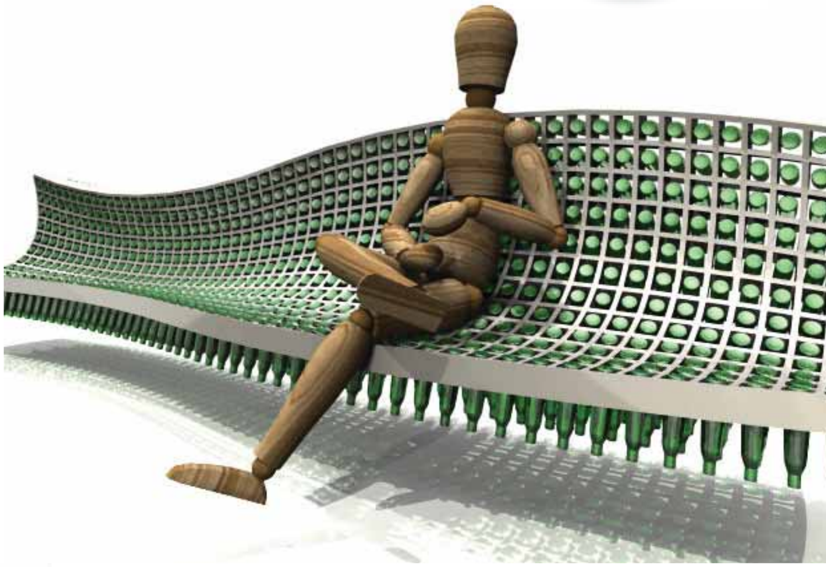
A thorough design—the author created a tension between hand and machine drawing. **–Ruth Gless**

Product and Industrial Design

"Benches for the Plazas of Tanshui"

Ming-Chieh Chen : Graduate, Studio
Advisor/Principal Investigator: **Chen-Cheng Chen**

Department of Architecture
Tamkang University, Tanshui, Taiwan

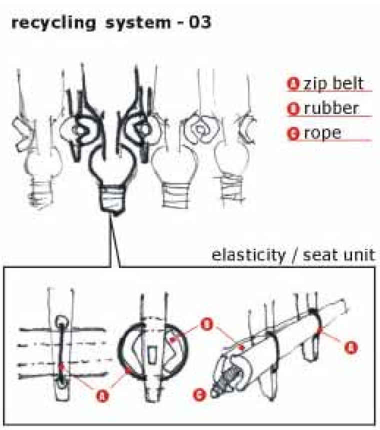


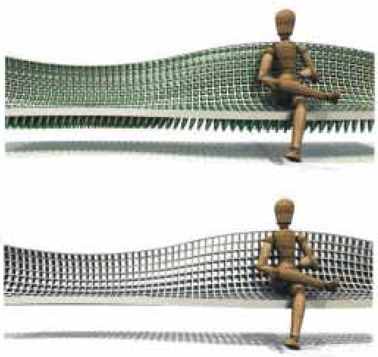
Summary description of project:

After on site observations, street lamps and benches are designed. They are intended for tourists to place the bottles of the famous Tanshui soda water, which results in interesting street furniture for the plazas of the town.

Reasons for the nomination:

In this project, the designer deliberates very carefully about which **form•Z** commands would best accommodate the different modeling requirements. After the bench is modeled in the software, part of it is also fabricated in one-to-one scale.



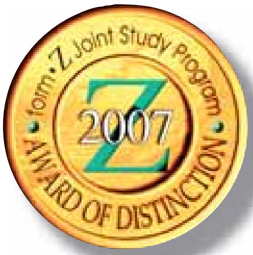


Jury comments:

The designer's passion to elevate the soda bottles of Tanshui to the level of art is commendable. The main idea of a bench for tourists is an intriguing one, albeit underdeveloped. It is a plausible idea. If we ignore the fact that as presented, the bench seems to defy gravity and float in the air, the modeling skills have been well-demonstrated. **–Mahesh Senagala**

A well-considered use of seating and soda water bottles, combined with the extended use of **form•Z** to generate a unique and innovative design. **–Gregory McCambley**

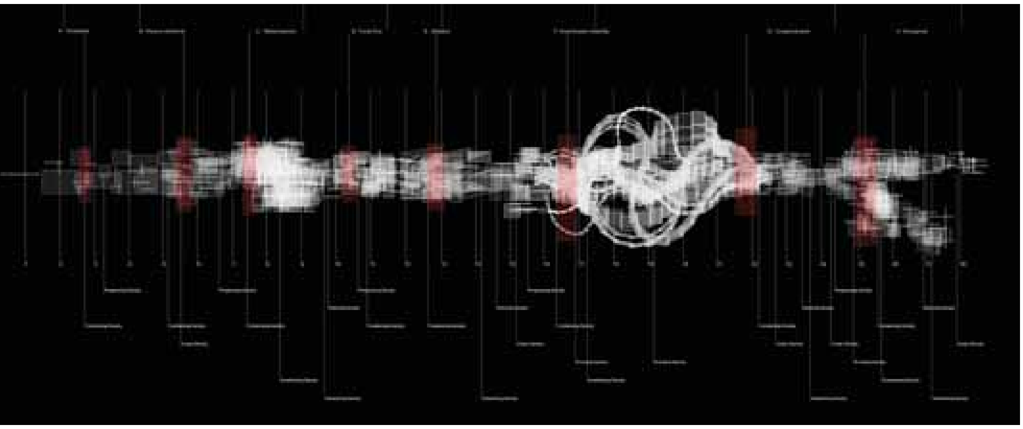
Quirky—universal yet local in its ties to place and products. **–Ruth Gless**



"Investigations"

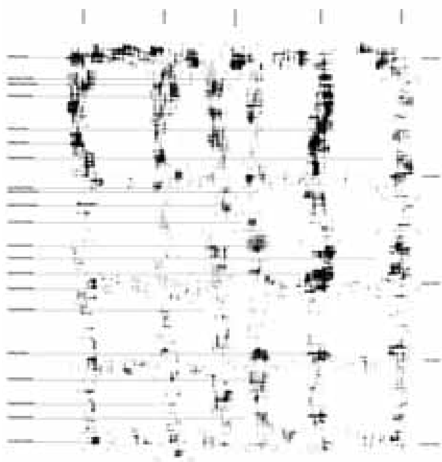
Pawel Ostrokowski : Digital Media
Advisor/Principal Investigator: **Robert Trempe**

Department of Architecture
Temple University, Philadelphia, Pennsylvania



Summary description of project:

Treating the computer as a tool for exploration and investigation, students were able to take seemingly abstract systems developed around the idea of an event (the accumulation of instances) and dissect/analyze them. Through this analysis students took part in the evolution of a basic idea from initial investigation through to final site intervention, deploying digital media techniques coupled with formal, scalar physical models and digital composites that forced students to test these results in more architectural terms throughout every step of the process.



Jury comments:

A truly genuine effort to exploit digital media's capability to synthesize myriad formal "notations" is commendable. The result of the qualitative mapping is a visual feast. Though it is unclear how these explorations translated into the architectural project shown in the photo montages, I am impressed enough by the conceptual explorations and their visual presentation. **–Mahesh Senagala**

Nice use of analysis and concept evolution to deliver the site model. **–Gregory McCambley**

Three investigations of communicating a new perception of time and space. **–John S. Hansen**

Visualization and Illustration

"Spaceport" (for Spaceport America, Virgin Galactic)

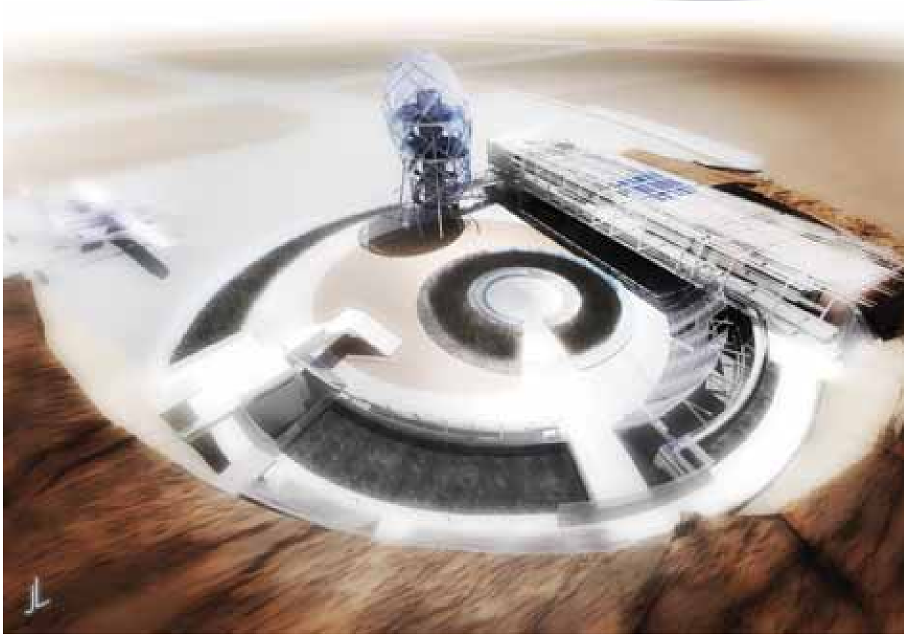
Jonathan Lim : Third year, Cooperative Education Program
Advisor/Principal Investigator: **Gensler and Associates/ Thomas Seebohm**

School of Architecture
University of Waterloo, Ontario, Canada

Summary description of project:

The intent of the design was to create a "heroes journey" through the New Mexican desert as the future of space travel provides the public with a chance to take off into space. The renderings map the points of arrivals and gathering spaces for both tourists, and potential space travelers. The circulation of the design was designed for multiple users (the astronaut, the tourist, the administrator). The whole circulation of the design was based on our story of the "heroes journey," and at the end of the whole journey, the circulation ends at the OASIS, the space where history will be made as the first public space travelers take off into orbit.

The 3D modeling process included the use of REVIT plans (massings). From there, details were added in **form•Z** using mainly box modeling techniques while Nurbz were seldom used except for the cloud like mission control structure. The fence like structure around the Oasis space was also a nurbz surface formed with thickness and through texture mapping in Max, it became the mesh that it is presented on the renderings. For some details for the cloud structure, Maya was also used. 3D Studio Max's FFD modifier helped with the details of the curtain wall as we modeled a flat version of the curtain wall for the cloud in **form•Z**, and using the FFD modifier, we were able to shape the details along the same curvature of the cloud shape. The student was working on both the design and the modeling part of this project, which was designed completely in 3D, with one or two sketching sessions.



Jury comments:

The renderings have ethereal and other worldly quality to them, which is very apt.
–Mahesh Senagala

A sumptuous presentation—very beautiful, and the images created support the design.
–Ruth Gless

Reasons for the nomination:

At our school, all students are enrolled in a cooperative education program where students alternate terms of study and work in offices, which is considered an integral part of their education. This project was done on a work term. While it benefited from the professional input of the office and their consultants, the project would not be what it is without the student's contribution to design, modeling, and rendering. It is a stunning project both in terms of the evocative geometric configuration and in terms of the renderings; both are very appropriate allusions to space travel.

Fabrication

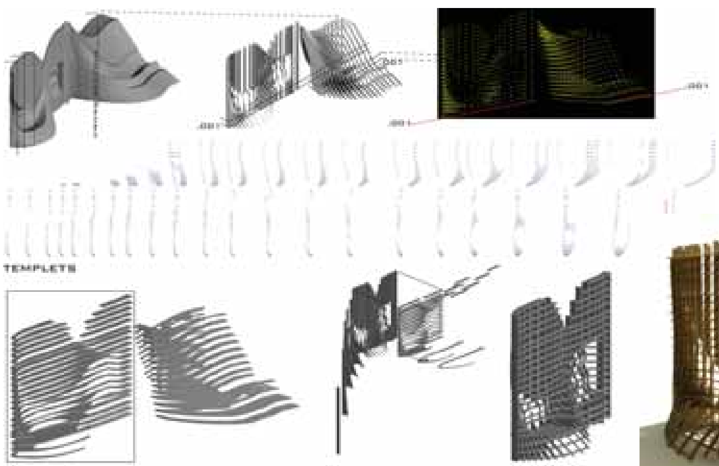
“Modulation+Mutations II”

Arturo Nunez : Fourth year, Architectural Studio
Advisor/Principal Investigator: **Tim B. Castillo**

School of Architecture and Planning
University of New Mexico, Albuquerque, New Mexico

Summary description of project:

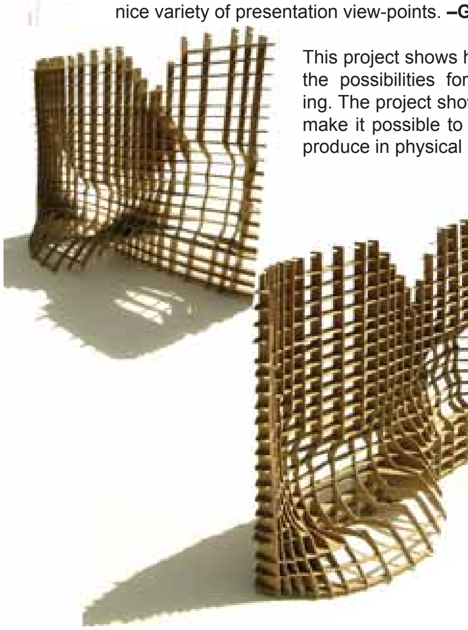
The exponential growth of digital information and continual expansion of new technologies has had a profound effect on the manner by which architects create space. Designers are now incorporating new methodologies that borrow from the automotive, aeronautical and cinematic professions. This multidisciplinary approach is challenging the traditional approach to the practice of architecture. As a result, a new studio environment must be established to enable young designers to engage in these new processes. This studio will aim to explore this continuingly evolving condition where extraction of space is no longer statically derived. It will rather define a more interactive model that is based on social forces defined through contextual specificity.



Jury comments:

Fabrication of complexly-curved surfaces into ribbed three-dimensional objects has been an established and well-explored process by now. The project would have been more interesting if it went into a greater detail and field testing. **–Mahesh Senagala**

Enjoyed the use of negative space and structure to evolve this unique and well derived design form. Excellent visualization of concept in a nice variety of presentation view-points. **–Gregory McCambley**



This project shows how little we have exploited the possibilities for furniture and room-making. The project shows how the electronic tools make it possible to test ideas that are hard to produce in physical models. **–John S. Hansen**

The clarity of thought is apparent, both in the use of fabrication techniques and in the development of the design.
–Ruth Gless

Reasons for the nomination:

This project researched new ergonomic possibilities based on cross-programmed spaces associated with furniture and dwelling. The wall is intended as a living element that engages a multiplicity of programmatic activities. The student’s ability to economically create a wall that utilized digital fabrication process allowed for a unique and poetic structure to be realized.

Fabrication

"Duke City Shootout Film Festival Insomnia Space"

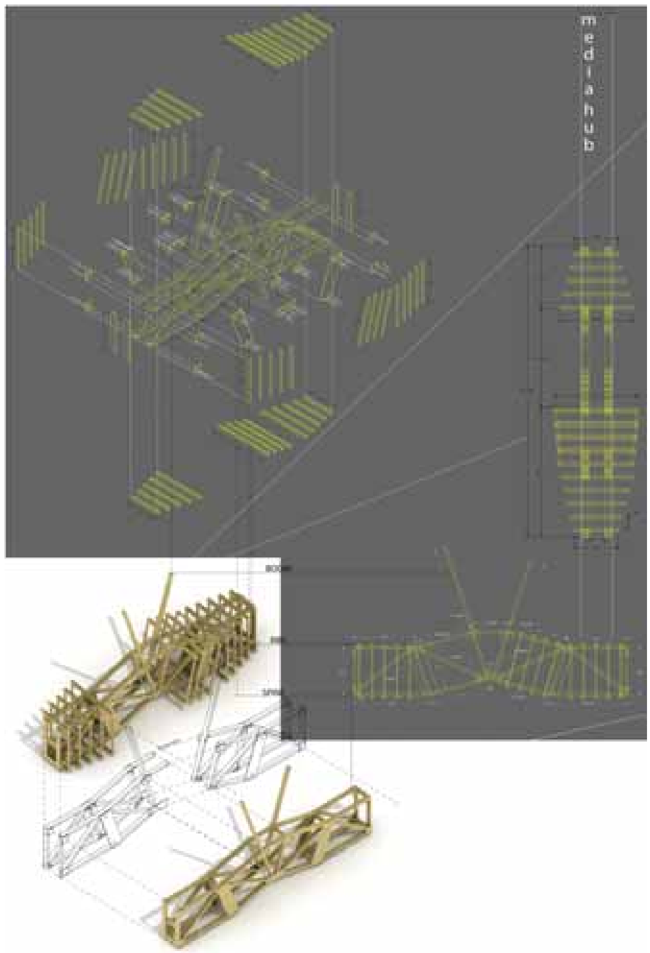
Jake Semler, Arturo Nunez, Alberto Rodriquez
: Fourth year, Architectural Studio
Advisor/Principal Investigator: **Tim B. Castillo**

School of Architecture and Planning
University of New Mexico, Albuquerque, New Mexico

Summary description of project:

This spring, the 400-level studio was given the opportunity to design the interior space for the Duke City Shootout International Film Festival. The studio was given a program that would accommodate spaces for digital editing, cyber dwelling, coffee/bar space and exhibit space.

The challenge of this project was to keep it within a very slim budget. Innovative uses of space and the use of inexpensive materials were the primary goals of the studio. The studio format was a competition and the winners fabricated the installation this July.

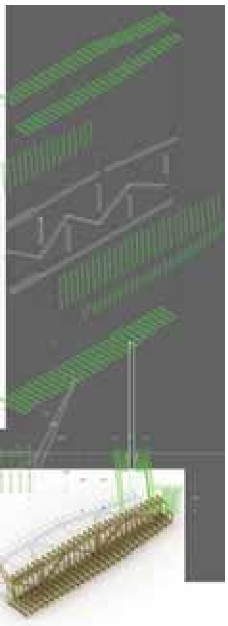


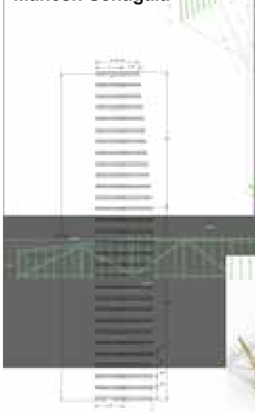
Reasons for the nomination:

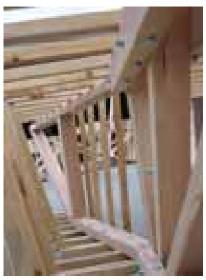
This project deserves recognition in that it utilized digital fabrication processes to develop an innovative formal and structural language. This project deviates from recent surface/pattern driven methodologies and focused on structural innovation as the basis for its aesthetic. The creative use of material and economy of form provided a compelling spatial environment at full-scale.

Jury comments:

Clearly, digital media have been used all through the process, but it is not clear what impact the digital process has had on the project outcome.
–Mahesh Senagala







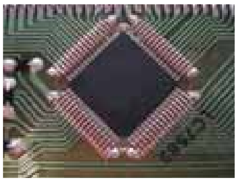
Animation

“Creating by Destructing”

Natalie Dibenedetto : Second year, Environmental Design
Advisor/Principal Investigator: **David Matthews**

Department of Interior Architecture
Ohio University, Athens, Ohio





Jury comments:

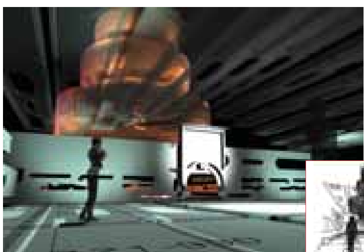
Not only communicating the ideas of the creator, but inspiring and educating the viewer in a total audio-visual performance! Great! **–John S. Hansen**

Animation

“The Spaces within”

Bridget Hyde : Second year, Environmental Design
Advisor/Principal Investigator: **David Matthews**

Department of Interior Architecture
Ohio University, Athens, Ohio

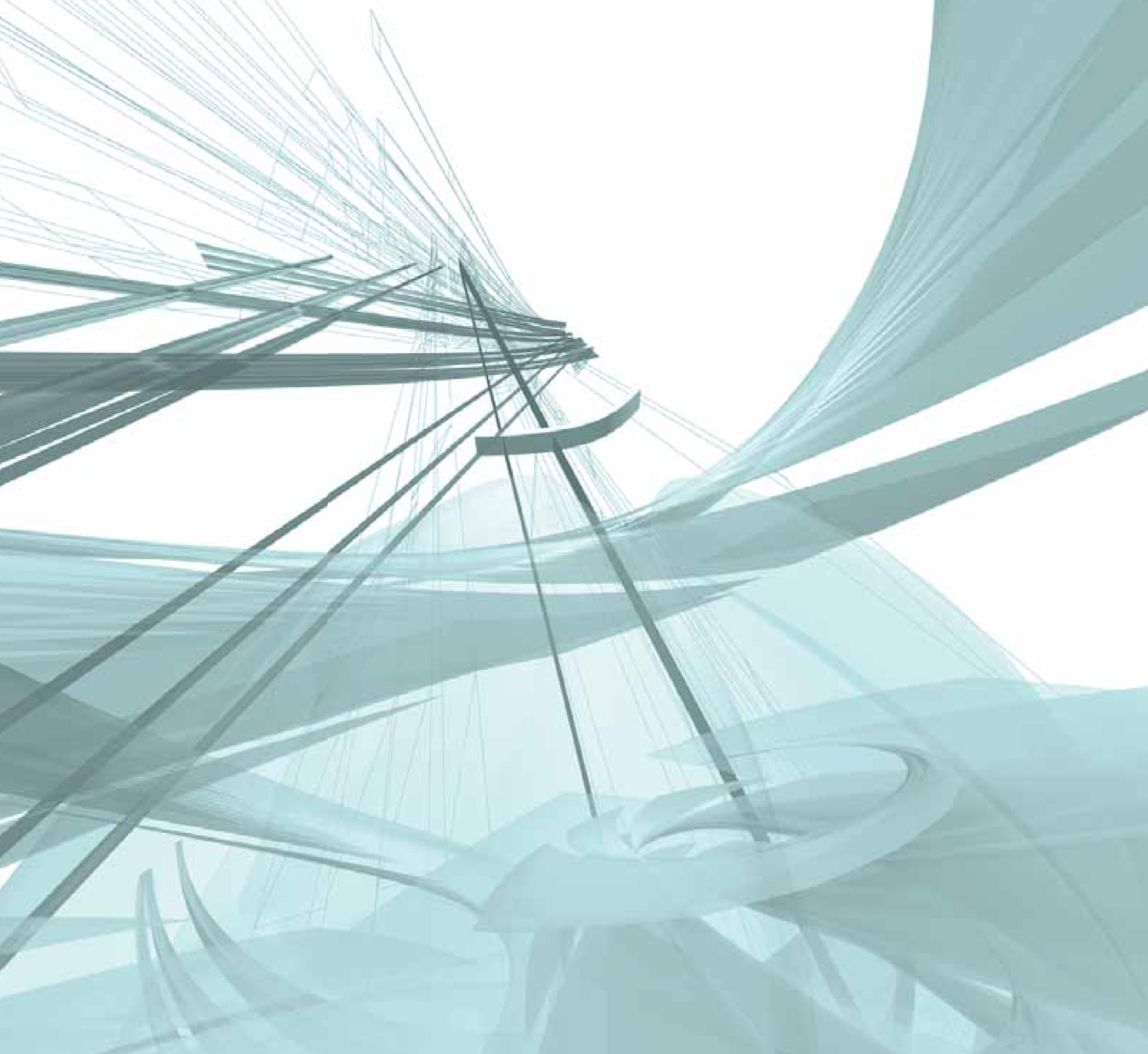




Jury comments:

Liked the transitions from sketch to **form•Z** animation, allowing the viewer to see the concept in its raw forms to rendered design. The music hit the right tone (not overwhelming the visual) and the visuals were well timed to the music and evolution of the concept. **–Gregory McCambley**

Chapter 1

Poetics of Computers and Visual Narratives



Texas Tech University
Lubbock, Texas

Poetics and Digital Tools

by Bennett Neiman

Simultaneous grasp is creative performance-seeing, feeling and thinking in relationship and not as a series of isolated phenomena. It instantaneously integrates and transmutes single elements into a coherent whole. This is valid for physical vision as well as for the abstract.

Moholy-Nagy 1965

The work discussed is from two sources, the first, an architectural studies seminar entitled, *The Poetic Potential of Computers*, and the second, an advanced topical studio entitled, *A Building which Exhibits Itself*. Earlier versions of the methodologies received the AIA Education Honors Award in 1994 and 1998. Over a 20-year period, the general philosophy of the approach has remained constant. Previous works, "Between Digital & Analog Civilizations: The Spatial Manipulation Media Workshop" (Neiman and Bermudez 1997) and "Digital Media and the Language of Vision" (Neiman and Do 1999), discuss at length the poetic aspects of integrating digital tools into design making. This article is an update on recent developments and a visual presentation of the results.

The pedagogy has shifted from an overt analog-digital migration to more of a digital-digital interoperability. The process usually starts in the analog, but it is quickly translated to the digital, where new media objects that are generated in one program are analyzed, broken apart and put back together in unique combinations. This data is freely exported and imported into other programs where throughout the process the data objects are rearranged, manipulated, transcoded and transformed (Manovich 2001).

Attempting to explain every nuance of this method is impossible. It has many beginnings and paths for jump starting and directing students' creativity. The exercises have varied over the years so that it does not become a static formula or dogma. The mystery of the approach is a part of the game of discovery. The crafting of the various design exercises does not in itself guarantee successful results. Continual criticism of student work, using contrast and comparison throughout the process, is a key aspect to this approach. Early phases of the studio or seminar feature a structured set of exercises where specific techniques or media are required. In the later phases, students are free to decide on their own, subject to criticism and questioning, what tools and techniques are best. As new media technologies evolve, other trajectories and combinations are possible. As each new group of students engage the exercises, new ideas and understandings are applied to the pedagogy for future groups. The quality of the tools as well as the teaching and the work itself is advancing. Thus, this is an evolving dynamic process for both the teacher and the students.

Creative Methodologies

For *The Poetic Potential of Computers* design seminar, the initial exercise, an analog space-light-motion box, is constructed according to ideas described in "Vision in Motion" (Moholy-Nagy 1965). Interesting material combinations and ways of creating movement and interchangeability are sought. The design methodology emphasizes experiential and sensorial perception enabling the study of form, space, material, light, shadow, color, transparency, translucency, texture, and motion (Neiman and Do 1999). Using a digital camera or digital video, unexpected images and spatially provocative viewpoints are captured from the space-light-motion box. Out of the many possibilities captured, several unique shots are evaluated according to Moholy-Nagy's eight varieties of photographic vision which are described as abstract, exact, rapid, slow, intensified, penetrative, simultaneous, and distorted seeing (Figures 1-4).

The digital schemas exercise is based on Wassily Kandinsky's analytical drawing methods (Poling 1986). Using vector-based software (Adobe Illustrator) a series of analytical diagrams (orthogonal, rotational, tension, and figural schemata) examine the hidden underlying geometries of selected space-light-motion box captures. In this exercise, the architectonic potential embedded in the schemas is emphasized (Figures 5, 6).

Figure 1: Mary Lopez and Josie Shaw: analog space-light-motion box captures - frozen gravity, tension, elasticity, explosion.

Figure 2: Justin Rice and Darell Westcott: analog space-light-motion box captures - delayed projection; the engagement and interaction within a set environment.

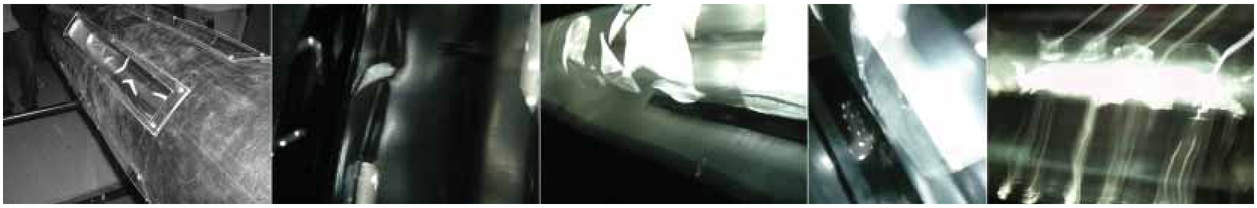


Figure 3: Jeff Nesbit and Filemon Aragon: analog space-light-motion box captures - rotary filtration apparatus.

Figure 4: Sarah Smith and Justin Webb: analog space-light-motion box captures - metal, contort, torque, bind, pull, stress, strain reflected, refracted.

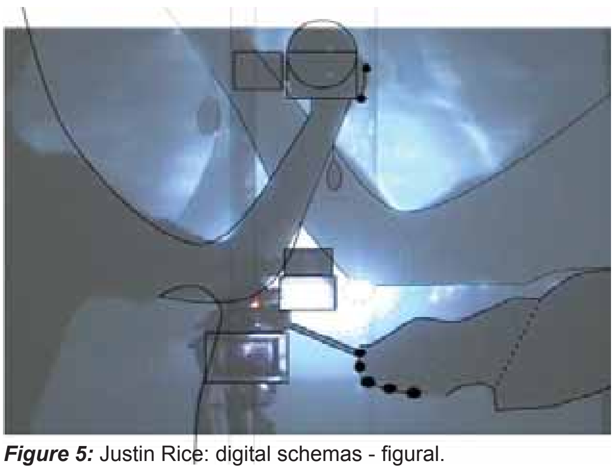


Figure 5: Justin Rice: digital schemas - figural.

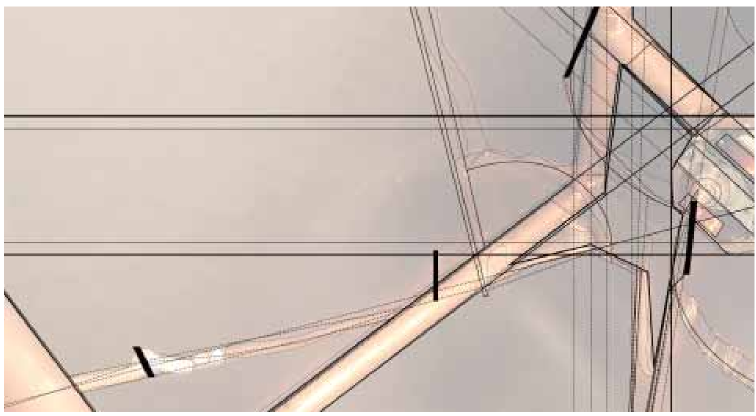
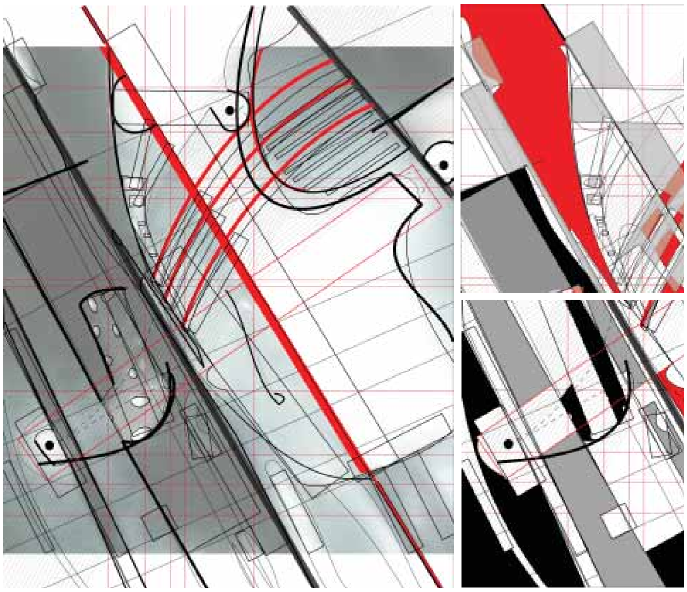


Figure 6: Jack Mussett: digital schemas - combinations of orthogonal, rotational, tension and figural.

Digital templates combine different layers from the source digital schema set. Using Adobe Illustrator's Live Paint operations, selected regions and lines are filled with different colors representing subliminal systems, sometimes metaphoric, other times organizational. Principles derived from the schemas are used as a guide. In this exercise, design is the selective expansion of formal possibilities, through additive and subtractive processes (Figures 7-9).



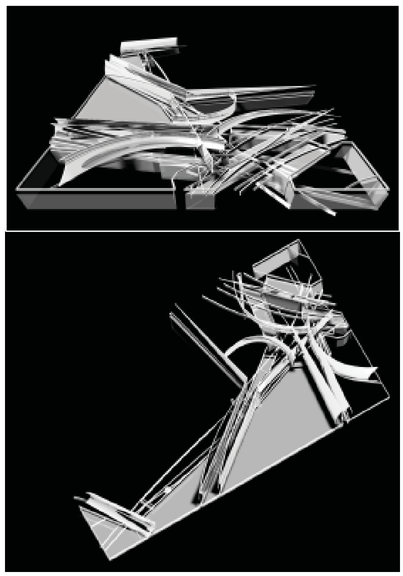
Figures 7, 8, 9: Jeff Nesbit: digital templates; schema layer combinations enhanced with Live Paint.

Using **form•Z**, the flat two-dimensional shapes of the digital schemas and templates are projected into digital relief models consisting of solids, voids, projections, depressions, and deformations of positive and negative space. The diagrams can suggest rotation, tension, compression, warping, bending, or smooth height translations. In this exercise, design is a transitional study between two-dimensional and three-dimensional worlds (Figures 10-13).

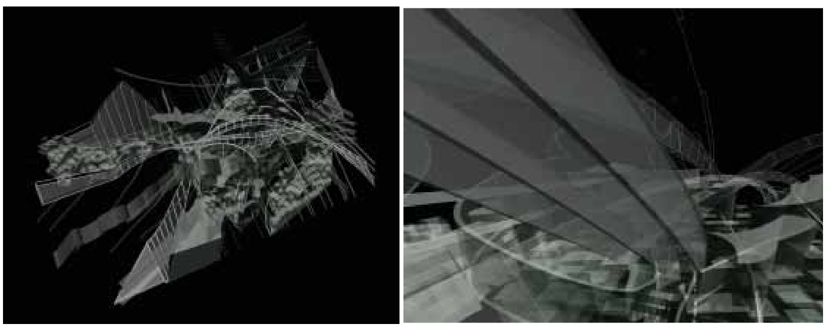
Once three-dimensional digital objects are created, their locations, number, and scale can be reconsidered within **form•Z** space. The digital space modulator consists of duplicated elements and freely arranged combinations of the digital reliefs. In this exercise, design is the interpretive arrangement and composition of objects in three-dimensional space. (Figures 14-17).

Spatially provocative views exploring the sequential possibilities of framing graphic space are discovered and recorded. This is thought of as a spatial narrative from outside to inside to outside. As in the analog space-light-motion box, Moholy-Nagy's eight varieties of photographic vision are applied as a guide. These digital paintings should exude the spirit of the original digital captures with mood, tonality, texture, lighting effects, color, and general organization. For the digital space display, Adobe Photoshop is used to enhance, adjust, crop, reframe, overlay, warp, and distort individual or combined digital paintings. A variety of painterly techniques in Zaha Hadid's work are suggested, such as: color modulations; gradients of dark to light; dissolving objects into their background; x-ray layering; multi-perspective projection, multiple distortions, fragmentation and deformation; magnetic field space; particle space; and continuously distorted space (Schumacher 2004). In this exercise, the relationships between the form, light and space of a constructed spatial fantasy must have a conceptual connection to the originating event (Figures 18-27).

The *Building which Exhibits Itself* studio uses similar techniques as in past and present versions of the *Poetic Potential of Computers* seminar. The project exhibits the self-referential process of making, through the exploitation of

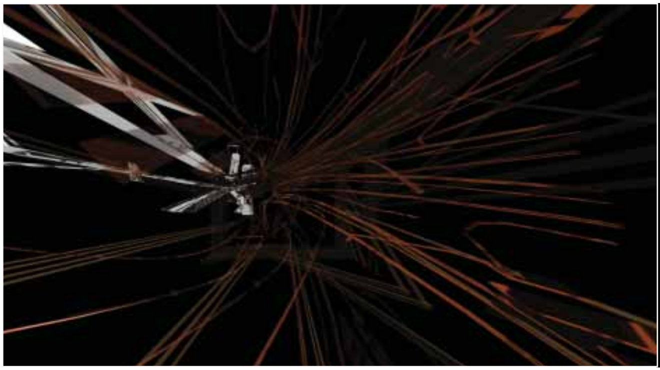


Figures 12, 13: Jack Mussett: digital relief.

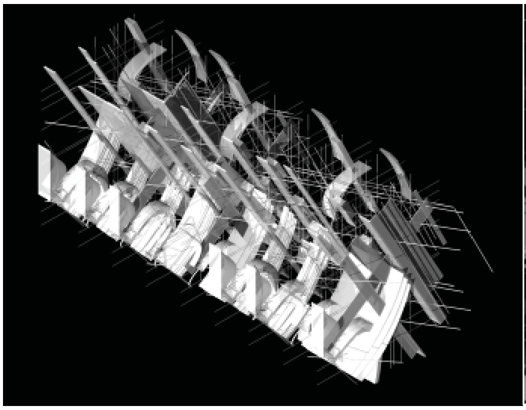


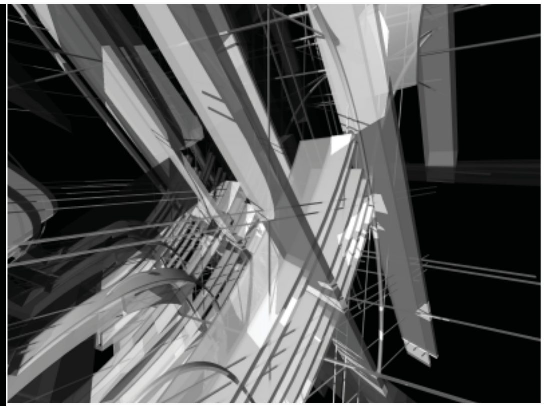
Figures 10, 11: Josie Shaw: digital relief.

Figures 14, 15: Jack Mussett: digital space modulator.



Figures 16, 17: Jeff Nesbit: digital space modulator.



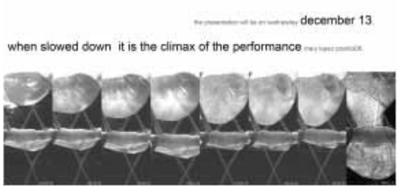


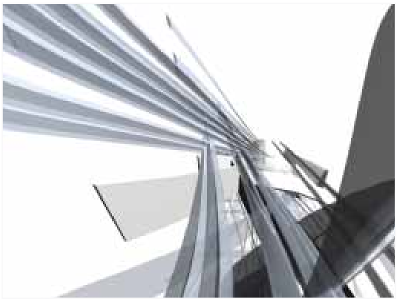
digital design technologies. It is a prototype demonstrating variations of a formal system. The transformations, sequences, variations, and generations are presented as exhibits. Every digital artifact generated during the design process is displayed within the building which exhibits itself.

According to John Hejduk, analysis involves seeing architecture from many different angles "… in this way the complexities and overlays of architectural thought and fact are revealed. The student begins to understand and realize how much really goes into the making of a significant piece of architecture. He dissects the work and reassembles it; …The analysis problem is one of recreation" (Hejduk 1988).

The process begins with an interpretive analysis that juxtaposes a pair of opposing canonical buildings, in this case from Le Corbusier and Mies van der Rohe. The most emblematic or essential plans and sections are selected. The relationship between plan and section reconstructs the idea of each building. Further analysis separates and extracts the architecture into component part systems such as planes, volumes, solids, voids, horizontal, vertical, columns, walls, piers, curved, rounded, angled, etc. These studies are reassembled into layered combinations of the systems. This is followed by a reverse excavation of the drawings, evoking the essence of the spatial order inherent in the original structure. A similar process of excavation or sequential removal of material is conducted on interior and exterior photographs of these buildings. Photographic parts from both buildings are selected, exchanged, and recombined into collage variations. Each collage structure must use an analytic plan and section combination as an underlying constant. Individual collage structures are linked as a five-frame linear sequence. The ordering of the frames as well as the transitions between frames are studied. Speculative transverse sections are cut through this continuous labyrinthian structure. There is an intentional de-familiarization from the original object. The result is a poetic reinterpretation of exemplary architecture (see Figures 28-31).

The analytic processes of abstraction condition the synthetic methods for a six-week architectural building project (in this case, a Steel Museum in Pittsburgh that is made of steel). Critical to the project development is the fluid interoperability between softwares. Of particular interest is the ability to take Adobe Illustrator Live Paint elements directly into **form•Z**, allowing for the rapid generation of multiple 3D prototypes. These experimentations are evaluated and adapted according to the circumstances of site and program. The architectural elements, the site, and the sequences of movement through the building which exhibits itself, are all regarded as exhibits (see Figures 32-44).





Figures 18, 19: Mary Lopez: digital paintings - climax of the performance.

Figure 21: Jack Mussett: digital paintings - indefinite creation mechanism.

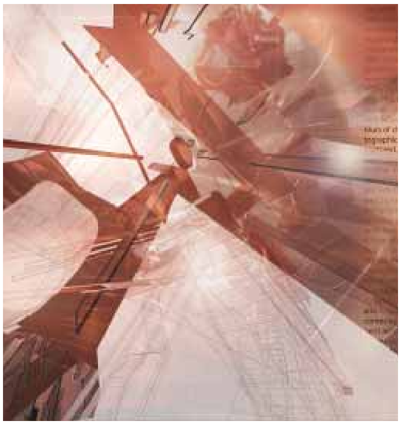
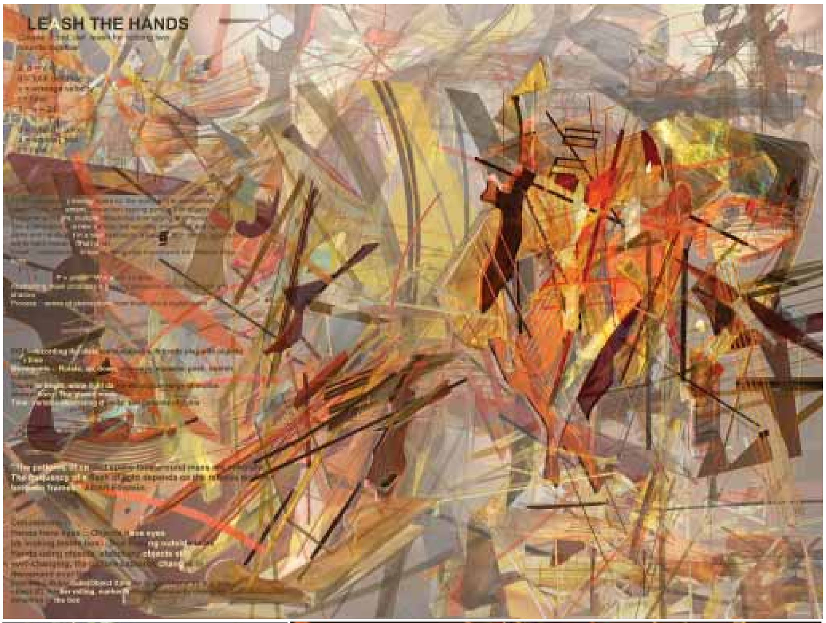


Figure 20: Amanda Glidewell: digital paintings - constant state of making and unmaking. The work as a constant state of making and unmaking, appearing and disappearing, perpetually alive. Images captured from the motion of the hand. Wires, lights, gloves, all veiled by a screen. Shadows cast, reflections, and blurs of chrono-photographic motion captured in mere nano seconds frozen in time. These contained images, then put into the analog and digital realm, being remade and reconfigured to form new images as a state of constant flux.



Figures 22, 23, 24: Jenny Welton: digital paintings - leash the hands.

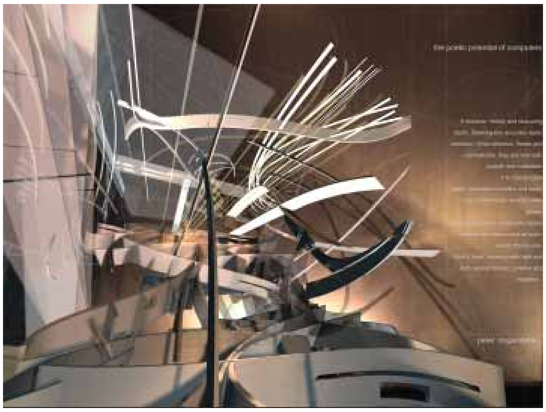


Figure 25: Peter Lingamfelter: digital paintings - a diorama, veiled and obscuring depth.

Figure 26: Justin Rice: digital paintings - auto architect on off. Seen as a stage, the light box project requires interaction among users within a set environment. This engagement is recorded, projected, then re-projected. This perpetual repetition of events is a machine that can create its own architecture. It is the auto-architect. It is designing through non-action by embracing the basic laws of technology.

Figure 27: Sarah Smith: digital paintings - a never-ending completion.

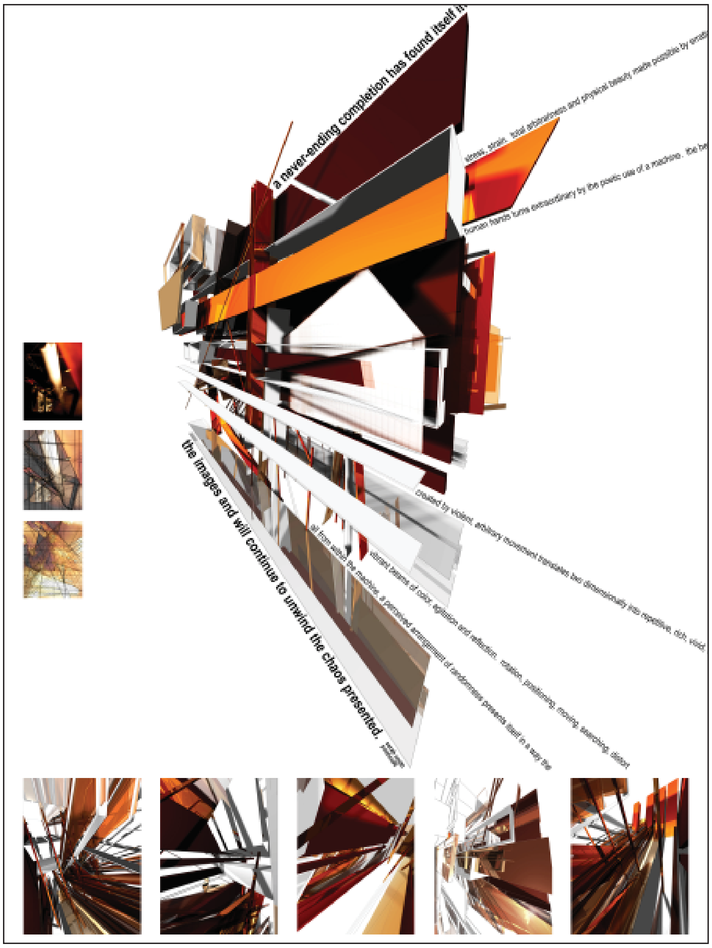


Figure 28: Joe Bloodworth: La Plata vs. Farnsworth interpretive analysis exhibit.

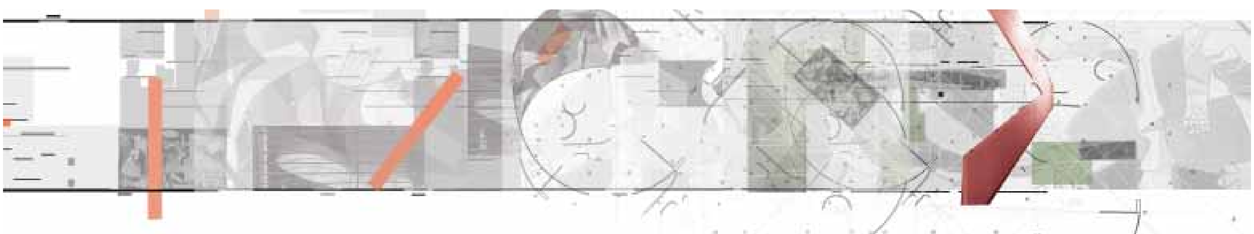


Figure 29: Clay Weiland: Savoye vs. House with Three Courts interpretive analysis exhibit.

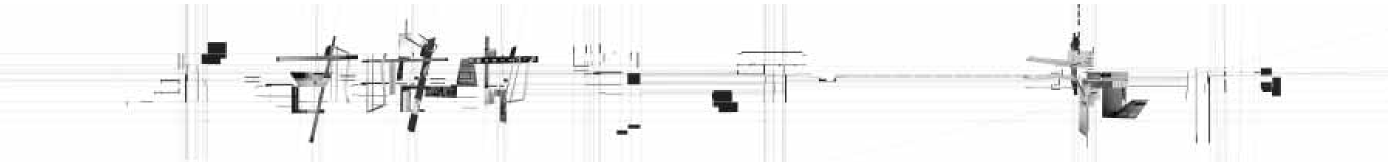


Figure 30: Brandon Weinheimer: Brick Country House vs. E1027 interpretive analysis exhibit.

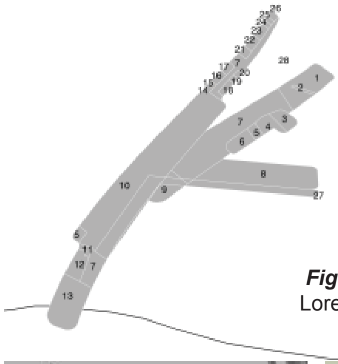
Figure 31: Cole Lorenz: Barcelona Pavilion vs. La Roche-Jeanneret interpretive analysis exhibit.

Conclusion

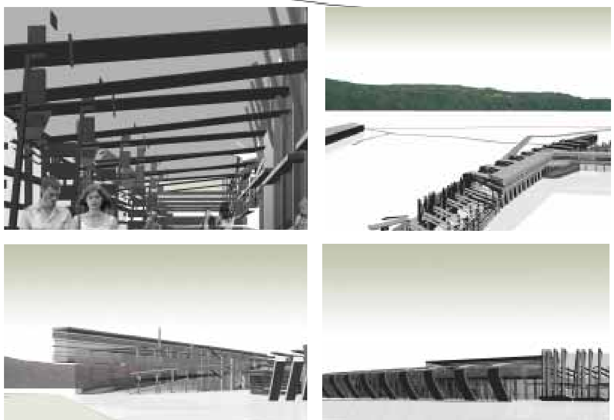
The creative techniques presented give students a procedural foundation for the integrated use of contemporary media in the design process. In both courses, digital tools are used as an interpretive playground for design experimentation. The process unfolds as a series of experimental exercises, each with its own set of interrelated media and time frames. The basic limits are established and the instructor coaches them as they explore. Specified digital tools focus more on being evocative, than on the technicalities. The method is not about being an expert in any specific software, but more about interoperability or the ability to move back and forth fluidly between media. Each course presents a broader application of digital tools that is critical to computational design, especially in the realm of today's media driven world. The methods employed find new paths toward creativity where play and interpretation create an inviting environment for design in the context of contemporary media (Neiman and Bermudez, 1997).

The wide range of results produced in these courses, and the fact that most of these designs would never be attempted by traditional analog methods, demonstrate the power of contemporary media to expand the intellectual horizons of design production. The methodologies deserve credit not only for the concrete results but also for another less measurable outcome: students leave these experiences with a renewed and informed enthusiasm toward the present and future of designing with computers (Neiman and Bermudez, 1997).

Digital tools speed up the designer's ability to create, find, develop, and represent. The many artifacts produced liberate the designer to make choices and set a direction. The cyclical nature of this incremental and additive process, oscillating between various media, allows the designer to create, evaluate, understand and then recreate from previous discoveries. The computer is a complex evolving tool that expedites and reveals a poetic creative process.



Figures 32, 33, 34, 35, 36: Cole Lorenz: Museum of Steel, a steel building which exhibits itself.



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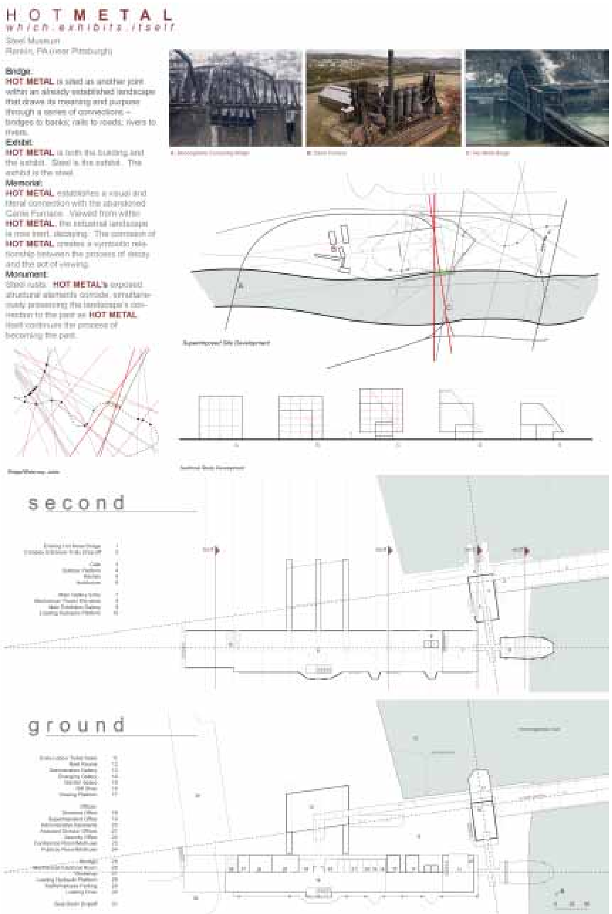
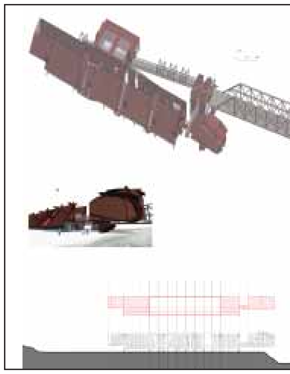
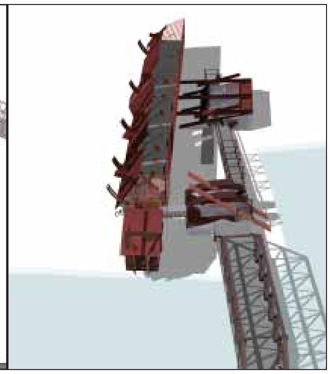
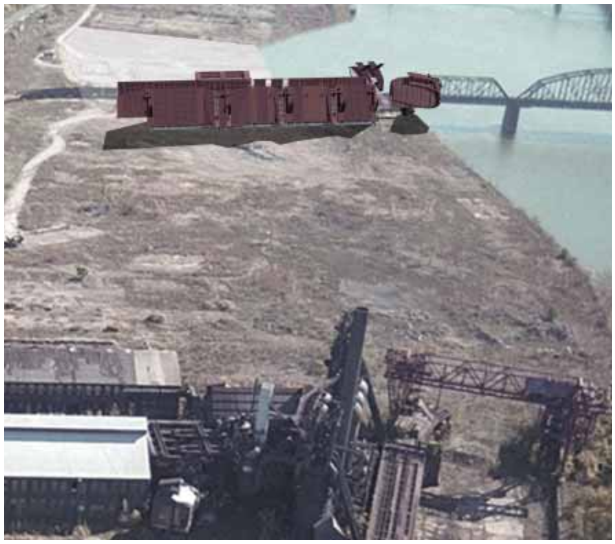
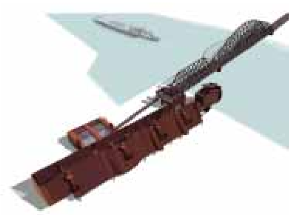
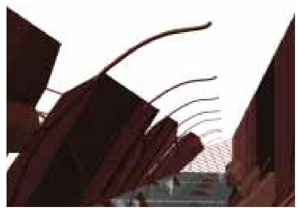
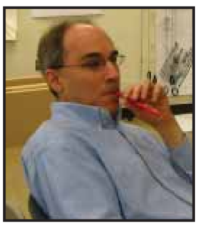


Figures 37, 38, 39, 40, 41, 42, 43, 44: Jeff Nesbit: Hot Metal which Exhibits Itself. The Hot Metal museum is another joint within an already established landscape that draws its meaning and purpose through a series of connections – bridges to banks; rails to roads; rivers to rivers. Hot Metal establishes a visual and literal connection with the abandoned Carrie Furnace, an industrial landscape that is inert and decaying. This corrosion creates a symbiotic relationship between the process of decay and the act of viewing. The exposed structural elements corrode, simultaneously preserving the landscape's connection to the past as well as a process of becoming the past.



Bennett Neiman holds a two-year Master of Architecture from Yale and a six-year Bachelor of Architecture from the University of Cincinnati. He taught architectural design at University of Colorado at Denver/Boulder from 1987-2004, earning tenure in 1995. He is currently a tenured Associate Professor at Texas Tech University College of Architecture. Since 1983, Professor Neiman has received several honors for a series of self-generated architectural design projects, competitions, and teaching involving improvisation, order, and variation on a theme. His design workshops, seminars, and studios exploit the strengths of both traditional media and digital technology in design. He received the American Institute of Architects AIA Education Honors Award in 1994 and 1998 for this work. He received the Association of Collegiate Schools of Architecture Faculty Design Award, in 1990 for Surrealistic Landscapes and in 2005-2006 for bebop SPACES. [Photo by Lahib Jaddo.]

Temple University
Philadelphia, Pennsylvania

Rules of Engagement

by Robert Trempe

We live in a world born of accumulation, shaped by deviation. From the DNA in our bodies to the text on pages, our world is understood and articulated through changes (deviations) in field[1] conditions. For example, my eyes are brown. Simple deviations in the repetitious system of DNA cause this. One reason you are able to read this writing is not because of the monolithic nature of text, but because of the repetitious assembly of a series of instances[2] or universals (individual characters) that are carefully crafted and articulated via a latent logic. This logic is instructional in that it provides the basic rules not only for the organization of our bodies and text, but for the articulation of an architectural logic, from initial investigation to turn-key habitation. The propagations (both in terms of the thematic and the instructional) of this investigational system are as follows:

Architecture is Inherently Four-Dimensional

…When there is a change in the basic framework of thought, then there has to be a shift in architecture because this, like other forms of cultural expression, is embedded in the reigning mental paradigms.[3]

Often architecture has been related to other forms of static art such as painting and sculpture, typically in a 1:1 formal relationship. This is by far one of the easiest relationships or analogies to make. However, this is limiting in that architecture must take into account time as a means of articulation. This propagation suggests that architecture is four-dimensional, more akin to music, dance, and film[4] in that architecture takes on spatial, material, and programmatic qualities, all of which employ time as a means of articulation. Materials change over time through issues of usage and age. Spatial conditions within a room change based on the time of day and shifts in light. Even conditions of programmatic usage change on time-based cycles ranging from minutes to hours to days and years through the temporality of usage.

The change in this "framework of thought" requires a change in the "rules" set out to investigate architectural scenarios. If we are to think of architecture as operating in a four-dimensional world, the first step is to understand the intricacies of other time-based forms of media and experiences[5], taking them apart as a method for understanding the logic that makes each work successful. Further, to help in the investigation of time-based media, a simple system of notations called *instances and universals* must be developed as a means of articulating the changes within the field (the whole body of work being analyzed.) Just as the organization of notes (each note is an instance) in a piece of music generates the formal quality of sound, so too can instances applied as agents of articulation in an architectural investigation through the manipulation of instances in a field.

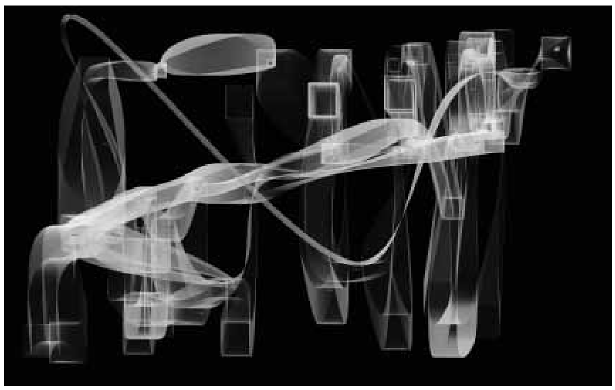


Figure 1: Melissa Chapman-Smith '08: Mapping of the film "The Jacket." Each of the three qualities of time in the film (cinematic time, event time, and historical time) are documented using three Cartesian axis (x, y, and z). The mapping is designed to not only expose qualitative relationships in the three times found in the film, but also to examine how these qualities of time influence the experience of the film through issues of reliance and overlap.

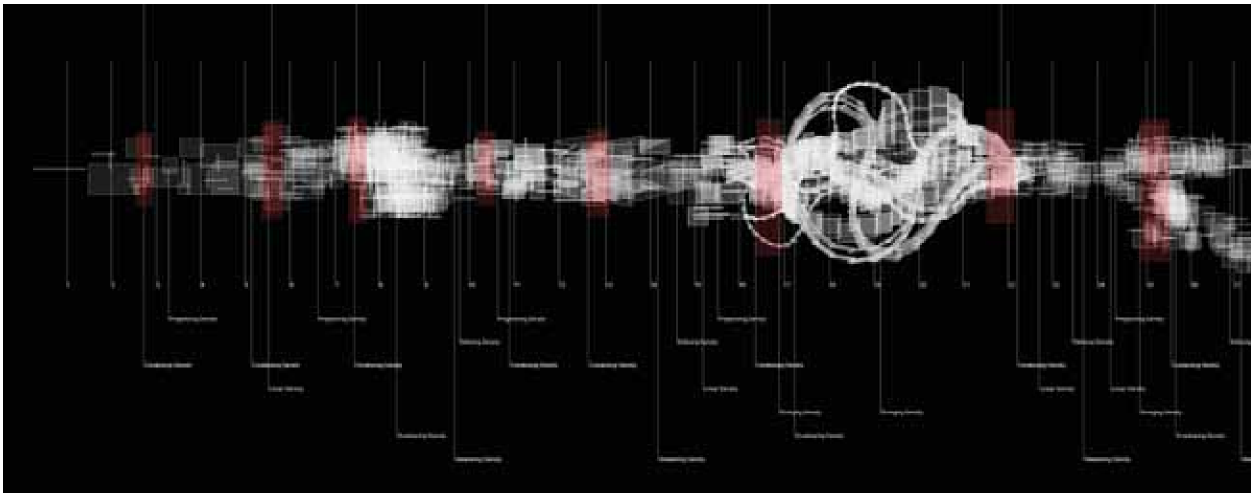


Figure 2: Pawel Ostrowski '08: Mapping of the film "Four Rooms." Through the repetition, orientation, and deviations of a singular element within a field, Pawel's mapping articulates the moods set in each of the four scenes (rooms) of the film as well as the relationships in emotions from room to room.

In the works of Melissa Chapman-Smith '08 (Figure 1) and Pawel Ostrowski '08 (Figures 2, 3) these ideas are manifested in the dissection of film, whereby each film is taken apart as a means of exposing the time-based qualities, notating conditions of qualitative change. In the work of Mark Faulkner '05 (Figure 4), the time-based analytical information comes from comparative changes found in a reoccurring bike-ride taken several times throughout the day. In all of these examples, simple instances are used as the repetitive element of the field condition, marking particular moments of the time-based experience. The gathering, organizing, and connecting of these individual instances operates as referential markers for qualitative shifts in the experience being dissected. This leads to the second provocation.

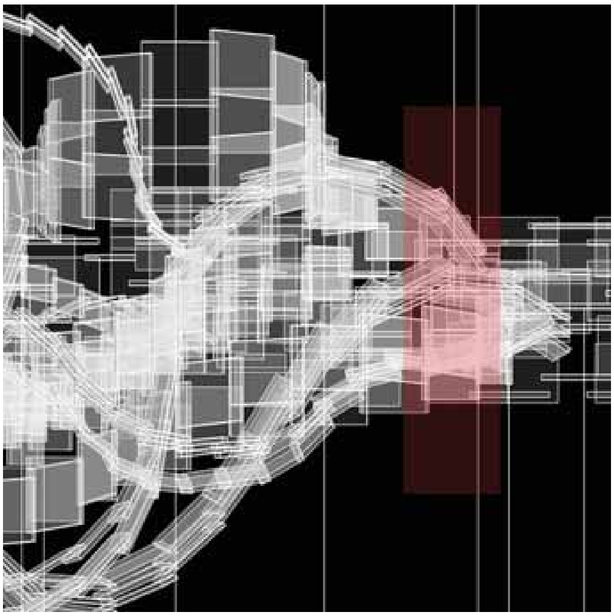


Figure 3: A detail of Pawel Ostrowski's '08 mapping of the qualitative experiences found in the film "Four Rooms."

Architecture is an Accumulation

Architecture is an organizational accumulation of instances within a period of time or field condition, with the organization forming an event. This idea holds true with any time-based media in that, the manipulation of a single repetitive instance within the field will force a reconfiguration of the networked (accumulated) result. This train of thought can be used in every aspect of an architectural design, from the investigational process (articulation and exploration through techniques such as mapping and diagramming) to architectural construction itself (tectonics are NOT monolithic but are based on the accumulation and organization and articulation of individual members…even concrete is built of bits and pieces.) Within this spirit comes the main rule of investigational communication: For a process-based exploration to notate qualitative shifts within the event, it must be based on the organization and manipulation of a field built of instances as it follows the guidelines that the event is formulated from the instance accumulation. In the end, the construction becomes less about the individual instance and more about the relationship of instances to the whole of the field (Figure 4 Detail).

In analog realms this has been proven over and over. We need only look at the works of artists such as Sol LeWitt or the music of Phillip Glass to see that the accumulation and organization of simple instances (the line for LeWitt and the singular note or musical phrase for Glass) can have a profound effect on the whole. As architects operating in a digital realm, we turn to Digital Assets as a means of simplifying the process of articulating this organization. We must be careful in how these tools are employed though, as to make sure we, the author of the composition, leave our imprint on the work rather than allowing the tool to make the decisions.

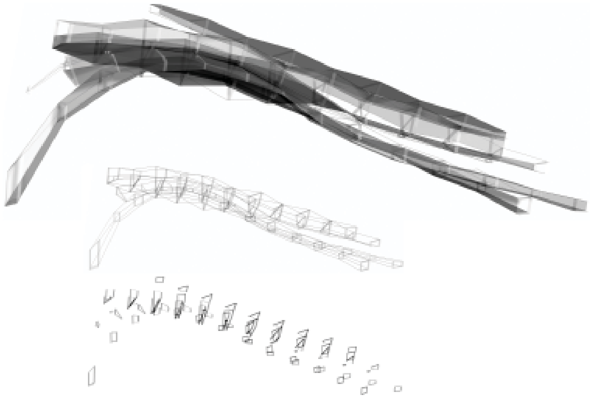


Figure 4: Mark Faulkner ’05:
Mapping of multiple bike rides through the same neighborhood at different times of day. Each bike ride was documented through the articulation of a series of rectangular sections with each section notating a moment of time. Modifications to each section were based on qualitative shifts that occurred during that particular moment of the ride. Orientation of each section from the base section notated conditions of positional shifting during the ride (avoidance of other vehicles, pedestrians, etc.) The sections of each ride were then connected together, forming a time extrusion. The end product is a composite of several bike rides, used as a means of notating similar qualitative conditions from ride to ride.

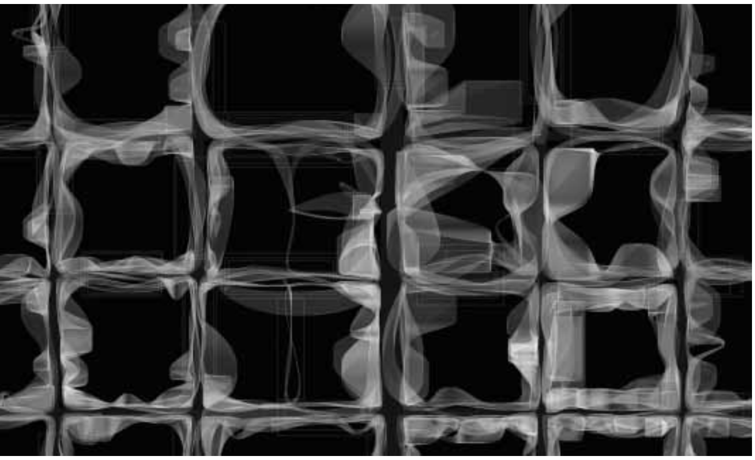


Figure 5: Melissa Chapman-Smith ’08:
Using the same techniques (both in terms of modeling and rendering) as well as the same time-based rules from the movie analysis, Melissa generated a study of usage densities within the project site. The criteria used for the movie analysis allowed Melissa to quickly visualize these conditions within the site and helped in unlocking information about changing programmatic usage as well as issues of reliance and overlap.

The Tools of Four-Dimensional Architecture are Tools and Should be Treated as Such

It can be put this way too: find ways of using instruments as though they were tools, i.e., so that they leave no traces. That’s precisely what our tape-recorders, amplifiers, microphones, loudspeakers, photoelectric cells, etc., are: things to be used which don’t necessarily determine the nature of what is done. There are, of course, pitfalls, but so is one’s finger when he points to the moon. What we’re dealing with is not things but minds. What else?[6]

John Cage’s commentary on the tools for music is completely applicable within the rules set forth here. We cannot let the tool generate the result, blindly pressing buttons and using every item in the arsenal until something pretty comes out as, if the tool determines the nature, what control do we the author have? Instead, we must become masters of the tools in order to move beyond the “things” and in turn reach the “minds” of our ideas. Of course, given the amount of toolsets at our disposal, understanding the characteristics of each tool is often not efficient and can lead to conflicting results based more on the accumulation of tools rather than the articulation of an idea. Instead, limiting our manipulations in a digital realm to a handful of key toolsets we have mastered will allow us (the authors) to leave our imprint on the investigation rather than the toolsets controlling and marking the result. In this respect, one or two tools operate on the idea of reduction, one of the quintessential goals of the diagram (and modernism in point of fact) in that articulation comes from refinement and control of fundamental information.

Working with fields is powerful to the author in that the simple manipulation of a field using the most basic of parametric constraints has a more powerful (and even more beautiful) result than the most complex command sets. In the example set earlier (eye color) whereby complexity was generated through the deviations within a massive strand of DNA through the manipulation organization of a singular element, the analogy becomes the fact that a singular tool in the hands of an author can accomplish the same richness of result. In Melissa Chapman-Smith’s mapping of site qualities (Figure 5) not only is a singular tool used as a method of articulation (lofting), but the same qualitative methods and quantitative articulations are employed from the previous study of film mapping as a method of not only creating continuity from one study to the next but also as a vehicle for learning every aspect of the tool employed. Through this continuity of quantity and quality we are able to control the result with full knowledge of the impact to the system. This means that we (as the generator of the study) can spend more time articulating the study, with results that clearly operate as a set of instructions toward the articulation of an architectural intervention.

This is not to say that an entire career should be spent working with a singular toolset. Instead, with each passing investigation, we learn more about how a different tool operates, building our skill sets as we move from project to project.

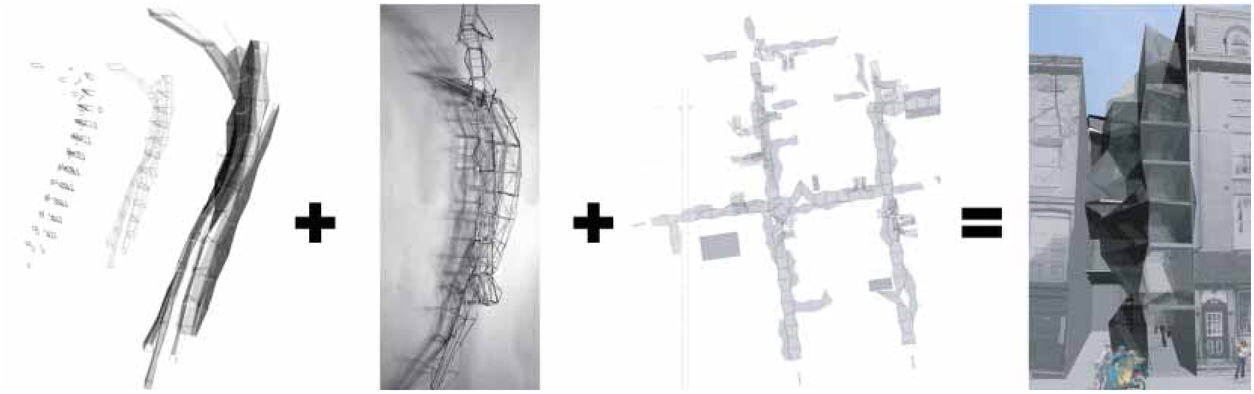


Figure 6: Mark Faulkner ’05:
From process to final articulation, it becomes readily apparent through graphical articulation how information from one step of the design process influences each other step along the way, concluding with a final site intervention (at right).

Investigations Operate as the Rules for Articulation

Many school projects operate under the assumption that the sooner the overall building is articulated, the sooner “schemes” can be developed, either through multiple visualized attempts, or a reworking of an existing intervention over and over again. With a process such as working with fields, the hard work of setting up rules and logic is accomplished early on in the investigational process. After developing the conceptual machine (the investigational graphic based in the manipulation of instances within a field), the same ideas are applied to investigations approaching the point of architecture, such as issues of site and program, both articulated through mappings using the same language found present in the initial field studies. The linkages from one set to another may not always be 1:1, but the logic inherent in each study does connect, creating relationships strengthened through the process. This is further fortified as the user moves on to the final articulation of an architectural intervention, using the same qualitative language as a means of crafting the final result.

This process reinforces the idea that information taken from the beginning of an investigation should be critically applied both as a set of rules toward further investigations in an architectural process. In Mark Faulkner’s ’05 work (Figure 6), the relationships from one step of a design process to the next are clearly notated from the most conceptual of investigations (the analysis of several bike rides through the same location at different times of day) through an analog investigation into body cladding, the mapping of time-based characteristics on site, and finally the intervention into an existing urban fabric. In the work of Melissa Chapman-Smith ’08 (Figure 7) the ethereal qualities of time found both in the analysis of film and site are manifested in (an albeit elevationally geometric) mixed-use facility with different programmatic functions continually fluctuating in and out of one another throughout the time cycle of each program. In the work of Pawel Ostrowski ’08 (Figure 8) the way in which simple planes (and their relationship to one another) found in both the film analysis and site mapping notate conditions of usage and change, so too do the planes used to articulate programmatic function in Pawel’s final site intervention. In all three examples, the rules for the “final” architecture are established very early on in the design process, making the process of articulating the ideas that much easier as all the author must do is look back on the previous investigation to organize a design. In all of the examples, the rules set forth early on in the design process influence every decision made by the user, in some cases through formal articulation, while in other cases through linkages in the qualitative information from conceptual information to programmatic and spatial organization.

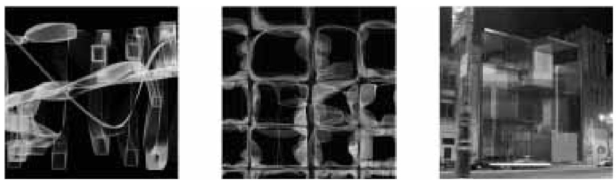


Figure 7: Melissa Chapman-Smith ’08: From left to right - Time-based media analysis, Site Mapping, and Final site intervention.

Summary of Propagations

It should be noted that the propagations elaborated on are by no means the only method for exploring architectures potentiality. Having said this, the methodology described has countless potential as a system of procedural evolution, ultimately resulting in new and unseen architectural interventions. In an academic setting where we are pushing students (and professionals) to understand the role of process, critical thought, and critical articulation, the “rules of engagement” described above allow for the development of clear train of thought and communication of idea in every level of architectural processes, and these rules become one more “part” in what should be an ever expanding “kit” of process.

Notes

[1] In this article, a field will refer to an organization of repetitious elements within a well defined space.

[2] The term "instances" has many identities, each based on the context to which the instance is associated. In music (for example) an instance might refer to a singular note on a musical staff or voice within a group. In architecture, an instance is defined dependent upon its function. In mapping, an instance refers to the individual character or symbol deployed into a field while in construction an instance can be referred to as the singular 2x4 of a roofing system.

[3] Maggie Toy, *New Science = New Architecture* (London: Academy Press, 1997).

[4] For this writing, music, dance, and film have been chosen as analogies as they can be thought of under the same "creative" umbrella as painting and sculpture. As people have made relationships in the past between architecture and painting/sculpture, it is hoped the same relationships can be made now through other time-based creative media.

[5] In an earlier version of the studio for which these propagations were applied, time-based experiences operated as the initial graphical inquiry, with each student taking apart a daily experience of mobility (from the phone to the bike) as a means of understanding how the mobile device modified a time-based experience.

[6] John Cage, *A Year From Monday* (Middletown, Wesleyan University Press, 1963), 124.

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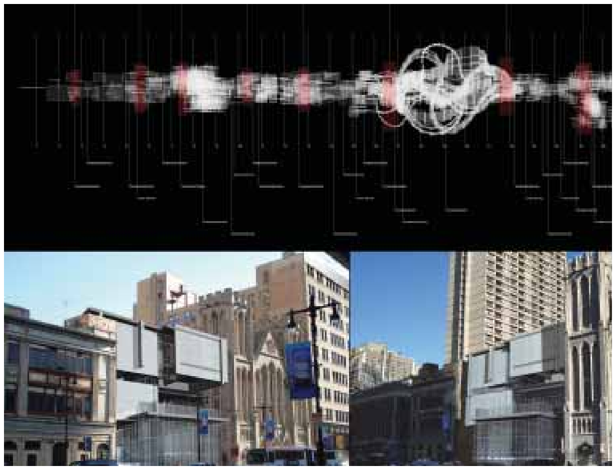

Figure 8: Pawel Ostrowski '08: From top to bottom – Time-based media analysis of the film "Four Rooms" and two street elevations of the final site intervention. While the intervention does not take on the formal characteristics of the media analysis in a 1:1 manner, it does use the logic of the planes and what these instances notate as a set of instructions for the relationships of programmatic overlap and skin.

Figure 9: Melissa Shilling '06: From left to right – Time-based analysis of a phone conversation with Melissa's sister during a hurricane, the final site intervention in elevation, and the final site intervention in perspective. The time-based analysis notates the power of the mobile device through moments of conversational displacement whereby Melissa felt as if she was in fact experiencing the hurricane with her sister. This issue displacement (as well as detachment) became the overwhelming logic for her site intervention both in terms of formal and programmatic qualities.

Bob Trempe is a designer and professor focusing on the instructional logic of repetitious systems. This research includes experiments with field manipulations, digital planer fabrication techniques, animation and mapping techniques, and theoretical papers. His research can be seen both his conceptual work through his office dis-section as well as professional work with the design office of Verspoor & Trempe. Speculative projects such as "Universal: The Superstructure of Skin" can be seen in the 2004 Birkhauser book "Diversifying Digital Architecture." Bob has been a semi-finalist in the 2003, 2004, and 2005 FEIDAD (Far Eastern International Digital Architectural Design) competition, the "Radical Radiator of the Future" competition, and the MACEF Breakfastware competition. His work has been shown in various galleries including the 2007 ACM/SIGGRAPH Electronic Arts Gallery. While in school Bob was a two-time winner of the Samuel K Schneidman Fellowship from the University of Pennsylvania as well as the Melhorn Scholarship for Architectural Theory. Bob was also a year 2000 Dales Traveling Fellow. Bob has taught at The University of Pennsylvania, Philadelphia University, and is currently an Assistant Professor of Architecture at the Tyler School of Art, Temple University.

Boston Graduate School of Psychoanalysis
Brookline, Massachusetts

The Manipulation of Reality and the Perceptional Quality of Virtual Environments

by Jean Perrin

Perception versus the Real

It seems that people respond very well to concrete limits. Psychically, they help people to reduce tension and take a definite course of action in life. What is even more interesting is that these limits do not necessarily need to be based in reality. It is as simple as driving in a car, red light/green light–we stop and then we go. In the design world, what I have discovered is that virtual environments allow for individuals to debate and refine various perceptions about visual reality.

In a psychological frame of mind, our defenses (e.g. denial, boredom) allow us to smooth over perceptions of the world that are not congruent with the way we experience life. They allow us to create a story that fits with our perception of ourselves in our world. Individuals learn and sometimes need to create a reality that fits with their interpretative way of seeing the world. In terms of visual expectations in the virtual world, the manipulation of 3D environments can offer individuals an unconscious redirection of emotions, from one remembered space to another. Eisenman, an educator and architect who extended deconstructivist ideas into the architectural realm, argues that the "electronic paradigm" challenges architecture because it *"defines reality in terms of media and simulation, it values appearance over existence, what can be seen over what is."* In essence, the virtual world starts to introduce the nuances between *"how and what we see."* As an inhabitant of space, the primary goal for an individual is to find an identity within a space, to find a reality that confirms our way of seeing the world around us. What I have realized through psychoanalytic study is that what is real, is the perceptional quality of the way we register space, not the literal physicality of objects or elements in a space. Through the dimensionality of virtual environments, the individual is able to pull fragments from past emotionally cathected space and reassemble these memories into a familiar perception of space unlike physical modeling efforts. Environments become compilations of our past visual experiences. Kant even argued that the world is not as it is, but as we are and in this sense and

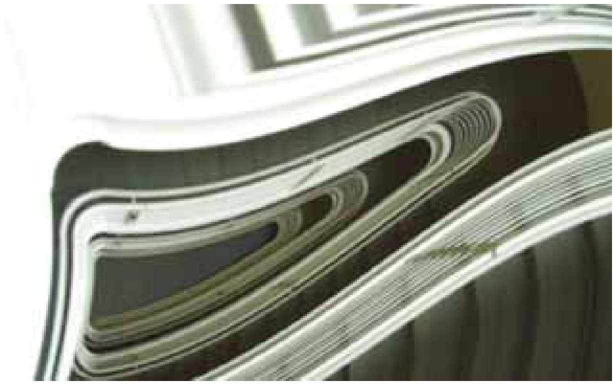

Figure 1: Design or deformity; purpose or coincident?

a space becomes flooded with unconscious that visually stored and reprocessed each time we enter a new space. Virtual tools can ultimately recreate a particular perception of an environment as "we are." Virtual tools have the ability to create the all-encompassing mood of space, in addition to the textural and emotional quality of an environment. When a person first inhabits a space, they react to their perception of the space, not the space as it actually exists. Psychically, individuals can shift and adjust their perception of events as is necessary to create a story unique to their perception and necessary for the psychological continuity of their life story. In summary, virtual tools have the distinct ability to explore the visual quality of space. Space can be created, discussed and then refined, offering designers and users the ability to begin a dialogue about the user's textural desires, needs and vision for a space.

Deconstruction and the Natural

Derrida, known as the founder of deconstruction, makes a similar point in a documentary made with and about him in 2002. When asked to discuss love, he poses the idea that love must be understood within a particular framework. It is the difference between "the who" and "the what" that defines a person's understanding of love. Derrida questions whether we love someone in their singularity or if it is our perception of their qualities that we love, placed underneath the broad umbrella of the word "love." Derrida states, "does someone love someone, or does one love the qualities about someone?" Similarly in the virtual world, it seems to be less about capturing the oneness of space, and more about recreating a particular quality or qualities that narrates a particular perception or experience of space.

Another deconstructivist thought is not to naturalize what is not natural. In terms of traditional architectural representation, a language has been created among design professionals to represent space. To assume that architectural symbols, plans, elevations, a stylistic way of drafting and lettering are "natural," might be considered false. People in the design community seem to have conventionalized a way of reading and experiencing space. In the 3D visualization realm, architectural representations not only have the ability to be universally understood, but can also capture life as they actually capture space compatible with visual intuition. Figure 2 demonstrates the highly reflective properties of a polished terrazzo floor. While its high degree of shine may seem unexpected, it feels correct. In other words, a person visually accepts this image in its entirety and would most likely not question its realness. Similarly, Figure 3 illustrates how the top of portion of a wall is visually darker than the bottom portion of the wall. Typically, we think of the bottom portion of an object as being not only physically, but also visually the heaviest. However, we visually accept this real representation and do not question this image as a whole. Interestingly in architectural drawing conventions, different line weights are used in an effort to create order and clarity in design representation. Typically in an elevation, the heaviest line is the ground plane where the bottom of a wall sits. In a sense, this reorders or teaches an individual to conform to a design standard, which is based upon a system of symbols, not the natural order of perception.

Virtual Environments and Dreams

With digital tools, designers can visually share their unique perception of space. In psychoanalytic room, the analysand's flat retelling of a dream is not as valuable for

Figure 2: Reflectivity versus intuitive expectation.

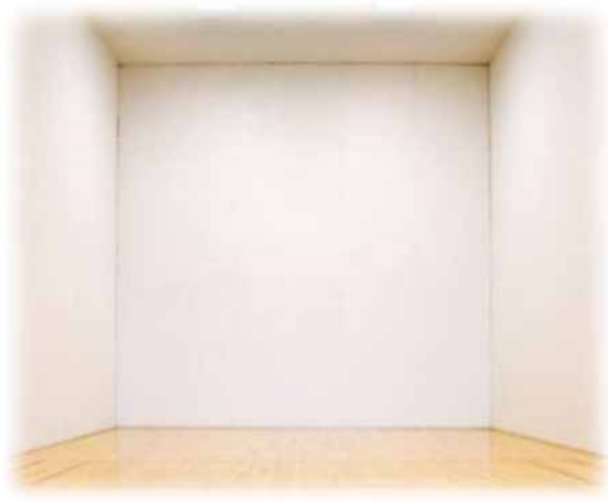

Figure 3: Reflectivity versus intuitive expectation.

the analyst, as the emotional, textural and visual quality of a dream. In this sense, the way a dream feels becomes more important than the flat retelling of a dream's plot. Similarly, virtual environments can portray the textural quality of the way we experience and remember space. Virtual environments are also capable of arousing emotion and triggering memory so that dialogues about the experiential of space aspects can occur. Ultimately in the professional world, individuals can potentially decide upon experiential aspects of a space before a space is physical created, avoiding a potential element of surprise, typically occurring when individuals see a completed space for the first time (even though prior to seeing it, there was full awareness of building materials, sizes, lighting fixtures, etc.).

In the Neighborhood

One important element in beginning a dialogue about the unconscious aspects of space, is understanding the narrative component of virtual animations. Similar to editing film, the narrator has the ability to control and manipulate the way in which a story is perceived. In virtual animations, the camera highlights and/or fragmentizes the way we experience space. Thoughtful narration can help the viewer to digest space according to the way it feels, rather than the way it physically exists. In the analytic session, Busch highlights the importance of being "within the patient's neighborhood" in the analyst's communications to the analysand. Busch writes that "the patient must be able to make some connection between what he is aware of thinking and saying, and the analyst's intervention." Busch continues to write that "no matter how brilliant the analyst's reading of the unconscious, it is not useful data until it can be connected to something the patient can be consciously aware of." Narration in virtual space is no different; the individual must be oriented to the space in a manner which is congruent with the way he or she first perceives space. In the analytic session, Busch seems to emphasize that the patient cannot fully

Figure 4: This image represents a particular visual moment—i.e. the dizzying feeling one has when looking up the side of a tall building. This image attempts to represent the texture of a specific reality.

register information foreign to either his/her intuition or experience; therefore the analyst must help the analysand by making his communications within the realm of the patient's current psychic locale. Similarly, no matter how thoughtfully a space is designed, if the narrative aspect of an animation is not within the viewer's visual realm of intuition or experience, the space might potentially hold less meaning for the viewer. The narrative component involved in virtual animations must help the viewer to understand the designer's pace and intent so that dialogues about virtual reality may occur. With strategic zooming and manipulation of the camera in space, comes a visual communication to the viewer that is hopefully within the neighborhood of how a viewer registers a particular space

Figure 5: The composition of this image demonstrates the experiential aspect of space.

for the first time. Furthermore, Gray emphasizes that there is a "developmental lag" between what we intellectually understand and what we can emotionally understand. In this regard, the way a person experiences space is no different. Comprehensively, a viewer might visually see all the components of a space, but cannot comprehend on an experiential or intuitive level how a space might be experienced without the designer directing the animation of the space.

Deciding on a Reality

The need to decide upon a reality becomes an important urge necessary for psychological survival. As architectural designers, the stories created for survival become testing grounds for augmenting and denying visual realities.

Interestingly it seems that there are individuals that believe that the most believable capturing of a space is the one based on the consensual agreement of how a sample number of people visually see components of a space. Whether a virtual rendering of space confirms the agreed upon physicality of space is ultimately less important than the concreteness of a story or an illustration that confirms a unique perception, or even better the collective unconscious of people at large. Virtual tools have the ability to challenge the perceptional qualities of space, ultimately redefining our visual stories and expectations for the physical world. Environments can shift and change, as old visual understandings latch onto new ones, redefining ourselves in the environment we exist. As designers we can start designing less in accordance to the limitations of our current physical environment and more toward the experiential aspects of space as created and defined by virtual tools.

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Jean Perrin combines her diverse interests in Psychoanalysis, Human Factors and Interior Architecture to explore the limits of human perception. She believes that the fusion of intuitive thinking and visual judgment can lead to innovative formations. Digital technology is primarily defined by human factors, but in-turn has the ability to help us transcend our own limitations in the area of conceptual, visual and emotional thinking/existence. Digital technology has an ability to inform our own emotional existence, and vice versa, our emotional intuition can help us to navigate digital landscapes. Jean Perrin holds a B.S. in Design and Environmental Analysis from Cornell University and a M.A. in psychoanalysis and is currently pursuing her doctoral degree in psychoanalysis at Boston Graduate School of Psychoanalysis.

California Polytechnic State University
San Luis Obispo, California

Motion Light Machines

by Thomas Fowler, IV

The (light) space modulator provides the opportunity to relate design to direct work with materials as against previous architectural methods in which structural inventions were hampered by the shortcomings of visualization on paper alone. On the other hand, structural projects could be solved just as well by working with the model alone; but again this would not give the experience in visualization and development on paper which is essential to the exploitation of a 'space fantasy', one of the main requirements of contemporary architecture.

Laszlo Moholy-Nagy

Students worked in four teams of three to four each and were assigned the construction of a light motion machine. Teams developed devices, which were an interpretation of László Moholy-Nagy's 1930's *Space Light Modular Machine*. These machines had to have moving parts for the purpose of studying light and shadow projections in motion. László Moholy-Nagy's *Space Light Modular Machine* was a mechanically driven rotating kaleidoscope projecting ever-changing patterns of light, shadow, and color. Students were provided information on Moholy-Nagy's machine and also shown a range of interpretations students developed in a previous studio[1] (see Figure 1).

The light motion machines projects had the following requirements:

- Materials to construct the light motion machine had to allow the device to have a range of abilities to capture and project light and shadow. Materials were to have a range of reflectivity and transmissibility and be designed to work within a two foot plexiglas light/shadow cube;

- Light boxes were constructed so one side was left open, so the light motion machine along with lighting source(s) were able to placed in and taken out of the this box as needed;

- Groups were required to invent a two- or three- dimensional vocabulary from their light/shadow experiments to whatever level they thought was appropriate;

- Groups documented the light motion machines with visual and textural stories about the qualities of the lighting from the motion machine using digital stills, video footage, digital and analog diagrams, relief models and 3D physical and digital models. This range of representations showed how the developed vocabulary evolved from the light study.

The learning objectives for developing these light motion machines were the following:

1. Opportunity to bring all students to a similar working knowledge in working with digital modeling software (students used a range of modeling software that included **form•Z**);

2. Exposed students to the tools (digital and analog) and strategies in the first week of the studio that they would be using for the rest of the quarter;

3. Students explored the range of poetic possibilities for understanding light and motion;

4. Provided each student with a launching off point for a 'space fantasy' (Moholy-Nagy) exploration for the studio's building design project to develop an airport.

Prior Student Interpretations of László Moholy-Nagy's *Space Light Modular Machine*

Kinetic Energy: Energy can be stored or in motion, it is perceived in a variety of ways as heat, wind, motion, light, most tangibly in its kinetic state. Light energy is a form that we are all aware of because we have evolved to perceive part of the spectrum visually, this form, so familiar as it is, to this day still remains an intriguing mystery to us. With his Light Space Modulator it was this mystery that Laszlo Moholy-Nagy was seeking to explore. This almost crude yet beautiful apparatus, which we have recreated utilizing discarded objects, sets light in motion using the principles of reflectivity, opacity, transparency and shadow.

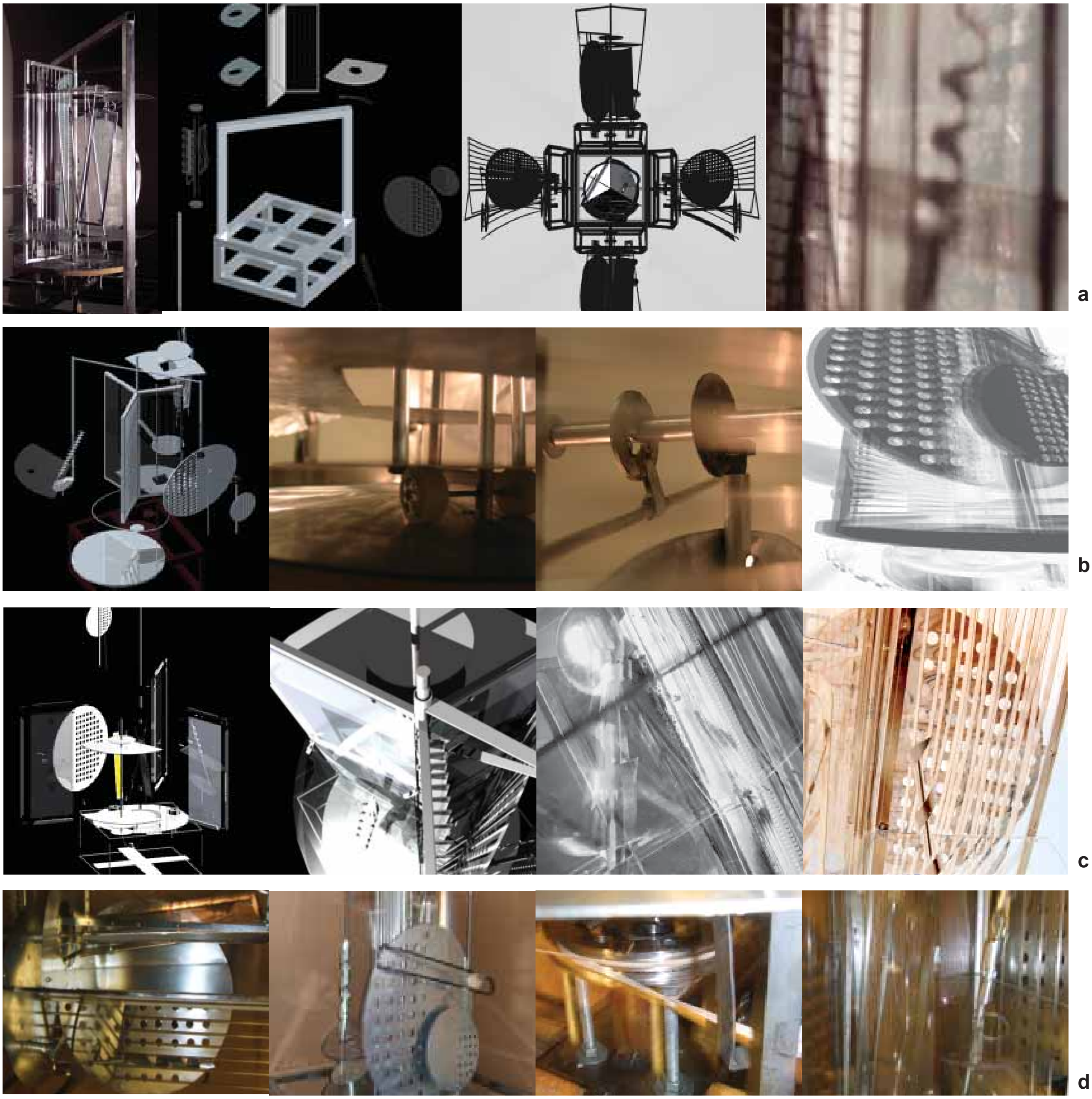

Figure 1: Prior student interpretations of László Moholy-Nagy's Space Light Modular: (a) Kinetic energy: (left to right:) physical model, exploded digital model, digital folded out shadow projection model, and same; by Rob Caras, Sergio Ramirez, Nate Kipperman, Sylas McFarland, and Katie Duncan. (b) Wholly Mo Holly: (left to right:) digital model, physical model detail, physical model connection detail in motion, and physical model photograph of device in motion; by Yiling Deng, Brandon Vielguth, Joe Lyman, and Francisco J. Maravilla. (c) Play of Light = Play of Movement: (left to right:) digital model, perspective view, view in motion, and detail view; by Frank Lara, Joe Moore, David Pak, Florencio Rodriguez, and Yimon Aye. (d) Mysterious Machine: physical model; by Nick Holbein, Carlos Villegas, Cuc Ngyen, and Mike Hernandez.

Figure 2: The Orbitals Light Machine, by Austin Duncklee, Denisse Martinez, and Nathan Mendelsohn.

Figure 3: Light Collisions Light Machine, by Celeste Madrigal, Corinne Mclaughlin, Jared Diganci, and Emily Pappalardo.

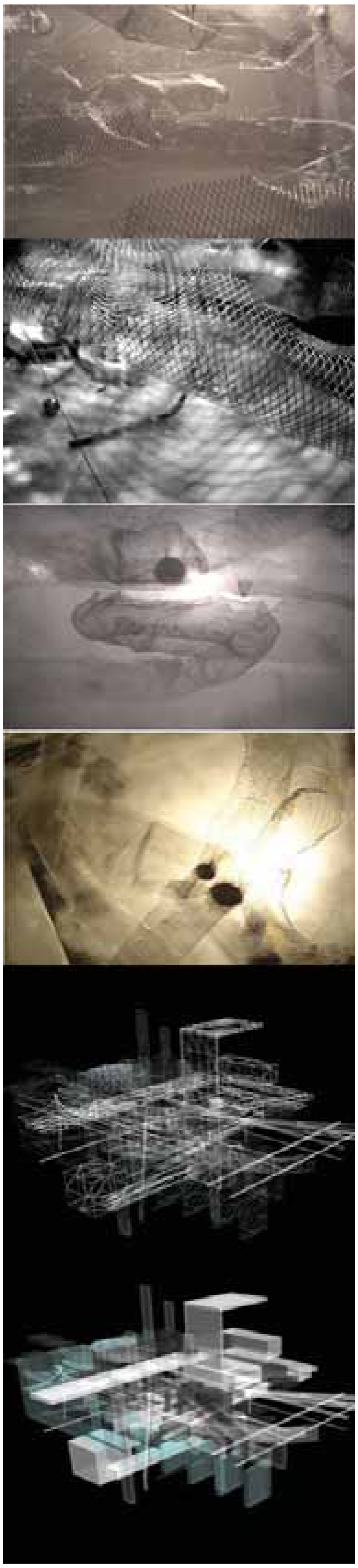

Figure 4: Transience Light Machine, by Rachel Glabe, Cesar Olivas, Laura Ng, and Lauren Lee.

Figure 5: The Superior Machine Light Machine, by Melissa Ramos, Judy Quan, Mauro Cardenas, and Jose Castillo.

Wholly Mo Holly: The objective was to re-create to the best of our ability a replica of the Light-Space- Modulator designed by Laszlo Moholy-Nagy. Our efforts were directed at approaching the experiment with the same spirit of Laszlo – to explore the different manifestations of how certain shapes and materials manipulate light and shadows through movement.

Play of Light = Play of Movement: Understanding every movement and what was created by this movement was a focus that was accomplished by understanding the light modulator digitally and through many different analog models. This allowed us to build a device that was equal to the Moholy-Nagy machine.

Mysterious Device: The device generates different lighting patterns that are simple by the use of different materials. It is a profound device; people see the light modular only to wonder, how it was constructed. The development of an interpretive Light Modular was unique and a good learning experience since it allowed us to better understand how different materials are manipulated or how light can create something out of the ordinary. We saw many aspects of light and shade and shadow in projected appearance, figure and volume.

This Year's Light Motion Machines

Figures 2 through 5 illustrate a few light motion machines produced by this year's class. Summary descriptions of these projects are as follows:

The Orbital Light Machine: Use of orbital objects provided an exploration into the qualities of light (textural patterns of light to dark) and space. There was an intentional emphasis for using a basic shape such as the orbital for the study of light.

Light Collisions: Light is captured through this mechanical device and twirls it around to provide for multiple shadow collisions into projected space.

Transience Light Machine (a.k.a "Bowel Movements"): The elusive temporal nature of shadows and light are captured through the morphing images projected from the inner structure of the light box. When illuminated, the exterior shows mysterious glimpses of the organism inside.

The Superior Machine: A compilation of diverse materials (a series of glass tubes with red-dyed water inside) provided a sculptural response that offers a projection of geometric patterns that become more interesting than the object itself. The exploited machine tries to escape —it runs —it screams —it shakes —it tries and once it finds itself trapped in its limited existence where it can only express beauty through light, it becomes docile and abides.

Application of Light Motion Machine Study

All students in the class were asked to use the vocabulary artifact (detail) that was developed from the group's motion and light study as the launching off point for the airport terminal building design project. Students first developed their grand main space for their airport terminal using the lessons learned about motion and light machine study. After students developed the main space of their building, the remainder of the project was developed.

One student's project and the respective thought and design process follow:

Rachel Glabe's Reflections on The Design Process[5]

Early Light Motion Studies

The early light box studies of light and movement inspired my precept of the activation of space and how an environment can best showcase a particular use. This translated into the airport project, driving the design process and influencing the configuration of spaces/program, as well as influencing the vocabulary. Throughout the design process, I used both digital and analog media. This proved very beneficial as each helped me to develop certain areas of my project. It was easier to digitally explore multiple variations and take multiple immersive views to get a better feel for the special qualities. Building analog models at various scales helped me to see the project in different ways and work out real connections.

Project Concept

The airport integrates plane and building to create an interactive space (continuation of the initial "light machine" study). Rather than connecting to the building externally, the planes are brought into the building underneath the grand space. The airport celebrates the plane by adapting it through the configuration of spaces, and the constant transformation that takes place throughout the day as the building's kinetic steel components extend to meet the plane.

Prior Digital Modeling Experience

Prior to taking this instructor's course I had some experience with computer modeling programs, but my skills were limited. Throughout the quarter, I built up my digital skills through each stage of the process. The first couple weeks forced me to use more digital and I became more comfortable with computer modeling as the quarter progressed. I focused on how to set up the lighting and apply materials in the modeling program. As my project progressed, I found it necessary to render my digital models to achieve

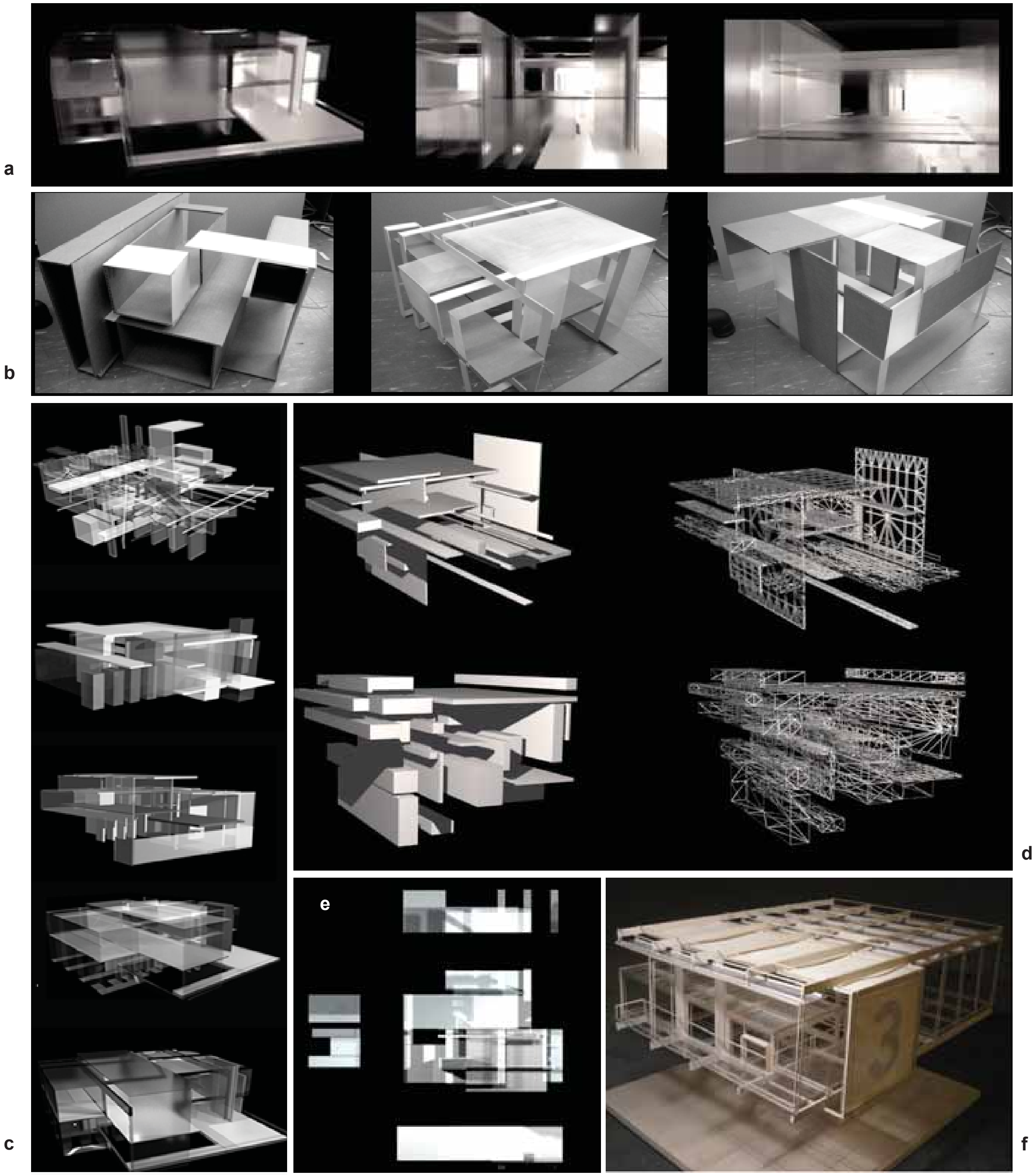

Figure 6: Rachel Glabe's building design process that evolved from Transience Light Machine group's vocabulary. (a) Stills of digital animation for the study of light. (b) Analog vocabulary models for the study of light. (c) Project vocabulary evolution. (d) More digital vocabulary study iterations. (e) Digital vocabulary developmental skin studies. (f) Physical model detail views of airport terminal.

the desired material properties and appropriate lighting. Before taking this class, I felt overwhelmed by digital media, but after a lot with both programs and figuring out a system, I feel much more comfortable.

I started the design process experimenting with light and movement and the effects they had on the larger environment, studying how the light box itself could best showcase what was inside. I carried this through into my precept in the development of the inhabitable tectonic detail. At this stage I focused on the configuration of shapes and spaces, as well as materiality. When I began the process of designing the airport, I thought about how an airport could best showcase and celebrate the airplane, and decided that the planes should be brought into the space.

Program development

As I began to develop the program spaces, I arranged the volumes around the planes to explore various configurations. I first started by building analog volumetric models and manipulated them digitally, which allowed me to explore different options more quickly. During this stage of development, I was also focusing on circulation and progression through the space. My next step was taking the program configuration and beginning to explore the building's vocabulary through a series of analog and digital study models. Creating positive, negative, and hybrid studies was helpful in generating interesting alternatives. Working out the program configuration and vocabulary made things easier when I began modeling the airport. Looking back on the process, I shouldn't have spent so much time agonizing over earlier study models, because it seemed like the stronger studies were the ones that I did faster and more intuitively. This process really helped me to focus on each aspect of the project as it related to the whole and my concept, making for a much more refined final product.

Project refinements

The midterm review was very helpful in that it helped me to pinpoint what needed tweaking and what I could do to take the project further. The feedback that I received focused mainly on how I could best convey my concept and how to most effectively bring the planes into the building. After the review, I concentrated on refining each part of my project. I refined the structure, skin, details and connections to make the design stronger. I pulled the steel structure outside the building to better express the horizontal extension out toward the runway, and developed connections for the glazing to hang from. One of the most important modifications I made was making the floor of the grand pace completely transparent rather than translucent. This slight change really transformed the grand space, providing an unobstructed view of the planes below.

Reflections

Going through this specific design process this quarter was very beneficial. The earlier light machine studies provided a good foundation for the process and the airport project. The use of both digital and analog tools helped me to really understand my project better and develop stronger skills in both areas. I really enjoyed each stage of the process, especially after realizing the importance of and opportunity in each step. This quarter I learned how to most efficiently and effectively approach a design project, as well as how important it is to stay focused in order to really move forward. I am anxious to apply this process to future projects.

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Thomas Fowler, IV is teaching third year design and building technology courses, and is directing his digital media facility founded in 1997, called the Collaborative Integrative-Interdisciplinary Digital-Design Studio (CIDS). This facility provides students with access to the latest digital technology for use in the design and constructability process. He has received a number of awards for his teaching and research activities, including Architecture Department's Faculty Teaching Award, 2005, nominations (2000, 2001) for U.S. Professor of the Year Award, Young Faculty Teaching Award, ACSA/AIAS, 1996-'97, and Young Architects Selection, Progressive Architecture Magazine, July 1994. Thomas has served as paper referee for numerous conferences, published a range of papers on his design studio teaching methods and interdisciplinary project activities and has had a successful track record for grants for his research. Recently his essay "A Teacher's View",was published in Becoming an Architect, edited by Lee Waldrep, Wiley 2006. He has also served as Associate Head of Cal Poly's Architecture Department (2001 2007), as ACSA's Secretary to the Board (2004-2006), on the National Architectural Accreditation Board (NAAB) as an ACSA representative (2007-2009), and has participated on NAAB visitation teams to 15 programs (5 of these he chaired) around the country.

Rhode Island School of Design
Providence, Rhode Island

Furnimals, Swarms, and Mutations

by Tara White

I entered the *Formal Mutations* Studio with minimal experience in three-dimensional digital design, having only worked for a short time with Vector Works prior to the course. I was eager to gain experience with digital tools, and interested in exploring the possibilities uniquely afforded by designing in a digital environment as opposed to using traditional methods of sketching and modeling. I dove into the first **form•Z** / Cinema 4-D exercise with what I hoped would be the kind of clueless-ness that can occasionally lead to unorthodox discoveries.

Materials

Through my experiences at RISD's Interior Architecture Department, I have developed an approach to design that emphasizes materials and their inherent qualities as the inspiration for ensuing forms. I started to experiment with re-creating materials, textures, and behaviors atypical of the digital world, such as fur, faceted gemstones, and particles that demonstrate living animal behavior, including breathing and moving as a school or swarm. Immediately, the difficulties involved in mimicking the irregularities and inconsistencies of real-life matter and behavior in the digital environment become apparent. One discovers that it is often through the subtle tweaking of the multiplicity of variables for each function that "life-like-ness" can be increased. Hand drawings scanned and included in the creation of digital materials and textures also help bridge the gap between recognizably computer-generated effect and a more naturalistic or "imperfect" vision that more closely mimics our own sensory perceptions of the material world.

Biology

With my material explorations, I realized that I was attempting to move toward a kind of integration of the biological and the digital – a blurring of the dividing line between living and non-living. Challenging the perceived visual divide between, or compartmentalization of, nature and technology, and working toward blending them seamlessly in fact reveals the connections between the two. Developers of Artificial Intelligence systems have long pondered the distance between the computer and the human mind, discussing differences in terms of knowledge and consciousness. It is no wonder that we see the same issues raised in relation to digital visualization of living forms and movements. The fact that multiple mutations of a form can be quickly generated through small changes in **form•Z** / Cinema 4-D's function variables suggests a familiar biological theory – that of evolution. In this way, digital design can mimic nature, where each occasional variation results in something that may survive if it proves beneficial to the overall design. All methods of design can be viewed as "evolutionary design" in that innovations are incorporated or excluded as the process moves forward. However, the use of digital tools has the potential to generate new and innovative design solutions through its singular and inevitable introduction of the unexpected! One of my very first experiments involved trying to achieve the effect of window blinds by manipulatring existing wall surfaces. The shatter function proved useful in horizontally splintering two walls that, after applying the twisting

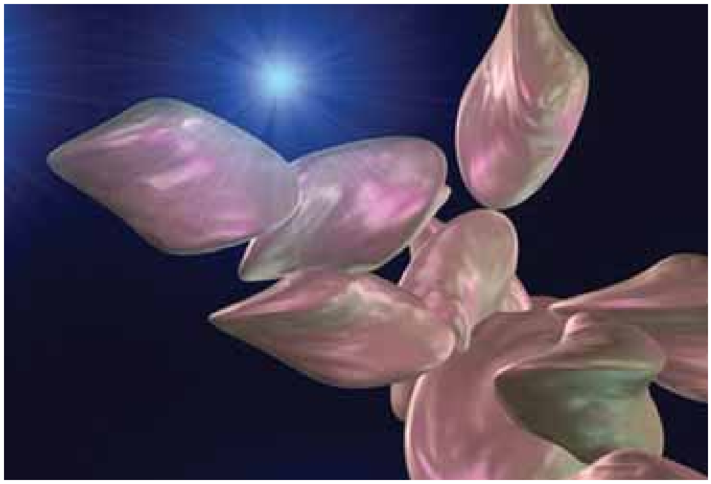


Figure 1: Experimenting with re-creating materials, textures, and behaviors.

function, intersected beautifully with each other to form a single wall. At some point while I thought I was altering the dimensions of the shattered particles, I was actually applying segmentations to a nearby sphere, and in all three dimensions. The resulting cluster of particles, unlike the almost flat wall, looked more and more like a school or swarm the more I studied it. In pursuing the idea for the swarm, I began looking for different ways to manipulate the shape and the motion of the swarm, and discoveries were made in toying with **form•Z**'s other functions, such as how to control the effects of wind. The swarm then evolved conceptually into the living sandstorm that operates in the Desert Grave Museum space, a place of pixels and shifting impressions.

Accidents and Exploration

The term mutation itself conjures images of the biological, of spontaneous changes in a gene pool, of "error." When designing in a digital environment, instead of visualizing the end product and then working to draw or model it, the creativity lies is in formulating combinations of effects and discovering the results, then differentiating between the more and less successful experiments. More and more designers are defining the design process as "finding" something or some combination of elements, rather than creating something "new" from scratch. A geometric multiplication of formal possibilities occurs with the combination of merely two functions, and many more than two functions may be utilized at one time. The element of chance is firmly re-introduced when digital experimentation derives forms outside of the visual library of the designer's mind.

The Furnimals concept originated with a folder of snapshots I was keeping on the side just because I liked the way they looked. I had been experimenting with rendering several different lighting schemes for a cluster of bubbles "growing" from the corner of a room, like beanbag chairs. I grew to appreciate the look of the first rendering pass which left its tell-tale trail of red dots in a pattern that emphasized the dimensions of the bubbles, and realized that if I paused the rendering, I could grab screen shots of my images coated with dots like chocolate nonpareils. The quest to find digital fur began with the observation of this "by-product" of the rendering output process.

In another situation, while setting up an animation for the desert sequence, I placed a camera inside one of the clear, reflective glass bubbles to capture the warped view of the other bubbles passing outside the sphere. Only when I watched the animation did I realize that a shattering disk moved through my selected bubble just as it was shattering. The marvelous cascading effect gave such a strong impression of passing through the cloud of fragments; I then worked to amplify this effect in the animation.

Another benefit of the digital sketching process is the ease with which the designer can render, save, label, and organize snapshots of their work and of each particular set of variables used in order to map the progress of the project for later reference and recombination. And just as with a digital camera, one feels free to experiment in a three-dimensional digital space. With the camera, one is not afraid to waste film or money on developing bad shots, and one is more likely to take a risk to capture something unusual. 3D digital design also permits the designer to take risks, or rather take advantage of a chance opportunity, with the safety net of always being able to return to the previous iteration of a design if the result is unsatisfactory. The rapidity with which the designer can see the re-

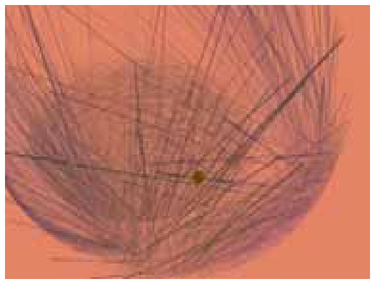


Figure 2: The Nest.

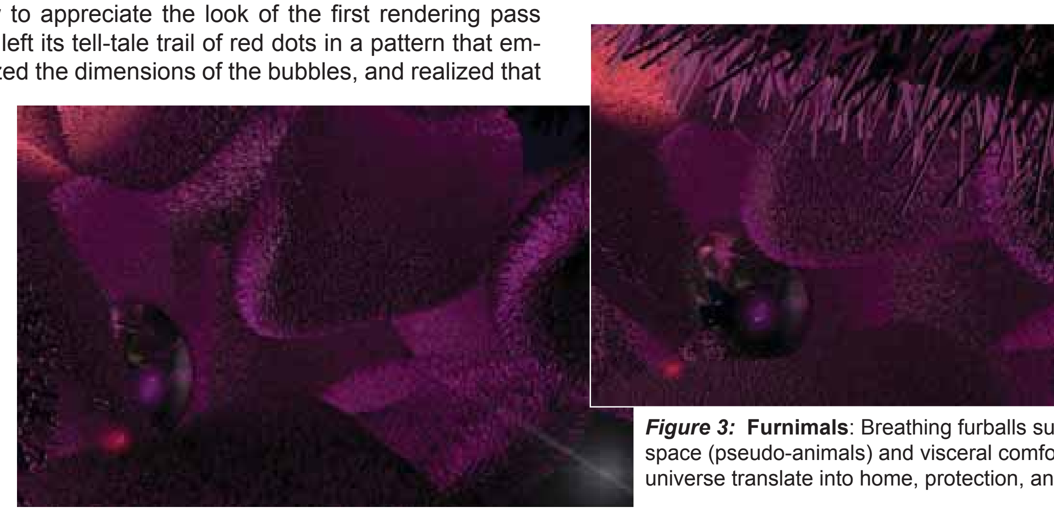


Figure 3: **Furnimals**: Breathing furballs suspended in space (pseudo-animals) and visceral comforts in a dark universe translate into home, protection, and self-reflection.

Figure 4: **Lanternlantern:** This animation puts the viewer inside a variation of Chinese carved ivory balls within balls and explores light effects. Rotations and strobe flashes mimic the workshop's trials and inspirations.

sults of these experiments leads to a multiplicity of "tests" and, we hope, broader formal explorations.

Additionally, the images saved from one's very first explorations tend to serve as a helpful reference later in the design process, and sometimes designers return to them when they feel they have lost touch with a project's essence as a record of their freshest interpretations of the design problem. An entirely overexposed rendering from one of my early radiosity experiments became the launching pad for the bleached-out, glaring white sun of the desert space. In this case the lighting mistake became a concept only after reviewing old screen shots with my professor's second set of eyes.

Existing Context

The Formal Mutations Studio's emphasis on starting with an existing structure (Eduardo Chillida's Mount Tindaya project) and manipulating it, rather than "inventing from nothing" proved particularly effective as it relates to the study of interior architecture, with its emphasis on renovation. Starting with "something" becomes just the type of limitation or frame that drives the most creative problem solving. Establishing certain restrictions effectively narrows the field of possible solutions to help focus the designer's attention more intensely on the remaining possible solutions. A set of "rules" or parameters gives the designer something to toy with in her mind rather than a great blank page to fill.

In the case of the Mt. Tindaya project, I was most attracted to the fact that there has been no structure built to "house" this interior space; rather it has been carved out from an existing mountain of rock. With this idea in mind as the "nugget" of what Tindaya was about for me, I went on to develop my digital home, workshop, and museum spaces with one prominent shared element in common. Each of the spaces floats or hovers in a vast and mostly empty environment. Here the relationship between the original structure and the resulting variations is very strong and serves as an excellent example of how a design solution can easily emerge from the essential nature of an existing space.

Many designers today view the careful consideration of context as essential to any successful and meaningful project. Digital design tools throw the relationships between design and context into strong relief. In contrast with traditional rendering methods, digital designs are not born with any given conditions, such as the light in the designer's room or the space of her work area. The digital environment begins as a complete tabula rasa, for which the designer is forced to consciously select every element of their manufactured world, from the textures of the building materials to the quality of light and the topography of the building site itself. The following paragraph summarizes writer and philosopher Alan Watts' thoughts on the interdependence of objects and space:

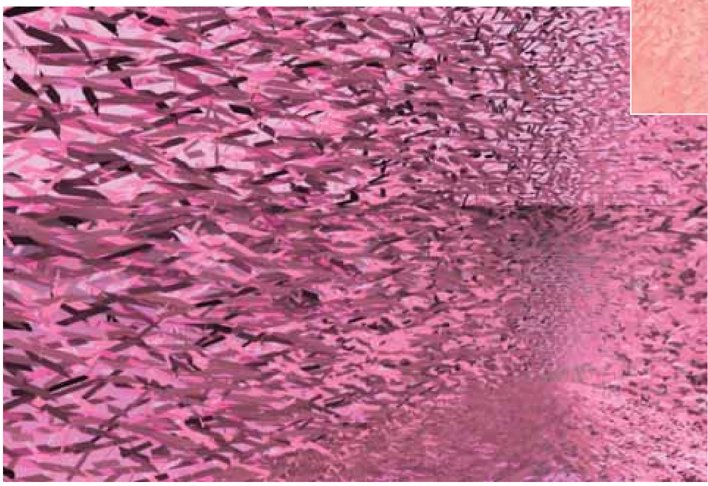
"We supposed that solids were one thing and space quite another, or just nothing whatever. Then it appeared that space was no mere nothing, because solids couldn't do without it. But the mistake in the beginning was to think of solids and space as two different things, instead of as two aspects of the same thing. The point is that they are different but inseparable, like the front end and the rear end of a cat. Cut them apart, and the cat dies. Take away the crest of the wave, and there is no trough."

Watts' ideas can easily be applied to our discussion of digital design. There is something about observing objects in digital space that seems to have an equalizing effect upon the two. Positive and negative spaces must be considered equally at each step. The digital world seems to make space more palpable. Nothing is assumed at the conception of a project, as the glaring blackness, the lack of ground, and the absence of any orienting objects at

Figure 5: A swarm of particles.

all forces the designer to construct a context, as well as its contents, from the start.

The blank, arid distance of the desert environment is broken by the presence of hovering translucent mirrors, viewable only from certain angles, just as mirages materialize in hot sands. Arrays of small particles in the desert call attention to the air nearest the viewer, which she might otherwise look straight through. The black night surrounding the Furnimals' writhing litter



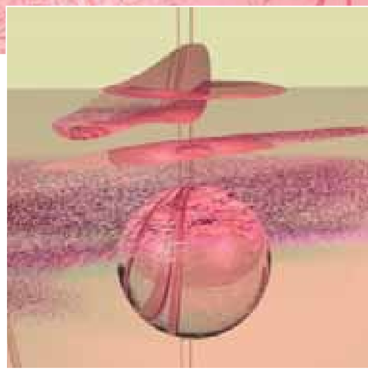


***Figure 6:* Desert Grave**: A swarm of particles animates floating structures and demonstrates the ambiguity between hot and wet sensations in this museum. The viewer is lost in mirrors and sand, disintegration, distance.

gains depth and strangely, emptiness, when it is punctuated by a few glinting stars.

Movement

The animations a 3D digital program can produce cannot be underestimated as tools assisting in communicating the inhabitability of spaces – an absolutely essential element of architectural and spatial design. The manipulation of the camera gives the designer another level of control over the viewer's perceptions of the space. She determines the way the space is looked at as well as the nature of the spaces and forms, thus putting the viewer "inside" the project. The experience of the swarm descending as seen from inside a glass desert bubble, the shifting stenciled patterns of light passing over you as you hover between two rotating spheres that mimic Chinese carved ivory balls-within-balls, the feeling of nestling evoked by the constant "fidgeting" of densely-packed Furnimals surrounding the viewer on all sides – these are perspectives that are accentuated by animated movement through three-dimensional space verses a single rendered image from one point of view.

Movement is essential to the experience of architectural space. Through movement, the viewer registers a series of sequential experiences and time is thus incorporated as an element of the design. However, the study of statics has long been the focus of much architectural planning, even when the effects of dynamic forces on structure are in consideration. The goal has always been to maintain the stability of the structure in the face of the variable and the unexpected. The application of animation to architectural representation appears to have introduced the concepts of growth and change associated with living organisms into the design of building forms themselves, and also into the human progression through a building's voids. A new view of architecture emerges, one that emphasizes the transient and improvisational over the static and planned. Why couldn't the walls of a building consist of rotating spheres, throwing dappled light patterns inward on themselves, and reflecting the nature of the art of the photographer who works within? Why couldn't your home and furniture be made of living, breathing furballs that calm you with their slow, sleeping rhythm?

In focusing on the sequential progression through a space, the route or path, as well as the possible ephemeralities, changes, and transformations of the structure itself (generated through digital manipulation) architecture may no longer necessarily be about monuments to eternity, in which the egos of men or the all-encompassing power of God is immortalized. A new view of reality as constantly shifting, contradictory, transitory, and fluid, supported by

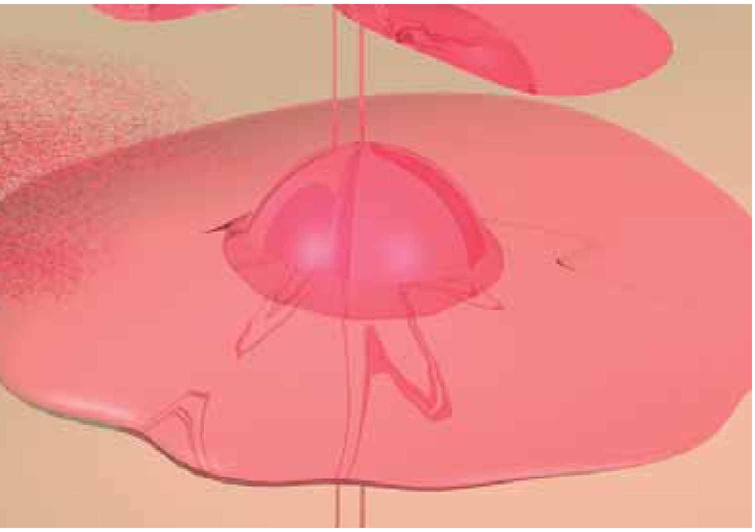


Figure 7: Animated transformations.

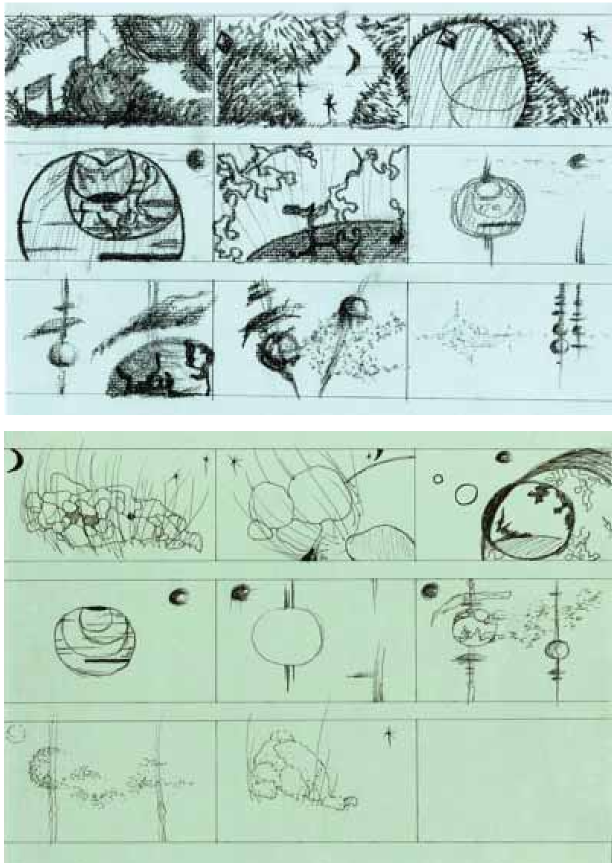


Figure 8: Storyboards.

a physics in which light is both a wave and a particle with no fixed, observable location, has been growing in popularity and acceptance. Might such trends in physics and architecture be influencing, or influenced by, our changing conceptions of identity?

Evocation vs. Definition

Overall, the students in the course produced a balance of work focused on both concrete and more abstract approaches to our design mutations problem. For my part, I took this class as an opportunity to work in a more abstract fashion than I had been able in my previous studios. Research for the project began with extensive lists of words conjuring associations, atmospheres, and sensations connected with my ideas about each of the three spaces. I see my designs as a series of moves intended to tighten the link between the conceptual and the real, and to translate visceral human sensory impressions and psychological metaphors into affective virtual habitats.

I could not resist the allure of "Impossible Architecture," suggesting the dreamscape, or sensory experiences we cannot actually have in our reality, such as penetrating a glass bubble to enter its concave interior, the contrast of our ordinary viewpoint with the sudden shift to the warping of the curved glass. The ability to visualize so completely and clearly a design that defies the laws of gravity, structural requirements, and familiar material properties was like a window opening for me. In the history of innovation, most often the inspiration for something "new" comes first, based on a common need and a possible solution, and then the designers and engineers strive to figure out HOW to make this idea a reality. An optimistic view of digital design conceives of the computer environment as a new venue for the discovery of possibilities we can then work to materialize in the non-digital world.

Tara White holds a Master's Degree in Interior Architecture (M.I.A.) from the Rhode Island School of Design (RISD) and a Brown University Graduate Teachiong Certificate. She currently works for Abernathy Lighting Design in North Providence, RI. Tara completed her undergraduate studies in art history at Yale University, focusing on documentation as meditation in the work of several conceptual artists of 1960's and 70's. She has participated in international studio/study programs in St. Petersburg, Russia, Kyoto, Japan, and Dubai, UAE. She has exhibited in the RISD Graduate Student and Graduate Thesis Exhibitions (Providence, RI, 2007), the Hermitage Museum's International Student Show (St. Petersburg, Russia, 2005), two Yale University Undergraduate Painting Exhibitions (New Haven, CT, 1994, 1995), The Yale University Women's Center Drawing Competition Show (First Prize, 1994), and the University of the Arts National Awards Exhibition for Metalwork and Jewelry (Philadelphia, PA, Blue Ribbon and Gold Medal, 1991). Her interests include art and architectural writing, as well as reading and writing fiction (2nd Prize, RISD All-School Fiction Competition, 2006), architectural lighting and luminaire design, photography, food, lists, Japanese Shinto Shrines and bathhouses.

Pratt Institute
Brooklyn, New York

Conceptions of Space:
The Dramatization of Space Through Non-Architectural Concepts

by Lara Guerra

This article will demonstrate various student works taken from an elective Fundamental of **form•Z** class which has been re-engineered into a studio format. The premise of the classes which I've taught and am teaching, for both the Department of Graduate Architecture and the Department of Continuing Education at Pratt Institute, is to use **form•Z** as a tool to conceptualize space, being that it is primarily geared for architecture students.

Figure 1:
In class exercise: spatializing text.

The idea is to use the software as a design tool that will help the student materialize their ideas and interests, in ways that might not be immediately associated to architecture and space. Too often 3D modeling software has been used as a means to represent an already established and polished design. This class trails away from this method of thinking and working. It primarily focuses on the intention to use software as an extension of thought and process. The representation of the design, through rendered images, is ultimately what students present; however, the questioning of space and development of the student's subject matter are entirely done through and with the 3D software itself (Figure 1).

Class Structure

Typically, architectural classes are structured around the purpose of creating a building or space using notions such as program, site specificity and the like. It is usually done so, to guide the student in developing a possible project, geared toward the requirements of the architectural market.

In contrast, the students in my class are encouraged to develop an idea which is of interest to them, without it being directly about architecture, or discipline they are studying or working in (see Figures 43-47).

The idea can be anything from a word, a routine, a fable, anything which the student uses as the basis for their spatial exploration. Some of those ideas have included notions such as water, embrace, light, to name but a few.

Contrary perhaps to other studio classes and environments, there is no formula to develop an idea, and most of the ideas explored have nothing to do with "architectural programs" or standard "architectural concepts" (see Figure 2, where the word "hair" was chosen as a concept for developing spatial explorations).

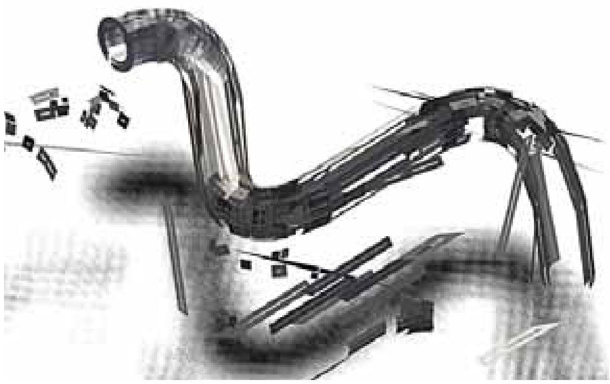


Figure 2: Adee: study structure of a strand of hair.

It encourages the purity of an idea and its consistency throughout the project. It's about being able to track the movement of the idea though repeated steps, visual clarify of the idea, etc. It doesn't rely on any past architectural references. It tries to break away from what we are taught and tries to allow the student to develop the purity of their idea, its visual representation and its implications to form and space (Figure 3). It relies purely on what the student would like to spatialize. What the students are asked to

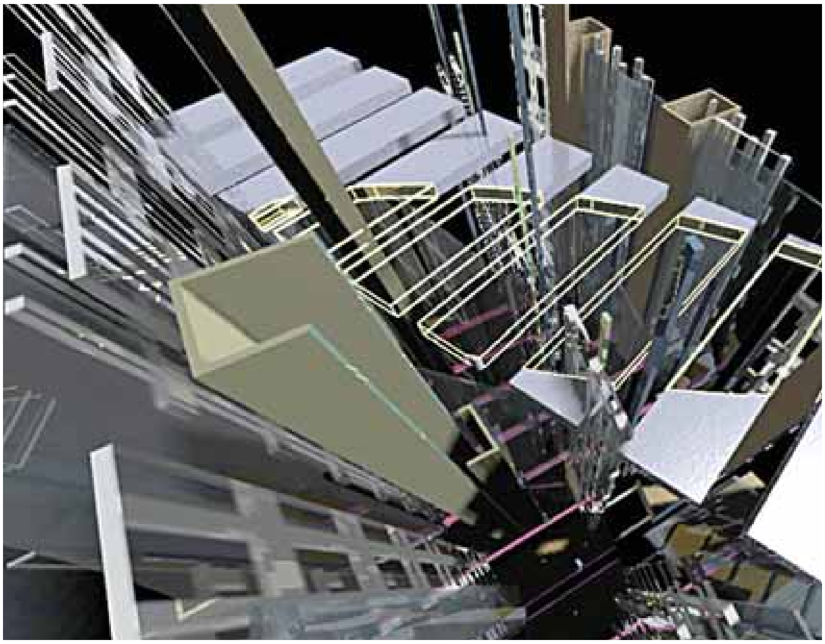


Figure 3: In-class exercises illustrating possible space relationships.

Figure 4: Paige Ridley: structure-study of a bird's wing.

Figure 5: In-class exercise: studying the combination of structure and surface.

do is to design a space that is not necessarily possible so they can explore how the software can alter their own spatial conceptions. The possibilities being endless, they choose a more concrete idea that they develop throughout the semester and reinterpret it. In order to aid the students in developing their idea, the project is divided in two parts: structure and surface. The student must design a minimum of three structural elements and three surface elements that support their concept (Figure 4). These elements are then confronted to one another in order to form a dialogue that creates a space (Figure 5). These elements are discussed and used as a way of getting away from what we already know and perhaps question daily. It allows the student to experiment with different notions that are just as common, albeit in a different environment. This in turn allows them to re-develop their pre set notions of space and relationships (Figure 6).

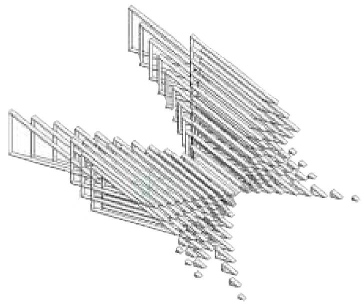


Figure 6: Dongwook: studies in structure.

This becomes quite a challenge since the student is, in parallel, trying to learn the software. They enter the class with no prior knowledge of the software and are asked to design with it. The experimentation takes a lot of space and time and the development of the idea is most often put on the back burner as the student struggles with understanding the software. The student does not become well versed in it until perhaps the end of the class. This tends to slow down the design process and satisfactory design results are most often seen toward the end of the semester (see Figures 38-42).

Language and Exploration

We do not use architectural jargons such as program or site, or any conditions that are concretely discussed in our working environment. We speak of Cartesian grids and spaces, repetition through random equations, center of rotation or transformation, distance, density etc. These are notions and languages that exist within the **form•Z** realm (see for example Figure 18).

Process and Outcome

Satisfactory design is not solely judged on the quality of the image, or representation of the space. A good design is one that supports the idea being developed by the student. Being that this is an experimental class, with so many varied projects, the criteria for judgment is primarily posed on the process of the creation of space (Figure 7).

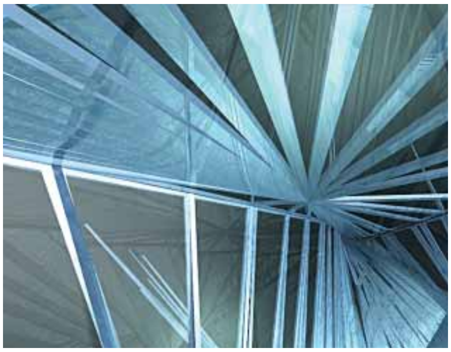


Figure 7: In-class exercise: complexity of space.

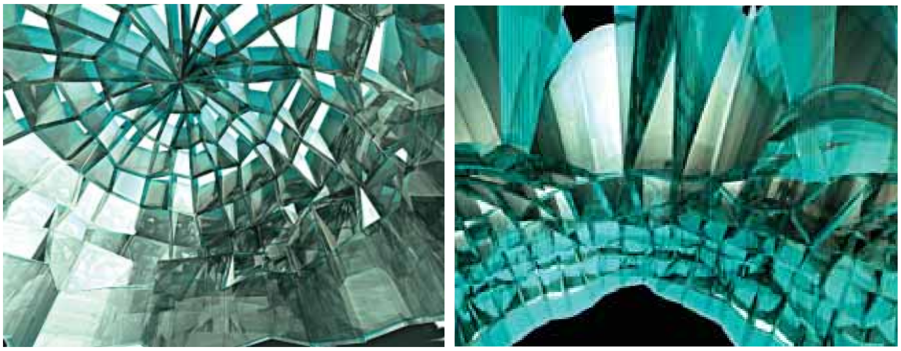


Figure 9-10: Pei-Yu: Jelly Fish: Final studies of structure and space.

How are the boundaries of this idea being defined, pushed and/or supported? The way an idea is being tracked in its development becomes primordial in understanding the strength of the final space and outcome. The process is the narrative, without it, the space would have no story. Consequently, I allow the students to develop their own ideas and concepts that are perhaps, at first hand, not relatable to architecture or space. However, the questioning and development of their concepts illustrate very strong relationships intrinsic to space and architecture itself (Figure 8). For example, the following student wanted to explore the imagined spatial qualities of a jellyfish. The word chosen to guide her project was just that: jellyfish. We can safely say that this is not a common “relatable” architectural concept. However, the student through her own interpretation of what the structural fabric of a jellyfish might be like, developed a series of triangulated and other deep set structures. This was her exploration which ultimately spatialized a very liquefied and reflective space that supported her idea (Figures 9 and 10).

If we consider that space exists everywhere through the relationship of two or more elements, then the possibilities are endless. The classes are re-engineered as studio classes, where an intensive exchange of ideas and possibilities of space conceptualization become the main focus. **form•Z** is utilized as a tool to engage in these possibilities. This exchange serves as a forum of thought for the students, who are given the opportunity to rethink space. We focus on the idea of the dramatization of space and relationships. The students engage in creating this space by narrating a story, event, a word, as system, etc. They take the opportunity to develop a topic that is of interest to them, all the while, trying to spatialize it. The idea is to work with the limitations of the software, questioning the boundaries of logic and working them into the projects (Figures 11 and 12).

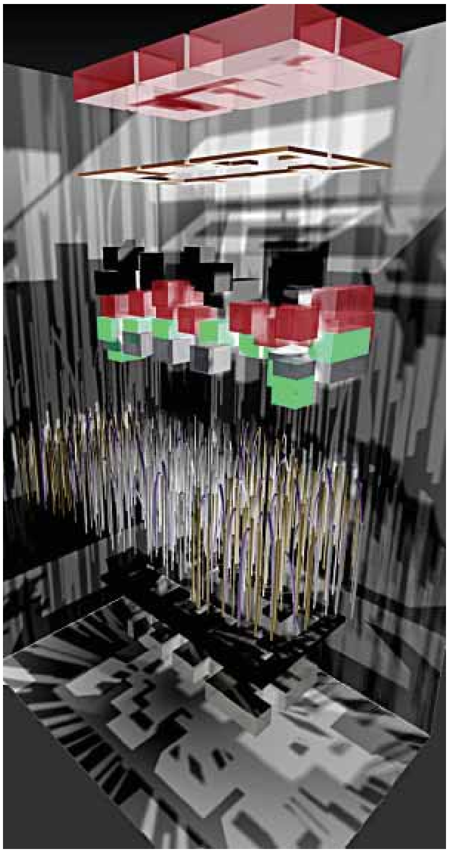


Figure 8: Emine S. Akkurt: process and elements of space complexity based on games and building blocks.

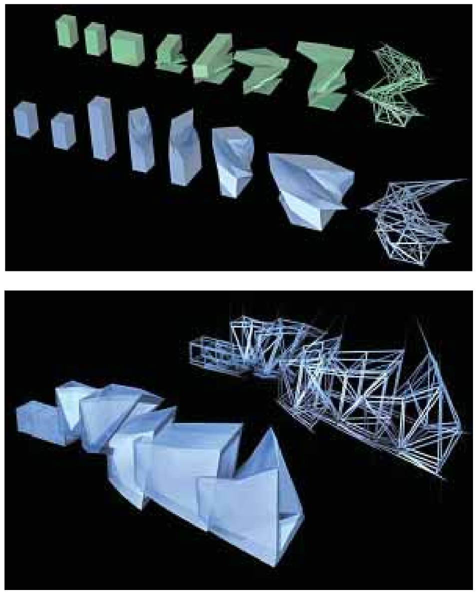


Figure 11-12: MW: Metamorphosis-final studies:
The deliberate programming of arbitrariness. The student set specific equations of transformation through angle rotations, repetition, movement and deformation, to achieve the gradual metamorphosis of a box. The process consisted in being deliberate about a series of arbitrary transformations to create a series of structures. The student programmed specific values of scale, move, rotate and deform to a box. By the repetition of the same values deployed in space she created various possibilities of space and structure.

Narratives and Scenarios

How this is achieved is through one major assignment that consists of inventing a space, be it a fictional one, possible or impossible. The idea is to choose a theme along which the students will design their environment by inventing the circumstances around that environment. That is, they invent a scenario to support their ideas which will also serve to help guide them in their decision making. They set up a narrative that can include ideas such as light (Figures 19-30), words (and the imagery and concepts associated with them), political events, psychological states, among other possibilities, anything that the student wishes to talk about by spatializing it. It is developed comparatively as a screenplay where key actors or "elements" come into play to dramatize the space which ultimately narrates a concept, idea or event.

The idea is that the space will tell a story. A story has a narrative and characters which engage with each other. The story is the idea or title of the project, for example some projects had titles or ideas such as: Water, Embrace Figure 16), Alice In Wonderland (which we will explore below, see Figures 13-14). Each student invents the circumstances of this story, for example:

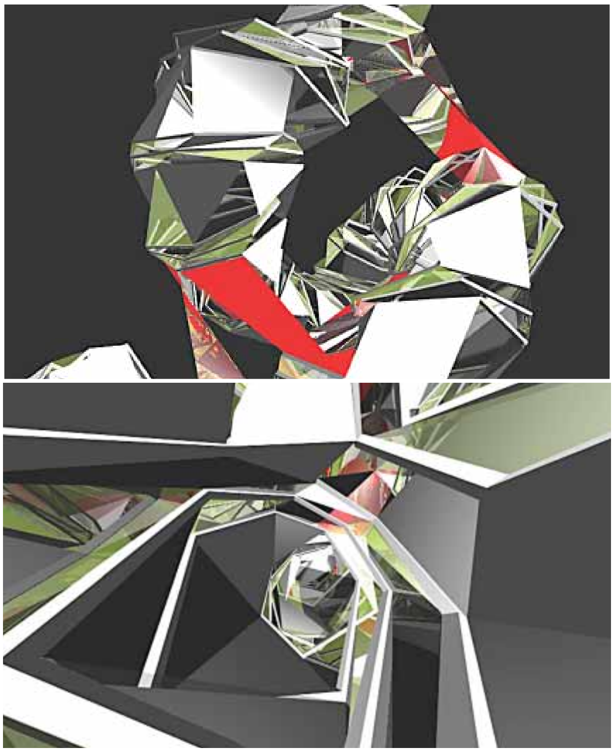


Figure 13-14: William C: spatializing Alice's fall through the rabbit hole-Alice in Wonderland. A series of octagonal structures were deployed, by increments of rotation and displacement through space to recount and re-interpret Alice's journey through the rabbit hole.

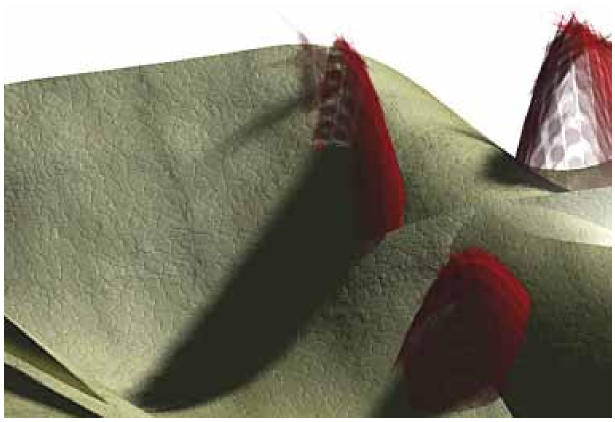


Figure 15: JJ: Miniaturization of space. Sewing and seam. Study of the space that exists within the movement of fabric and between a seam.

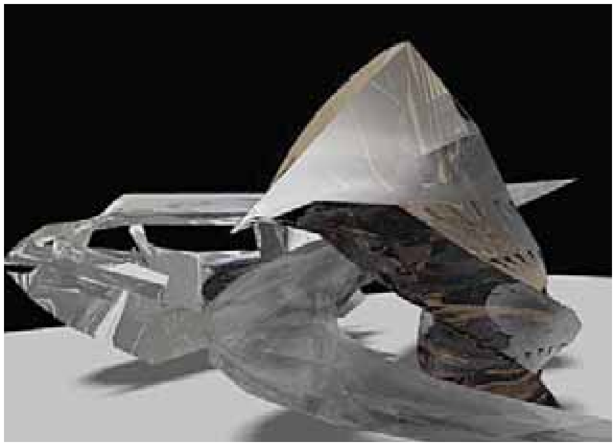


Figure 16: Carrie L.: spatial study of an embrace by the confrontation of 2 boxes, which underwent a series of deformations.

The student wanted to spatialize Alice's descent into the rabbit hole. Alice in Wonderland's trip down the tunnel was recounted with the use of basic geometry.

The geometry being a series of octagonal frames fractured and connected together, perpetually shifting to create movement from the beginning of the descent to the end of the tunnel. In this one example the scenario is a familiar one, however re-interpreted through a set of circumstances imagined by the student. Geometry was used to narrate Alice's descent.

The context for the project becomes an important part of the project itself. It is a chance for the student to explore notions which they are interested in but which are typically marginalized by our pragmatic environment (Figures 15-17). Studies of form and relationships are developed along many different topics such as: Water, Embrace, Metamorphosis (Figures 11-12), Installation art: space versus image (Figures 31-32), insomnia, sound (Figures 36-37), Alice in Wonderland (Figures 13-14), Deep Surfaces (based on Yacov Agam's art, Figures 43 and 47) and the Cuban missile crisis (Figures 33-35), to name but a few. Each one of these topics is then spatialized by a set of rules which the students develop to support their narrative.

The software's notions of repetition and re-iteration, mathematical Boolean operations, direction, sequencing are constantly being confronted and utilized in the search of form (Figures 19 and 38-42). I encourage the deliberate actions of arbitrary rule, notion of computational error in the limitation of a tool, the deployment of repeated structures, the definition of objects and their components in the development of the students' ideas.

Figure 17: Menaz. Transparent labyrinth.

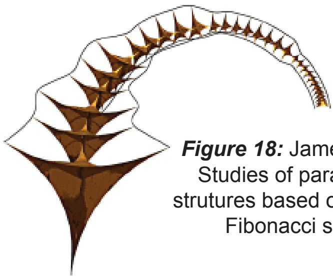


Figure 18: James R.: Studies of parabolic strutures based on the Fibonacci series.

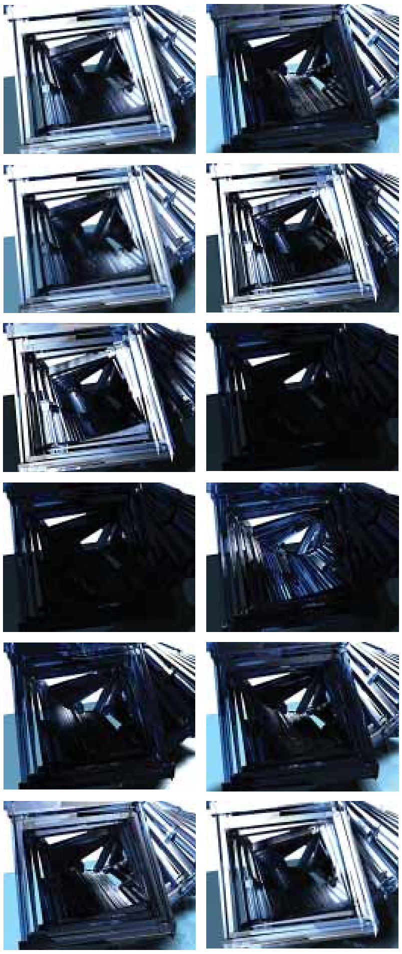


Figure 19-30: Michael Chan. Studies of light-definition and negation of space. Creation of a space punctuated with twisted structures and openings, to track the movement of the sun and light. Observation of the moment when space is negated through the absence of light.

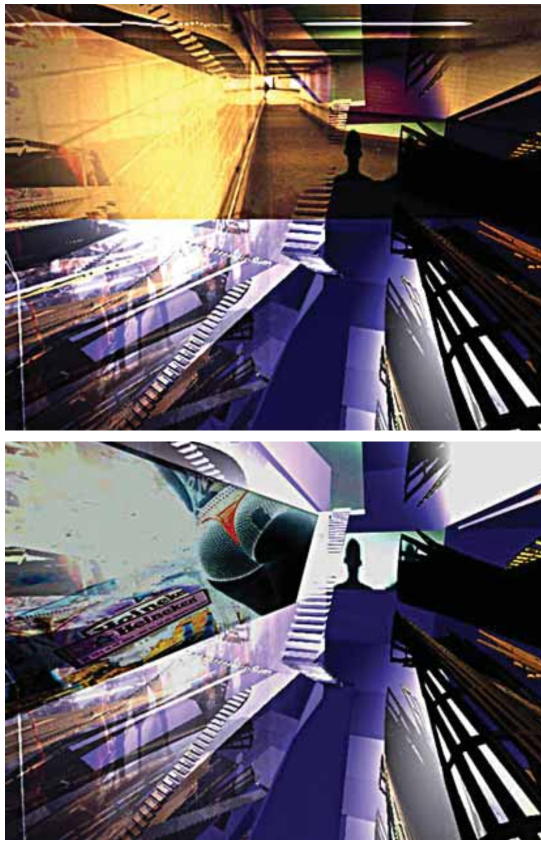


Figure 31-32: M.V: Installation art – Juxtaposition of space and image: obliteration of space through image.

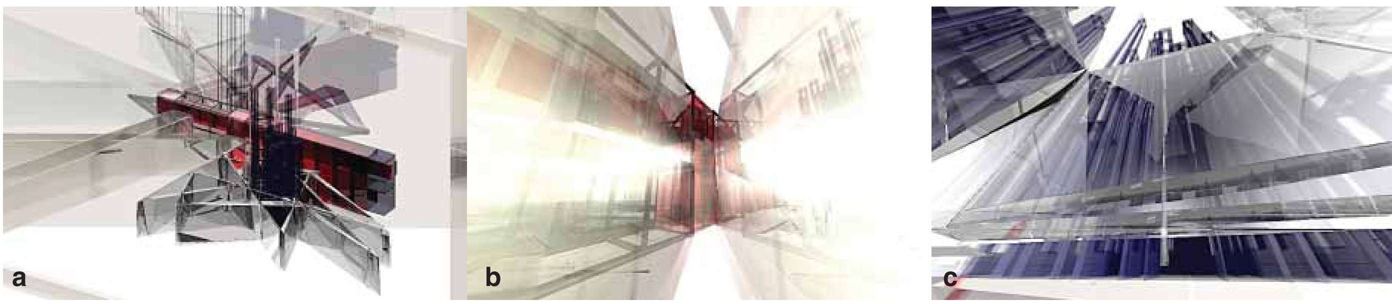


Figure 33-35: Yvonne: *Spatializing the Cuban Missile Crisis:* Strategies and consequences: (a) Here, the student orchestrated her narrative around the idea of the time line (left) and possible consequences, if certain decisions were taken versus others, during the Cuban missile crisis. (b) The center space of time is illustrated, when the final decision of attack versus retreat (and vice versa) was being taken. The transparency is meant to illustrate time running out. (c) The image depicts the casualties of an attack from either the Cuban or American side. The images show the time line and the possible spaces that reflect a strategy taken, the toll of casualties if the position of attack was undertaken by the respective government and the transparency of the moment when time ran out and a decision was made.

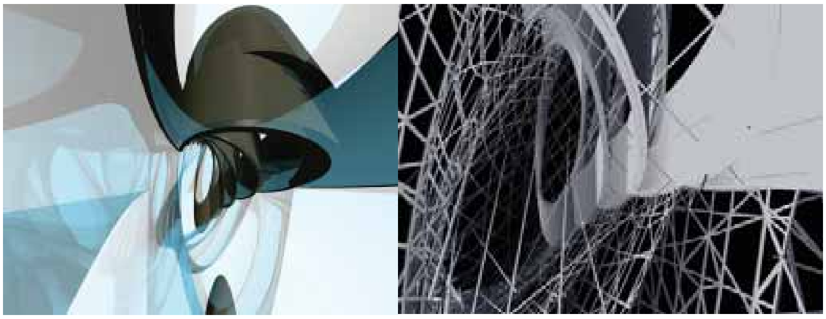
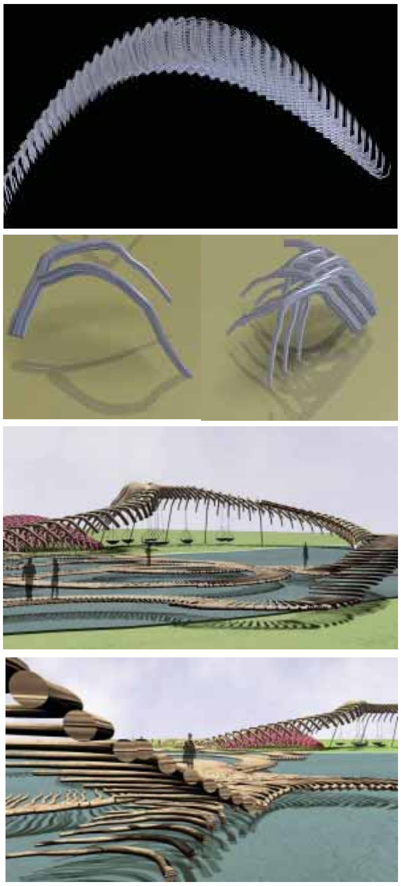


Figure 36-37: Carolina Del Rio: studies of sounds reverberation and its spatial interpretation.

Conclusion

In conclusion, the following examples of student work are a testament of the varied interests that are encountered in these classes, each one trying to recount a story, that perhaps at times seem to defy any implication of space and architecture, but that ultimately exemplify the notion of space and its dramatization, through any means possible.



Figures 38-42: Kate Elliot: Outdoor park: Movement & tactile experiences. Weaving structure studies through the repetition and deployment of one basic element.

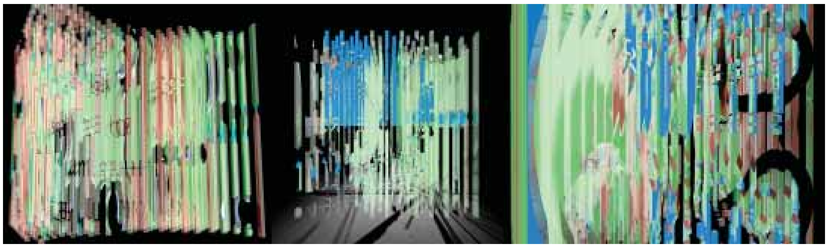


Figure 43-45: Aileen Iverson: Deep Surface – studies of meta-organizations- influenced by the work of Yacov Agam. The student quotes one of his statements as the catalyst of the project: 'The absence of motion negates the image' – Yacov Agam; This project was featured in the **form•Z** Joint Study publication of 2004-2005.

"This project seeks to explore the creation of surface as a 'meta-organization'. The quality of such a surface is influenced by the information held by these smaller elements (the density, number, form, color, etc.), a quality referred to as resolution. By introducing distance between objects carrying this information can we speak of the space thus created as having a spatial resolution?" -Aileen Iverson.

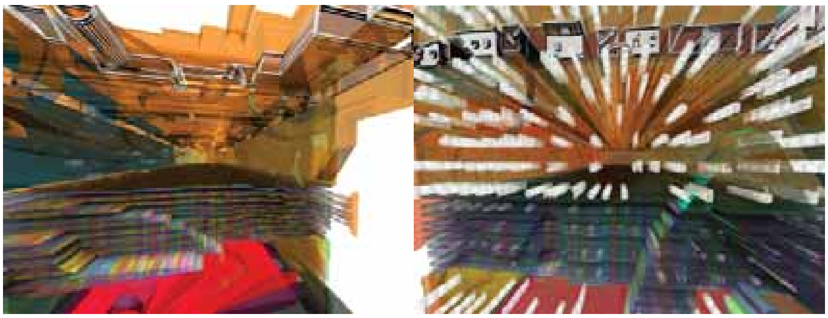
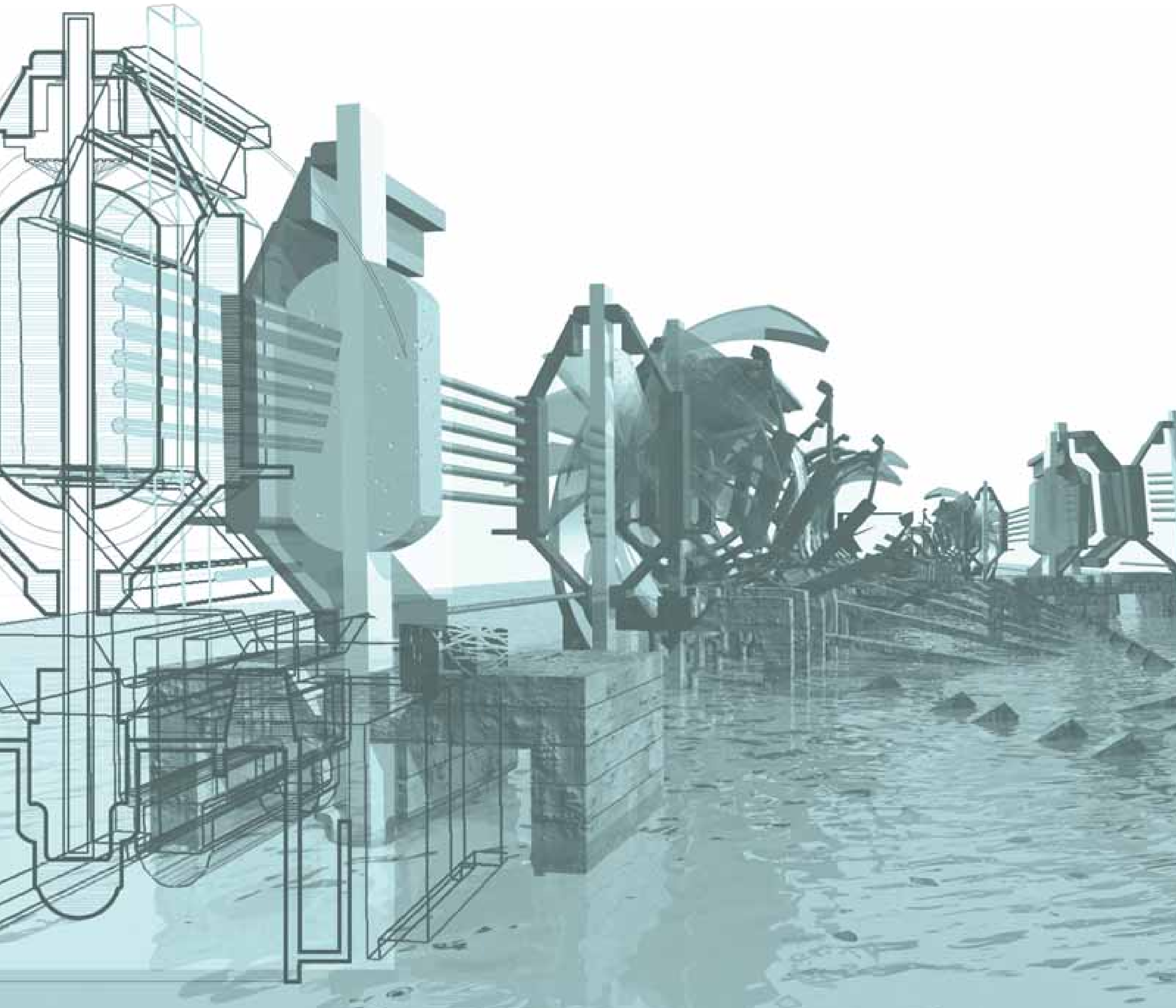


Figure 46-47: Aileen Iverson: "This field composed of objects in space; each combine through time and distance to generate the meta-organization or image becomes a 'Deep Surface'. If image can be defined as a perceivable, complete, recognizable picture than to imprint this image on a field of object in space is to create an image that is spatial i.e. relies on movement to be perceived."

Lara Guerra has been teaching at Pratt Institute for the Graduate Architecture department since 2001 and the Continuing Education department since 2003. The classes are elective classes reengineered into a studio format. The premise is to design space using 3D software as a catalyst of ideas and spatial possibilities. The intention is to gear away from the mere 3D representation of an already established design, which is polished and rendered mainly for marketing purposes. She is a fine artist and an architect working in New York City as an Associate at Perkins Eastman. She primarily works on affordable housing with non for profit organizations, countering gentrification in Harlem. She has completed more than 20 buildings in this effort and continues to fight for the right of affordable housing.

Chapter 2

Form Tectonics



Riga Technical University
Riga, Latvia

Bric-a-brac of Creative Computing:
Studying Fractal Shapes with form•Z

by Modris Dobelis
Project by Dmitriy Averyanov and Vladimir Katz

And how the One of Time,
Of Space the Three,
Might in the Chain of
Symbols girdled be.

William Rowan Hamilton

Generally, a fractal most often referred to as "a rough shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole." The father of fractal geometry Benoît Mandelbrot formulated this term in 1975. A fractal has a complicated shape. Certain features characterize a graphical representation of the fractal by mathematical equation: it is self-similar, has fine structure, and is very difficult to describe it using Euclidian geometric language. It might seem like a nice mathematic abstraction, but fractal geometry, as we believe – is the foundation of everything that exists.

The theory of evolution, which emphasizes on chaos, natural selection, and gene, has come to dominate the world scene. The universe described as an intricately complex system emerged from some preset condition a long time ago and differed greatly over the course of its history. The diverse life forms are all a part of the evolved complexity, one that can be described using mathematics.

Quoting Ian Malcolm from Michael Crichton's "Jurassic Park", "Fractals are everything!" – meaning that all of the creation, from macrocosmic scale down to quarks follows the same rule of organization. A rock resembles larger pieces of rock in its structure and form, and ultimately it looks pretty much like the mountain that it is forming.

The reason for starting this project was our interest in fractal geometry as well as a desire to produce a program that would generate 3D fractal shapes for creation of convertible models. As to our knowledge there is limited number of software that draws fractals in 3D space, where you can "touch and feel" or explore them from different viewpoints.

Mathematicians have been generating 3D fractals for a long time. Just a few programs to mention are Quat 1.2[1] and TetraBot Explorer[2] – first thing, you are likely to find upon typing "3D fractals" in any internet search engine. These applications serve as a good medium for generating 2D images of 3D fractals. The problem is that you cannot get a complete 3D fractal, rotate it, zoom into it or use it as a separate model for your design project. There are plugins and applications for CAD software that assist in drawing fractal trees and mountains. However, there is practically no software that generates real-life fractals, which are described by algebraic methods rather than geometric.

There is a fine difference between 2D and a 3D fractal. Ripples on the water, or patterns formed by the wind on

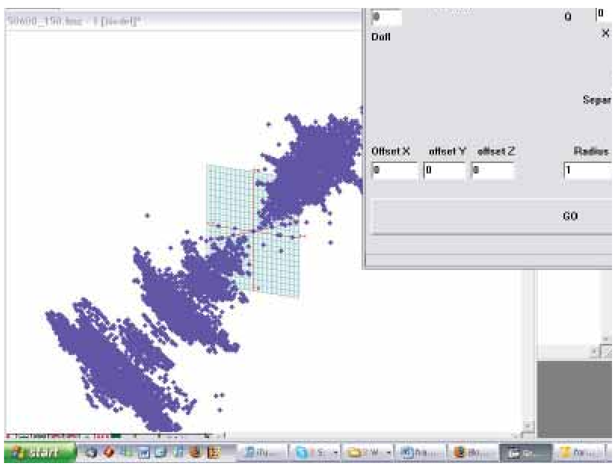


Figure 1: FractalZ application running simultaneously with **form•Z**

the sand, or the fabric of a leaf are all examples of 2D fractals when viewed from the appropriate viewpoint. Some plants, trees and the above-mentioned rocks – all are examples of 3D fractals. Their complex structure is not visible at first glance; it exists nevertheless. Living organisms belong to this second group. Although some of the main features, like repetition of separate parts in smaller scale are not present, human beings display symmetry and fine structure of their organs.

At the beginning, an application was written that performs the required calculations (Figure 1). For this specific purpose, quaternion numbers were used. The fractals defined in programs like Quat or FractIt were generated likewise. It is not the only way to generate fractals. Geometric methods can be used as well, but – as it was already mentioned before – this is not the case considered in this study (Figure 2).

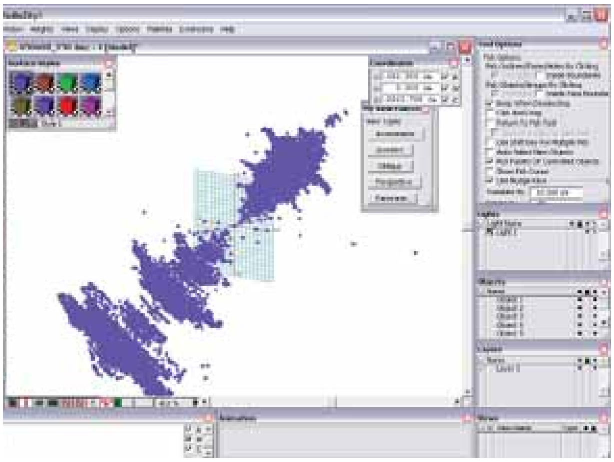


Figure 2: Fractal shape rendered by **form•Z**

The tale of quaternion numbers is an amazing story in itself – one that deserves a separate topic. In mathematics, quaternions are a non-cumulative extension of complex numbers. They were first discovered and described in the middle of the 19th century by Sir William Rowan Hamilton[3], a mathematician and physicist from Ireland. Hamilton was searching for a way to expand complex numbers, which represent points on a plane, into a higher dimension. He failed for three dimensions, but succeeded with four – thus finding the quaternion. Quaternion was met coldly in the mathematicians world and were quickly proven to be pathologic because they disobeyed the commutative law ab=ba, and therefore were completely replaced by vectors. Quaternion resurfaced in areas of 3D object orientation and geometric analysis during the computer age, finding their application in the computation of the objects of higher order.

Quaternion number consists of four parts – “1”, “i”, “j”, and “k”[4]. The resulting figure of the computational analysis is a 4-dimentional shape that can later be projected. Quat and similar applications do just that – they draw a projection of the resulting shape on a 2D plane. We went one-step ahead or in other words, an attempt to project or model a 4D quaternion equation in 3D space was performed in this study.

The calculation of the shape begins with an equation: $x_{n+1} = x_n^2 - c$. In this equation x_0 is the starting value, which is the point that has to be calculated; n assigns index to x $(n=0, 1, 2, 3, ...)$. The c value is the predefined quaternion that defines the shape of the resulting fractal. It is evident that the sequence of all x_n defined by the iteration formula, sometimes referred to as “orbit”, can have three resulting values:

1) the sequence converges toward a fixed value (e.g. zero);
2) oscillates periodically between some value;
3) approaches infinity.

The resulting object is the amount of all points (numbers) x_0, for which the sequence defined by the formula does not approach infinity or zero – in other words – which does not follow the scheme 1) or 3). This formulation is not complete because the computer is not capable of carrying out calculations up to infinity to see if the sequence is convergent. A maxiter value bypasses the limitation of our material world. After a certain amount of iterations, the calculation was interrupted. To verify, whether the sequence approaches infinity or not, the value bailout was introduced. This term comes from FractIt and Quat applications. If the value is exceeded, the computer assumes that the sequence goes toward infinity. Therefore, the calculation is the amount of all point-numbers x_0, for which the sequence defined by the iteration formula of the x_n did not exceed the value bailout after at most maxiter iterations.

The output was a little bit trickier. While the basics of fractal calculation are well known for a long time, handling the resulting data is far more difficult. The programming was simplified by the fact that it was not necessary to write the code responsible for the graphical output. The data of the generated points were fed directly into **form•Z** application. This involved writing a keyboard control module using a Delphi compiler. No changes were made in **form•Z** software. FractalZ is the name of the developed application that ran into separate window, and feeding point coordinates into active **form•Z** application. Thus, two programs – **form•Z** and FractalZ – ran simultaneously in some sort resembling a chalkboard that records a single point in 3D space for every coordinate FractalZ calculated.

At this point, we encountered serious problems. One thing to note is the speed with which the calculations or the input process was carried out. Using the method described above, it takes 200 milliseconds for **form•Z** to draw a single point and some 15 to 20 minutes to generate a 3,000-point fractal model. Another thing to mention is the amount of data that **form•Z** was able to handle. With shapes consisting from 20,000 and more points, application and computer crashes became more frequent. In fact, it takes several million points to generate a smooth fractal shape like seen in Quat. Our models, consisting from several thousand points, do not look much like fractals. Microscopic details very often are hidden at the lower levels.

It should be explained in what way 2D fractals are different from 3D and why handling them is more difficult. When the point is projected on a 2D plane, it is possible to control the size of the resulting image by lowering the resolution and adjusting its dimensions. That way, while some fine fractal details will disappear, the overall picture will remain. In case we want to go deeper, it is possible to zoom into a specific part and calculate it. The same cannot be done easily with the resulting points of 3D fractal shapes. They consist of a collection of individual points, a point-cloud that need to be visualized somehow. One way is to replace each individual point with a 3D shape (an analogy is voxel rendering), or drape the shape, creating a NURBS surface. To simplify the work with the resulting model, data filtering was performed. Excluded from the process of calculation were all those points that were found "inside" the model and could not be seen from outside, thus leaving only the outer layer. This approach considerably reduced the resulting model size and facilitated its easier manipulation.

Rendering of the object was finalized using point-cloud processing software Points2Polys from Paraforms (Figure 3) and Point Cloud (v.1.0) from Floating Point Solution. These applications connected the adjoining points, forming poly-meshes from the input data material, while Point Cloud is also capable of draping a point-cloud with a 2D plane. To achieve this it was necessary to export **form•Z** model into *.obj file format. Further visualization was complicated. It was not possible to reach the level of detail found in similar applications, for the simplest reason that our hardware and software was not adequate to handle the complex models consisting of several thousand points. To truly appreciate the 3D fractals in all their glory it would require many more iterations to be carried out on a finer scale with the resulting models much more complex, and much "heavier" (Figures 4-6). Similarly to a man in a dark cavern poking at walls with a stick. we were able to reproduce a part of that hidden, complex topology, while most of the nooks and crannies remain hidden.

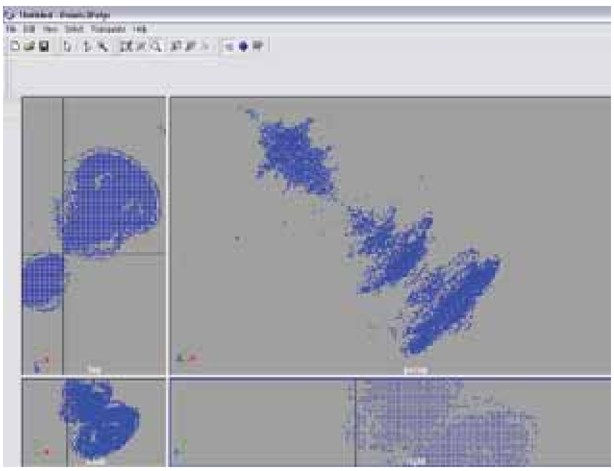


Figure 3: Fractal point-cloud in Points2Polys application.

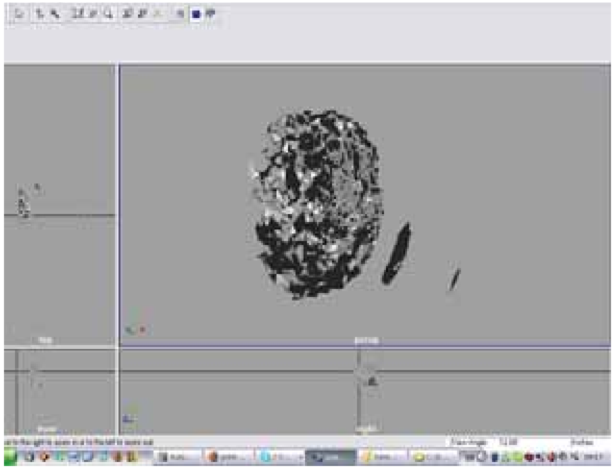


Figure 4: Mesh-cloud converted from point-cloud.

Figure 5: Artistic rendering of the mesh model.

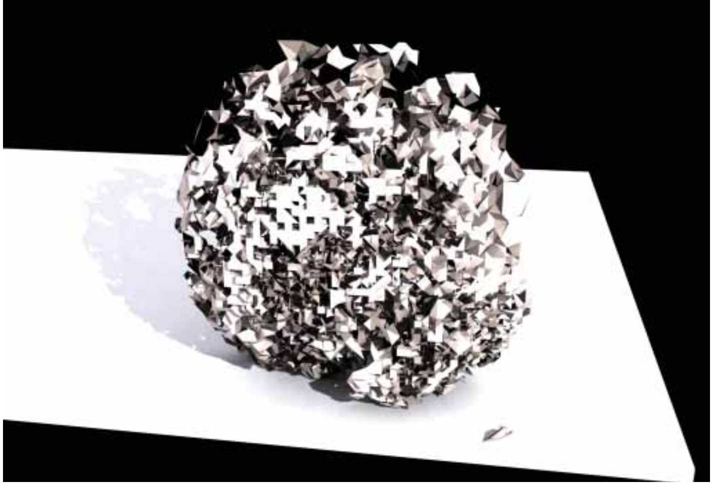


Figure 6: Artistic rendering of the mesh model.

The practical value of this work, as to our knowledge, is in its similarity with the study of the modern theoretical physics[5]. On the forefront of contemporary cosmology is the idea that our universe is just one of the many universes that forms a far bigger cluster called “the multiverse”, or “megaverse” as some scientists prefer to call it. String theory describes particles as vibrating strings of energy – because strings vibrate at different levels of intensity – there exist varieties of particles in our universe. The expansion of the universe is fueled by the so-called “dark energy”, an energy that represents the cosmologic constant (Λ). Now, the value of cosmologic constant is very important for our existence. If its value had been different during and right after the Big Bang, our universe would have ended up in a completely different state. If the cosmologic constant were lower than its present value, all the matter following the gravitational pull would collapse onto itself. On the other hand, if its value would have been greater, all of the matter would be blown apart, the expansion of space would occur so fast that galaxies and stars would have no chance of forming, and likewise, there would be no time for higher intelligence to evolve.

While calculating the 3D shape generated by the equation, FractalZ application was looking for specific values that would produce meaningful results. In case the results of the equation converged to zero or infinity, there would be nothing. We did a listing of all the valid points on the surface of that 4D shape.

The same can be applied to cosmology. Cosmologic constant, which seems to be so fine-tuned to satisfy our needs, could be completely different in some other universe of the multiverse thus making that other places uninhabitable. Scientists are busy constructing models of multiverse, called “landscape”. Now “landscape” is a difficult term. It is not something that exists in reality; rather, it is a “map” or the model of possibilities for the “shape” of the multiverse. Our universe, with our particular value of the cosmologic constant is just one of the many possibilities or points on the landscape.

What we did in our study was the mapping of the “habitable” places on a 4D shape, in the same way as physicists today are trying to map the landscape of the multiverse. To follow the analogy – cosmologic constant is our x, the result of the equation, where c – the quaternion – represents the four fundamental forces in our universe (gravity, electromagnet force, strong and weak nuclear forces). Now, this was not an arbitrary choice: since each force has messenger particles (gravitons, photons, gluons, W and Z bosons) that can be described by string theory as being the same vibrating string, it is possible to unify all of these forces into one quaternion number, assuming that they are permanent in their affect on the universe. That way, the topology of the landscape, where the universal constant changes and the four fundamental forces are locked into a hyper-complex number, the only thing missing is the equation itself, the formula that governs the shape of the landscape, and consequently – the multiverse. The four forces do not even have to have the same value; they can change as well, affecting the value of the cosmologic constant. It might seem a bit far-fetched, but linking these two principles might produce a coherent picture.

A trivia, a curio, bric-a-brac of creative computing are the words we would use to describe this study. The main value comes in the form of expansion of conscience. We achieved our goal – some very attractive visual masterpieces are presented for your evaluation (Figures 7-9). No conclusions have been formulated so far and the work on the study is continuing. Too many things are still not clarified yet. For some reason, certain quaternion values bring no result at all, while others blossom in various forms and shapes emerging from minor changes. New quaternion values are tested and new methods of graphical representation are under development.

A universe is an open-ended system. It exists in itself and has no perceivable end – neither in time nor in space. Mathematics, being an abstract plane of symbols and relations, shares that same quality – there is no end to it. Likewise, we would like to keep our project going on rather than placing a full stop at the end of this sentence…

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Figure 7: Rendering of point-clouds after processing by Point Cloud 1.0.

Figure 8: Rendering of point-clouds after processing by Point Cloud 1.0.

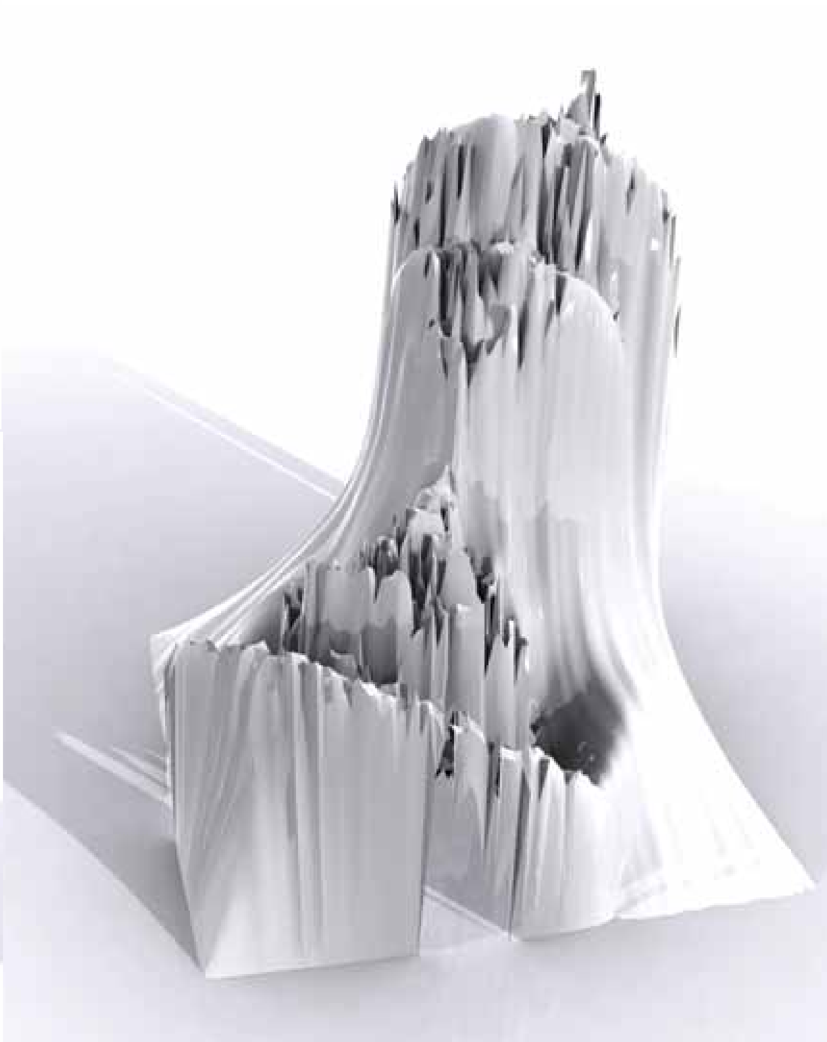


Figure 9: Rendering of point-clouds after processing by Point Cloud 1.0.

Modris Dobelis is Professor and Head of Department of Computer Aided Engineering Graphics at the Riga Technical University in Riga, Latvia. He teaches graduate and undergraduate students computer aided architectural design. He has received a Certificate of Appreciation and AP600 Program Award from Westinghouse Electric Corp. in recognition of superior performance as a member of the AP600 Project working on 3D modeling of piping and equipment (1994-1996), and Honorary Award from the Ministry of Science and Education of Latvia about promotion of CAD ideas in education (2007). He is a president of International Baltic Association for Geometry and Engineering Graphics BALTGRAF. He strives to promote the Building Information Modeling idea into architectural design process. Email: Modris.Dobelis@rtu.lv.

Dmitriy Averyanov is a bachelor student of architecture at the Riga Technical University, Faculty of Architecture and Urban Planning. He is a freelance artist doing part-time jobs in several architecture bureaus in Latvia, as well as in Russia. He is mostly involved in urban planning and renovation.

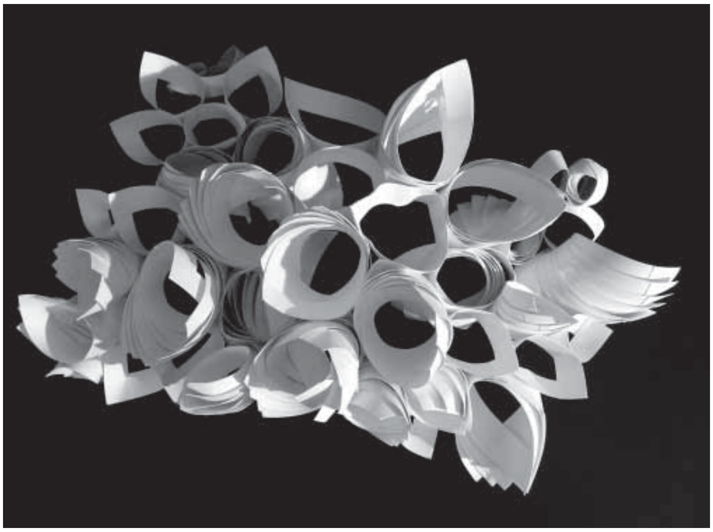
Vladimir Katz is a 4th-year student of mathematics at the University of Latvia, Faculty of Physics and Mathematics. He is an assistant programmer at a telecommunication company, Belam Inc., and a full-time fractal enthusiast.

Technische Universität Darmstadt
Darmstadt, Germany

Form Defining Strategies

by Asterios Agkathidis

"Form Defining Strategies" is a seminar, which has been held in the Technische Universität Darmstadt since 2006. Its main aim is to investigate form-defining mechanisms in architecture and design. Form and geometry are generated according to rules and parameter based applications. To avoid direct reference to architectural planning, aspects of scale, program and urban planning are left out. Instead, a set of abstract techniques based on manufacturing principles, linked to suitable materials, function as a form generator. The emerging physical "pre-tectonic" models can be read as spatial prototypes, which then function as abstract machines for architectonic and design solutions.

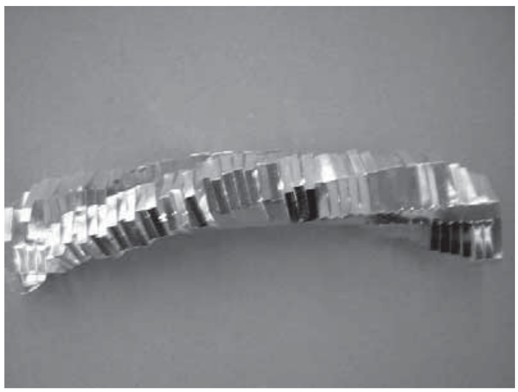


The class consists of three phases, which build on each other and are held as short-term workshops. In phase one, students are asked to create a series of physical models by applying a set of rules on a given two-dimensional geometry. Thus, a number of unpredictable but non-arbitrary objects emerge, which can function as a mechanism for architectural archetypes, even though it is not true architecture yet. Physical models prove to be extremely valuable, by introducing materiality aspects and physical properties.

The characteristics of different materials that were used for the models did not just influence geometrical possibilities, but brought with them material specific effects, with which spatial qualities could be intensified, explored and organised. This methodology is based on the conviction that working with physical models is indispensable even in today's all-digital climate. Architects are able to explore unpredictable, unimagined, and exciting spatialities that can emerge organically during the design process. Novel, experimental spatial structures and systems are discovered and inform this process and subsequent decisions.

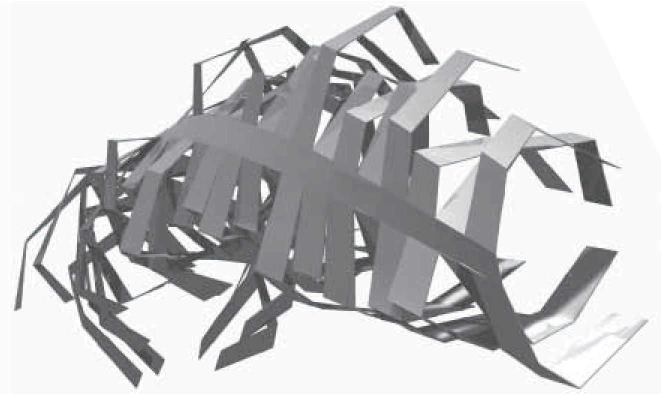
In the second phase, the students are asked to digitalise the physical geometries developed in phase one. A process of mapping and analysing is therefore necessary, enabling a deeper understanding of the models and its geometry. Additional modelling and animation techniques introduced by **form•Z** are becoming essential tools for object determination and its further development and translation into architecture. Students who often never had any contact with 3D modelling, discover an exciting and efficient tool which allows them to draw, control and modify complex geometries.

In the third phase, the students have the opportunity to 3D print the modified models, thus establishing a relation to contemporary manufacturing technologies. This interplay between analogue and digital model proves to be highly successful not only as means to interconnect these two ba-



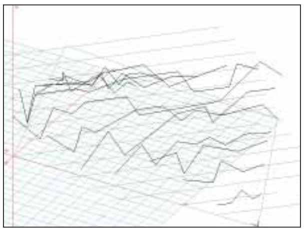
sic architectural skills, but also as an efficient didactic for teaching 3D modelling. Basic physical modelling attributes like materiality, performance, physical forces and allowance for coincidences or mistakes are later integrated in a digital determination process, which develops the geometries even further. Digital attributes like precision, parametric modification and animation are enriching the geometries while solving unclear points or problems.

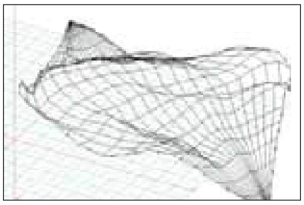
Physical models allow the quick translation of the chosen setup into form. The techniques used have to be applicable to the modelling material chosen. The chosen material dictates its own rules and informs, in that way, the emerging geometry. The final product is usually a non-static object which can be performed.

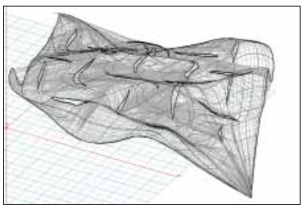


Digital techniques allow precise application of the form defining setup. Materiality can only be simulated. Testing modified variations, reproducing and optimizing components becomes a routine. Geometrical perfection becomes possible and complexity can be increased. The applied techniques are not linked to any materiality, but to the tools given by the software. Most often, the physical techniques have to be translated: bending becomes “sweep along path”, thermoforming gets translated into “nurbz“. This process contains both chances and dangers. It is definitely changing the structure of the emerging model.

The final 3D-ploted models are in no way perfect clones of the manual manufactured models. They certainly carry the “information” of both applied processes. Nevertheless the, lost sense of materiality is inevitable. The final product is static, but definitely more complex than its original. The differentiation of a structure’s “skin and bones” becomes relative. The models are precise but abstract at the same time, almost immaterial.





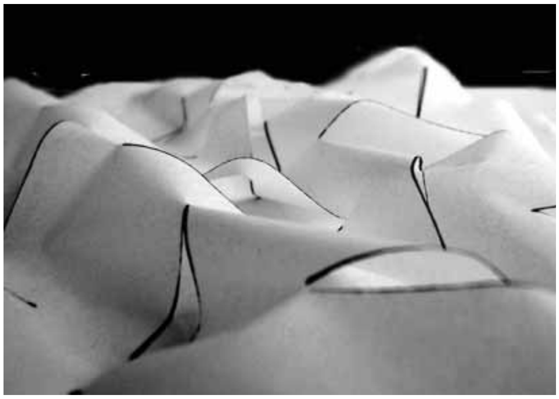


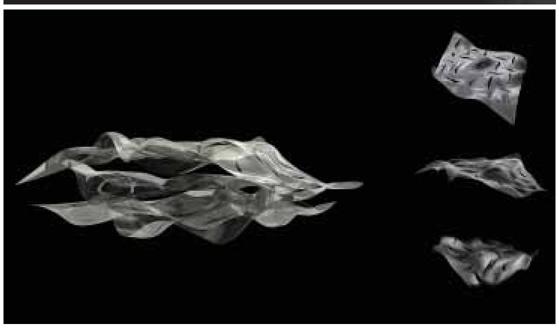
In sum, the described circle “analogue – digital – analogue” proves to be a very valuable architectural form defining procedure, which integrates traditional architectural techniques with the newly introduced manufacturing technologies. Joint venture instead of digital monotony. Analogue aesthetics via digital settings.

Perforated Skin

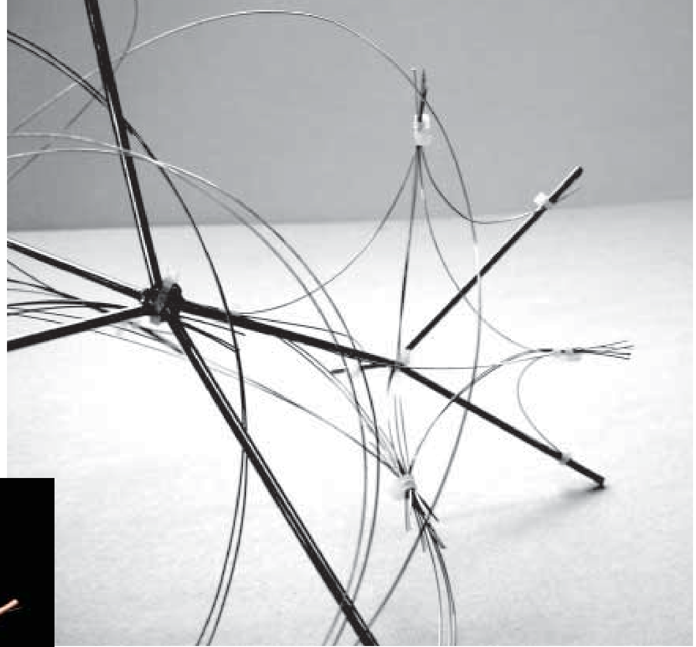
This model aims to explore spatial surface conditions. By using cutting and thermo-forming techniques, the two-dimensional surfaces deform to create a three dimensional structure. Three additional layers are overlapped and rotated by 45°. The final product could be read as a spatial landscape or as an instrument for generating architecture.

Physical Techniques cutting, bending, stretching, thermoforming, layering
Digital Techniques nurbz, trim with outline
Material Pvc foil



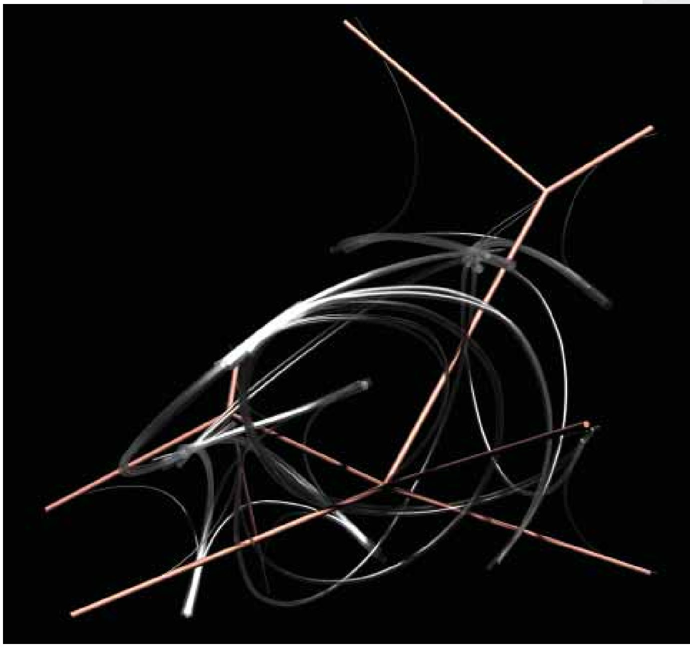


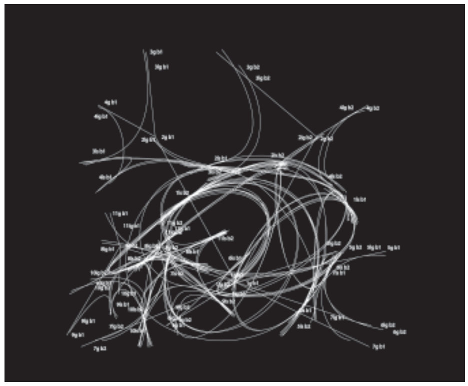
Synbot

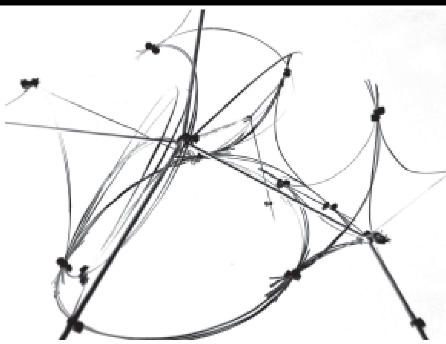


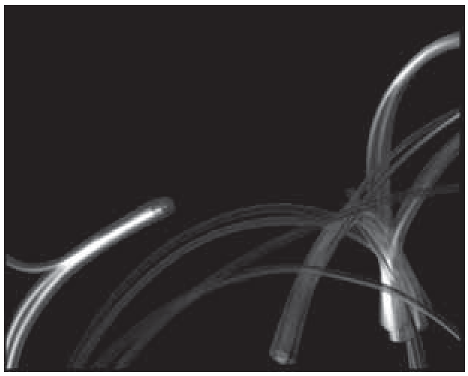
The functional schematic of a robot is translated into a dynamic system of knots and hinges. The model generated can perform movements in different directions, independently of its relationship to the ground. This sophisticated system can function as an organizational or structural diagram in an architectural design process.

Physical Techniques: bending, knotting, bundling
Digital Techniques: splines, sweep along path
Material: metal wire









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AsteriosAgkathidis was born in 1974 in Thessaloniki, Greece. He studied Architecture in Thessaloniki and completed postgraduate studies in Advanced Architectural Design at the Städelschule in Frankfurt in 2001. He was a partner in the architectural practice b&k+ in Cologne until 2004, then at VMX architects, Amsterdam until 2005. He later founded the architecture and research laboratory a3lab Frankfurt-Thessaloniki. Teaching and lecturing experiences include AdBK Nuremberg, FH Frankfurt, the University of Patras (as online distance-learning lecturer) and the Städelschule. Today he teaches at the Technical University of Darmstadt, where he is currently working on his PhD.

Rhode Island School of Design
Providence, Rhode Island

Formal Mutations
Designing a Transformative Experience

by Andrzej Zarzycki

This series of projects, titled *Formal Mutations*, explore tectonic possibilities in architectural form and space. They combine my personal design and research practice with lessons learned during a recent architectural digital design studio at the Rhode Island School of Design Interior Architecture department titled "*Formal Mutations; Designing a Transformative Experience.*" This article highlights findings and discusses students' and my design journey.

This studio focused on the dynamic aspects of architectural environments that adapt and interact in a similar way as life forms need to do in nature. While other similar approaches often limit themselves to tectonic expressions in architecture, our studio also stressed spatial and experiential dimensions—as signaled in the subtitle for the design studio--designing a transformative experience. Students were expected to apply digital tools to simulate morphological variations in architectural forms while considering a space's functional and perceptual requirements.

My interest in studying tectonic evolutions and simulating form mutations in design comes from the observation that these operations are natural ways to manipulate data and models. Editing already existing data is more native to digital environments than inputting new data. Architecturally this could mean that transforming already existing forms is a potent and effective way to derive new forms, ideas, and designs. This comparative approach is already present in architectural theory and history, but is slow to enter a design field where it has an opportunity to redefine creative relationships from individualistic drives to interdependent landscapes. This tendency is also evident in our civilization progression and particularly history of science, where progress is realized through iterative refinement of the past paradigms such as the Newton's Law of Gravity to the Theory of Relativity. In a broader conceptual sense, this means that creating new ideas from scratch is almost always more difficult than arriving at new ideas by gradual transformations of the old. This brings us to the main natural precedence for this method—biology and the emergence of life.

Figure 1: An evolving particle form, Andrzej Zarzycki.

Studio Methodology Origins

The Formal Mutations studio design approach grew out of an academic necessity— the need to educate students with good visual judgment and often-limited technical skills. It is the type of situation, when faced with limited time and a wide diversity of student skills where one has to improvise. My past experience with script-based design in studio settings showed me that it requires a major amount of dedicated time committed to teaching students the intricacies of programming and debugging. While scripting is a very promising design approach, it is usually hard to achieve more comprehensive architectural results that call for more than a tectonic solution while try to engage experiential as well as narrative component within a semester's time.

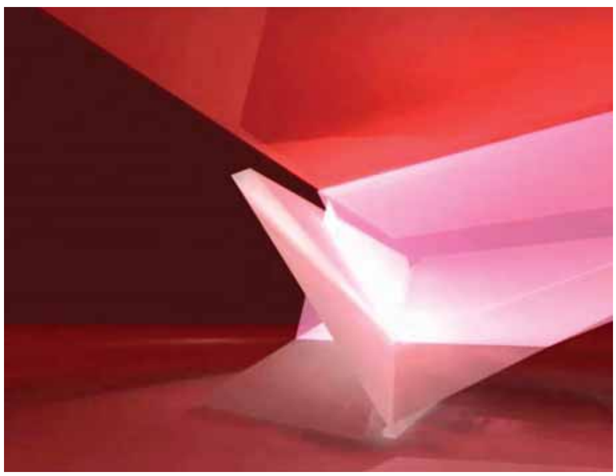


Figure 2: A transformed cube forms a digital landscape, by Nick Brunetti.

Thus, the Formal Mutations studio approach emerged. It mimics what one would do if given the ability to topologically transform physical objects, not unlike children do with clay (plastelin). This approach is a comprehensive take on the issue of transformation-based design and combining tools in a larger design methodology framework with ability to animate these transformations to derive new designs. In many aspects it mirrors what can and is often done with script modeling, but it keeps it on a user-friendly interface. It provides a designer with instant feedback regarding shaping of a form. Consequently, this allows for channeling design toward more promising solutions and, not necessarily, being over-committed to a particular approach.

Formal Mutations is an alternative to the script-based design approach focusing on the intuitive use of digital tools, shifting the balance from an emphasis on tool knowledge to intuitive explorations of form and space. It introduces poetry in form finding along similar explorative paths as when investigating light and materials.

The design is executed by applying simple rules and behaviors to the original form. Each of these rules represents limited vocabulary and produces very recognizable effects, like the ‘bend’ transformation. However, by compounding even a small number of simple transformations, the forms’ complexity and design possibilities are growing exponentially and escape predictable visual patterns. The phenotypic results of a single transformation may often appear not to change qualitatively its resultant form, but the transformation is still present in its genotypic definition of an object waiting to emerge. This dormant transformation may be later responsible for a rapid emergence of the form/design once other transformations are applied leading to complex and sophisticated forms. This rapid form emergence results from narrowing the difference between the phenotype and genotype potentials.

Studio Theme

Students were given an existing architectural environment and asked to design a space that could be a home, a workshop and a museum. However in this case, we were not looking to design a generic multipurpose space that could accommodate all three program components simultaneously. On the contrary, we were looking for three separate, highly specific, idiosyncratic spaces. Although sharing some common threads, each space would have a unique character. Later, we looked into ways to digitally transform these spaces (map one onto another) using their common threads as morphing trajectories and explore ‘in-between’ solutions that often emerge as ‘missing links’ in architectural environments. As a result, these three spaces (home, workshop, museum) formed distinct stages of a single architectural metamorphosis not unlike many organisms undergo in nature. One simple analogy in nature would be larva, cocoon to butterfly.

“Out of the Box” Designs

To jump-start the design process, the main studio project was preceded by a sketch problem that focused exclusively on the exploration of advanced **form•Z** and Cinema 4D modeling and morphing tools in context of architectural environments.

For this assignment, each student started with a simple model of a cube (Figure 3) as a set of six bounding square plates and explored its morphological possibilities. These cube transformations were executed with a limited set of software commands—transformations such as bend, taper, bulge, and translations such as move, scale, and rotate using objects’ various topological levels.

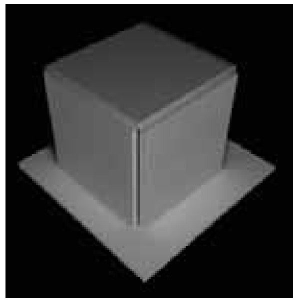


Figure 3: The original cube given to students.

This singular and directed focus helped students to work exclusively on form related aspects of architectural spaces, while developing an intimate feel for the parametric design intricacies of digital tools. Intricacies that emerge from compounding parametric functions and, in some instances, transformation non-linearity.

The final result was a transformed cubic form-space that offered a visually new architectural reading distinct from the original cube. In addition, students produced a number of animations that investigated the in-between forms. These investigations and design methodology became a foundation for the main studio project.

This preliminary exercise was designed to get students acquainted with digital tools and level out the differences in computational knowledge among them. It helped to develop awareness toward digital technology’s ability to achieve innovative results with a limited toolset and fragmented knowledge. This helped to shift students’ attention from chasing the “newest and coolest” software features and hiding behind technicalities of digital tools, toward a careful and thoughtful use of these tools as modes to express architectural ideas. It also emphasized the point--while knowledge of computational tools is crucial, it is secondary to students’ ability to imagine possibilities and visually judge their digital designs.

Software we were using, **form•Z** and Cinema 4D (the strength of the interface and intuitive modeling commands), worked well in this assignment since I was able to identify and limit my students to a small number of computer tools (commands) while not necessarily limiting their design outcomes.

Figure 5: A transformed cube, by Laura Lister.

The reduced number of tools helped students not only to limit the software's learning curve for the purpose of the sketch assignment, but also helped them to focus exclusively on the design challenge.

Sketch Outcomes

Students followed various design paths, some of them incorporating one or more additional tools to their design repertoire, resulting in a visually distinct architectural language. Laura Lister's cube transformation preserves its identity of individual components, while developing a space with a strong sense of light. It is a relatively subtle gesture, but it effectively redefines the original object's reading. This is how she talks about her design: *"Using the cube as a starting point, I worked to create soft and feminine forms from each side. The mutation of the cube gives a normally rigid object a new life that is reminiscent of robust curves of the female figure. Each piece was given weight and substance to fatten the texture of the object and smooth the harsh lines. The active mutation in the animations gives the cube a more dynamic and romantic character."* (Figures 4,5)

Han Seok Nam experiments with form fragmentation resulting in unique material expressions. While animating elements' fragmentations, one observes the emergence of textual qualities out of smooth forms. (Figure 6) This excises introduces an interesting ability of fragmenting transformations to populate design with newly emerged geometries. At the same time, Hye Young Yoo is pursuing a fluid space as a result of mesh displacements with chaotically behaving functions. (Figure 7)

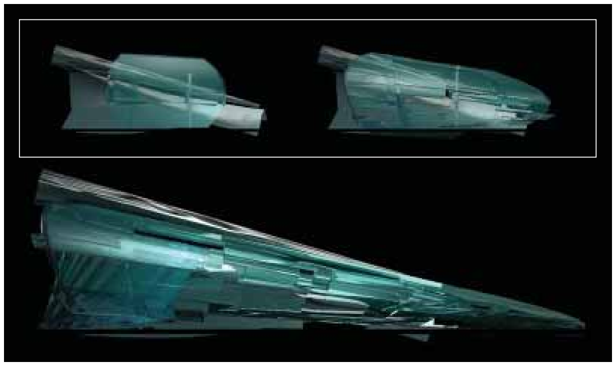


Figure 6: A texture emerges from a surface transformation, by Han Seok Nam.

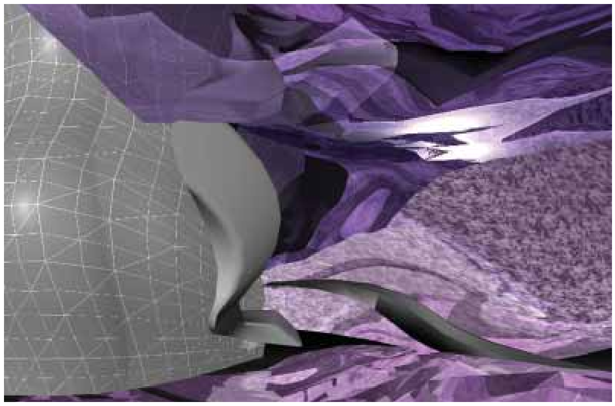


Figure 7: Orthogonal forms are no longer recognizable after the introduction of random functions, by Hye Young Yoo.

Figure 4: The stages of a cube transformation--top view, by Laura Lister.

All the above examples were successful in achieving a purely architectural reading, both as an object and as a spatial experience. However, the same method can be extended to other virtual designs used to develop virtual landscapes as well as sculptural forms (Figures 9,10). Illustration 10 shows an evolution of an original cube into an organically behaving form. These cube transformations while shown here with still images are best experienced and judged with animations where one can observe not only a progression of an evolution but also dynamism, rhythms, and punctuated blossoming of forms. In seeing these animations one quickly realized that, while we often speak about design continuums, interesting solutions are distributed randomly and often emerge unexpectedly. There seems to be gravity to the distribution of design solution that becomes evident once these solutions interpolated with animation tools.

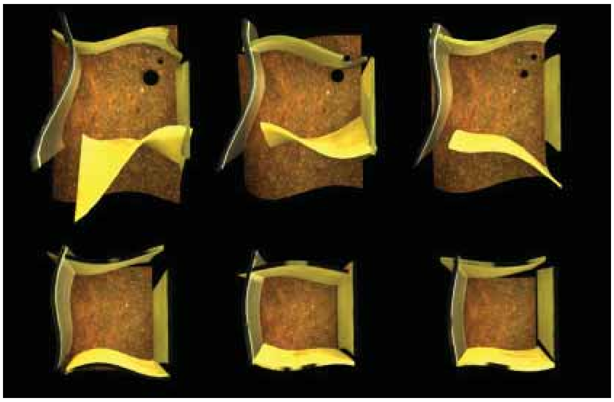


Figure 8: The stages of a transformed cube—reflected ceiling plan, by Amy Song.

Figure 9: A transformed cube with light as a space positioning device, by Andrzej Zarzycki.

Figure 10: Three phases of form emergence, by Andrzej Zarzycki.

Lessons Learned:

We learned from this sketch assignment that the combination of simple transformations such as bend, twist or taper; combined with tools like move, scale and rotate operating on various topological levels became a potent and effective way to derive sophisticated designs. Design complexity emerges from a relative small number of transformations and rapidly escapes predictable visual patterns. It is the way these transformations are being applied not necessary a number of them that has a decisive impact on form characteristics. In most cases, the order of applied transformations is critical. Different orders will produce different products.

There is a subtle but direct connection between the form of an object and its texture—facture. In this use of the term, texture is not a material bitmap associated with an object but a three-dimensional surface topography. Form and facture are two scale polarities of an object's continuum in a similar way as physical objects are in nature. In digital environment facture (texture) is related to tessellation and lower topological levels such as points, edges and faces.
Finally, the sketch became an opportunity to discuss the conceptual framework behind morphing and form emergence as well as a look at precedence in other creative disciplines.

Based on these observations, we were able to postulate some broader implications of transformation-based design methodology and apply them to the main studio projects.

Toward Transformational Design

Since change and transformation become the norm and basic building element in the creative process. The new set of instructions is necessary to direct these design agents. These instructions may involve simple form transformations and topological changes including object discontinuities as well as exotic entities like meta-formz or particles. These objects respond to dynamic and kinetic [1] stimuli and often are associated with behavioral properties. These behavioral properties allow for the interaction between objects. For example, particles can respond to gravity, friction, as well as other objects. Emergence of these new design agents was welcomed by students who quickly adopted them into their design concepts. The meta-particle experience examines spatial transformations resulting from particle dynamics associated with material and light changes (Figure 11). The spatial enclosures, while continuously changing, are further realized through morphing material characteristics such as fog to air to glass. In another project, animated meta-objects (meta-formz) are used to simulate spatial variations of the Home|Workshop|Museum design (Figures 12,13).

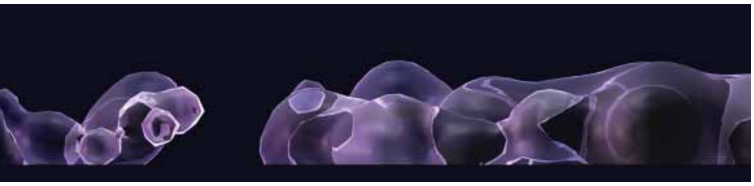


Figure 11: Metaball-particle evolving forms, by Nick Brunetti.

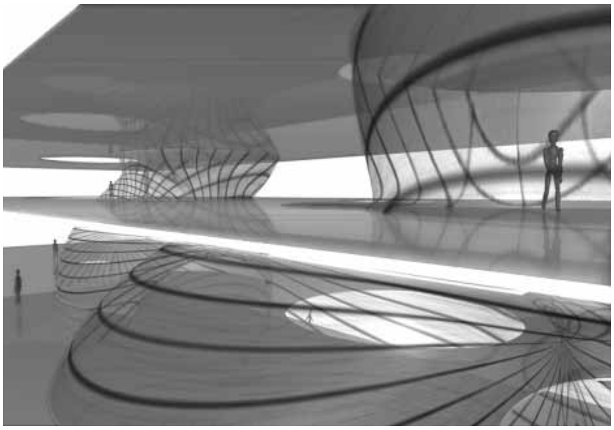


Figure 12: An interior perspective of a museum space, by Kazy Umeki.

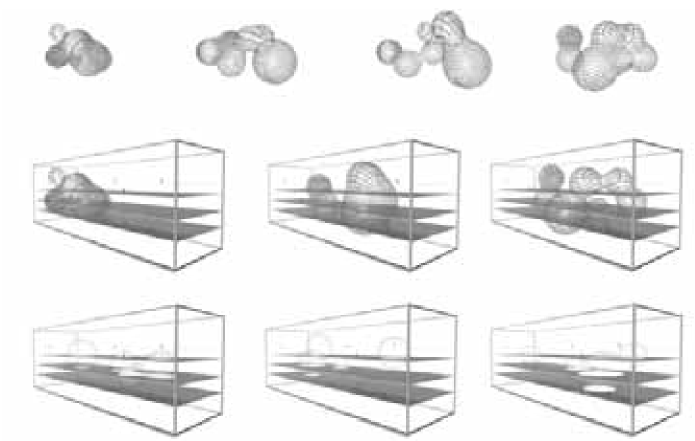


Figure 13: Stages of metamorphosis, by Kazy Umeki.

Figure 14: Museum spatial trajectories, by Han Seok Nam.

Design Versus Context

With an introduction of animation into design, two classes of transformations emerge: form and space deformers. Form deformers change the object's geometry, which is a permanent change even if it only exists for a short period of time. This new form is an attribute of an object and is not location dependant. Form deformers are reacting only with particular objects and do not interfere with other objects that are in the same locality.

Space Deformers, also called Space Warps, are the properties of space and affect any object that is within a space unless specifically excluded from the operation. They allow transformations that are only relevant to space or context not, a particular object. Furthermore, their influence is location-in-space related, which means that the form of an object is dependant on the location within a space warp and will change if the object is moved. This distinction, to form and space deformers, is particularly applicable for architecture since space deformers can be seen as the design context or environment. Ability to assign properties to space, not much different than in real life, allows for a global and holistic treatment of design. It also creates favorable conditions for the simulations of form mutations and dynamic systems.

Other Morphing Approaches

A classical morphing method is similar to parametrically driven tectonic interpolations and extrapolations. It relies on two parent objects as "genetic" sources with the new resulting form being placed somewhere in-between parental phenotypic characteristics. This design approach was under utilized in the past because of the limitations of digital software placed on parental forms. In the past, both parental forms required the same number of vertexes in order to be morph-able.

The only pragmatic way to achieve both parent objects having the same vertex number was to take one of the original forms and transform it into another without changing the number of vertexes. However, this very action defeated the purpose of the creative use of a morphing tool, since for a designer to create the second parent object he would already go through transformation and investigate in-between possibilities.

These days, with tools like **form•Z**, we are able to morph between two objects without a concern for topological or vertex consistency. Software does it for us. One could feel a bit uneasy about deferring a small amount of control to the program that does follow a particular procedure and as such could narrow tectonic possibilities. However, I feel that the rewards are greater than possible losses. Perhaps we could hope for some level of control over these morphs by, for example, applying functions to interpolations. While some of these morphs are predictable like a hybrid between a cube and a sphere—we all can immediately tell the outcome, others are less predictable like a morph hybrid between a star and a cube. I often find myself nicely surprised especially in moments when I dare software with more complex objects.

Again, the same rules apply to these morph-based transformations—a complexity and individualism rapidly emerges through compounding simple gesture/transformations.

The Form Future

Introduction of morphing tools into design defines a form as a continuum of all its possible implementations. This new definition sees a form not as an object (being), but rather as a process (happening), which further changes how we qualify the object from its physical properties of shape, etc. to form potentials and capacities. When we say that a form is defined not only by what it is but what it could be, appropriately or not, we relate it to concepts of quantum mechanics where we often say that a particle would travel through all the possible trajectories—suggesting it could be in two places simultaneously. Since form morphing approach is specific to digital creations and emerged through them, perhaps, it reconnects conceptually the products of computational tools (morphing form) with the very physical laws that govern processes on microscopic levels within microchip architecture—quantum mechanics logic. However, this connection is more allegorical than causal, at least at present understanding of computational issues.

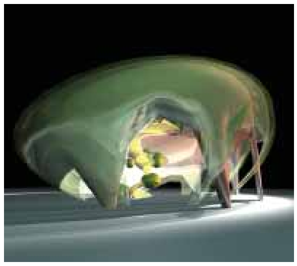


Figure 15: A transformed museum space, by Laura Lister.

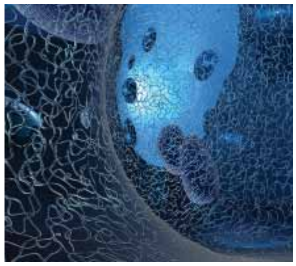
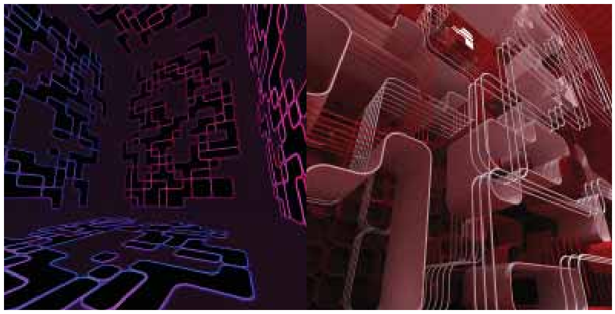


Figure 16: Cell-like space as a metaphor for home, by Hye Young Yoo.



Figures 17, 18: The emergence of forms from shapes; museum space transformation stages, by Sun Kyu Koh.

To learn more on the Formal Mutations topic including theoretical discussion with technical detail as well as to preview digital motion pictures of students' and my work, visit *www.FormalMutations.com* and *FormalMutations* channel on *YouTube.com*.

Notes

[1] "Dynamic" refers to what is routinely called Dynamics and "kinetic" refers to what is called Inverse Kinematics (IK) and Forward Kinematics (FK).

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Makoto Sei Watanabe; Induction Design: a method of evolutionary design; Birkhauser 2002;

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Andrzej Zarzycki is a Boston-based architect and educator who employs digital tools to create experiential architectural spaces. He brings more than 10 years of design practice combined with design teaching in the Interior Architecture Department at the Rhode Island School of Design. Research and experimentation is important component of Zarzycki's practice. Since 1996, he was part of the Architecture, Representation and Computation group at MIT. While there, he produced video presentations of Unbuilt Monuments for MOCA, Siggraph, and other venues. At R.I.S.D., he teaches advanced digital design studios. Zarzycki has also published several design process and digital conceptualization essays. His speaking engagements include: *Formal Mutations*; Bauhaus Colloquium 2007; *Cinematic Approach to Spatial Narration*; Build Boston 2006; *Abstracting design, designing abstractions; Use of computer graphics in early stages of architectural design*; Siggraph 2004; *Digital Technology and Design Process*, Build Boston 2001. E: zarzycki@alum.mit.edu | W: www.FormalMutations.com.

University of Texas at Arlington
Arlington, Texas

Flux Architecture
Digital Sensibilities:
Quasi-Mathematical Expressions, Evolutionary Blur, Morphological Fusion

byThomas Rusher

Digital Sensibilities

Architecture finds itself at an exhilarating and dizzying confluence of multifaceted methodological approaches to design generation vis-à-vis *"digital sensibilities."* A departure from fixed static ideologies, pedagogies, and frozen prescribed typologies based on standardization and modular units is being replaced by an exhilarating liberating moment of dynamic digital design methodologies of fluctuation and evolutionary connotations, *"Flux Architecture."* The emergence of Digital Fabrication Techniques that transfer data directly from computer to controlled manufacturing devices are creating potentials for the resurgence of idiosyncratic and variable components, assemblies, and system possibilities in architecture. Linear methods of thought and modular incremental thinking are alien concepts to the multi-linked web like thought connections associated with growing digital design methods. Greg Lynn references sensual forms, developmental processes and complex assemblages as issues that designers have struggled with in the past (Architectural Design, "Folding in Architecture)[1] . Flux Architecture lends itself to variability, morphological sequencing, temporal analytical studies, evolutionary links, relational models and dynamic moments of intervention that allow designers to adapt and reevaluate design methods instantaneously. Powerful computational software like **form•Z**, 3D Studio Max, and Maya afford designers the opportunity to explore with parametric controls, intuitive real-time responsiveness, and output for prototyping.

The digital age has irrevocably changed the character of architecture. Its directions and mantras are as diverse and dispersed as quantum particles with base theories in play and new hypotheses being developed and discovered each day. We are just beginning to understand the possibilities, boundaries, and ramifications of the digital to the architectural profession. A new generation has emerged that is ostensibly comfortable with technology and seeks methods to advance and leverage the technology of their time to be as innovative and expansive as design predecessors from the previous century. New directions are being created by many as quickly as the technology changes. **form•Z**, with its new dynamic tool set, key frame animation and deformation tools give students a range of possibilities to explore temporal tectonic issues associated with flux architecture. The accelerated exponential growth and change of the digital as it relates to humanity is one of the greatest issues that face not just architects but all of civilization.

We are moving into an era of the digitally connected and disconnected. This has to do with access, familiarity, and acceptance or rejection of digital technology. It is difficult to move through our urban centers without being digitally documented with video cameras. Toll road authorities conveniently take snapshots of our vehicles and send us bills. Credit cards leave digital traces of our presence and behaviors. Society seems accepting or oblivious to the invasion of privacy at all levels from a grocery store savings card that clutters our wallets and key chains, to documenting which Web sites you frequent, the time spent there, etc. Privacy issues proliferate; liberties are eroded, while at the same time freedom of connectivity and expansion of thought breed through digital means. Those that accept seem to be very accepting, perhaps to the point of dependency. Who wants to leave home without their cell phone or all-in-one-communications device? If left at home, do we feel disconnected and incomplete? Notions of phantom buzzing from non-existent cell phones and blackberry communication devices are being equated to phantom limbs of amputees. The body readily adjusts to new associations and adapts to loss. Those that reject seem to be adamant about the glory days of pre-digital concepts or are genuinely unable to adapt to the accelerated pace that is demanded by the technology. Perhaps there is a

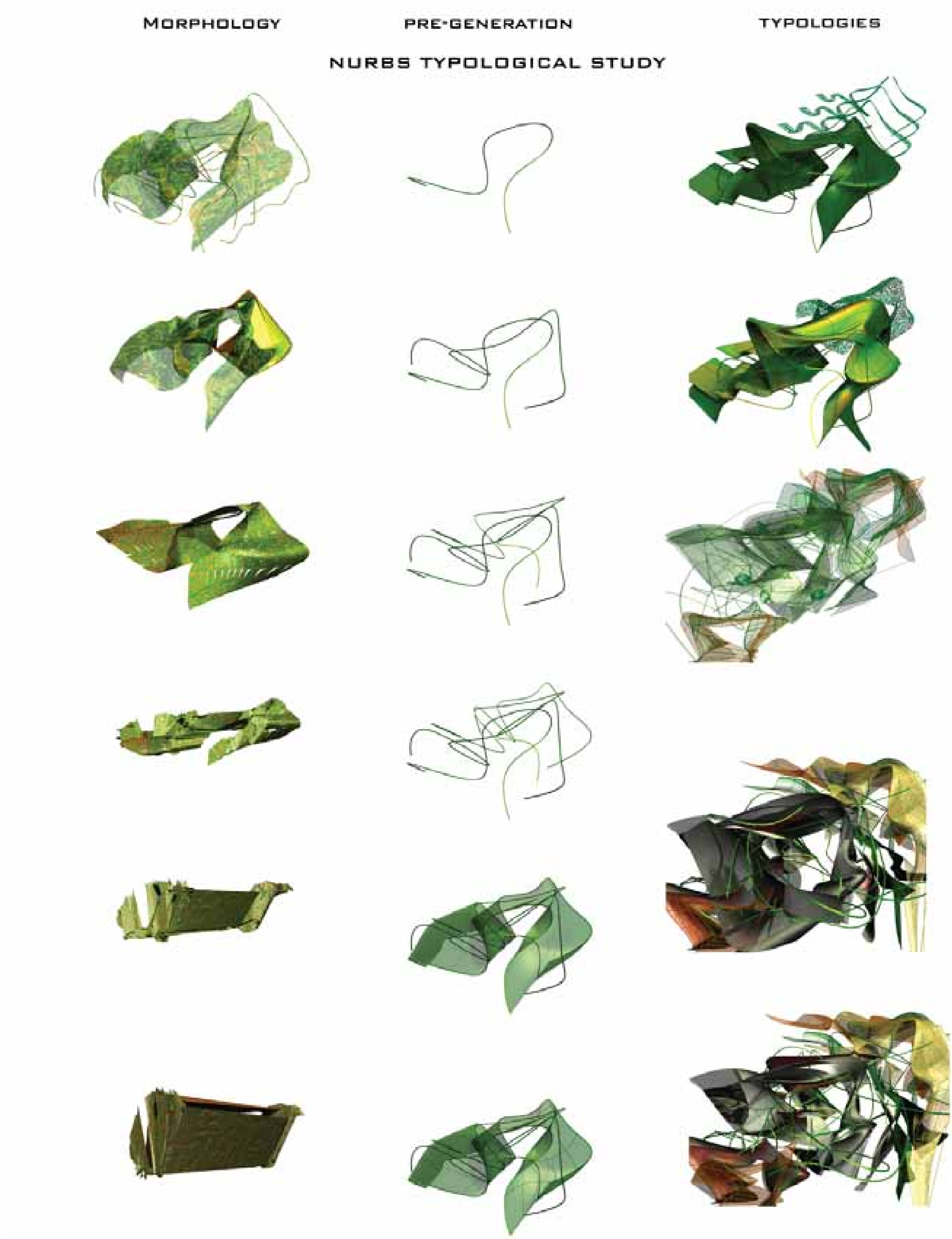

Figure 1: NURBS Typological Process Diagram of Animated Structures, by Chris Medina.

Figure 2: Fluid Component Typologies, by Jorge Trevino, Jordan Pennington, and Hyun Lee.

middle ground between being overtaken by and overly dependent on technology, and knowing when the human component should intervene in a process be it design or otherwise.

If the device automates everything for the architect/designer, will it have a soul? If the computer generates a parametric form, space or analogous tectonic device, is it valid? Do we keep it? What determines value of the discovery? What is it that makes architecture of a period a timeless event as opposed to the bastardized formulaic construction or building of established conventions, which somehow lacks a soul? What does it mean to practice architecture in the age of computers and proliferation of information both fact and fiction via the World Wide Web? The answer lays within us as the ultimate computer and human filter of design iterations.

Architecture has always been a slow beast for change but the connections to digital design now have forced the profession to deal with this technology and attempt to keep up with its rapid growth. In most instances, it is still a documentation and representational device being utilized to accelerate production and capitalize on one of the inherent properties of the computer, its ability to quickly modify, replicate, and output preconceptions. This is and has been an outdated approach to the digital. It has been going through revolutionary and evolutionary changes in flexibility of modeling control, digitally animated relational structures, and mathematically-based parametric controls. All of these tools lend themselves to study, enhancement, and naturally what the architect is best at, deciphering the inherent value of these tools as it relates to the constructed world and virtual domains. The same way that the elevator and the steel frame changed the face of architecture in the last century, digital design is moving architecture in many directions that have as of yet not settled on a singular approach. Perhaps this is the nature of this beast, diversity of methods.

Having stated these immense potentials for digital design, the question of Man and Machine emerges. Conceptions of Digital Automation vs. Human Intuition, Digital Fabrication vs. Conceived Fabrication, Intelligent Structures vs. Responsive Structures and finally Design Authorship, Co-Authorship and Relinquishment are issues of paramount concern. I explored these topics in a series of digital design classes as well as in Upper Level Design Studios at The University of Texas at Arlington's School of Architecture. There are three specific sensibilities toward digital design generation that are of interest to me, which are explored in each class at varying degrees of complexity. Digital generation as *Quasi-Mathematical Expression, Evolutionary Blur, and Morphological Fusion* are terms that I use for each sensibility. In all instances, varying degrees of intervention, and categorization by the designer at critical moments becomes essential in the digital design process. Digital Intuition through partial automation, Conceived Fabrication, and Responsiveness of systems lend themselves to each of the aforementioned Digital Sensibilities. This dances around the broader issue of Co-Authorship and Authorship while attempting to maintain a logical series of events and avoiding Relinquishment.

Quasi-Mathematical Expression: Tooling Up/Labs/Digital Operatives

The use of scripting of forms, surfaces, and spaces as both repetitive and rhythmic variant structures generates fascinating formulaic mathematical possibilities. Digital objects like Meta-Clay, **(Meta-Formz)**, NURBS, C-Meshes, Inverse Kinematics and the like contain inherent properties that have behavioral attributes that are controlled by a series of parametric settings and *"Digital Operatives".* Digital Operatives are the development of a series of sequential variant transformative digital procedures that acquire behavioral attributes which have tectonic and spatial implications. Through the use of Macros in **form•Z**, students can initially set visual parameters to a digital operative and then develop variations on a macro and/or modify the formula to derive the desired visual impression. Some settings are formula based, others are manually or visually set but in each instance, it is generating a mathematic expression of the "Digital Operatives." I call this a *"Quasi-Mathematical Expression."* One that is visually set to

Figure 3: Evolutionary Components, Assemblies, and Networks: Temporal Spatial Construct, by Chris Medina.

achieve design objectives, may or may not be parametric, but can be reconstructed, regenerated, reused, and create variable conditions.

When scientists run experiments, they are running through a series of possibilities with a multiplicity of variables and constants in order to test some ideas and have discoveries. They typically have control subjects, placebos, and a variety of other elements to make logical conclusions about their findings and to test assumptions to form theories. In the process, there will be many failed experiments and a few successes. The analogy applies to digital approaches in the creation of organizational matrices, fluid surfaces, and tectonic armatures. My students begin by leveraging the wide array of digital tools available in **form•Z** and design a series of "Digital Operatives" to extract Quasi-Mathematical Expressions. Quasi-Mathematical Expressions as opposed to Pure Formulaic Expressions because of the nature of engagement of designer to machine and the visual nature of the experiment as more a qualitative study that in turn had quantitative results.

The idea behind developing specific digital operatives to uncover these visual expressions deals as much with failure as with successes similar to a scientific experiment. Empirical Model Building has long been a device for discovery. The understanding of the inherent properties of digital constructs and their value as analogous or new tectonic typologies is a complex function that students perform (Figure 1).

There is a tendency to accept what the computer gives the designer simply because it is a scripted or formulaic expression. In some cases these lead to semi-predictable structures. In our case, we dive in and out from formulaic to manual override when the opportunity presents itself. Here the designer is Co-Author. To what degree depends on the sophistication of the designer's ability to digest, assimilate, and synthesize the visual data being formed. The computer used in repetitive commands is not the intent but rather to use the computational power to develop multiple iterative states rapidly is the key to initially inventing novel typologies (Figure 2). In other words, multiplicity through linked variations as apposed to simple replication or repetition.

Students ran through a series of "labs" in order to simultaneously "tool up" on **form•Z**'s extensive modeling pallet while being open to experimental possibilities. Instead of entering the vacuum of the digital with preconceived notions of "architecture" they deal with more abstract notions of developing typologies of spaces, components, assemblies, networks, and tectonic constructs through the development of "loose" digital operatives (Figure 3).

Evolutionary Blur: Animated Analysis/Typological Extraction

Time-based modeling as an analytical and generative device was a topic explored by me back when I was a graduate student at Columbia University's Graduate School of Architecture, Planning and Preservation. Having been involved in one of the first "paperless" studios there, stirring dynamic analytical digital models exploring active change over time were explored using high end software like Softimage and Alias Wavefront. At the time, **form•Z** was leveraged for its strong modeling abilities and at times exported into the other two programs as a base point of departure. Since then, software has become more expansive, relational, and nuance-based than ever before. This allows for greater parametric controls, formulaic expressions, and manual overrides at critical moments. The new animation functions in **form•Z** are now allowing students to be exposed to intriguing animated controls that have evolutionary connotations. These new tools lend themselves to the aforementioned time-based studies and relational model building as exploratory digital sensibilities.

Much can be gained and discovered by visualizing the past through abstract digital notation and extrapolating information both actual and visual from the animated analysis. Although all of my classes dealt with "Flux Architecture" as a topic this last year, the methodology to each class is unique. The upper division classes approach to "Flux Architecture" is through a series of temporal studies using the new digital modeling and animation functions in **form•Z** to run their labs. This class investigates tensile structures, digital objects such as NURBS, and performs animated surface studies to develop and categorize typologies of events, spatial conditions, tectonic structures, and surface phenomenon (Figure 4). The development of an animated temporal sequence from lab experiment(s) to new spatial typologies while creating specific relational links to synthetic digital environmental structures is one of the objectives for the Advanced Digital class. Evolutionary Blurs are constructed through animated means, then re-

Figure 4: Porous Web Assembly Typologies, by Jorge Trevino, Jordan Pennington, Hyun Lee.

worked and incorporated. The concept of the "Evolutionary Blur" is to examine moments in the morphology and make interstitial temporal connections between beginning and end states of the studies. In many cases, the intervention has more to do with co-authorship with a slant toward authorship where the extraction of events is a specific design decision. The purpose is to not simply allow the computer to continue along its animated parametric path but rather to extract temporal moments and reevaluate residual moments (Figure 5). This class has more to do with understanding the inherent qualities of digital structures and making analogs to the perceived real as both organizational potentials and physical possibilities. Issues of interdependencies, segregation, flexibility, limitations and synthesis of animated constructs are incorporated into the final animated sequence. Initial surface studies began using Non-Uniform Rational B-Splines, (NURBS) as unique interdependent rationalized digital entities. **form•Z**'s lofted NURBS capabilities are robust and combined with a variety of line generation types allows for understanding of the NURBS as a variable construct digital object type with unique properties. Pre- and post- generative exploratory labs were ran to extract, understand, and ultimately leverage the NURBS as rational variant surfaces. Placement, orientation, and rhythmic sections were studies in the development of NURBS surface types that then expanded into an aggregate of spatial and soft component typologies. Material qualities were then looked at independently of NURBS as a second surface iteration then collapsed to form layered relational conditions. A multi dimensional relational construct with surface and sub-surface connections was then designed with the previous labs. Tectonic structures emerged from assembled component typologies based on the inherent properties of each to form a logic of assembly. The use of Adobe Premiere Pro 2.0 was commissioned to add a final cinematic quality and allow for editing, splicing and reworking of the animated sequences. The use of layered animated structures, compositing of 4D renderings to evoke evolutionary and developmental phases, and sinking of sounds aided in the development of a cinematic capturing of an audience. The end results are a series of designed responsive systems assembled into a new spatial typology through temporal evolutionary links with relational interactive layered "skin" types.

Morphological Fusion: 2D to 4D Frozen Dynamics

Frozen dynamics from two-dimensional to temporal constructs, analysis of tectonic structures and their evolutionary links, and variability culminating with a new series of components, assembly, and spatial typologies are concepts explored in my undergraduate classes. Students

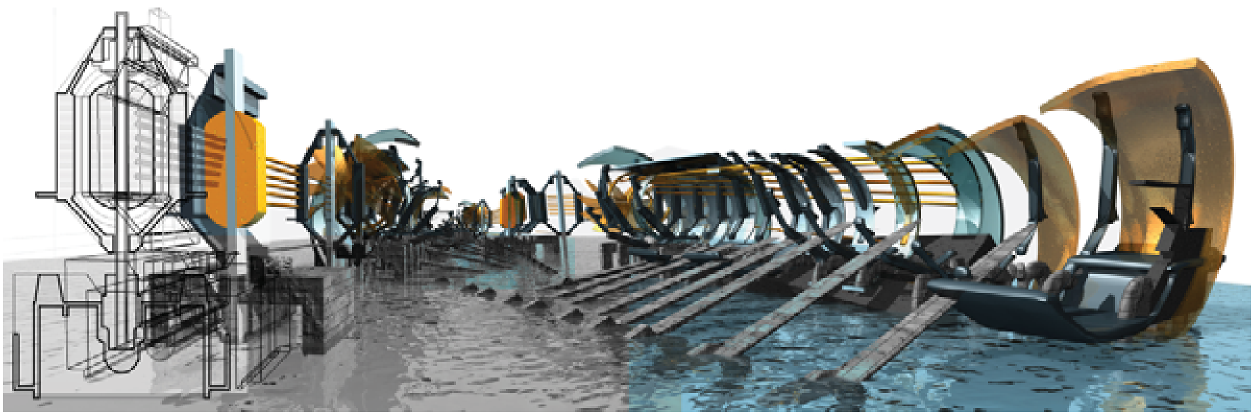

Figure 5: Temporal Extractions & Reassembly Morphological Fusion: Tectonic Event by Sean Farrell.

are given programmatic events that were linked to digital operatives. They study and extract inherent qualities from tectonic components in order to design a morphological sequence into new tectonic elements. The conceptualization of material, form, space, structure, and environmental change simultaneously collapsing temporal morphologies allows for students to explore a sophisticated range of interconnected variant conditions. Flux Architecture, but derived from extraction of evolutionary moments of disparate and connected objects with spatial, organizational, and tectonic ramifications. Analogues to known architectonic systems assemblies and components are always kept in the sites of the students. Here the students discover uncharted types from synthetic and natural structures that implicitly have within themselves organizational implications. The development of their structure combines the “tooling” aspects of digital skill acquisition, with the discovery process. Through the tooling process, students learn how to negotiate from Vector to Raster and back in order to develop an Evolutionary Spatial Typology through a “Morphological Fusion” of temporal events (Figure 6). Objectives included developing a logical Morphological Blur between pre-states, developmental moments, and formed frozen animate proposals (Figure 7). Students leveraged the inherent qualities of each program that they were exposed to, AutoCAD 2007, Photoshop CS2, and **form•Z 6.1**. The theory is to extract inherited traits from previously studied structures and develop a morphological sequence from ancestor to new type(s) to projected moments. Blurring the distinction between complementary

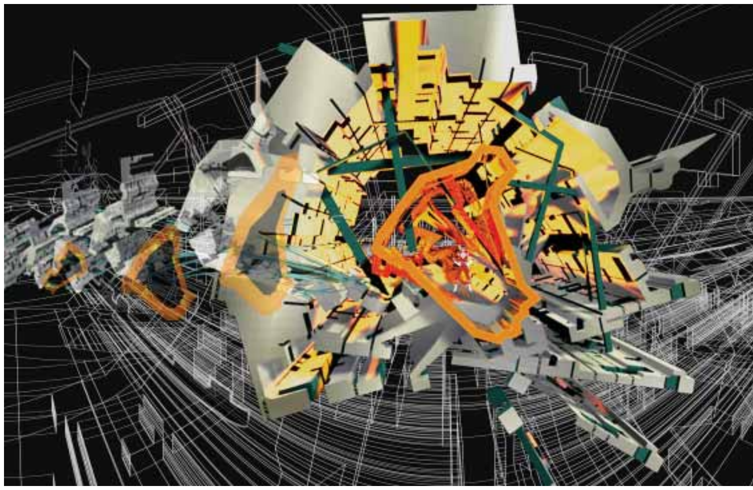

Figure 6: Morphological Fusion, by Montano Giancarlo.

software packages and collapsing ideas, discoveries, and graphics to convey a fused temporal evolutionary spatial construct is the final outcome of the project. Variability, transformative conditions, and intuitive responses were characteristic of the Morphological Fusion.

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[1] Greg Lynn, Architectural Design, “Folding in Architecture,”, Revised Edition, Introduction, Published by Wiley-Academy, a division of Wiley & Sons Ltd. Copyright 2004.

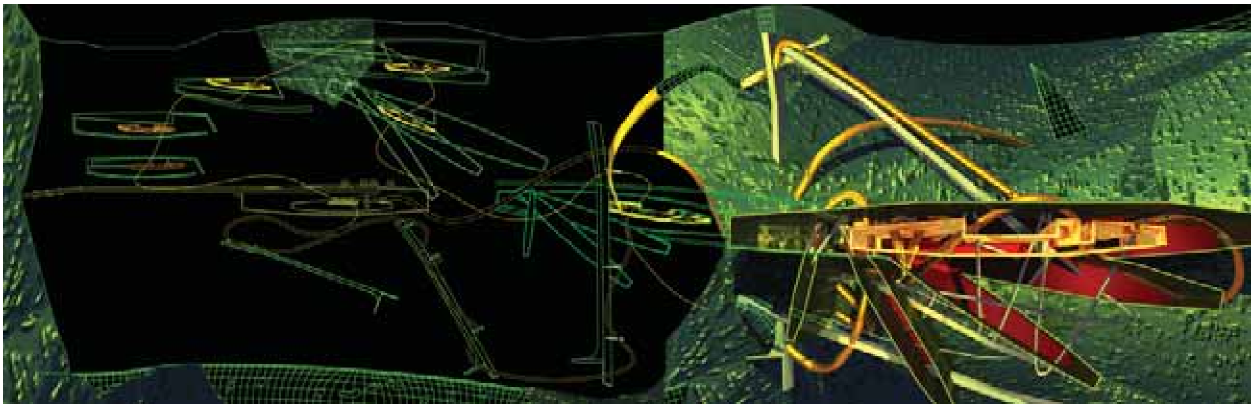

Figure 7: Morphological Sequence, by Triana Vidargas.

Thomas Rusher was born in New York City and has a Master of Architecture: Columbia University GSAPP, NYC, B.SCI. Architecture: University of Texas at Arlington. He is the recipient of the Ronald E. McNair Graduate Research Fellowship in Architectural Design. He is currently an Adjunct Professor of Architecture at the University of Texas at Arlington’s School of Architecture. He worked for Skidmore, Owings, and Merrill LLP, NYC, Columbia University Planning Department, NYC, Polshek & Partners LLP., NYC, B-Five Studio LLP, NYC and is currently the principal of Rusher Studio LLC, a design consulting firm in the DFW area. At Columbia he received the Lucille Smyser Lowenfish Memorial Prize for best design thesis in Greg Lynn’s Studio (1996). His works are published in Abstract 1994-1995, Abstract 1995-1996 (cover), Interior Design, Skidmore, Owings, and Merrill: Architecture & Urbanism 1995-2000, Texas Architecture, Tex Files, and AutoDesSys Joint Study Annual Report 2002, 2003, 2004, 2005, 2006.

Carleton University
Ontario, Canada

A Model Dialogue

by Benjamin Gianni

I've worked with **form•Z** for more than two decades – having been introduced to the program before it was officially released. My first attempt at building a model in **form•Z** (or Archimodos as it was then called) resulted in an immediate and fundamental empathy for the tool. I recall sensing that I discovered the instrument I had been waiting for -- both a complement to my design sensibilities and a mechanism for exploring design processes in a studio setting.

My enthusiasm for the tool was no doubt related to the fact that **form•Z** was developed in an academic environment. The development team solicited feedback from the teaching staff as it considered ways in which designers might use the software to explore and manipulate form. Competing programs were geared to production and/or presentation drawings -- supporting the dialogue between architects and their consultants and clients. By contrast, even the earliest versions of **form•Z** incorporated 'esoteric' functionality that permitted designers to explore (among other things) iterative transformations and to trace the effect of processes over successive generations. From the outset, the program was strong in Boolean functions and enabled users to combine translation, rotation and scaling operations into aggregate, macro transformations. In this regard, the program supported the dialogue between the designer and the design. **form•Z** was conceived first and foremost as a design tool and only secondarily as a tool for production and/or presentation.

My predilection, both as a designer and a design teacher, is to treat design as a process of transformation – from an idealized form (type or primitive) to something that engages and reflects the myriad forces that inform it (site, program, orientation, budget, social context, geographic context/climate, symbolic function, etc.). It is enlightening for designers to track both where they began and how they got to where they gotten. The logic of this transformation informs the inherent logic of the building and is the basis of the dialogue between the designer and the design. Optimizing a solution is not only a question of altering the form to better accommodate various site, programmatic and aesthetic considerations, but engaging it in a dialogue, adjusting the logic behind its transformation, and modifying the rules of engagement.

Tools like **form•Z** help to make this process explicit. Tracing the path they've taken enables designers to better understand their predilections and, most importantly, the logic of their intuition. While all designers must take a stab at a solution based on informed intuition -- indeed, good designers are exceptionally good at this -- developing a proposal beyond its sui generis state requires an ability to deconstruct the logic of one's intuition and to engage the emerging design in a meaningful dialogue.

In the urban context, the design of a given building can tap into a larger, pre-existing set of transformations on the site and the city as a whole. Accordingly, I have found **form•Z** especially useful for urban design projects. Students use simple massing models to explore urban sites as 3-dimensional palimpsests -- accumulations of settlement over time – and to engage the larger urban context as a collage of discrete patterns and transformations. This, in turn, facilitates the exploration of transitions, thresholds, overlaps, and blurring -- both laterally (i.e., between different sizes and grains of fabric) and “vertically” (i.e., between different eras and scales of development on the same site). It also opens the possibility of discovering part-to-whole relationships, comparing, for example, the relationship between the site and the adjacent neighborhood to the relationship between the neighborhood and the city as a dynamic whole.

By way of example, I’ve asked students to use **form•Z** to track the migration of a business district from the center of a small town to the commercial strip that connects it to a nearby interstate. In this investigation buildings (commercial establishments) not only moved but changed scale and position both relative to each other and to the road. These morphological changes were, in turn, applied to a second generation of transformations in order to produce a speculative, third-generation business district (i.e., the transformation from past to present formed the basis of the transformation from present to future). I’ve also used **form•Z** to explore anamorphic variations on the suburban strip -- bending and distorting facades to better address drivers from key intersections. Here the ability to design in perspective and to manipulate cones of vision was extremely useful. More recently, my students have used **form•Z** to explore the redevelopment of Regent Park – a 69-acre complex of public housing in downtown Toronto.

Whatever the nature of the design investigation, it is helpful to be able to move fluidly and iteratively between scales. Rather than working with several (physical) models at different scales, digital tools permit students to work with a single model – into and out of which they can zoom to assess various moves at multiple scales and from a range of viewpoints. The ability to jump scales (and therefore work at several scales simultaneously) permits students to detect similar patterns at different scales and, in so doing, to strengthen part-to-whole relationships. Similar connections can be made between various projected views (plans can be misread as elevations, etc.) to reinforce internalized references – all in support of a higher degree of design integrity. In this line of thinking, buildings must not only talk to their sites but to themselves.

3D modeling programs extend and greatly enhance what is possible in the design studio; they are an invaluable complement to traditional modeling and representation tools. While the choice of 3D modelers is an important one, a school’s criteria for supporting one program over another may be based on a variety of considerations (cost, functionality, availability of support, interoperability, usage in the profession, faculty champions, etc.). It’s important to keep in mind, however, that modeling programs have steep learning curves; like languages, students can’t be expected to learn too many or switch between programs too frequently without compromising their fluency.

As a long-time **form•Z** user, I can attest both to the program’s staying power and to **AutoDesSys**’ commitment to supporting and enhancing the program. Moreover, the developers have cultivated a long-term relationship with academic users through the Joint Study Program. While it’s significant that **form•Z** is versatile and can do most of the things other programs can do (photorealistic rendering, animations, splines, meshes, etc.), the point of this short essay is to reinforce that **form•Z** is designed to do things other modeling programs do not, namely privilege design logic and promote design integrity by supporting a more meaningful dialogue between designer and design. This is invaluable in an academic environment.

Benjamin Gianni is an Associate Professor in the School of Architecture at Carleton University. He is also Senior Advisor to the National Judicial Institute where he coordinates computer-based education initiatives and oversees the development of electronic resources for the Canadian judiciary. He received his B.A. from the University of Pennsylvania in 1980 and an M.Arch. from Yale University in 1984. He came to Canada in 1992 as Director of the School of Architecture at Carleton University. He has worked with a variety of software developers in the areas of 3D modeling, web application development, user interface design, and usability engineering. At Carleton he was also founding Director of the School of Information Technology, which he headed for three years.

Georgia Institute of Technology
Atlanta, Georgia

Automated Generative Synthesis Systems in Architectural Design

by Maher El-Khaldi.

Abstract:

Designing by generative synthesis systems (GSSs) can maximize the quality of design solutions. Such a gain is directly related to: A) the system-building process, which entails: dismantling problems' components, unpacking embedded relationships, tracing dependencies, clarifying design objectives, and critically acknowledging reasoning mechanisms (subjective or objective); and B) the systems' ability to generate alternative solutions (Heisserman, 1994), which offers the designer a chance to compare between possible candidates and select the "better" ones. The capacity of such systems is best explored within a computerized environment where automation is not only possible, but also accelerated.

1. Introduction:

The idea of structuring design synthesis processes around generative synthesis systems (GSSs) and design languages is not new. Expressions of such a concept can be found in the works of: Vitruvius, Durand, Louis Sullivan, Le Corbusier, Peter Eisenman, Alvaro Siza, among others. This "movement" continued to evolve as the architectural landscape witnessed the works of Christopher Alexander, Lionel March, George Stiny and James Gips, William Mitchell, Charles Eastman, Terry Knight, and Chris Yessios, among many others.

Parallel to these works, was the continuous flow of computational technologies (mainly programming and CAD) into the field of architecture. This fueled the process of building generative synthesis systems as designers gained access to independent programming languages such as: C, C++, Java, Visual Basic, etc; and CAD-hosted ones such as: Auto-LISP (AutoCAD), MEL (Maya Embedded Language), RVB (Rhino-Script), Max-script (3D Max), FSL (**form•Z** Scripting Language), among others. As a result, a "new" type of synthesis systems started to take its shape through automation.

Krishnamurti described the architectural design process as a function of knowledge and strategy (2006). The deeper the knowledge is, the more informed our design decisions become. And the richer a strategy is, the more alternatives a design process generates. Knowledge and strategy drive the quality and magnitude of alternatives generated by GSSs. In Algebraic terms, these alternatives resemble vectors that span a space of solutions. Solution spaces are system-specific. Their definition depends on the components used to build their generating GSSs. Thus, there are no generic metrics to measure or evaluate their characteristics. However, the fertility of GSSs (how generative they are) is mirrored in the capacity of embedded design rules.

Rules are expressions composed of a left side, an operator and a right side. In algebra, rules can be written as functions like (A(X)-->Y), or equations like (X=2+Y). The first maps (transforms) element X into element Y through a function A, and the second assigns the value of 2+Y to element X. The first type can be also viewed as replacement rules, and the second as associative rules. Replacement rules erase input, and place output. In this regard, (A(X)-->Y) is interpreted as: replace element X by element Y through rule A. Associative rules establish associations between both sides. In this regard, (X=2+Y) is interpreted as an association between element X and 2+Y. Associations are of two types, mono-directional and bi-directional. Mono-directional associations enforce a "Parent-Children type" of relationships where a hierarchy drives the flow of data from top to bottom only. Thus, manipulating "Parents" propagates to "Children", but not vice-versa. Bi-directional associations allow data to flow in both directions.

Rules manipulate elements through their representation. Elements' representation is system-specific. For example, in a Cellular Automata (CA) system (Wolfram, 2002), elements are expressed as cells, usually arranged in orthogonal grids. Figure 1 illustrates how CA rules work in general.

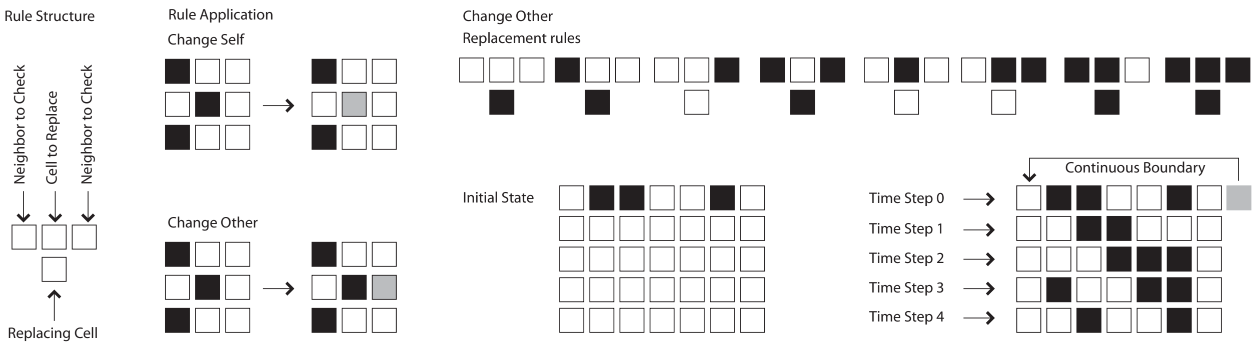

Figure 1: The application and mechanism of applying Cellular Automata rules.

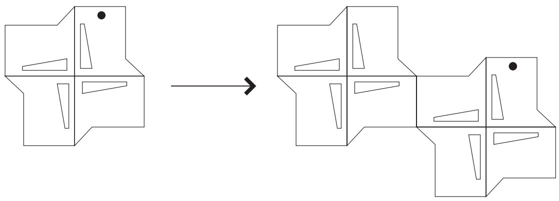

Figure 2: A Shape Grammar rule that translates the initial shape (left side) and creates a copy.

In Shape Grammars, elements are expressed in shapes with labels, axes, and notations. Figure 2 is an example of shape grammars rules.

Where in L-systems (Lindenmayer & Prusinkiewicz, 1990), elements are presented as strings of characters (Axioms) as shown below in Figure 3. L-systems Axioms are usually used to represent (package) geometric data, growth directions, or nested strings of data.

L->RL
MR -> G

Figure 3: L-system replacement rules. The first rule replaces "L" by "RL", where the second replaces "MR" by "G".

When building GSS, designers may choose to combine, edit, or even invent new representations for the design elements within a system.

One might argue that design processes cannot be approached holistically as a set of algebraic "left and right" rules because they do not accommodate for the designers instantaneous intuition. A distinction should be made to clarify the context in which design is best produced by rules.

Architects usually build methodologies for solving different types of problems to develop prototypical solutions. One of the most famous published works in this area is Christopher Alexander's "Pattern Language". In his book, he breaks down different design contexts of different scales to a number of objectives and requirements, and ways to provide possible solutions. More familiar examples on prescribed, "off the shelf" type of solutions can be found in the Architectural Graphic Standards books where extensive solutions and rules can be found for almost any architectural design concern.

In the light of this discussion, design rules can be articulated in different ways such as: if site context (X) is true, then build a fence (Y); or drive the numeric value of slope (A) by the ratio B/C, or the position of stairs (M) is always perpendicular to walls (B); etc. Design rules are processes devised to offer solutions under specified conditions.

Prototypical solutions are not to be mistaken for systems. They only present the right side (output) of design rules. Generative systems are structures capable of processing input and generating output through utilizing design rules. One of the most famous examples on generative synthesis systems is the "Palladian Grammars" that Stiny and Mitchell (1978) built using a Shape Grammars. Figure 4 below shows a number of alternative solutions generated by the system. The grammar was designed to reproduce alternative solutions for an extracted design language from the works of Palladio.

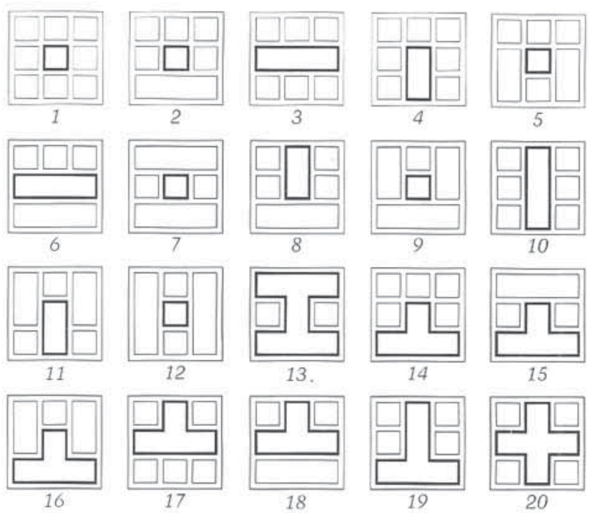

Figure 4: Twenty (of many other) alternative villa designs generated by the grammar. (Mitchell, 1989).

Generative synthesis systems are advantageous (and applicable) to the design process if and only if the designer was able to define: A) clear definition of design objectives; B) a design language through which these objectives are to be expressed (Yessios, 1975), which is necessary to bound the scope of system building; C) and a formalism to describe the generation process (expression of objectives). Design objectives are expected gains from a certain design schema. Design languages are material expression of design objectives. Design formalisms are combinations of design rules and representations. Rules are built or extracted in relation to both the design context and the design language being implemented. Rules manipulate design elements (units) through their representation. A design element can be represented in various ways in relation to different contexts. Each representation method highlights certain aspects of the design elements. Hence, rules are functions that manipulate units through an interface defined by representation. In that sense, Palladian Grammars is a generative system for synthesizing alternative designs of Palladian Villas through Shape Grammar, a formalism that manipulates units via a representation of drawn shapes.

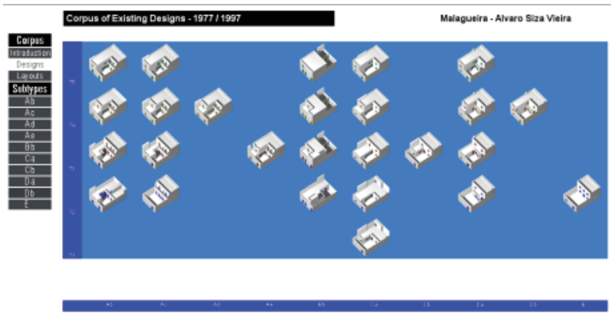

Figure 5: Alternatives of Siza's design by Duarte's Malagueira automated grammars (2005).

In Siza's work, one can notice consistent methodologies for form derivations such as site lines, geometric proportions, use of materials, compositions of volumes, relationships between solids and voids, etc. The richness, clarity and consistency of Siza's work made it possible for Duarte (2005) to automate the generation process of Malagueira houses as shown in Figure 5.

2. Projects:

The following two projects illustrate a different design scope, buildings' skins (A more common implementation of generative systems to the architectural practice nowadays). The first project, Smart_Component_01, shows an adaptive assembly of flat panels built with standard joints. It presents a design instance, a singularity or rather a building brick that can be used repeatedly to produce a mechanically adaptive skin. The project was realized by two environments: CATIA and **form•Z**. The former provided a parametric environment allowing for building numeric and geometric rules (relationships), where the second provided a partially parametric environment offering a more transparent modeling experience and allowing for faster conceptual studies of initial design configurations. The second project, Panels_Optimizer_01, offers a paneling methodology for complexly curved surfaces. It shows a top-down approach for finding design solutions through iterative loops of construct-and-improve algorithms. This project was realized by two environments as well: Rhino and **form•Z**. The former was used to automate design rules through the offered scripting language (RhinoScript) where the latter provided extensive tools for conceptual digital modeling and 3D-printing purposes.

2.1 Smart_Component_01:

The initial design objective was to create a surface with various levels of transparency driven by its curvature. This transition was approached as different degrees of porosity. Throughout the early experiments with digital and physical models, the design concept evolved from a holistic view of a surface to a singular view of a component. The design strategy was to create one smart component capable of configuring itself to a range of different conditions, namely surface degrees of curvature. While the component was designed to deliver various adaptation modes, it maintained the flatness of its geometric elements by utilizing a number of strategically placed joints. The robust system of joints helped avoid shearing, bending, and stretching. It also allowed for using only two types of panels, which facilitates easy assembly. Two possible solutions were developed using the same number of joints and panels, but configured differently. Based on the quality of the required adaptation, the second configuration was selected as a final solution. This was due to the fact that it had a fewer number of degrees of freedom, thus a better-controlled behavior in comparison to the first one.

The initial studies of design configurations were achieved through utilizing **form•Z**. The richness of its environment allowed for fast construction of digital representations, and translation to different file formats to communicate with fabrication equipments. After the exploration of different design ideas through **form•Z**, a GSS was built within CATIA by embedding numeric and geometric rules (relationships). The generative synthesis system was composed of four sub-systems: "Controlling geometry" responsible for driving the assembly of components; "Responsive geometry" responsible for mapping the changes in the previous sub-system onto a hexagonal point-grid; "Mediating geometry" responsible for translating changes in the previous system to the "Adaptive geometry". Figures 6, 7 and 8 show initial studies of joints, GSS structure, and population of the selected configuration.

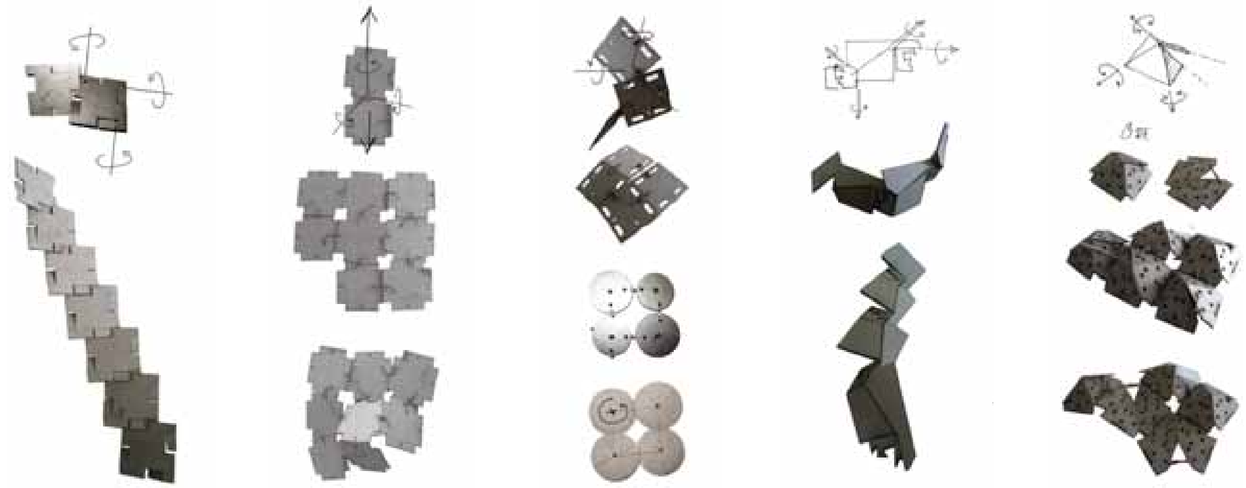

Figure 6: Initial studies of joints.

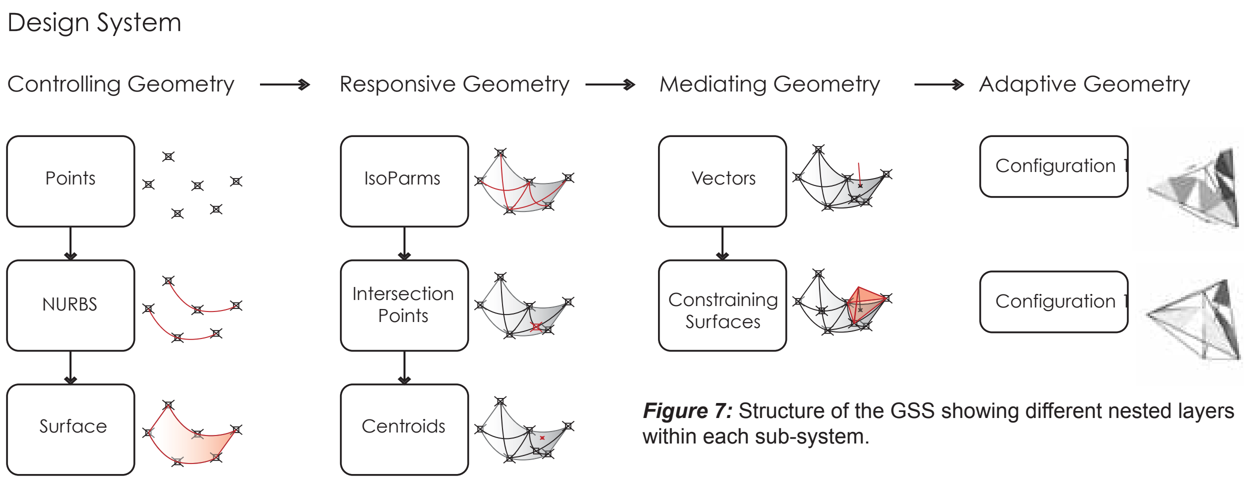

Figure 7: Structure of the GSS showing different nested layers within each sub-system.

2.2 Panels_Optimizer_01:

In the second project, the design objective was to devise a generic subdivision methodology for complexly curved surfaces. Initial studies of subdivision methods were achieved in **form•Z**. Its powerful engine provides a state-of-the-art solid modeling tools making it a perfect design environment for generating physical mockups via 3D printers. This helped define a design language and extract a set of design rules in a timely manner. After defining a language, the GSS was built in RhinoScript as a recursive algorithm. A main system component, Moderator, dictates the solution generation process (rule implementation) and selection (recognition) of elements.

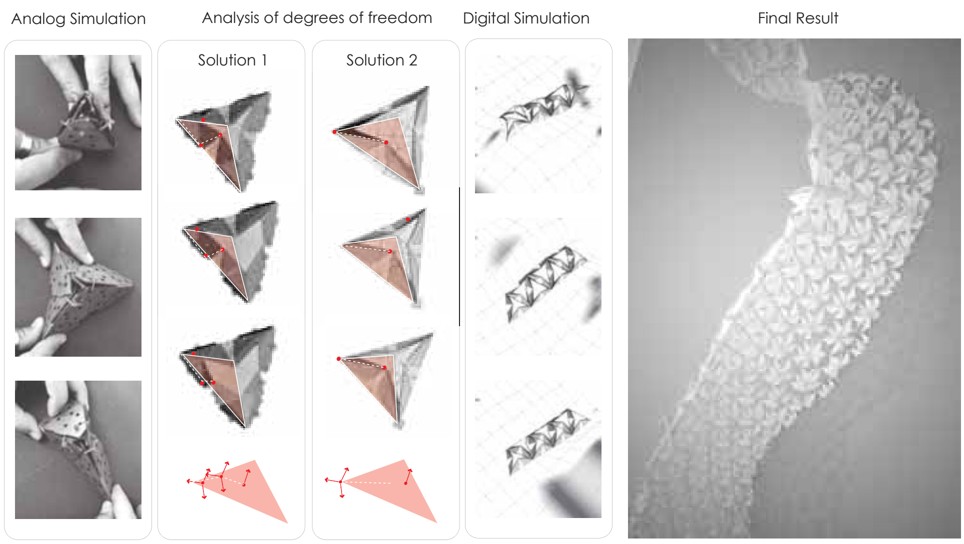

Figure 8: Showing a developed physical model; two designed configurations; a strip of “Solution-2” adapting to a deforming surface; and finally 1,000 components populated within a space defined by a curved surface.

There were two major goals: achieving speed in assembly (evaluated by the number of panels); and attaining the smoothest appearance (evaluated by the minimum size of panels). The trade off between these two drivers demonstrates a very simple, but true model of the architectural design process where conflicting demands have to be resolved. For example, the more panels there are, the slower the construction process becomes, but also the smaller the panels are and the smoother the final shape is. In contrast, the fewer number of panels, the faster the construction process becomes, but also, the bigger the panels are, the more angular the final shape is. To resolve this conflict, two other parameters were introduced: panel-curvature and style. Curvature suggests the integration of cost-related variables where flatness is desired. Style empowers aesthetic judgment to guide the generation process. In this case, the style chosen was fractal-patterns, which were generated by subdividing the diagonal panels. The design strategy was to recursively sub-divide and rebuild optimized panels until a stopping condition is achieved. In this case: A) an acceptable panel curvature, or B) a minimum panel size. The number of panels was driven by these two parameters, while the fractal pattern was generated by the embedded sub-division rules.

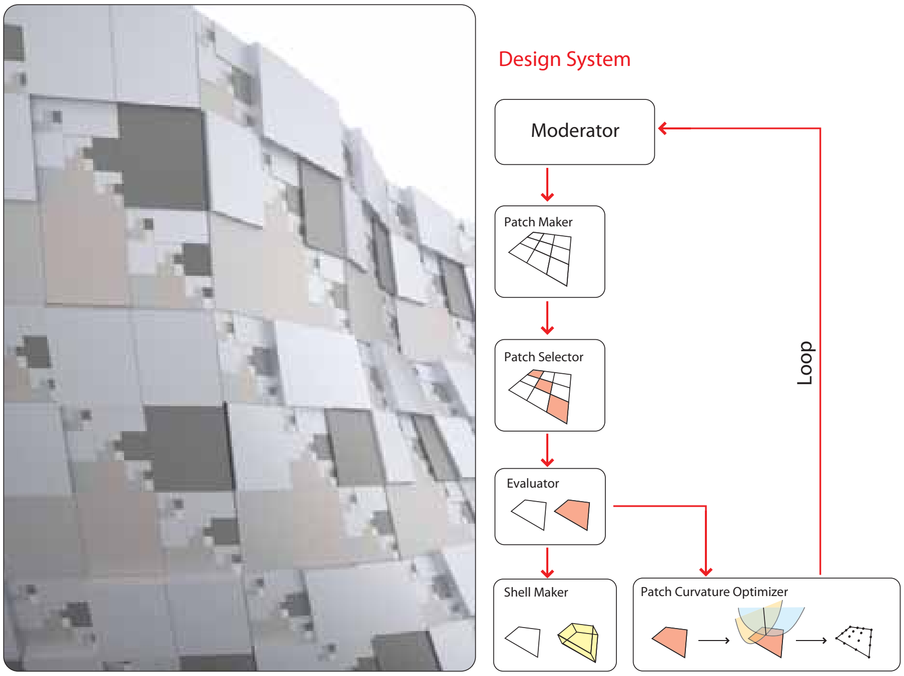

Figure 9: Left: showing a surface sub-division with different thicknesses based on each panel's curvature. Right: Showing the structure of the generative synthesis system for Panel_Optimizer_1.0.

Finally, each panel was given a thickness based on its curvature as a suggestion of material properties. Figure 9 shows the structure of the implemented GSS and a solution for a curved surface.

3. Conclusions

Generative synthesis systems require clear descriptions of the architectural languages being explored. Once a language is defined, it becomes possible to extract rules and formalize generation processes. Generative design processes offer a larger number of synthesized alternatives in comparison to the classical design processes. Building design synthesis systems urges the designer to understand their intuition, dismantle design problems, define design objectives critically, acknowledge decision drivers whether subjective or objective, and outline solution spaces rich of alternatives.

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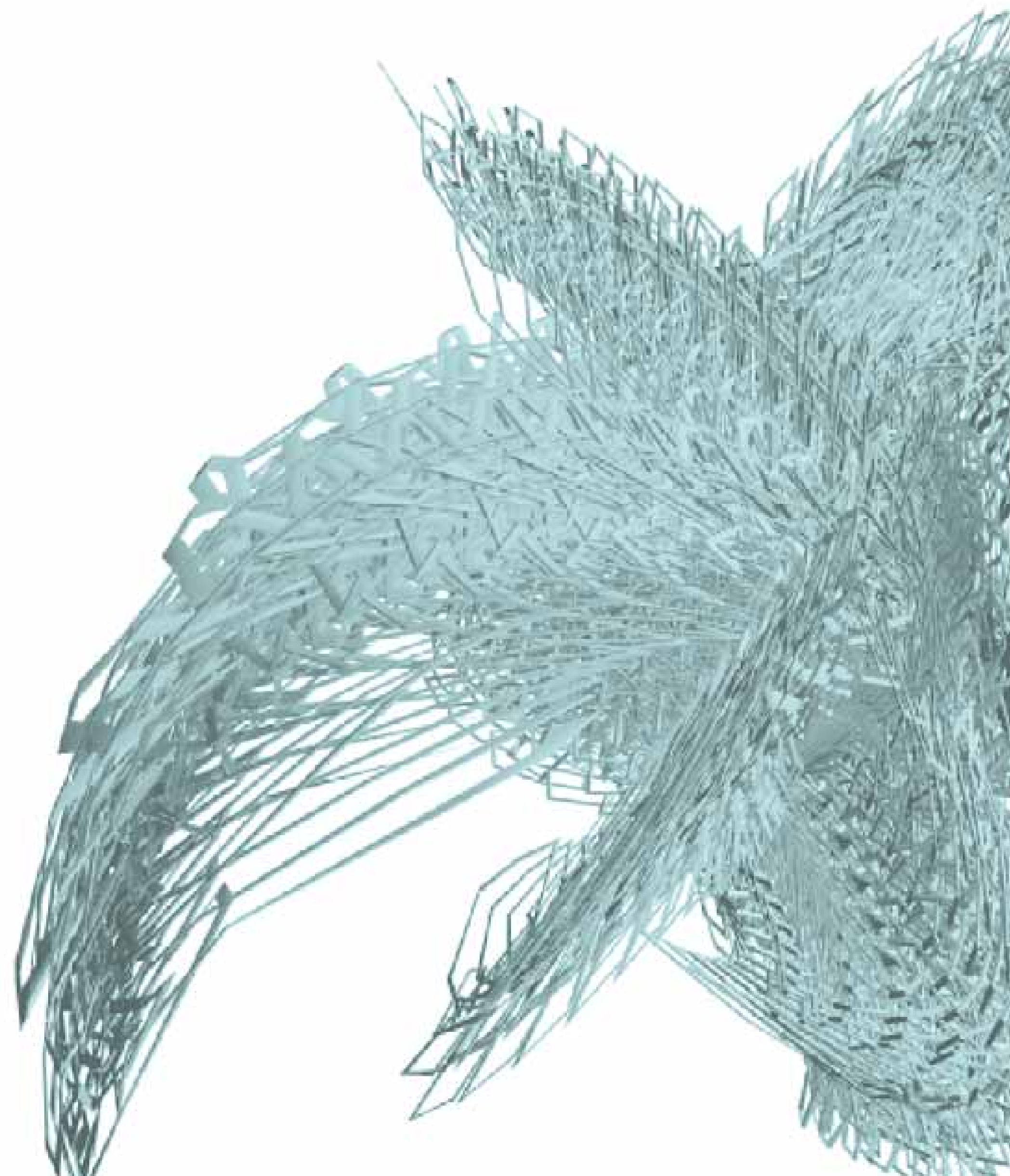
Maher El-Khaldi is a researcher at Georgia Institute of Technology pursuing a PhD in Design Computing. He received a Master of Science in Design and Computation (2007) from the Massachusetts Institute of Technology, and a Bachelor of Architecture (2004) from the American University of Sharjah, United Arab Emirates (UAE). Maher is the director of design computing division at Shape Architecture Practice + Research, UAE. Email:maher@shape-arc.com.

Chapter 3

Analog versus Digital



Rhode Island School of Design
Providence, Rhode Island

Tradition, Tools, Technique & Technology

by Naomi Crellin

The capabilities and possibilities offered by **form•Z** as modeling software are a recent development, opening new doors of opportunity to the furniture maker whose methods of creation are otherwise rooted in tradition. Yet, the traditional methods of making provide us with a vocabulary and set of tools that are the basis of our understanding of modeling. When I began this study, my intent was to compare the similarities of use of tools in **form•Z** with those tools used in woodworking. As I built the study model, I realized that the correlation between tools is more nuanced and the implications are further reaching than a simple comparison of their similar functions in the virtual and physical environments.

Figures 1,2: Conditioning and sizing the lumber to create 'billets'.

The table I recreate for this article is comprised of solid sculpted legs and a bent lamination table top - it was designed and is made by Peter Trumbull Crellin. Prior to commencing studies at RISD in the Masters of Interior Architecture program, I assisted with the making of this and other pieces of furniture – this experience gave me an appreciation for possibility of creating sculptural forms from wood through a number of different processes, methods, tools and with many stages of refinement. I was interested in recreating this table in particular because its form challenges our assumptions of how a table crafted from wood should appear. At RISD a commitment both to the value of making and the value of computing skills, has provided me with the opportunity to move from an analog to a digital mode of representation. Since the start of my studies I have maintained an interest in furniture and as I have acquired 3D computer modeling skills, I have been interested by the similarities of making in the virtual and physical environments. As my ability to model with **form•Z** grew, I was able to envision for the first time digitally modeling a table that is made through sculptural processes of grinding, shaping and pressing or bending in the woodshop.

Figure 3: Leg templates are created in **form•Z** to create the rough leg form.

Tradition: *"A part of culture that is passed from person to person or generation to generation."*

Though developing in the 21st century with the growth of digital technologies, the traditional techniques of woodworking persist as the guiding principles in the making of craft. While **form•Z** provides new methods of modeling, and opens up opportunities for the designer-maker to experiment with material properties, possibilities and perhaps impossibilities, it is these traditional principles of working with wood that have defined many of the terms and approaches used to craft objects and environments in a virtual setting. The tools available to woodworkers, and the manner in which they are used, often shape the end result. This is as true in the virtual world of making as it is the real world of craft.

Figures 4,5: ‘Boolean Operations’ conducted using the band saw tool in the workshop.

Figure 6: ‘Controlled rounding’ conducted using the router table.

While the processes used to create a sculptural piece of furniture can be argued to have parallels in the virtual and physical worlds, this simplifies the comparative methods of making: in truth, they are not and cannot be the same. The similarities between our use of tools in the virtual and real making processes are born of our experience of traditional techniques - tradition provides us with the framework and language system we use to understand the basic concepts of making in the digital sense.

Tools: *“Mechanical devices intended to make a task easier”*

In the woodshop, the sculptural process of making is a subtractive one – the furniture maker begins with a raw material and a significant portion of time at the front end of the woodworking process involves conditioning and sizing the lumber to useable dimensions, from which the form is then carved. As designers working in **form•Z**, we have the luxury of specifying the dimensions of our component pieces without this process – in this case I began with my ‘billets’ sized to the dimensions of the lumber after the initial cutting and conditioning required in the actual making (Figures 1,2).

Leg templates were created, and using the Boolean intersection tool in place of the band saw used in the workshop, the two leg profiles are cut from the solid billet (Figures 3-5). The next stage of shaping in the workshop utilizes an elliptically shaped router bit, rasps, hand filing, grinding and sanding to achieve a smoothed final form. In the virtual environment, this smoothness is achieved through a combination of edge rounding, filleting and meshing to emulate these sculptural stages of the wood working process (Figures 6-8).

Figures 7,8: The rough leg forms are shaped and smoothed in **form•Z**.

The making of the top of the table is in the woodshop achieved through a lamination of layers of veneer over a form, adhered and then pressed in a vacuum bag (Figures 9-12). Achieving this end result in **form•Z** required the meshing of a 1/16” solid to simulate the elasticity of the veneer material. I created a replica of the form used in the workshop and from this defined a profile curve, which was used to move the mesh by pushing it into the desired form. The tabletop thickness was built up in **form•Z** by

Figures 9-11: The veneer pieces are cut using templates, ‘stitched’ together with veneer tape and formed to a profile using the vacuum press.

placing layer upon layer (Figure 13). The final layer for the tabletop in reality comprises 81 pieces of veneer, hand cut to a checkerboard pattern that in its bent form simulates a draped or melted effect. This design is defined on the flat, unbent lamination layer. In **form•Z** as in the real world templates were created to guide the process of cutting, in this case splitting.

The sculptural process of woodworking is a subtractive one, iterative methods of removing material to create the desired end form. In the virtual process we can use Boolean and other functions to simulate the removal of material, yet if we wanted to experiment, the processes offered up by the software allow us to consider sculptural possibilities that the material of solid wood would not ordinarily permit. We need not be concerned with grain direction or material flaws – just the parameters of the software capabilities for forming and deforming a solid object. So, many of the tools in **form•Z** are analogous to the tools used in the woodshop, but ultimately **form•Z** has the ability to become another tool for the maker.

Figure 12: The layers of veneer that make up the core of the tabletop form are glued and laminated.

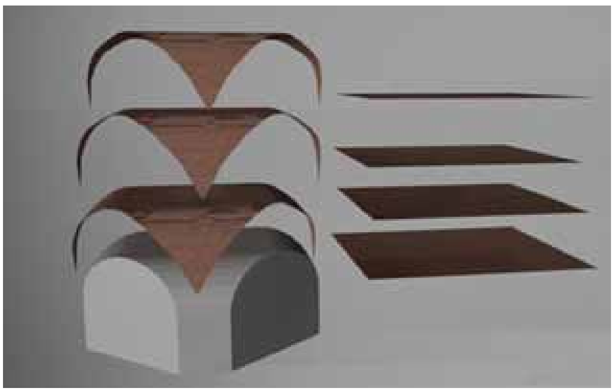


Figure 13: Veneer layers are likewise formed, using the Move Mesh tool in **form•Z**.

TECHNIQUE: *"A way of accomplishing a task that is not immediately obvious."*

Much of the development of furniture product is created through a process of trial and error. Materiality is a big part of this in the woodshop. The trial and error approach is one of experimentation, exploration of the best, most efficient method of creating the object we want. This holds true for the process of making in **form•Z** as it does in woodworking. Yet **form•Z** gives us additional options for creating sculptural forms – two source sweep for example – that are conceptually based and a departure from the tradition based Boolean operations. These are options that designers explore through their own process of trial and error in the software environment.

The creation of this table in **form•Z** took little time relative to the physical effort, time and expertise in working with a material required of the furniture maker. As I reflected upon this relatively swift mode of creation, I realized that there is a great difference in working with a material that brings with it properties and peculiarities, and its own inherent textures. Wood workers will point out the difference between working with maple or mahogany – while the overall processes used to achieve a form may stay the same, the difference of the materials is felt through the hands on nature of woodworking. Part of the reward of working with wood is accentuating and selecting the material details and textures, and revealing them through the sculptural process of creating form. In the virtual world, it is comparatively easy to create the desired form, the texture of the material being applied as a secondary consideration. This difference allows the user of software to experiment with the form and the materiality of the sculpted object from a different perspective, one that can push the boundaries of a form beyond that prescribed by the material. Here then we can move beyond the consideration of what form, for example, a brick would wish to take as considered by Louis Kahn, and begin to push the perception of what forms the material can be applied to.

TECHNOLOGY: *"the study of or a collection of techniques."*

For makers accustomed to the traditional methods of making, software such as **form•Z** provides opportunities to innovate both creatively and in the methods of production. It is difficult however to entirely remove the presence of the woodworker; nor might one want to in certain fields.

I see three possible areas that digital technologies can contribute to the furniture maker: conceptual/creative, selling the idea, and efficiency of production. On the conceptual/creative level, possibilities presented by the software affords the craftsperson the opportunity to step back from the prescriptions of a material and consider a range of forms outside of the context of material, opening up a whole new realm of possibilities. In selling work, the ability to create digital, often photo realistic, representations of an end result can be of great value in selling work as it allows the client to visualize the product beyond the traditional elevation or perspective hand sketch. I asked Peter about the value of digital technologies to his work.

"Yes, the capability of 3D software to provide a visual representation is of great help in selling one's craft; but it can also be restrictive – once a patron is sold on what appears to a photograph of an end product, it can be difficult then for the maker to exercise an independent judgment during the process of making, to change dimensions, details or materials."

So, the powerful possibilities of digital representation of custom furniture should be recognized, and managed – carefully selecting what is modeled, what views are shown and what degree of photorealism is sought.

I also asked Peter about the possibilities for incorporating modeling software into his making process:

"Part of the appeal of what I do as a craftsperson is that my work is created by my own hands, each piece being different and unique. I am a designer but I am also a maker. That said, if I had an interest in mass producing this table, then the modeling software could be used in conjunction with a 5 axis router to create the solid components and the veneers could be laser cut…I imagine that this would be precise, efficient and would cut labor cost…"

It is my point of view that though the maker's hand would be reduced by the use of software in conjunction with machinery, it could never entirely be removed from the process of making – the material selection and working to produce a refined finish are elements that require a discerning and experienced eye and hand.

So, while digital software may offer ways to make production faster and easier, this does not necessarily mean that it usurps the role of the maker or undermine the value of craft:

"A lengthier making process does inform my design. Decisions about shape and form often develop through making: You have a rough idea of where you want the form to go, but it is not always something where you could look at an end result and decide what you do or don't like, it's a shape that develops through making, and the decisions made along the way. Oftentimes design decisions that determine what things will look like are made through full scale drawings and templating before it is built and then refined to a final shape through the lengthy making process…"

But is there not a digital equivalent to the lengthy making process? Are we not able to adapt and refine through iterations of the software environment: creating an object, applying materials, placing it in a context to test our reactions? Coupled with easy access to compatible production machinery, the designer/artist/maker would be able to incorporate the physical product with this process of

Figures 14, 15: The final table: from the Workshop, and from **form•Z**.

refinement. Still, for furniture makers whose perspective is shaped by the prevalence of traditional methods of making, this argument will only be successfully made in the context of a wider adoption of modeling software such as **form•Z** by their peers in the maker community.

You could get a rough idea of what something would look like in a new design but in terms of adapting designs to different sizes and subtly refining the form to fit the new proportions, I don't know that this can be done digitally. It is this level of refinement of design that comes from a lengthier making process and which is often missing from mass produced work – you can make a cabriolet leg with five axis machinery, but it will not have the grace that a cabriolet made by hand will have.'[1]

In considering how a furniture maker with no formal training in using modeling software might be encouraged to adopt **form•Z** as a new technology or tool in his toolbox, it strikes me that **form•Z** would need to be an immediate and intuitive benefit to the maker whose focus tends be practical considerations. The software would need to address the following questions: First, can I draft with this? Is it intuitive enough for me to figure out how to digitally produce the traditional drawings I am familiar with? Second, can it produce a model of an idea I have already defined through traditional methods? Can it perform in a way that I understand, with functions analogous to the tools I am familiar with? With these conditions met, I would speculate that the creative maker would establish a level of comfort with the program and begin to experiment with incorporating this technology into the conceptual as well as making processes.

Figures 16, 17: The final table: from the Workshop, and from **form•Z**.

Conclusion

As I modeled this table and reflected upon the processes used, the possibilities and implications of digital technologies for the furniture maker, I came to understand that making in the virtual and real worlds are not just separate yet parallel processes, but that digital exploration of form can itself become another tool for the furniture maker. The possibilities provided by digital modeling extend beyond just that of generating an image of an intended object but can influence creative possibilities and the making process. So, as a tool, **form•Z** has great potential for the maker. In order to become more widely adopted by the woodworker, software such as **form•Z** needs to be intuitive, multifunctional (meeting the everyday drafting needs of the maker as well as providing its current modeling capabilities), and the machinery used in conjunction with the software more affordable, easily accessible, to the individual maker for the purposes of experimentation and development of technique. While it could be argued by some to challenge traditional methods of conceptualizing and creating furniture, the adoption of digital technologies as a tool by studio furniture makers, and the broadening of techniques this represents in addition to those offered by tradition, is already underway.

Note:

[1] For a more complete discussion of the use of digital technologies in making, and the debate about balancing digital methods with the traditional values of craft, see 'Furniture Makers Exploring Digital Technologies, ed. John Kelsey, 2005, The Furniture Society; For an interesting review of the history and modern practices of producing bent lamination furniture, an example of the role of modern production machinery and software in furniture making , see 'Bent Ply' by Dung Ngo and Eric Pfeiffer, Princeton Architectural Press, 2003.

Naomi Crellin is a Graduate student at the Rhode Island School of Design in the three year Masters of Interior Architecture program. Prior to her studies at RISD, Naomi received her undergraduate honors degree in Modern History and Political Science from the University of Sheffield, England. In addition to designing and making furniture with her husband, Peter Trumbull Crellin, her prior professional experience includes working in professional development and training for a global strategy consulting firm, and in human resources and business administration for an architectural firm where she led the creation of a formal professional development system. During her studies, Naomi has maintained an interest in learning and development and has been appointed to teach the Introduction to **form•Z** course offering by the department of Interior Architecture during the 2007/8 Winter session.

University of New Mexico
Albuquerque, New Mexico

Digital Mutations: Exploring Methodologies in Fabrication

by Tim B. Castillo

The emergence of digital fabrication processes in architectural practice has reconfigured our methodology in creating constructed space. As the profession begins to incorporate these processes, architectural education becomes the forum for exploration into these new technologies. As many design schools across the country have begun to incorporate digital fabrication such as CNC mills, 3D digital printers and laser cutters into their pedagogical mission, the University of New Mexico has limited resources and is not currently able to incorporate this technology within their curriculum.

The challenge for our institution is to develop a methodology for educating our students in emerging digital fabrication processes, so that they can be competitive in the professional environment. The studio was set up as a design build process, the client being the Digital Filmmaking Institute. The program was to develop the interior space for the Insomnia Lounge for the Duke City Shootout Film Festival in Albuquerque, New Mexico (Figures 1, 2).

In working with a very limited budget, the students were asked to be innovative in their approach to developing the space and to incorporate processes of digital culture as a way of informing the production of the installations (Figure 3). The focus on innovation is critical in working with limited financial resources as it forces new readings for material and spatial exploration. Relying on traditional material and fabrication processes in many instances inflates monetary expenditures. The positive use of digital technology allows a series of visualization studies that can explore several material options that are integrated into spreadsheet data sets that give projected cost analysis (Figure 4).

Figures 1,2: Fabrication studies for Duke City Shootout.

Figure 3: Cardboard panel mutation study.

Figure 4: Digital rendering study of installation.

The insomnia installation program defined the pedagogical framework for the studio and investigated innovative spatial creation through fluid production based in digital and analog mutations. Exploring the potential of digital information and understanding how it affects architectural spatial configuration was a primary goal of the studio. By incorporating new methodologies that borrow from the automotive, aeronautical and cinematic professions, the students were asked to reconsider traditional design practices. Utilizing vector based principles and simulations, the studio worked with imprinting processes as a means to develop analog constructs. This systematic operation can be defined as versioning, a process that attempts to rethink the design in terms of procedure and outcome in ways that common practice and conventional design methodologies cannot conceive [1].

As the profession continues to evolve using digital technology, information practice has become the standard for contemporary building execution. The emphasis on data organization and comprehension has become fundamental in translating between modes of production. Design data information migrates through various forms of translation (i.e., vector drawing to digital scaled prototype to construction document to full-scale fabrication) in the process of any architectural project. It has placed an added burden on academics to pursue models that incorporate a more holistic understanding of data design integration. The opportunity for this research to occur in academy allows for more innovative analytical design methodologies that expand beyond comprehensive design tools, such as building integrated modeling systems. The downside is students are not as well versed in s specific parametric software that might make them more viable to step into a professional setting right away.

The mission of this studio is to develop analytical evaluation tools to understand the migration of data through various informational systems and critically assess the opportunities for both analog and digital innovation. Through a series of performance modules the studio researched computer controlled manufacturing principles and began a dialog of transference spatially and materially.

The foundation for the exploration began by understanding how data can inform and inspire new spatial possibilities (Figure 5). The students were asked to create a series of vector animations in Flash MX mapping ergonomic activities. The students documented movement by photographing a series of time lapsed images that focused on the various forms of movement. They researched structural organizations by documenting the fluid movement traces and then converting them into 3-dimensional spatial data.

This data then migrated into 3-dimensions, utilizing NURBS (Nonuniform Rational B-Splines) modeling in **form•Z** they captured the dynamic spatial activity. The students then

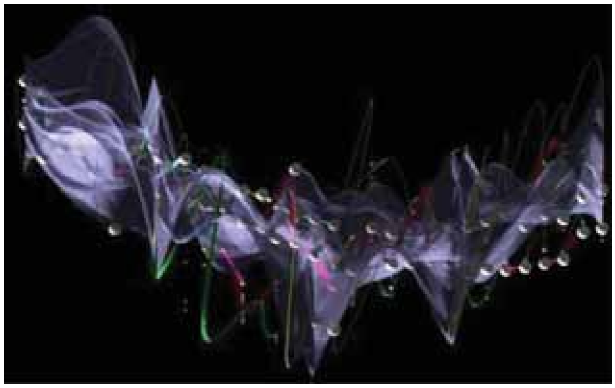


Figure 5: Network model images.

began to probe the models and delineated the result in orthographic and axonometric drawings (Figure 6).

These drawings were the basis of form translation into analog prototyping. Understanding how parametric process can inform design we began to explore the digital models to understand how they could be translated into analog prototypes. By analyzing the data produced in the visual simulations, a methodology of extraction was critically probed for each model. Applying mathematical and scientific operations, the students uncovered spatial, tectonic and network formulations for further development (Figure 7).

The analog translation inherently produces visual information that each student must read as a framework for further exploration, unlike digital analog prototyping technologies (3D printing, laser cutting, CNC milling) that produce direct translations of digital data into analog models. These mod-

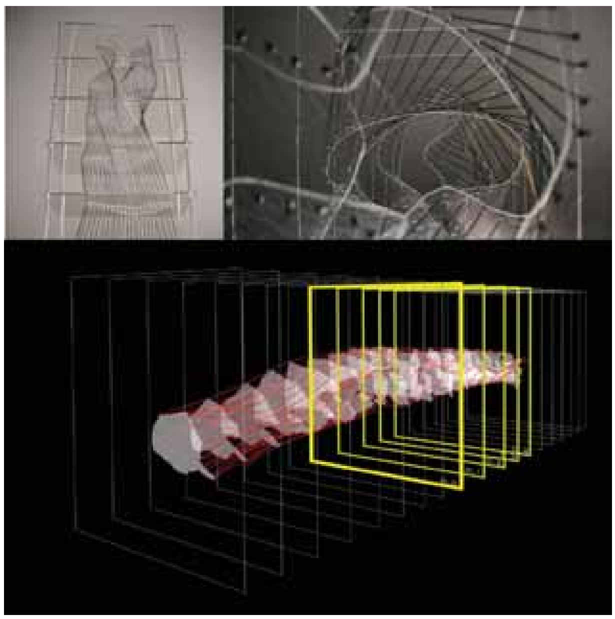


Figure 6: digital + analog translation studies models.

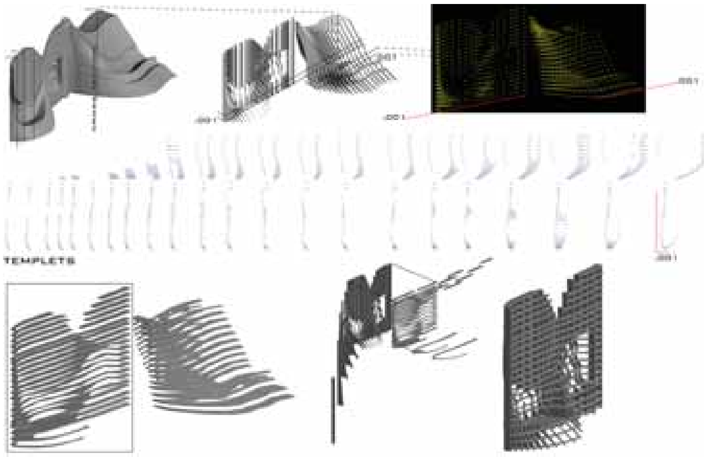


Figure 7: Digital translation study.

els are intended as mutant systems that explore a multiplicity of conditions and allow for various modes of design development. This included material innovation, exploration of dynamic structures, spatial networking, and tectonics.

This research allowed the students to begin to be anchored in real world forces, permitting an opportunity to understand how the migration into physical systems forces reconfiguration of the data. The ability to work haptically is essential to understanding the architectonic application of these studies.

The studio then applied the extraction of this data to a small-scale program that demonstrates the economy of production and material. These studies focused on fabrication innovation, template organization and digital data mutations. The result of these studies informed the foundation for development of the insomnia space for the Duke City Shootout (Figures 8-10).

In order to work efficiently, the studio was broken up into five teams. Each team engaged the insomnia program and created an innovative scheme for the insomnia lounge. The challenge for the teams was to create space that was economical both in material and process. The students started by exploring materials that would be cost effective and structurally sound for the space.

Figure 8: Digital mutation scheme.

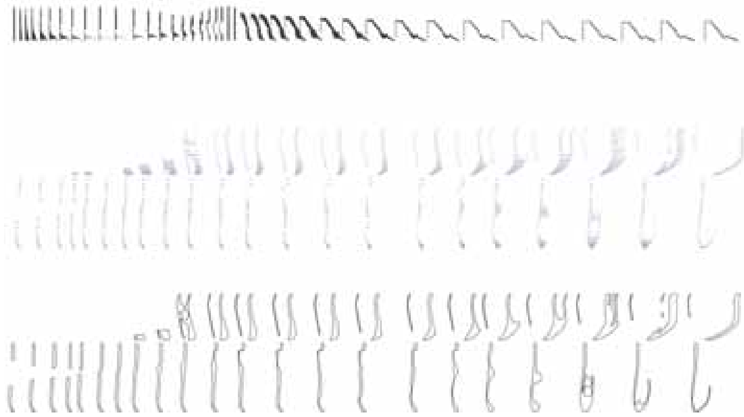


Figure 9: Fabrication templates.

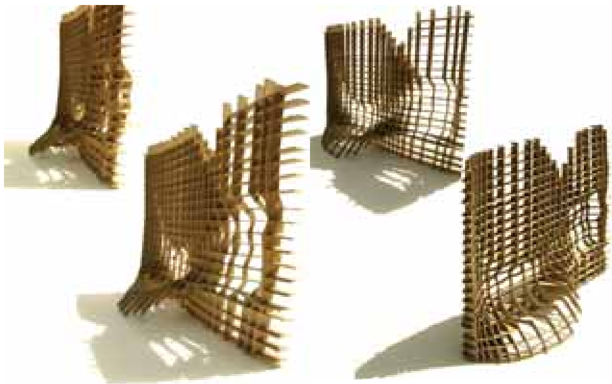


Figure 10: Analog model.

The development of the Insomnia Lounge for evolved as a competition format. Each team was to develop a scheme that the board of the Digital Filmmaking Institute could critique. The final iteration engaged in a process of full architectural production. The students were to expand on the research developed in the previous modules and produce a full-scale installation investigating material, tectonic and tactile permutations derived through digital experimentation. The main objective was to work on a performance driven methodology that incorporated digital and analog prototyping strategies to select the most efficient design (Figure 11).

Figure 11: Full-scale tectonic + material study.

Figure 12: Digital rendering of spatial configuration.

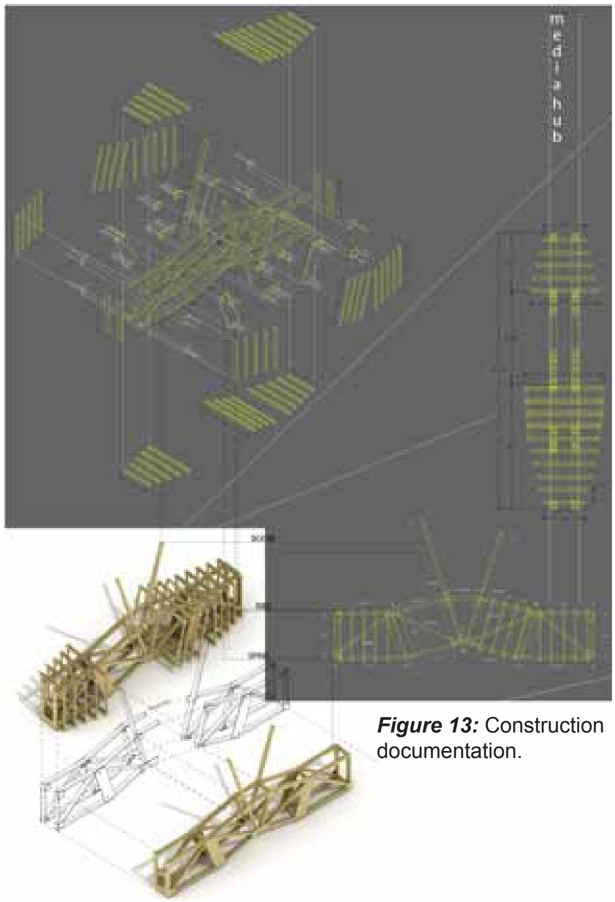


Figure 13: Construction documentation.

The final project began with *performance base modeling* [pbm] techniques that respond to critical data dictated by spatial forces and contextual specificity. The students were to produce an installation that addressed a series of spatial events including event seating, an editing station and bar (Figure 12). By generating a series of performance models, design intentions could be evaluated spatially and programmatically.

As the process evolved we spent considerable time focusing on material analysis, probing for structural capacity, modularity and economic efficiency. These investigations yielded a variety of latent systems that challenged traditional fabrication strategies. These materials required research into new patterning and geometric processes to uncover methods of assemblage. Ultimately, what emerged were several composite systems that were dependent on interactions between surface and structure. Singular systems were no longer applicable; rather everything was interconnected to function as a collective whole, producing intelligent performance derived systems.

The selection of the final scheme was a challenge for the board and ultimately yielded the selection of two schemes. The collaboration and integration of the two schemes was a relatively easy process as the students were able to apply the fluid methodologies explored previously and derive another mutation for the final installation.

The execution of the final fabrication required construction documentation that was generated in **form•Z** (Figure 13). The economy of a pattern driven process allowed for a fluid and economical construction process to evolve. The final installation was constructed summer 2007 and exhibited at the main event, where more than one thousand visitors participated in the film festival (Figures 14-16).

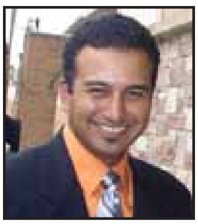
As the digital fabrication process continues to evolve in architectural practice, academy will continue to face new challenges to provide students the ability to think within the parameters of these emerging technologies. In creating a forum that allows students to probe digital processes, we allow creative options for problem solving. Developing studios that engage diversity of manipulation of design data is critical in gaining exposure to all facets of contemporary practice.

The success of the studio begins to offer trajectories for new opportunities to emerge out of digital pedagogy. The ability to realize full-scale design and work with budgetary constraints, models professional practice in a way that the traditional theoretical studio models cannot engage. The students were rewarded with opportunities that could provide innovative solutions for impacting our spatial environments and advancing the academy of architecture.

Reference

[1] Sharples, Holden and Pasquarelli; Versioning, New York City (Architectural Design, V. 72, Sept. – Oct. 2002) p.7-9.

Figures 14-16: Final installation and process images.



Tim B. Castillo is an Assistant Professor at the School of Architecture and Planning at the University of New Mexico. He is currently the Coordinator of Undergraduate Design and the director of the Laboratory for Digital Research. While at the University of New Mexico he has rigorously been pursuing new pedagogical courses that explore applications related to digital technologies. His studios and seminars continue to investigate new progressive strategies for design that are defined by informatics, digital media, and CAD/CAM processes. In 2007, Professor Castillo was recognized by the Association of Collegiate Schools of Architecture (ACSA) and the American Institute of Architecture Students (AIAS) as the National New Faculty Teacher of the year. He is also the founder of Hybrid Environments, a critical design office that focuses on new technologies for architecture, research, and design. His work has been published and exhibited nationally and internationally in various locations including the Institute for Advanced Architecture of Catalonia (Spain), Ecole Polytechnique Fédérale de Lausanne (Switzerland), Pavillon de l'Arsenal (France), Bienal of Sao Paulo (Brazil), and University of Waterloo (Canada).

Ohio University
Athens, Ohio

Integration of the Actual and the Digital: Folding Modeling into Beginning Design Learning

by David Matthews

Our nervous systems are "...grown to the way in which they have been exercised, just as a sheet of paper or a coat, once creased or folded, tends to fall forever afterward into the same identical folds."

Philosopher William James

Introduction

This article outlines a critical method of introducing processes of making digital and actual models in a beginning design studio. The central objective of the studio is to introduce the students to a method of using material and digital models that reflects the values and practices desired in advanced design practice. Concepts and theories from educational psychology are applied in the beginning design studio to enhance opportunities for practicing cognitive processes required for advanced/higher thinking skills such as analysis, synthesis and evaluation. The ideas presented in this article were developed in a cooperative process with Steve Temple, Associate Professor, University of Texas San Antonio, as an effort to unify concepts learned in the wood shop and computer lab.

Theory

Robert Leamnson, in *Thinking about Teaching and Learning, Developing Habits of Learning with First Year College and University Students*, discusses the importance of establishing good habits of learning early. "Learning as brain-change, rather than brain use is critical in establishing good habits of learning. Learning is defined as stabilizing, through repeated use, certain appropriate and desirable synapses in the brain," (Leamnson, 1999). The project outlined in this paper provides the first experience with digital technology in the design studio. The processes in which students engage are to serve as an initial model to be repeated in upper-level courses.

The introduction of design processes on the foundation level can have profound and lasting physiological impressions on the brain. Beginning design studies are the first steps in establishing the neuro-pathways that will be used in advanced design practice. It is the objective of the instructor to provide an experience that establishes a conceptual foundation that allows students to build their own understanding of the relationship between the virtual and the physical processes of designing.

Critical thinking with digital and physical model making is the central "brain exercise" of the studio. Bloom notes higher-order thinking as analysis, synthesis, and evaluation (Bloom, 1956). These higher-order thinking skills serve as the basis of what will be employed in the class. Bloom's higher-order skills are brought into greater focus when combined with the work in critical thinking. Halpern states, "Critical thinking is purposeful reasoning involved in formulating inferences, calculating likelihood, and making decisions," (Halpern, 1984). The course is structured to allow students to make decisions on how to create abstractions between the processes of transforming from physical to the digital and just as important the process of making the digital into a physical form.

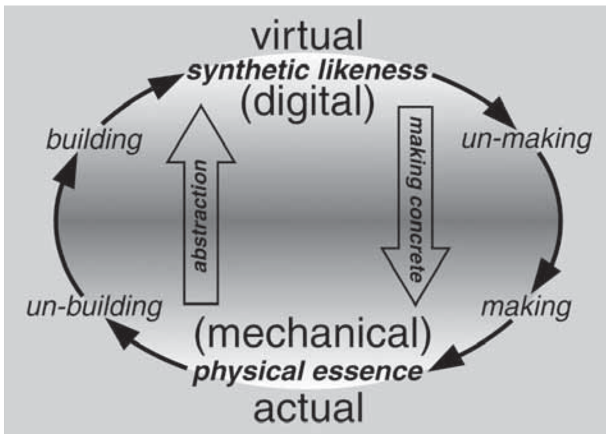


Figure 1: Model of digital and physical integration.

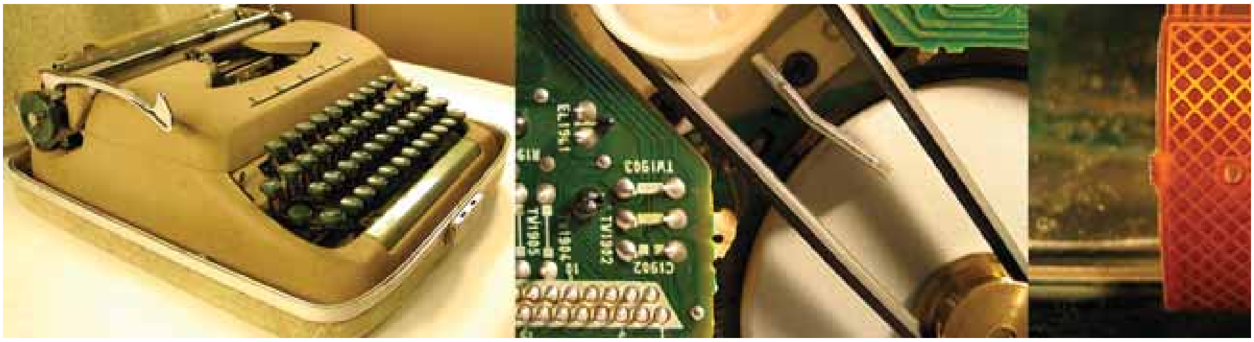


Figure 2: Un-building appliances.

form•Z represents the central tool integrated into the studio for digital making. Critical thinking occurs when students are able to make cognitive links between the physical and digital realms by using analysis, synthesis, and / or evaluation that employ purposeful reasoning and decision-making. The studio is based on creating a tension between digital representation and physical actualities. The model in Figure 1 illustrates how students move between the digital and physical. Students start with the actual and moving toward the virtual. The student will abstract the physical in a process of un-building and building as they work in the digital realm. The process of transformation from the digital to the physical is one of making concrete. In the process of making concrete, students must un-make the digital and make the physical. The studio presented in this article implements the model illustrated in Figure 1.

Phase 1 - Physical to Un-building

Students find an existing appliance for the purpose of discovering the physical qualities, they take the objects apart in a systematic manner that results in a pile of singular objects. The process is documented with digital photography. Note Figure 2. Phase One introduces the students to the material qualities of the selected appliance. Due to a general unfamiliarity of how things are constructed, students often struggle with the process of un-building. The methods that are employed to construct the appliance create a physical and cognitive interaction of problem solving. Mechanical processes of joining materials such as set screws, slot and tab, spot welding, and glue challenge the students to interact with construction methods and processes used to make the appliance when they take it apart. Analytical skills are required to systematically disassemble a complex appliance.

The experience of un-building introduces the student to the importance of materials, fabrication, precision, and accuracy needed in the process of making. The exercise is to introduce students to look at objects not only as what they are, but how are they are constructed and what qualities are inherent within the materials and fabrication? The process is to build neuro-pathways that strengthen the relation of systems of materials and fabrication and the creation of objects and environments as beginning designers.

Phase 2 Abstraction - Un-building to Building

Students use the disassembled components of the appliance and complete a series of formal design fundamentals exercises. The transformation of the appliance into a new set of potential design ideas is a process of abstraction. The project does not require a reference the utility of the original appliance in this phase but rather investigate a new potential for building by being aware of the inherent qualities found in the objects created in Phase One. The process requires higher-order thinking skills such as analysis of shape and form to be successful. Students must search for new opportunities that have logical relationships with elements and principles of design in this phase.

Fundamental design concepts such as radial organization, rhythm, and diagonal transformation are created with existing objects from the appliance. Students are introduced to the idea that the process of abstraction in design is a synthesis of knowledge of the physical reality of the object and the building of new ideas. Using analysis and evalua-

Figure 3: Design Fundamental Investigations.

Figure 4: Design Fundamental Investigations with Photoshop.

tion of existing objects discovered when the appliance was taken apart leads to new design potentials. The process in Phase Two is to reinforce that ideas for design are a relationship of making analysis of the external world (the pile of objects created in Phase One) to abstract ideas such as design fundamental ordering principles. The process exercises the brain in a manner suggesting that design ideas are not purely cognitive, (i.e. the light bulb coming on in the brain,) but rely on analysis and synthesis of the physical world. Note Figure 3.

Students continue the investigation in Phase Two by using the computer as a tool of abstraction. Photographs of the appliance parts are manipulated to enhance design concepts such as color, form, and pattern with Photoshop. Graphic investigations employing computers are introduced as a process that engages analysis and knowledge of the physical world to realize new opportunities through abstraction of physical objects. The computer is introduced as a decision-making tool. This process is to reinforce the relationship of the physical world and the virtual as a symbiotic process. Note Figure 4.

Students analyze the photographs for inherent qualities such as pattern, color, and form and use the tools in Photoshop to intensify the quality. This is a process that requires the student to simultaneously emphasize the quality and de-emphasize visual distractions in the photograph. Tension is created due to the depth of abstraction that Photoshop affords. The students are challenged to emphasize a quality of the object and, at the same time, not destroy or overtly distort the object.

Phase 3 - Building to Digital

Students in Phase Three take a "deep dive" into the realities of creating digital models with **form•Z**. Thirty pieces from the deconstructed appliance are chosen to be built in **form•Z** in a one-week period. The process requires the students to transform material form and shape into a digital abstraction. Note Figure 5.

This process has similarities and differences with the use of the computer in Phase Two. The similarity is the computer is being used to abstract a physical object. The difference is in the way the computer is being implemented as a cognitive tool. In this phase, the emphasis is on accuracy and precision. This process allows the student to understand how the computer can be used for detailed visual representation of shape and form.

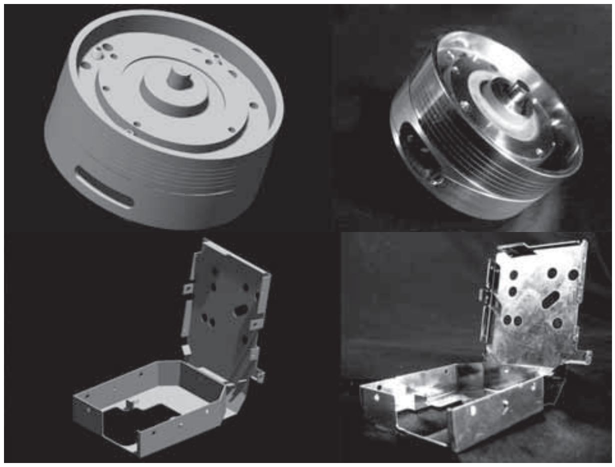


Figure 5: Building to the Digital.

The exercise has pragmatic implications. By requiring the students to model existing objects, they are often challenged to learn modeling tools from necessity. This reinforces that the computer creates a tension between what exists on a physical level and the skill and knowledge of creating a visual representation on the computer. The brain is exercised in a manner that places emphasis on knowing the computer as a tool to represent desired physical realities.

Phase 4 Abstraction - Building in the Digital

Objects modeled in **form•Z** during Phase Three are used to create a proposal for an inhabitable environment. The focus is on using **form•Z** as a tool of abstraction based on known physical forms. Attributes such as transparency, reflection, and color, added only by light sources, are exploited as part of the digital investigation. The transparency, reflection, and light color studies are selected due to the difficulty of reproducing them in a physical model.

Figure 6: Digital Spaces.

Students focus on the creation of space and the representation of space with perspective. Diminishing space, foreground, mid-ground and background composition, foreshortening, atmospheric condition from using the blur post process, and the angle of vision are elements emphasized to enhance communication of space. Note Figure 6.

Students are encouraged to create an environment based on new relationships discovered in the 30 objects. The initial form of the appliance is greatly abstracted into new potentials of space. Objects are rescaled and placed in new ordering systems practiced in Phase Two. The creation of space requires complex skills of analysis, synthesis, and decision-making required in higher-order thinking that are practiced as part of the profession. Equal emphasis is placed on quality of spatial representation. Quality and manipulation of representation allow the student to learn how to use the computer to analyze the quality of space and synthesize shapes and forms to make environments. By emphasizing the quality of representation, the student learns attributes of accuracy and precision inherent in three-dimensional digital modeling.

At this point in the studio, the student has used information found in physical objects that have been abstracted with the computer three times. Abstracted once with Photoshop, once with constructing objects from the disassembled appliance, and once by building space with the objects from the appliance. The repetition of the computer use as cognitive abstraction tool based on physical realities is a practiced neuro-exercise.

Phase 5 - Un-making to Making

The transformation from the digital to the physical is the focus of Phase Five. Students begin by making images that they estimate to be helpful in the construction of a material model, based on their digital model completed in the previous phase. The images are used to create models constructed from brown corrugated cardboard.

This step is one of the formidable phases in the process. The cardboard becomes more than a representation of space. It is an element of design with affordances and resistances that dictate transformation of the design. Students must employ critical thinking skills such as “formulating inferences, calculating likelihood, and making decisions” in the transformative design process. By creating a design in cardboard initially created on the computer, the student must make new decisions based on the quality of the material, infer new possibilities of space based on the material, and transform ideas.

At the same time students are realizing the palpable aspects of cardboard, they are reflecting on the abstract nature of **form•Z** modeling. Students in later studios will be making design proposals of environments constructed from physical materials and represented in a digital form. This phase is to exercise the tension between the affordances and resistances of the digital realm with the realities and resistances associated with the physical environment. For example, making a primitive shape such as a sphere in **form•Z** is relatively easy. It can be represented

Figure 7: Cardboard Models.

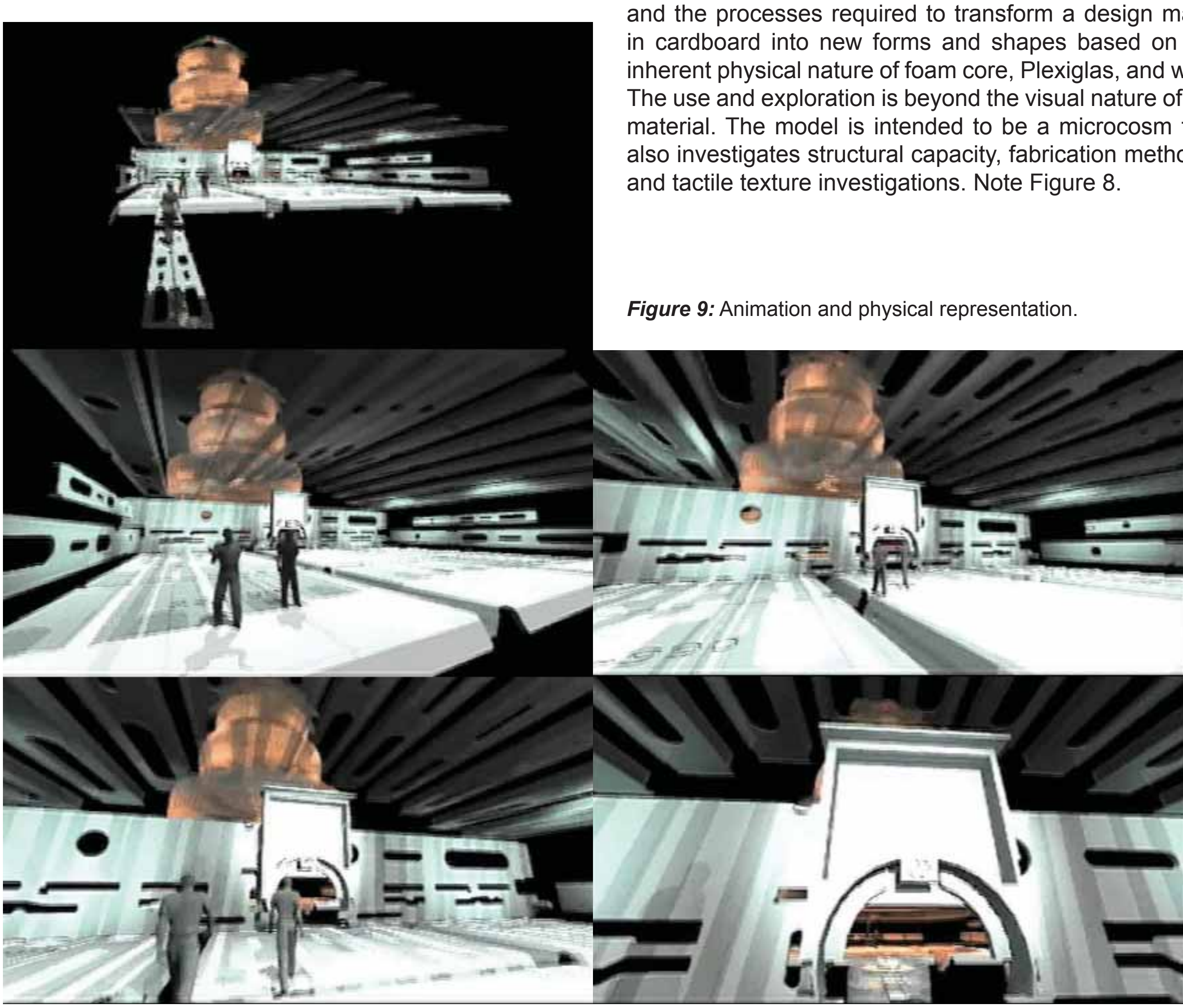
Figure 8: Foam core, wire, and plexiglas models.

with great accuracy on the computer. Making a sphere in cardboard requires a transformation in thinking that is based on the knowledge of the material and fabrication of cardboard. The link between knowledge of material and the creation of space, form, and shape is a neuro-exercise repeated in the following phase.

Phase 6 - Making Again

Foam core, Plexiglas and wire are used as new modeling materials in this phase. To reinforce the importance of the knowledge of materials in the design process, students must analyze and evaluate the new set of materials. Students must think critically about the nature of the materials and the processes required to transform a design made in cardboard into new forms and shapes based on the inherent physical nature of foam core, Plexiglas, and wire. The use and exploration is beyond the visual nature of the material. The model is intended to be a microcosm that also investigates structural capacity, fabrication methods, and tactile texture investigations. Note Figure 8.

Figure 9: Animation and physical representation.



In Phase Five and Six, understanding material is introduced as a primary higher-order thinking skill that is abstractly related to the computer. Students are building meaningful relationships between the use of physical models and digital models through transformation. Students are synthesizing the abstract nature of the computer with the palpable realities of materials.

Phase 7 - Digital Representation

The final phase of the studio is to return to a digital medium and explore unique aspects of digital modeling difficult to reproduce in a physical form. Students are to investigate concepts such as transition, sequence, movement, change, and speed. The aforementioned concepts can be thoroughly explored through the animation of digital models. The students are asked in this phase to explore how they can bring physical qualities to digital models. The integration of physical qualities is described as a process of abstraction and should be realized for the affordances the computer application can provide. By returning to the digital model in the final phase, the student can incorporate aspects of the physical explored in phases Five and Six and simultaneously exploit the advantages of the computer model.

Conclusion

One of the major limitations of the studio is limited movement back and forth between the digital and material. To build strong neuro-pathways, the process outlined in this course must be repeated in concept within other courses. Other limitations include the formal investigations with minimal regard to cultural and social issues associated with the design of environments. The studio experience is one largely based in formal investigations of design.

Leamnson provides a structure to understand learning as a biological process. Within the biological process, special care must be given when new information and experiences are presented, as these first neuro-pathways will tend to be the ones that will be repeated. The introduction of the computer in the design process is one that should not be isolated but rather integrated in a tension between the realities of the digital realm and the material realm.

The strength of the studio is reinforcing analysis, synthesis, and evaluation of digital and material realities. The motivating factors for the above strengths are transformation and tension. Students are transforming materials into digital representations and back to material models. The transformative process creates a tension between understanding material and space as represented with digital modeling and physical modeling. Students who successfully complete this studio tend to have good decision-making when deciding how to investigate space in advanced studios. Students are introduced to when and how to use a computer, when and how to investigate materials in relation to digital mediums, and how to synthesize the two to create and represent and idea larger than either medium alone.

The processes and methods introduced in this beginning design studio are to reinforce cognitive processes required in advanced design courses. The introduction of digital modeling with **form•Z** is presented as a part of a holistic process of design that engages many different media simultaneously. The objective is to exercise the brain in a foundation design studio in a manner where digital tools are part of the larger investigative realm that introduces higher forms of learning and critical thinking as essential aspects of design.

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David Matthews is an Associate Professor in the Interior Architecture Program at Ohio University. He holds a BFA in Studio Art and a BS in Interior design from Ohio University, and a Master of Architecture from Miami University. Specializations include digital technology pedagogy and beginning design studies. He has been recognized by NCARB as a prize-winning finalist for his collaborative work with architecture and design professionals. Work created with his students in collaboration with Perkins and Will / Eva Maddox Associates has been exhibited at the Art Institute of Chicago, Chicago Architecture Ten Visions.

Intimate and Transparent Production of Space

by Thomas Fowler, IV

This paper illustrates the design work from an integrated third-year Architecture Design Studio and a Professional Practice (a.k.a., project constructability) Studio. There are two parts to this paper. The first part shows how students were involved in a collaborative interdisciplinary project with New Media Arts students in the Liberal Arts Department on campus. Students in collaborative teams designed and constructed a temporary pneumatic structure to house a virtually interactive technology called "Intimate Transactions". Lessons learned from this design build collaboration in working with the inventor of this technology system, along with the reading of a range of essays on new media design, and additional vocabulary generation exercises provided a launching off point for each of the architecture students' individual design projects. The second part of this paper shows the follow on building design process and design reflections for one of the student's studio projects (Jeff Hammerquist, who received the 2007 **form•Z** Honorable Mention Design Award for his Satellite Automobile Assembly Plant project).

Assigned activities in both the Design and Practice Studios are a continuation of a methodology of this author for using digital and physical media in a tightly structured framework for integrating building system principles into design studio projects. The main learning objective for the integration of these two courses was to create a range of improvisations early on in the quarter to create an intense focus on a kit-of-parts understanding of the technical aspects of environmental systems that can be shaped and molded into design project vocabularies later in the quarter (1,2,3,4). In the case of this particular quarter, much of the lessons learned by students about experiential aspects of interactive digital space were acquired from the process of determining the spatial needs for housing a technology system called "Intimate Transactions". In meeting with this technology system developer, along with working in collaboration with New Media Arts students (the university's film students) and the short and very intense period of time for the actual design and construction of this space, many lessons were learned for translations for individual design studio projects.

1. Intimate Transactions Space (Figures 1-11)

The "Intimate Transactions" technology allows for two people, in separate locations, to interact with each other in an immersive digital environment. Spring Quarter 2007, students in this instructor's Third Year Spring Quarter Design Studio worked with a colleague in the New Media Arts and English departments, Professor David Gillette, along with a visiting digital installation artist, Keith Armstrong, from Queensland University of Technology in Brisbane, Australia. Keith developed an interactive technology system called Intimate Transactions. Students had only three weeks to figure out how this technology system worked along with designing and constructing a temporary theatre space to house it. Notions of Archigram's (1960s experimental architectural firm) [5,6] plug-in and Instant Cities, the Living Pod, and Airships very much did set the tone for the development of this structure.

Intimate Transactions [7] allows for each participant to climb aboard a device called the Body Shelf (similarly to a computer mouse that you stand on – Figures 1, 2), which tracks their movements as they travel through a virtual world and interact with one another through a live Internet connection. The body shelves can be in two different rooms in the same building, or on different sides of the planet. The participants are also each immersed in a

Figure 1: The Body Shelf, with author's six-year old daughter, Hannah, using it.

Figure 2: The Body Shelf in use.

The Design Concept

Figure 3: Concept models for pneumatic structure.

Figure 5: Physical model of pneumatic structure.

Figure 4: Montage of pneumatic structure in architecture building's stair court.

Figure 6: Detail of proposed pneumatic structure.

complex sound environment comprised of an advanced surround sound system of eight large speakers combined with small, wearable speakers that send sound vibrations directly into the body of each participant. As participants move on the body shelf, their body motion is tracked and allows participants to mix the sound for the system on the fly, thereby creating a different sound experience with each new use of the system. One of the goals of Intimate Transactions is to provide participants a first-hand experience with cutting-edge interactive technology, while also teaching participants about the importance of sustainability and collaboration as they interact with each other to create a beautiful and sustainable virtual environment of light and sound.

Background

Intimate Transactions is a multi-award winning new media work created by the Transmute Collective, a group of internationally recognized media artists, performers, sound artists, programmers, scientists and system designers with other designers and technologists at the Queensland University of Technology in Brisbane, Australia. Intimate Transactions has been presented in many shows across Europe and Asia, and was recently selected to represent Australia in the China International New Media Arts Exhibition accompanying the 2008 Olympics program in Beijing. Due to the work that the Cal Poly Architecture and English/New Media Arts students and faculty have contributed to Intimate Transactions, Cal Poly, San Luis Obispo has now been added as a "performance node" for

The Construction Process

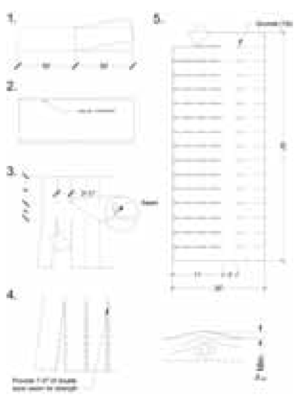


Figure 7: Construction drawing for the polyethylene skin configuration.
Drawing by Jef Hammerquist.

Figure 8: Polyethylene being rolled up to hoist into place.

Figure 9: Students using the heat-sealer to connect polyethylene material.

the Intimate Transactions Olympics show in 2008. This connection between Cal Poly and Beijing installations of Intimate Transactions will be the only live and completely open interactive Internet link between the exhibit participants in Beijing and the United States.

Due to the limited time and funds, it was decided to create a pneumatic structure to house one of the body shelves of the Intimate Transactions technology system for Spring Quarter 2007 design and construction installation (Figures 3-9). The second body shelf was housed in a space on the third floor of the architecture building. The idea was to simulate collaboration over at network over a long distance. Students worked in teams to generate design concepts and the design that was selected and ultimately constructed was the one that proposed to develop a double-skinned space that would fill the vertical void in the stair court of the building. An aluminum scaffolding structure was also built to help support and contain the pressurized pneumatic structure. The interior skin (the black polyethylene material) related to interaction of the person occupying the body shelf in this interior space. This space had to be free of outside light, so the video projection system would work well. There was also an initial idea that when the inhabitant entered or exited this inner space, the envelope of the pneumatic structure would collapse or inflate (depending on whether the person was leaving or entering) due to the opening or closure at the entry point. Several students thought it would be even more interesting to have the space pulsate in sync with the movements of the inhabitant on the body shelf – but not enough time to work out the details for how to get this to work. The outer skin (the white polyethylene material) was an attempt to reflect what was happening on the inside space by the projection of live data from the

Figure 10: Final installation in the architecture building's stair court, views from the first and second levels.

body shelf via a range of video projectors. The finger-like details of the outer pneumatic skin allowed for an ability to walk between the two skins and to also see aspects of the inner black skin from the outside of the structure.

The Construction Process and the Installation (Figures 7-10)

There was an estimated quarter of a mile of polyethylene material used for the construction of the pneumatic structure skin along with an endless amount of time that the students devoted to heat-sealing (Figure 9) the seams together.

2. Production Space

"Thinking, no matter how clear or correct, is not equal to actual doing. Exercising improvisation and intuition cuts through all of the pre-thinking and delivers us into ordinary processes readily accessible to designers, and therefore a more useful response to "real world" situations."

Based on the lessons learned about interactive space from the design and construction of pneumatic structure, early diagramming of digital space and readings on the theory of interactive space students were provided as a beginning point for developing the Satellite Automobile Assembly Plant. The site was located at the south end of the parking lot for the South Campus of the Art Center in Los Angeles, California. This facility was designed to allow students to test car design ideas by constructing them in this facility.

Group Exercises 1-3 Analog & Digital Vocabulary Building (Figures 11-13)

In groups, students work together using a several-step analog & digital process based on Bauhaus principles of craftsmanship and visual perception [1,2,4] for analyzing a particular source image by Char Davis. The dissection of these images provided students a way of a having an integrated full body immersion, interactive 3D digital imagery and sound, and navigation via a breathing interface…Char Davis' works do provide a radically alternative approach to immersive virtual space…[8,9]. A strict set of guidelines applied the foundation principles of the Wassily Kandinsky

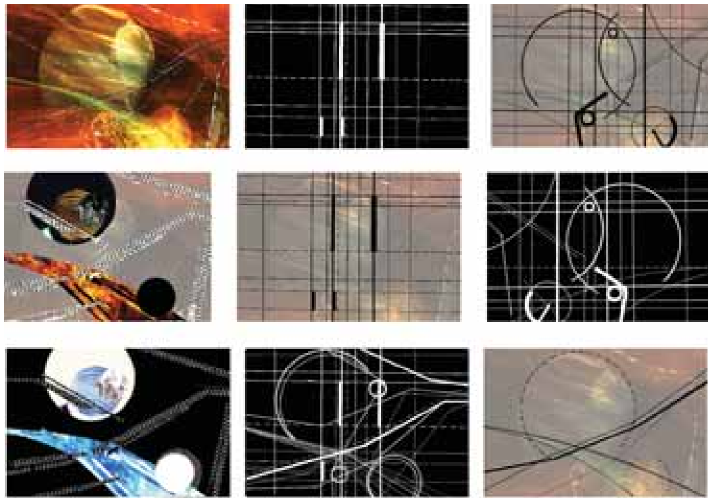


Figure 11: Group warmup exercise 1: Analog diagrams of source image.

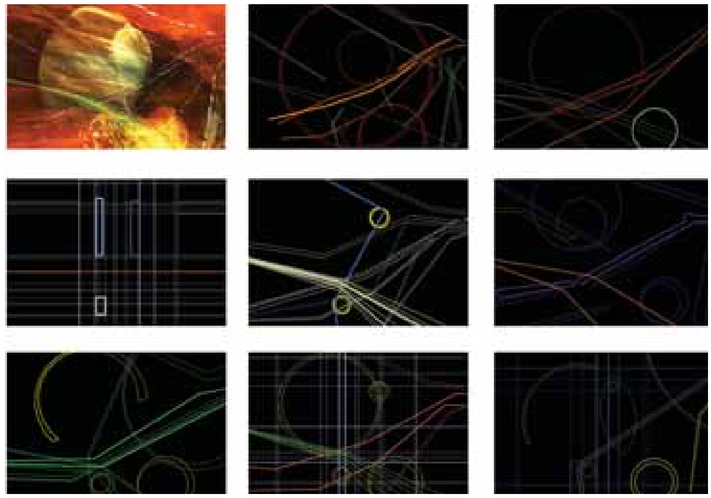


Figure 12: Exercise 2: Digital diagrams.

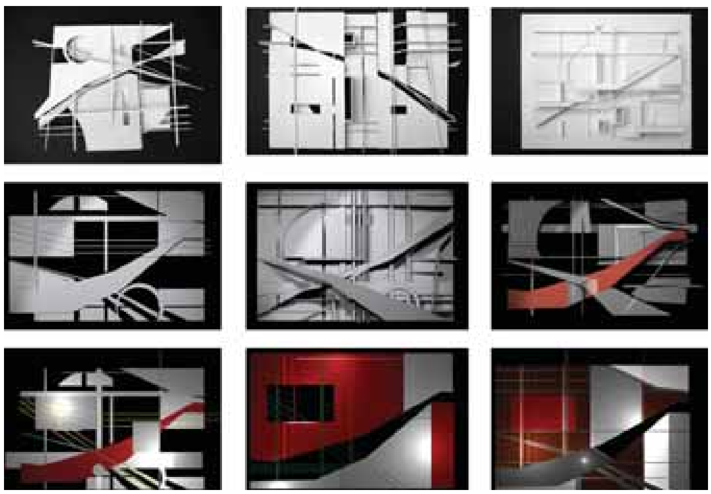


Figure 13: Exercise 3: Digital relief models.

Above images by Jeff Hammerquist, Zhong Ren Huang, Karen Kemp, and Bradley Chicone.

method of analytical drawing that breaks a still life composition into diagrammatic forces to express tension and geometry. Each step alternated between analog and digital media. This exercise started with still life images, then to acetate overlays, to analog/digital diagrams, analog/digital relief models and ended with a spatial manipulation device. The outcomes from these group projects provided a foundation vocabulary for individual student projects [1, 2].

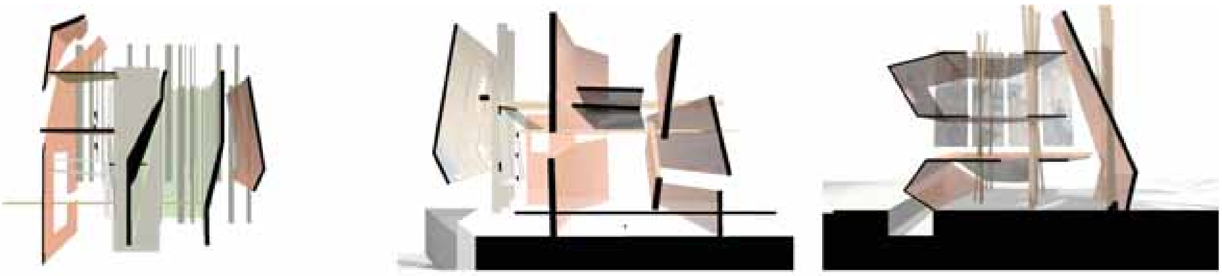
Individual - Foundation Vocabulary Study Mash Ups (Jeff Hammerquist) (Figures 14-20)

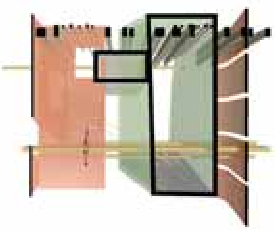
Students were asked to translate the tectonics of the 40' cube of the Intimate Transactions space along with their interpretations of the group vocabulary studies as a strategy to develop a series of mash ups (e.g., a collision of both studies) for responding to the project site.

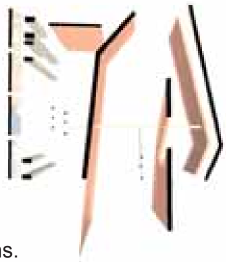
3. Reflections on Design Process by Student, Jeff Hammerquist [10]

Project Concept

Transparent Production — The Satellite Automobile Assembly Plant was designed to showcase and expose the production process of a twenty-first century car. By focusing an audience on these transformations, it will help them quantify the volume of resources that go into the fabrication of a car.







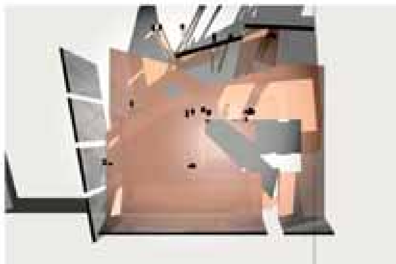
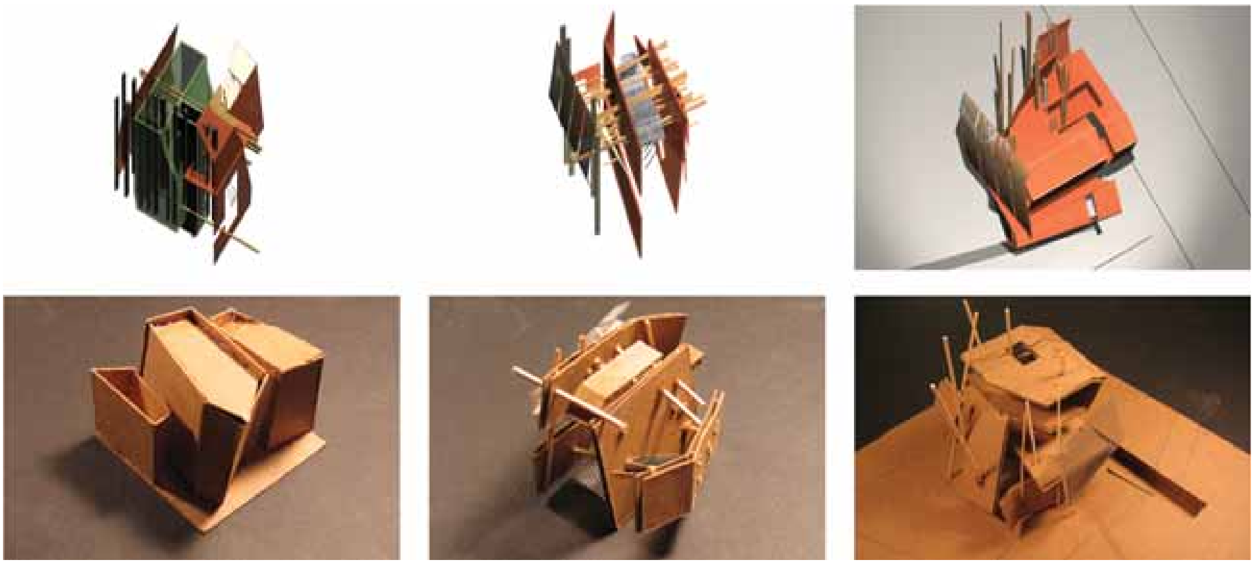


Figure 14: Digital cross-sectional mash up translations.

Figure 15: 3D physical and digital model mash up translations, both by Jeff Hammerquist.



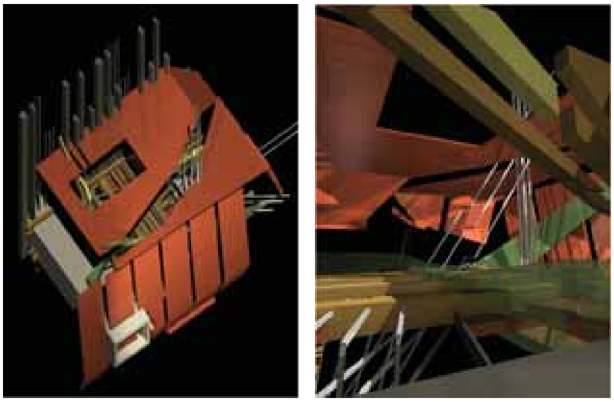


Figure 16: Initial digital axonometric and immersive view of axonometric vocabulary model mash up (between intimate transactions cube and group vocabulary study), by Jeff Hammerquist.

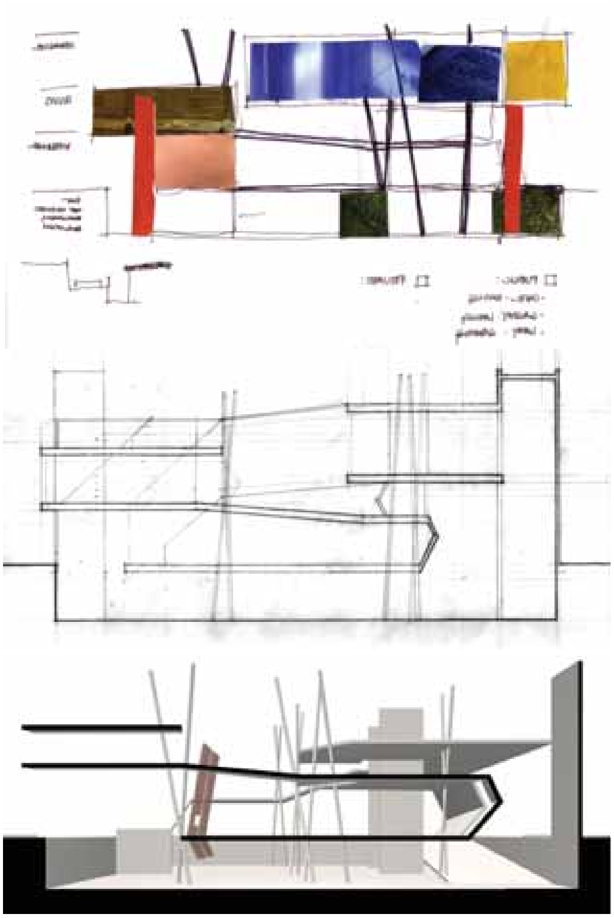


Figure 17: Studies of Satellite Automobile Assembly Plant, by Jeff Hammerquist. (a) Analog vertical cross-sectional collage. (b) Refined analog vertical cross-section drawing. (c) Refined digital cross-section drawing.

Process Overview (Figures 16-23)

My process was characterized by taking my project through a series of translations (mash ups) between representational types and media. These translations allowed the project to evolve and adapt to a formal vocabulary, programmatic requirements, site considerations, and an approach to structure and skin. While these elements were at first unrelated (i.e., the design and construction of the pneumatic structure for Intimate Transactions interactive technology, the analysis and dissection of the Char Davis Immersive image) they all began to inform each other, eventually coalescing into helping to evolve and formulate one cohesive concept. This was particularly true for how the vocabulary and program for my project developed and how this had a key role in how the project evolved.

I came into this class with significant previous experience using **form•Z**, mostly from when I was a first year student. Although my modeling ability has improved dramatically during this quarter, being familiar with the program helped immensely. Early in my process, digital modeling provided a quick way to generate formal vocabulary. I constructed initial diagrams with AutoCAD, which I found to be most useful for two-dimensional drafting. Once I began to work in three dimensions, I moved the diagrams to **form•Z**, where I used them to generate three-dimensional shapes. Both by duplication and by Boolean operations, I was able to quickly generate positive, negative and hybrid vocabulary alternatives that retained the initial shapes and vocabularies derived from the diagrams, but differed significantly from each other.

Later in my process, I used the **form•Z** digital model as a tool to complement physical modeling and hand drawing. Digital immersive views gave me a new view of the project, helping me see opportunities not apparent in other modes of representation. The digital model also facilitated analog methods by providing a consistent reference to the project's geometry. I used this by printing out templates for drawing or cutting, eliminating the need to measure.

While I have always considered the computer to be an essential tool in my design process, I have learned to be wary of the digital models lack of scale. Since a digital model can be zoomed in on… the way a physical model

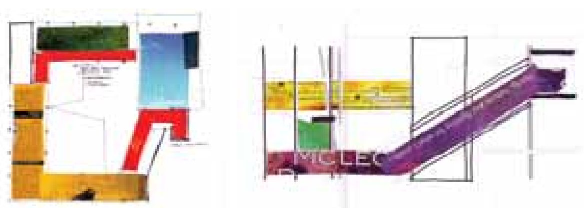


Figure 18: Analog vertical cross-section collage drawing study of Satellite Automobile Assembly Plant, by Jeff Hammerquist.

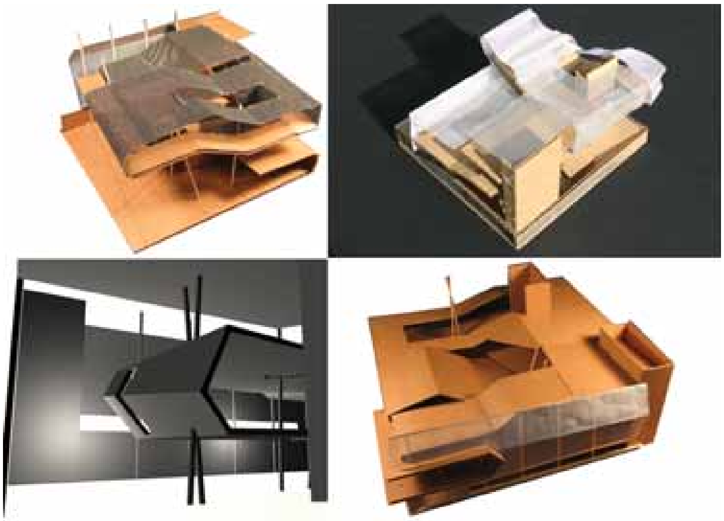


Figure 19: 3D physical model translations and immersive view of digital model of Satellite Automobile Assembly Plant, by Jeff Hammerquist.

cannot, one can easily waste time by focusing on details too early on in the project (whether it's analog or digital media) that are irrelevant to the larger scope of design approach. I have improved my ability to recognize this tendency, and to change to a different media before I begin wasting time.

I actually began my design process in assisting with the collaborative design and construction of the pneumatic structure and continued my discovery of space through the analog and digital vocabulary building exercise. These two experiences gave a different sense of how to develop my ideas for developing a production space for the design and manufacturing of cars. Going back and forth between using the digital and analog media and generating numerous iterations during various stages of the design process was very helpful in getting me to commit to a project vocabulary early on in my development process which was an essential step in providing an opportunity to develop and refine it.

To explore program, I built several analog program models exploring different ways the programmed spaces could be arranged to work with the site and with my concept of 'transparent production.' This helped me gain a physical understanding of the proportional relationships between different parts of the program, and how much room they occupied in relation to the site. These models were important because they showed my approach to program in a simple diagrammatic way, providing a reference for later stages of my project.

The feedback I received from the midterm review primarily focused on the introspective nature of my project, and how the interior courtyard space worked not only as an observation platform, but also as a stage. I addressed this criticism by placing the café in the center of the space, providing a spectacle for those in the surrounding spaces to enjoy.

This class led me to realize the importance of thinking through doing, providing a physical record of the design process. Design is really the art of making decisions. Since the quality of a design is defined by how well it addresses the conditions present during its physical existence, the quality of a designer is defined by how many of these conditions he or she can discover and address. Since the enormous amount of information we as designers need to process is far too complicated for us to store in our own memory, it is essential that we develop a way of storing it in artifacts that we can reference as we face the myriad of decisions inherent in design. During the class, I found that by physically recording the trail of my process, diagramming, physical models, and constant written reflections were best at keeping my previous discoveries and decisions in my design conscience when I made new decisions. Working between drawings, the computer, and physical models also kept me aware of these different aspects of the project by continually changing my point of view.

I expected to learn how to generate form in this class before I entered it. After completing the quarter, I would say that more than learning how to generate form, I learned how form influences and is informed by program, site considerations, and other forces to create a complete project. This cross-pollination is much more important to a project than any pre conceptions of a vocabulary we may harbor. This intensive approach to handling vocabulary and form is the best thing I will take from this class.

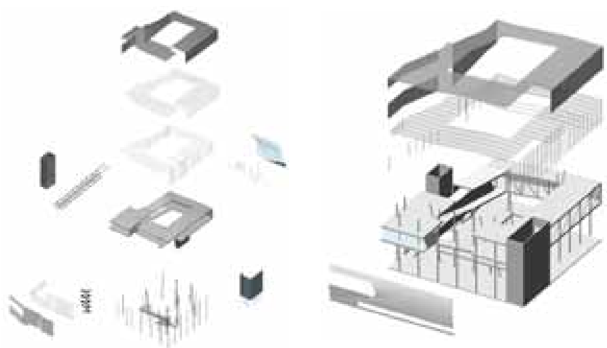


Figure 20: Digital exploded axonometric and axonometric models of Satellite Automobile Assembly Plant, by Jeff Hammerquist.

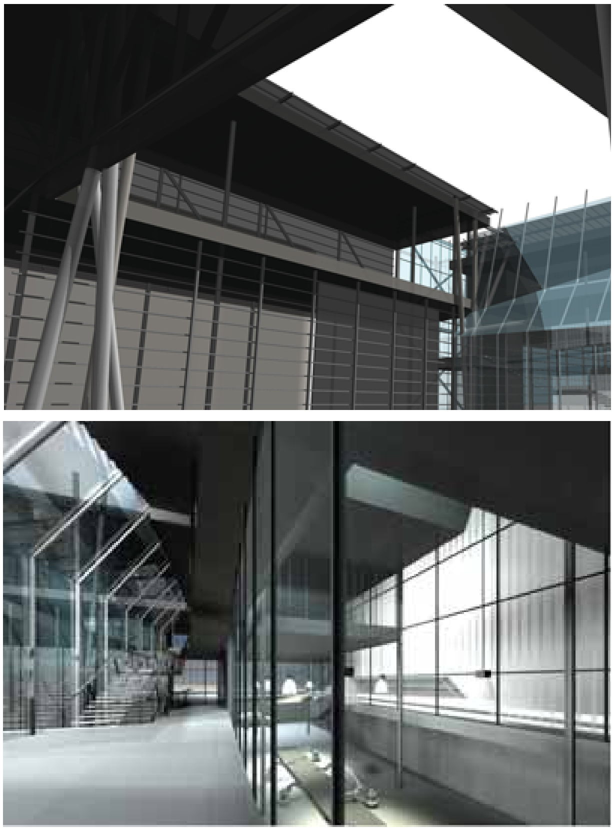


Figure 21: Immersive digital view of Satellite Automobile Assembly Plant, by Jeff Hammerquist.

Interdisciplinary Collaborations Background

Professors David Gillette and Thomas Fowler have been building these temporary theaters with the assistance of Architecture and English/New Media arts students over the last three years. The first theater was built for the University's Open House in 2005 and housed a developed virtual reality movie that allowed visitors to also interact with the movie by creating 3D virtual immersive drawings. These temporary theaters are proof of concept projects for the evolving Lumiere Ghosting Device <http://ghosting.calpoly.edu/> project. The Lumiere Ghosting Device is an ongoing project for developing a low-cost portable theatre that will allow for individuals to have fully immersive virtual reality interactive 3D cinema theater connection to other Lumiere Ghosting devices through a high-speed Internet connection.

The concept is for the participant in each Lumiere Ghosting device to see, talk to, and freely interact with other participants from distant locations who are represented as full-scale 3D interactive puppets modeled on the actual images of the live participants. All participants share the use of the same virtual environment in each device (theater), which can be used for open collaboration, artistic expression, gaming, training, and various forms of cinematic storytelling. Participants in the device also interact in this shared virtual environment with a number of artistic

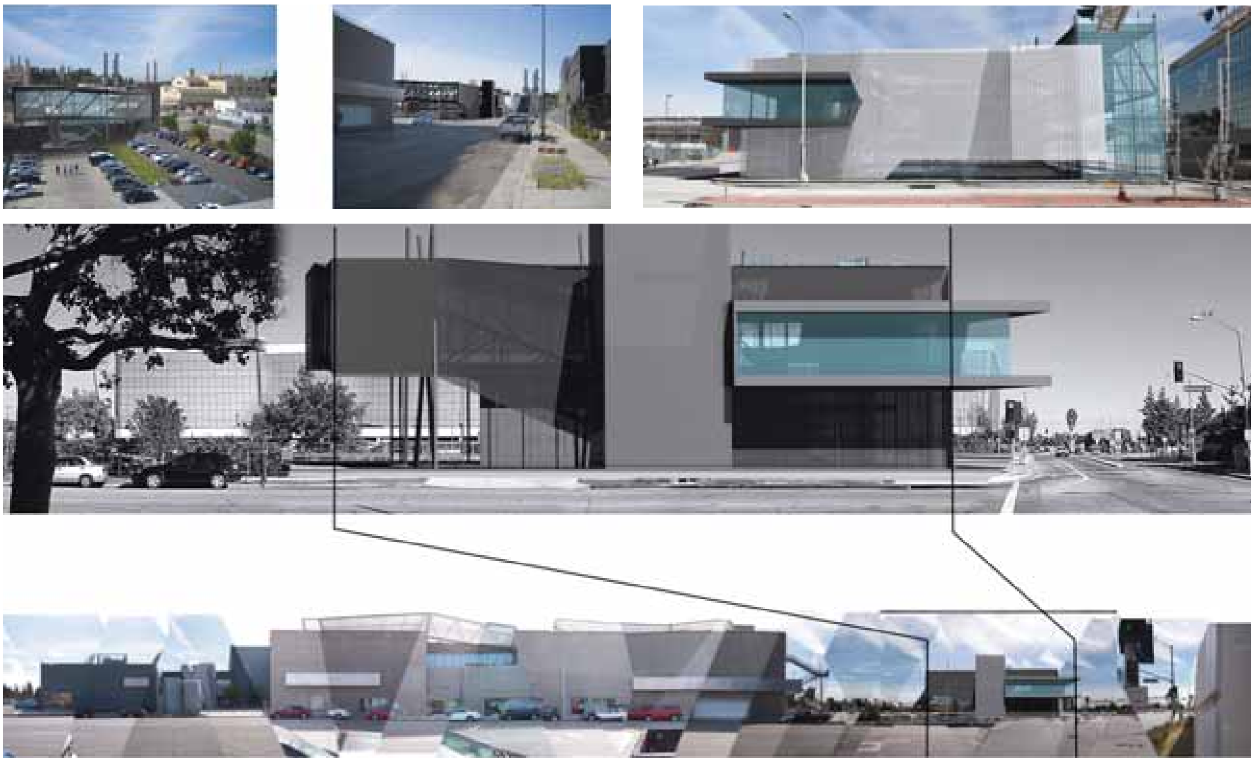


Figure 22: Digital model of Satellite Automobile Assembly Plant shown in context, by Jeff Hammerquist.

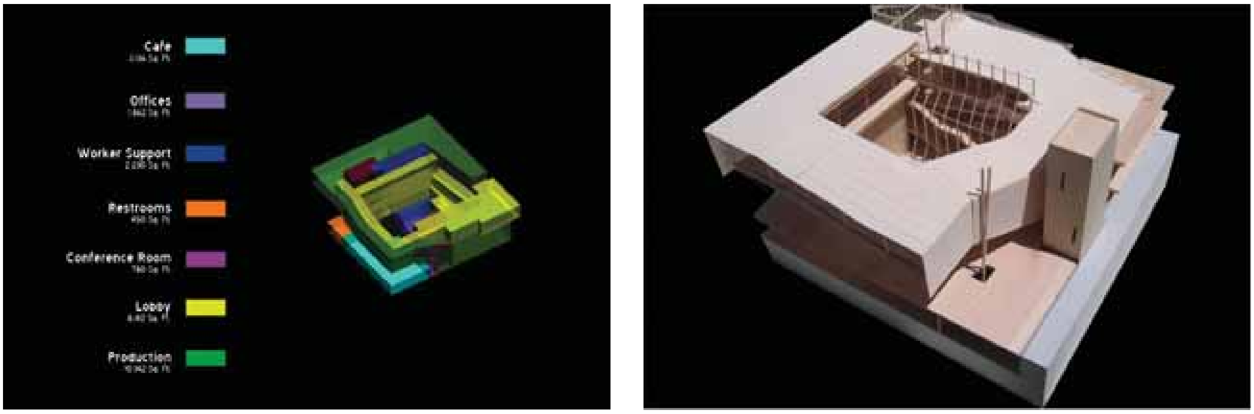


Figure 23: Digital diagram and program model of Satellite Automobile Assembly Plant, by Jeff Hammerquist.

data visualizations (Blog ghosts, video storm clouds, global beach balls, data mosh pits, virtual architecture spaces) created out of samples selected from a continual stream of live data gathered from every part of the Internet.

The Lumiere Ghosting device essentially creates a cinema-like environment in which individuals can easily interact with live participants and with video, audio and textual data gathered from all over the globe. This system is an innovative integration of live 3D digital display and artistic data visualization techniques combined with non-invasive motion tracking technology, connected through a high speed Internet connection that allows for a seamless exchange of interactive data from one Lumiere Ghosting device to the next. Making use of recent developments in higher processing speeds and smaller computing and projection systems, the Lumiere Ghosting device is designed to be portable so the entire device (theater) can be built, calibrated, connected to the Internet and fully operational in an afternoon, using a small technical crew of three or four people.

Credits for Construction of Pneumatic Structure

There are many people to thank for helping with the construction of the pneumatic structure for the Intimate Transactions technology system installation during spring 2007. Thanks to the College of Liberal Arts for inviting Keith Armstrong to Cal Poly. Thanks to David Gillette and Keith Armstrong for their interest in working with my architecture students in the development of the temporary pneumatic theatre structure. Thanks to Elbert Speidel from the Construction Management Department who provided students with an overview of how pneumatic structures work along with loaning us his heat sealer device which allowed students to piece together the polyethylene material. Also much appreciation to all of the instructor's design studio students (Bradley Chicoine, April Fame, Walter Garcia, Paul Goss, Matthew Granelli, Jeff Hammerquist, Ben Handy, Ren Huang, Tucker Huey, Jason Immaraju, Ahmadreza Kashani, Karen Kemp, Jai Kumaran, Ryan Lamb, Arthur Loh, Guillermo Perez, Jason Pignolet, Alexander Polzin, and Lulu Saleh) for spending the long hours in the design and construction of this pneumatic structure (along with trying to get other things accomplished for class) in such a short period of time. Thanks also to all of the Media Arts students that were involved with this project.

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For a biographical summary of Thomas Fowler, IV, see page 41.

TAMKANG UNIVERSITY
TANSHUI, TAIWAN

The Processes of Setting Out

by Chen-Cheng Chen

In his book “Digital Gehry,”[1] Bruce Lindsey compares the canoe lofting process with the digital manufacturing process and discusses the relationship between drawing, modeling, and setting out. In the following design centered discussions, I probe into the role that digital tools can play in different setting out processes.

Our department has a requirement that the first semester design studio freshmen get acquainted with basic drawing skills, model making, and the fundamentals of object proportions and construction. We generally start with an assignment titled “Object Enlargement.” The students are asked to choose an object from their daily life, measure it, and then make a hand drawing of it at a larger scale. After this is done, the drawing is transferred onto foam boards and cut into series of sectional profiles. These cutouts are then assembled together into a 3D model. Figure 1 illustrates the models of an enlarged hammer and an enlarged toothbrush, both done by students.

Figure 1: Models for enlarged hammer and toothbrush by Hsin-Yi Huang and Yen-Chen Lu.

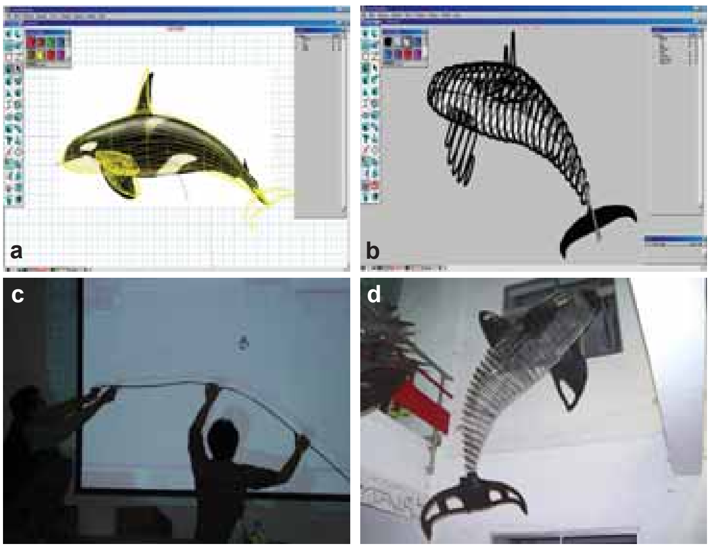

Figure 2: The process for making a killer whale model by Chi-Fu Shiaw and Chi-Li Chang.

A few years ago, in order to acquaint students with the setting out process in a computer environment, we had graduate students make models of ocean fish as an assignment for the Computer Applications in Architecture class. Students had the option to select the material for their models. Some of them selected a computer model of a killer whale from the available 3D resources (Figure 2(a)). They produced a series of cross sectional profiles of the whale using the Contours tool in **form•Z** (Figure 2(b)). In those days, our department had no digital fabrication machines. The students had to paste the cross sectional profiles on plastic corrugated cardboards and to cut out the profiles manually, one at a time. To create a bendable bridge that kept the profiles together, wires were strung through plastic tubes. This appeared to be a metaphor for the longitudinal direction of the skeleton of a whale. Assembling these pieces together was not a straightforward process. The students had to project an image of the whale on the wall (Figure 2(c)) and use it as a guideline when configuring the profiles together. They also used the projected image when bending the wires inside the plastic tubes (Figure 2(d)).

This past summer, the United Ship Design and Development Center asked our Interior Design Department to design the guest rooms of their 50-meter long yacht. In addition to the overall design, the assignment also required a decomposable model. The 1:50 yacht model was about 1 meter long. Making the hull of the yacht presented a real challenge for us and, after some discussions, we decided to use the canoe lofting method in **form•Z**.

First, we used the Nurbz tool in **form•Z** to construct a digital model for the body of the yacht. Next, we brought in fiberboards and piled them up until they matched the height of the 1:50 yacht model. Then we used the CNC Miller to carve out the body of the yacht. Because the CNC Miller we used only had three axles, we divided the process into two parts and built the yacht separately. First, we carved out the shape of the yacht (Figure 3(a)) and left some supporting pieces to connect with the fiberboard block. Then we turned the piled fiberboard block over in the exact same location (Figure 3(b)) and milled out the middle part of the fiberboard block. This part of the process was similar to the canoe making process. After this was finished (Figure 3(c)), we turned over the fiberboard block again, and carved out the supporting pieces. The yacht hull was now complete.

The furniture making process was much easier; we used the digital laser cutter to cut out the acrylic panel. To get the profile pieces, we designed and piled them up together. The finished model images are shown in Figures 3(d), (e), and (f). The main purpose of the model was to allow a potential buyer to understand the interior design of the yacht during the exhibition. There were four interior design choices for each room. A buyer could replace the original design with the one he liked. Even though what we built was only a scale model, we still gained an idea of how much labor is required by a yacht designer to build a real yacht.

The three projects we discussed so far have dealt with the issues of enlarging and reducing the size of objects. We shall next deal with the issue of structural strength. Figure 4 shows a wooden ellipsoid frame with a diameter of 2, 3, and 5 meters, which was also built by our students. We picked an ellipsoid shape because it has two centers and X, Y axes of different lengths. Its curvature also varies at different locations of its perimeter. As it deviates from a conventional orthogonal structure, it offers an additional challenge when practicing construction. The size of the ellipsoid was determined by the size of the working space. We wanted to allow one or two persons to be able to work within it. The inner space of the ellipsoid is intended for individual students to exhibit their work. There are wheels underneath the ellipsoid, which allow it to be moved around. Due to budget limitations, the main body of the ellipsoid was built with 18mm thick plywood, connected by glue and joints.

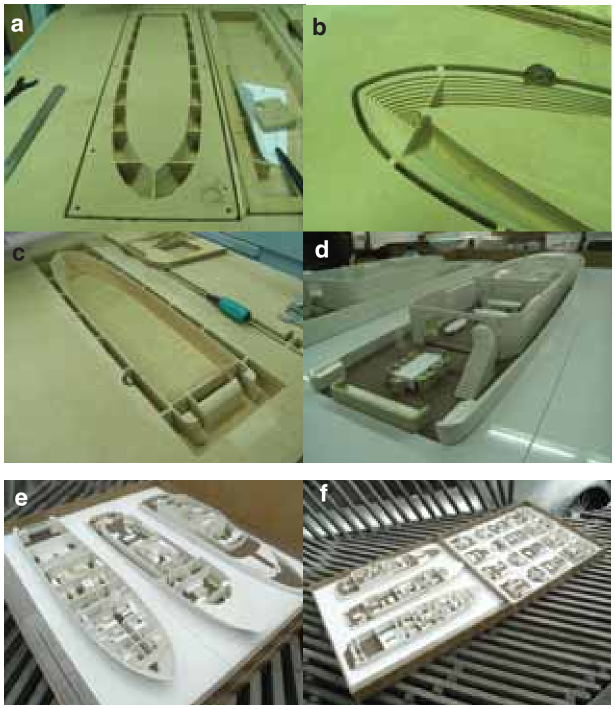

Figure 3: 1:50 yacht model by Hong-Ming Chen, Yi-Shan Chen and Chen-Chia Lee.

The ellipsoid consists of five distinct parts, three of which have been completed. Each was done using a different elliptical topology. The first part is located at the center of the ellipsoid and is rather symmetrical. For the second part we tried different construction methods and was made as a non-orthogonal structure. The third part is located at the end of the ellipsoid and is made of pentagon and hexagon frames joined together. After the ellipsoid is completely finished, different finishing materials on the surface will be tried. While the ellipsoid should not be considered a complicated structure to make, we also need to recognize that, without the help of CAD/CAM software such as **form•Z** and VISI-CAM, it would be notably hard to complete a 550-piece ellipsoid within such a short time by a single person.

The monumental fish sculpture by Frank O. Gehry and the enlarged sculpture by Cales Oldenburg helped us realize that, nowadays, it is possible to copy nature's creatures and artificial objects and turn them into works of art at a much larger or smaller scale. CAD/CAM facilitates scaling up and down and helps turn the ordinary into something extraordinary. We can now integrate different materials together in accordance with their different functionalities. Setting out is a process that requires elaborate thought. Digital tools make it possible to engage with precise "construction" experiences in the real setting out process.[2] Mathematically, constructing a 3D model in CAD through 2D supplementary lines or curves is similar to "integration" in calculus, and setting out a real model in CAM is similar to "differentiation" in calculus[3]. As we know, differentiation

Figure 4: A wooden ellipsoid frame by Lee-Peng Chen.

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and integration are complementary to each other, helping students to better understand calculus. Consequently, design and construction become a mutual interactive process for design studies through the CAD/CAM manipulations.

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[2] Hovestadt, Ludger and Mueller, Dennis, "ESG Pavilion – Digital Technologies in Design and Production", "Microarchitecture", "DETAIL" (Chinese Edition), CN 21-1488, p.94-97, Liaoning, PRC, April, 2005.

[3] Emmer, Michele, "Mathland: from Flatland to Hypersurfaces", Birkhauser, Basel, Switzerland, 2004.

Chen-Cheng Chen is an associate professor and coordinator for computer studies in the Department of Architecture at Tamkang University, Taiwan. He teaches undergraduate and graduate digital design studios, and courses for computer applications in architecture. His current research interests are focused on information technologies in architecture and the integration of computer-aided design and manufacturing for construction. He is the editor for the Chinese edition of "IT in Architecture" series. He received his B.A. from Tamkang University, M.S. from Carnegie-Mellon University, and Doctor of Technical Science from Swiss Federal Institute of Technology (Eidgenossische Technische Hochschule, Zurich, ETH-Z). Email: 097016@mail.tku.edu.tw.

From Model to Made: Digital Fabrication and the Artist

by Brad P. Jirka

History:

Computer modeling, and specifically **form•Z**, has been a key component of MCAD's 3D programs in Furniture and Sculpture for over a decade. Originally adopted to aid our students in the professional visualization and presentation of proposed projects, it soon became one of their basic ideation tools. As our programs are about "making", the further addition of a Digital Fabrication Lab with RP and CNC capabilities appropriately extended these skills into studio production.

Within a series of program courses including "Presentation Techniques", "The Object and the Computer", and "Digital Fabrication", the students not only acquire modeling skills, but explore the possibilities and impact of computer modeling on the design and creation of 3D objects and environments. The dialog extends from its direct and current effect on design, its future impact on our explorations, and the implications of personal fabrication.

Premise

Art is birthed in concept and realized in execution…

At MCAD the creative process always seeks a balance between concept and execution. As a community of artists we relish the theoretical exploration but have come to expect its physical realization. Neither is viewed as dominant or initial, nor is presented as being more important or imperative; as both merge to define our individual "practice".

The beauty of being an artist is that one is not only the "designer" of their work but usually its fabricator, engineer, material specifier, and installer as well. Within our Sculpture and Furniture programs, this approach results in students that are skilled "makers" creating works that reflect a conceptual understanding of the concerns and needs of the object, space, content, and context.

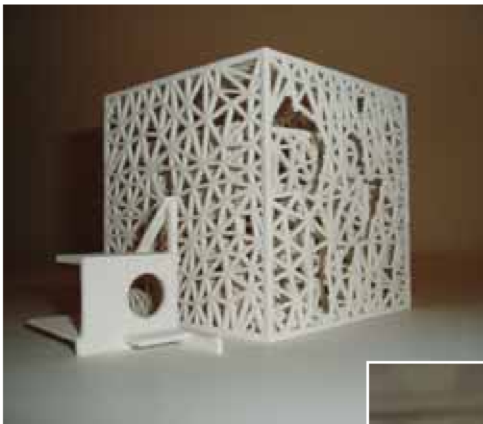


Figure 2: Brian Jorgenson; Drawing Untitled structures; Structural works derived from cut paper drawings. RP Gypsum.

Figure 3: Karl Zinsmaster; Furniture Design "Lines in Space". RP vessel line model "floating" in space. RP Gypsum; mirror.

Figure 1: Karl Zinsmaster; Furniture Design "Phones". The Objects themselves take inspiration from iconic objects, like the radio horn and umbrella, while exploring an almost Seuss-like freedom of form to rejoice in the absurd. RP Gypsum, wood.

Figure 4: Daniel Dreke; Sculpture-Installation "Facades."
Installation of modeled facades in situ. Detail.
RP Gypsum, photo documentation.

The possible difference between the artist's "practice", and that of other CAD users, may be in this relationship between theory and result. As the "makers" of our creations, the work is most always "ours" striving to eliminate any disconnection between design and fabrication and, to varying degrees, the interpretive loss of the artist's vision. For the artist there can be no compromise in the "reality" of the envisioned work.

Within this premise we introduce 3D modeling as yet another tool to our students' repertoire of techniques. It can take on a number of roles, ranging from presentation and ideation to design and fabrication assistance, but it is not indispensable. It may enable the exploration of new realms, whether it is visual data mining on the Internet or even the ability to visualize the ephemeral nature of smoke trails, but the greater concern is about our ability to see something new and bring it to life.

We explore the realm as it undoubtedly impacts our future, and the nature of form and the object, but not as a creative imperative. How, or if, the digital is ultimately applied to an individuals work is solely their concern, driven by their practice and as appropriate to their individual investigations.

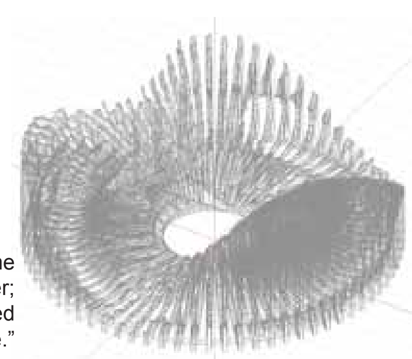


Figure 5: Wireframe by Alex Schroter; Sculpture "Stellated Landscape."

Process

In teaching 3D modeling and digital fabrication, however, it is expected that the student engage the media, and explore its possibilities in relationship to their work, regardless of their existing practice. This always starts with learning the modeling software but is expected to end in the "physical" as bringing the object to fruition is our "imperative."

The initial training is based upon the **form•Z**-modeling tutorial to introduce the depth of the interface and the hundreds of tool and modifier combinations. In our semester long courses we work through the entire tutorial which gives the students not only modeling skills, but presents the tutorial as a reference source when they run into a visualization issue that is unfamiliar.

The "creative" process begins at this same time with ideation and exploration via simple "visualization", or a definition of form. This simple process allows them to explore the compelling forms that can be rapidly realized with digital modeling, while learning the software and adding to their visual vocabulary. Modeling enables them to see new things.

Figure 6: Maquette: The "Stellated Landscape" was developed while working directly in **form•Z**.

Artist's Statement: "There were certain parameters and personal rules afoot when creating this object. Informed from previous work, I wanted to stress experimental process over refined result. The object should work in concert with future objects, in order to chisel out a visual language, which bridges and makes oneself aware of the space between visual language to mathematics. Escaping the conception that mathematics is cold and sterile, and understanding it is a government within the poetry of visual language. RP Gypsum, found figure, wood.

Figure 7: **form•Z** model, Nathan Meagher; Sculpture "Mining."

Figure 8: maquette,reflective of direct ideation in **form•Z** "Mining" was developed as a manipulated post "unfolded" form. RP Gypsum, wood.

Predetermined Visualization

This typically leads to the illustration of objects that already exist or have been sketched out in some detail. This applies the techniques learned in the tutorial instruction while requiring the students to seek out the best tools and process to represent their objects. They soon realize there are probably a half dozen ways to create each element of an object and how their determination of the best approach will effect later steps in the modeling process. Part of this learning process includes many starts, stops, and "re-do's."

This requires the student to exercise their manipulation of the application and seek solutions to modeling problems rather than letting the modeling tools dictate form.

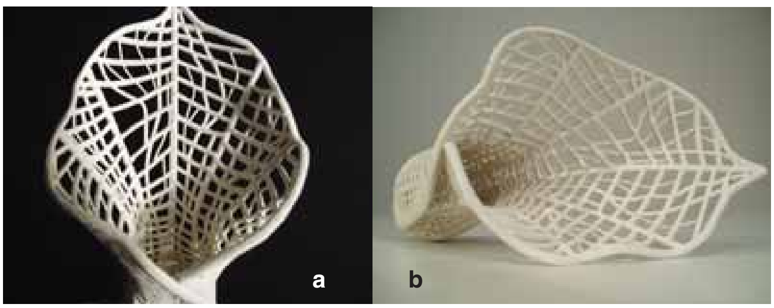
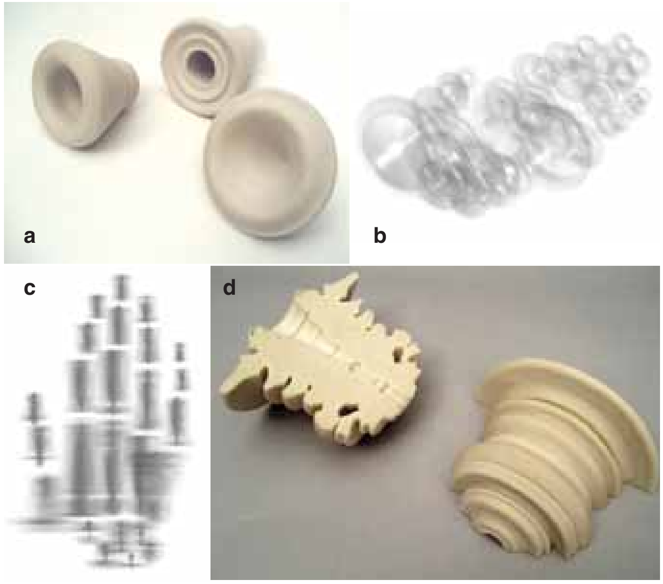


Figure 9: Matthew Hayes: Interpretation of an Iris' vein structure. RP Gypsum.

Exploratory Projects and Ideation

Finally there is pure exploration within the software. Essentially "direct ideation" or trying to work the digital like a plastic material. This amounts to "messing around" within **form•Z**, based upon the understanding acquired in the earlier training, while often incorporating "digital found objects" and 3D scanned elements. This extracts them from the designed intent of the tools and application to explore beyond these "planned" limits. To explore without constraint.



Figures 10: Furniture Designs by Claire Moyle.
(a), (b), and (c) "Phalanges Rotations"
This work shows the development of form that would probably not happen outside of the computer. Claire generated rotated forms based on x-ray images of her hand.
Z Renders and RP objects.
(d) "Cervical Organ"
Rotated sections of Claire's cervical vertebrae from x-rays.

Figure 11: Rubber Stool by Steven Mullenbach; Stool modeled as "built" in **form•Z,** including all joinery, then CNC cut on the Techno router. The cushion was cast of urethane rubber in a mold modeled in **Z** and machined on the router.

By this time the students are confident enough to act intuitively and "mis-mix" tools exploring what can actually "happen" in a "virtual" 3D world and what can become "real". The ultimate and simple functional test of these explorations is generating a physical object using one of our RP or CNC machines. A machine, after all, can only accept proper file formats and "real" objects.

Building in form•Z

As our students are already experienced makers, we can teach them to model as they would "build". Simply meaning that they are taught to "fabricate" in 3D rather than simply "visualize"; they are "making" a virtual object not "representing" it. This seems like a natural translation from the studio process and incorporates the needed information to realize the work into the modeling stage.

"Building" or "fabricating" in 3D implies the application of their understanding of materials and process gained from studio practice, while exploring the enhanced forms made possible through 3D modeling. For example, it is not considered adequate to simply model a sphere, but that they ultimately define its fabrication in their modeled work. What material or process they define, from sheet metal to composite construction, is of little consequence as long as they specify the true material and reflect process in their final design stage. This includes issues like material thickness, consideration of structural capability, assembly systems, etc.

Modeling in **form•Z**, as similar as it is to actual fabrication, then becomes a "planning" tool in the processes of fabrication that translate directly to the objects creation in either the traditional studio or in our Digital Fabrication lab.

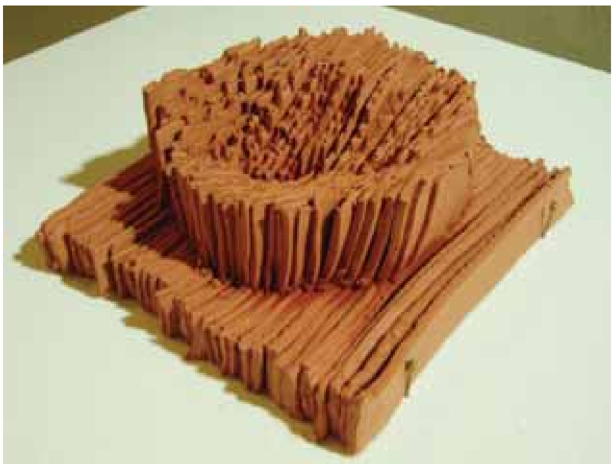


Figure 12: Sculpture by Caleb Coppock: "A View From Above." Mining Data: One of the objects from a series. It was generated by the displacement of data "found" on the Internet. The object itself was formed of layers of laminated clay sections cut from contour slice patterns of the model.

Figures 13: Furniture Design: "Wally's Chair" by Nate Moren. (a) **form•Z** rendering of the chair model. (b) OSB panel on the CNC router after cutting the sections for one chair. (c) Stack lamination: OSB components assembled on the laminating jig. (d) Two of the finished chairs.

"Wally's Chair" was modeled and rendered in **form•Z** including the steel rod legs and mounting system. Contour slices from the model were extracted as cutting lines for the CNC router to make the OSB stack laminated sections. These were then laminated on a forming jig, hand finished, and assembled with the integrated steel legs.

They are challenged to search for form possibilities that might be tedious, difficult, or even impossible utilizing traditional studio processes, while maintaining a focus on the conceptual issues of the work.

Object Translation

While the fabrication or "creation" of an object on a rapid prototyper has become as easy as color printing (all one needs is a "good" STL file that fits in the "build" area of the machine) it does tend toward the glyptic object and is limited in scale and structure. The result tends toward the maquette, "precious" object, or smaller "components" of a work. To expand to "real" materials and larger scales requires either the application of traditional studio skills, access to larger scale CNC equipment or, most often, both. To translate larger projects to traditional studio techniques, while maintaining the accuracy of the design model, we often use the **form•Z** Unfold, Contour and Section tools to generate patterns. These can then be scaled to size and printed on one of our banner printers, or projected to size and traced (even directly onto the materials). These patterns are then used to generate full-size cutting patterns, traditional sheet metal patterns, and traditional "lift" sections for solid objects eliminating a considerable amount of "layout" time.

Figure 14: "A View from Above" sculpture by Caleb Coppock. Four of the **form•Z** displacements from digital images "found" on the Internet. Painted and printed wood, RP Gypsum, machined acrylic.

Mining DATA: From the Artist's statement:

"My works are part of a tiny sculptural series titled, "A View From Above". The elements of the project consist of many small, sushi-size works in wood, plastic, paint, and gypsum. I am exploring our contemporary perspective on the world around us and imagery's influence on how we frame our landscapes.

The process starts with finding imagery on the internet that deals with visual depth and perspective. Examples include color wheels, optical art, elevation data, and satellite imagery. **form•Z**'s image-based displacement tool allows me to quickly map visual information onto the surface of a three-dimensional model. From these literal transformations into real space, forms emerge as part of a strange lexicon of landscape hors d'oeuvres.

The models are created through rapid-prototype printers and desktop CNC machines. They are arranged alongside small paintings and sculptural works that act as parts to a re-mixable whole. The "A View From Above" series seeks to explore the vastness of visual information available in today's world by cropping in tightly to various fragmented bits."

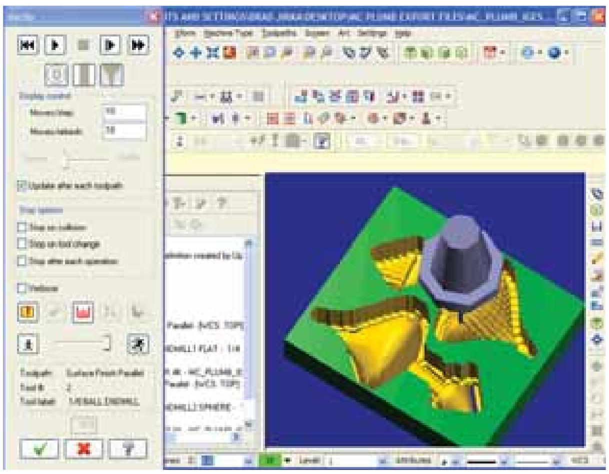


Figure 15: MasterCam toolpath verification showing virtual machining animation.

Of course cutting components, or "carving" 3D forms, on a CNC machine eliminates even that step and facilitates the generation of complex or repetitive forms. The generation of digital forms on a CNC machine requires simply the correct file format if one chooses to use contract shops.

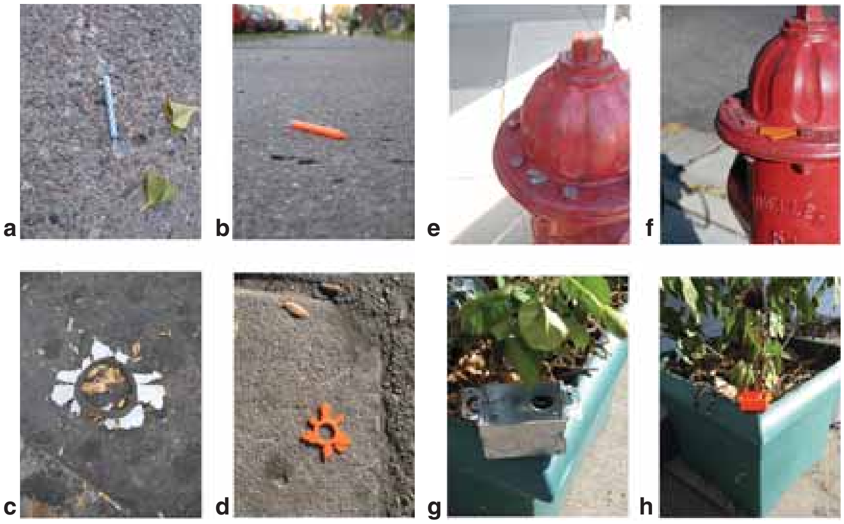
The use of an in-house CNC router does add another layer to the learning process but its complexity is dependent upon the machine and software choices. Within our own digital fabrication lab the machine requirements range from "drop and build" for the Zcorp rapid prototyper, and nearly that with the Roland Modela, to the Techno router that demands some knowledge of computer aided machining techniques and general machining processes including machine set up, bit selection, and feed rates relative to material and spindle speeds.

Figure 16: "Chickens" sculpture/installation by Nathan Meagher. The "Chickens" spoke to Nathan's impressions of flocking and consumption. Modeled in **form•Z**, the original model was halved, carved on the CNC router, laminated with a steel base, and used as a vacuum form mold to produce the "flock."

To translate a file from **form•Z** to a CNC machine, whether you do it or it is part of the out-sourcing of the work, also requires "deconstructing" larger forms to fit the machine parameters and the use of a CAM software package to generate the machine control toolpaths.

Deconstruction and Preparation

There are physical constraints and process limitations that must be considered in the preparation of a "model" for fabrication, preferably during our digital "building." The machine constraints primarily include envelope size including "depth of cut" and, therefore, overall depth of the object; while the process on a three axis machine is limited to 3D machining in a "relief" like mode (i.e. from one side) or 2D "cutting." To fit the machine constraints, larger objects must be sliced into contoured "lifts" while multisided objects are often divided in half (or a "flip" fixture employed).



Figures 17: Sculpture/installation “Found Object Displacements” by Anna Kaiser.

(a, b, c, and d) Displacements 1: Candle and crushed plastic form; original objects and RP placements (orange)

(e, f, gt, and h) Displacements 2: Plastic scrap and electrical box; original objects and RP placements (orange)

Anna recreated found objects in **form•Z** and fabricated them with MCAD’s Zcorp Rapid Prototyper. These objects were then placed in their original environment. Objects are painted RP Gypsum; Images are digital prints.

Machine Files

While there are again choices in software, even allowing a “drop and build” approach, at MCAD we adopted Mastercam to generate machine code. We chose Mastercam as it is an industry standard and would run any machine we elected to add to the lab in the future. Aside from importing a number of file formats, it allows us to generate “virtual machining” animations to “proof” and ensure the student generated toolpaths while generating the required toolpath files for our specific router. (Mastercam also includes full model building capabilities which we rarely use as we are avowed Mac and **form•Z** users.)

Once the students have an understanding of **form•Z**, the use of Mastercam has proven to be a simple step for them within structured guidelines. There are a considerable number of variables that we have yet to fully explore but our students have been able to explore these themselves.

The Product

The students apply their modeling and fabrication skills to such diverse ends as commission and competition proposals, product rendering, maquettes, idea development, studio and production furniture, sculpture and installations. While our goal is to impart to them the processes and techniques of modeling and digital fabrication, our expectation is that they absorb them into their production vocabulary and the creation of their individual work as they might any other process or technique, and be conversant in the media.

Our program is not about imagined results but real results. The students’ digital fabrication experience offers additional options to realize their vision and, indeed, reflects a new ability to “see.”

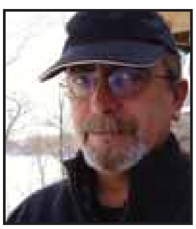
But it always comes back to the balance of concept and execution…not letting the process limit the idea nor let the idea succumb to the process. Our goal is to produce what we envision, what we see, and expand upon the nature of our work as artists. For us, digital modeling and fabrication is not an end but, rather, simply a means. It is its application as a tool, in research and fabrication, that entices us the most.

It is also our hope that our students continue to realize some things are better made by hand…

References

[1]. Digital modeling for Fabrication; Brad Jirka; **form•Z** Joint Study; 2004.

[2]. **form•Z** Joint Study Student Awards, Fabrication; Dan Tesene; 2005.



Brad P. Jirka is an Associate Professor of Fine Arts at the Minneapolis College of Art and Design focusing in Sculpture, 3D Computer fabrication, and Foundation Studies. In addition to 30 years of teaching studio arts, Jirka’s professional history includes working with the collaborative group “Midwest Electric Art”; co-founding the American School of Neon; and VP of Design for St. Elmo’s Inc., an internationally recognized producer of creative lighting. His current studio works focus on the tradition of the Philosophical Instrument while becoming objects of “modern mysticism”. These works “explore and discover” the phenomenology of our environment while his Public Art Works, with collaborative partner Katherine Jones, strive for the creation of an “event” often incorporating light, motion, and technology. Recent public works include “Lax Communica” for UW LaCrosse and “Geometrica Kinesic” for UW Parkside. Studio: Bohemiawerks.com

Recent Works

by Dan Tesene

After working in the realm of prototyping for more than a year, I became more fascinated with the process of layering two-dimensional images than what the form originally was in the computer program. I began to trace layers from the dissected stl files and cut them out of paper to then be assembled as an object. This was an important step in beginning to understand a new methodology and way of thinking about forms.

While working on *Paper Complex*, I came across the work of the French physiologist Etienne-Jules Marey, whose life work stemmed from his fascination with movement and time. Working as a medical doctor in the 1880's, Marey invented the first cardiogram by attaching a stylus to a diaphragm connected to a patient's pulsing veins.

His work then moved to the study of human and animal locomotion; he created a photographic gun to capture multiple images of birds in flight, which was followed by a slotted disc camera which captured multiple images of human movement layered all on one piece of film. Moreover, his inventions led to the development of moving pictures and animations, as well as the strobe.

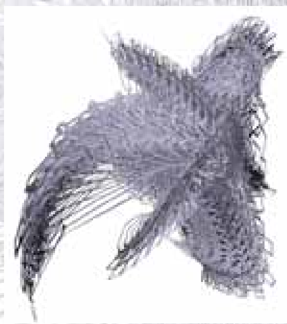


Figure 1: Fossil render example of earlier "Fractal Fossils"; non-algorithmic forms fully dependent upon 3D modeling and the interaction of the artist's hand.

Figure 2: Paper_Complex; Paper "lift" construction.

My interest in prototyping as a layering instrument, and the work of Marey and the early animators, clicked instantly. Why not use cells of animations and film to produce objects?

Figure 3: Smoke
Paper "lift" construction from video frame tracings of laser defined smoke patterns.

Figures 4*:* (a) Monkey 2; (b) Monkey 3; (c) Monkey 4; (d) Monkey 5.

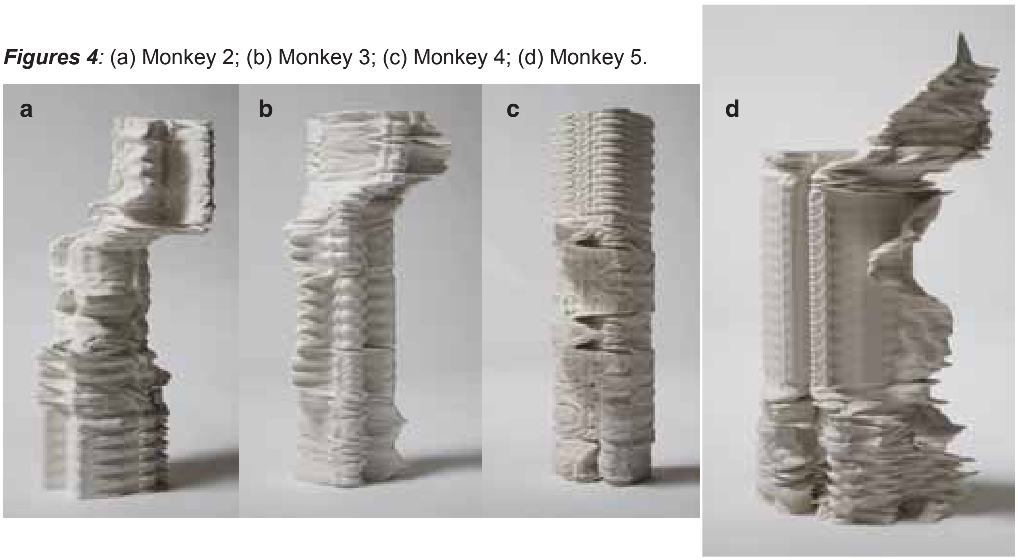


Figure 5: Monkey 5.

Using **form•Z**'s lofting tool, I joined together frame upon frame of imagery derived from turn of the century cut out animations and the experiments of Marey. The final results are quite jarring and abstract, only to reveal themselves on the ends as their true animated form.

This work for me is about the creation of philosophical objects, questioning how we perceive the passage of time. Therefore, prototyping led me to discover a synthesis between process and concept, where the process reveals a deeper meaning of the form.

Since these original animated forms I have delved more into representing natural phenomenon which are fleeting or unnoticed. In my piece titled *Smoke*, I cross-sectioned a plume of smoke with a spread out laser beam and documented it with video. The video was traced frame-by-frame and hand-cut out of paper to solidify its ephemeral nature.

In a recent experiment, I worked with a 3D scanner to document a flower as it naturally transitions over the course of ten hours. In the end, all the data is compiled into one form that shows its passage of movement which would normally be unnoticed by the naked eye.

Prototyping, as a medium, has changed not only the way I build but also my own perception of reality. My work has branched out beyond the prototyper into a new way of thinking and capturing data for the creation of forms.

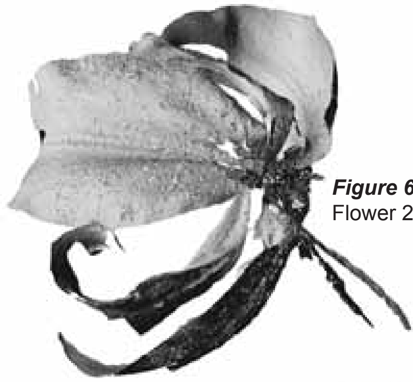


Figure 6: Flower and Time: Flower 2--3D digital scan.

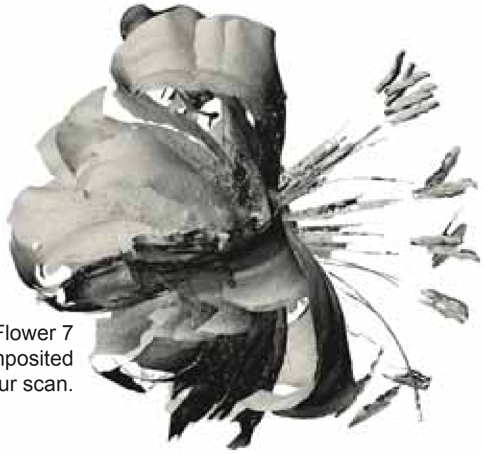


Figure 7: Flower 7
Final render of composited 10 hour scan.

Figure 8: Flower 4--3D digital scan.

Dan Tesene grew up in rural Iowa, where, from a young age, he developed a deep appreciation for the beauty and intricacies of nature. Tesene completed his undergraduate degree at the Minneapolis College of Art and Design, where he became fascinated in the relationships between mechanical and natural systems, manifested through his 3D modeling work. After graduation, Tesene was awarded the Jerome Foundation Fellowship for the Arts and also won the 2005 **form•Z** Joint Study Award of Distinction for Fabrication. During his fellowship, Dan began analyzing the process of prototyping and the breakdown of forms, which led him to the work of Etienne-Jules Marey and other revolutionary inventors who laid the foundation for this type of thinking. After completing his fellowship, Tesene traveled to Cairo and Alexandria where he participated in the group show Convergence. Tesene now lives and works in New York City.

Chapter 4

Design Process in the Classroom

Rhode Island School of Design
Providence, Rhode Island

Reconstructing or Inventing the Past: A Computer Simulation of Unbuilt Architecture

by Andrzej Zarzycki

There is a certain mystery surrounding the *unbuilt* projects or unrealized ideas of famous architects. Often times there is the expectation of a deeper meaning and hidden genius present in unrealized buildings. Some critics go so far as to claim that the best and most interesting projects remain unrealized because of the progressiveness of the ideas associated with these types of buildings.

Whether we agree or not with this point of view, most would admit that there is an intellectual value to be derived from studying and (re)creating *unbuilt* buildings. Designers operate within an intellectual continuum that is evident through their work. This continuum is successively redefined and the designer's vision transcends with each consecutive project. In this sense, *unbuilt* projects are the *'missing links'* and serve as the *'stepping stones'* in an architect's creative development.

Studying *unbuilt* architecture allows one the ability to trace the origin of concepts and the architect's persistence of thought. In a broader context, unbuilt projects, as well as those that no longer exist, remain a part of our cultural heritage. Their presence continues to be felt through the impact they had on their contemporaries. Tracing back these threads of connections and influences is not only an exciting but also an informative exercise. It helps us better understand our design motivations as well as the present state of architecture.

Why Digital?

This is a valid question that needs to be addressed. There have always been attempts to resurrect past structures or immaterialized ideas. In the past, this was achieved through physical models or perspectival renditions. We are familiar with 19th century illuminations of ancient Egyptian structures or models of Rome that successfully conveyed architectural intents (their histories). So why with the emergence of digital technology do we see an increased interest in reconstructing past designs digitally? Why are we bringing past designs back to life, or perhaps, giving them a life that they never had?

The primary motivation for creating virtual models of *unbuilt* buildings with computer graphics tools is that the drawings and physical models for these building do not reveal the full meaning and potential of the crafting of form, light, and materials into powerful, resonant space.

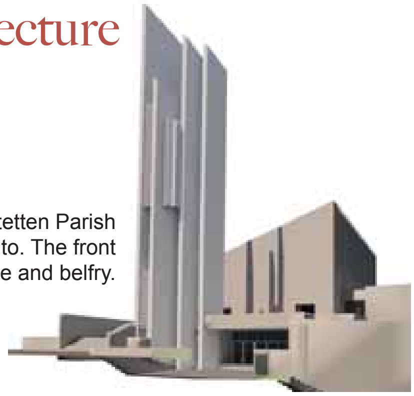


Figure 1: The unbuilt Altstetten Parish Church designed by Alvar Aalto. The front facade with the main entrance and belfry.

Virtual models are the only medium which can deliver an experience compatible with real life observation, by inserting perceptual realism into three-dimensional representation. Specifically, digitally produced photorealistic representation leaves less opportunity for an observer's free interpretations and speculations. While this effect would not be desired in the conceptual stage of design, it is well appreciated as a precise communication method of carefully-formed designs. When employing photorealistic textures and light simulations, digital representation is also visually more explicit directing what types of associations can be inferred. As a result, digital images capture all the details of a scene typically with less visual holes or room for detached, distant associations. This, at least perceived, completeness of visual information when combined with the evocative and narrative character of digital representation, translates into a high authenticity of experience.

Digital representation allows for dynamic and innovative ways to visualize architectural environments. It embodies and extends the traditional use of the word "representation" into new visual conventions. Unlike physical models and similar to drawings, digital representation has the ability to symbolize and evoke a feeling about a space, not merely for capturing the photorealistic exactness of a perspectival view. In this sense, it relates to cinematic narratives. It can also convey the essence of an architect's intent or an overall spatial design framework. Consequently, digital representation has potentiality to go beyond a utilitarian need to visualize or describe a building. It presents unique opportunities for conveying mental impressions and intentions because of its ability to easily manipulate reality and tailor it to particular expectations.

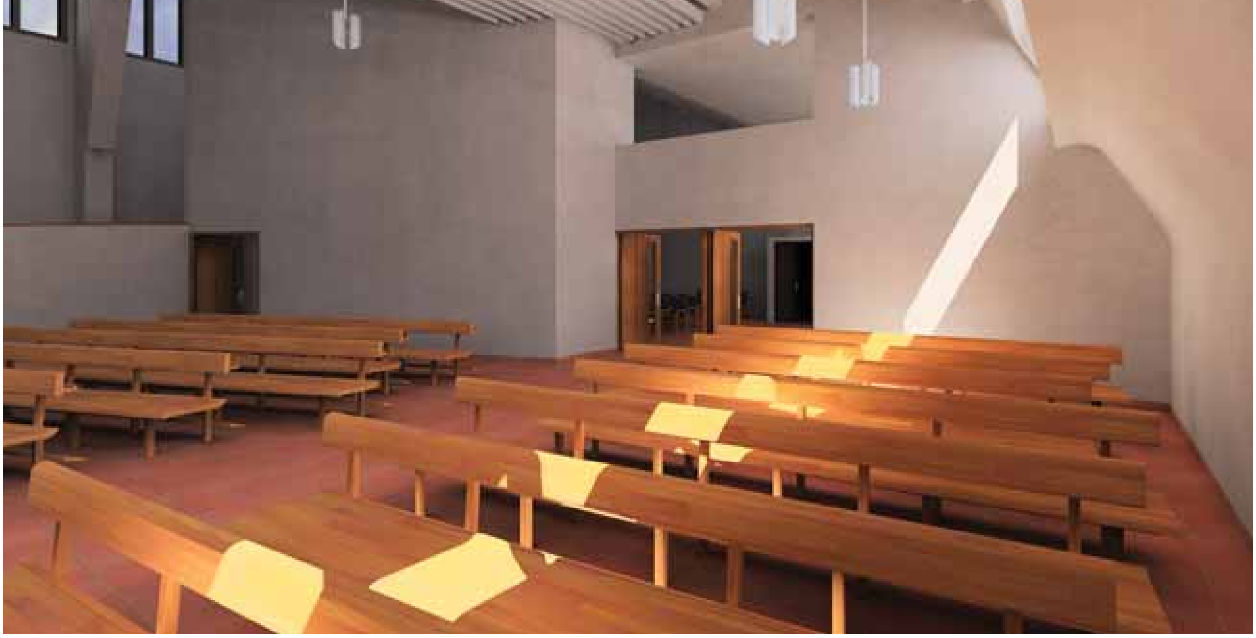


Figure 2: The interior space of the unbuilt Altstetten Church. A view from the altar toward the entrance.

Interestingly, even the view shown in the Figure 2, while highly photorealistic and consistent with an observer's mental picture, could not be achieved with standard photography. Its field of vision is wider than that of a camera or a human eye. The image (Figure 2) was achieved by a multiple offsetting of perspectives and splicing them into a single image. While this representational approach is not unique to digital media—it was used successfully in traditional media over centuries—it is well suited to the ways digital representation works.

Figures 3, 4 and 6 present the building in less usual ways. Figure 3 captures an impossible view that cannot be photographed or seen with human eyes in a single moment. However, it is a view consistent with the type of mental image one would form if experiencing this physical space from multiple perspectives and at different moments in time. In fact, it can be described as an accumulation of individual images-fragments that are being renegotiated by our mind into a coherent experiential impression. Figure 6 shows a spatial sequence of an individual building's components. It addresses the building's experiential continuity while acknowledging the intricacies of individual spaces.

The digital representation provides a unique combination of an evocative image (like a drawing) as well as the spatial and experiential character of a physical model.

This dual, dialectic-like, quality of digital media is further empowered by its dynamic aspects—an ability to account for time. An interactive (navigate-able) or animated three-dimensional digital model is closer in its representational quality to the act of interaction between a model and an architect, than to a physical model as a bare object. When interacting with a virtual model, we undergo a parallel experience similar to an architect designing a building (by interacting with multiple drawings or a model).

Figure 3: A sectional perspective with a semi-transparent partition wall; addressing spatial continuity and intricacies of individual rooms.

Figure 4: The main hall, view from the altar.

Principle of Uncertainty

Whenever we try to restore ancient ruins, interpret a piece of art or translate a poem, we come across a dilemma: to what extent do we (re)create the original artifact through our own preconceived ideas. Many questions emerge:

- Just as a built project after its completion gains a new existence and meaning contextual to its users outside its architect's intent, does the digital recreation of *unbuilt* projects go outside or beyond the original architect's intent? (*Do we create meaning where there is none?*)

- Has an *unbuilt* project been carried out or has it begun again with a different designer's intentions?

- What are the rules for resurrecting *unbuilt* projects and presenting them with photorealistic images?

- To what extent does the present inform the past?

- To what extent are we unable to comprehend or understand the past, because it is always conditioned by the present moment or, in this case, interpretation of 2D plans?

I was aware of these dilemmas during my work on the visualization of the Alvar Aalto's Altstetten Church and set up a methodology for addressing them. The same methodology, albeit a simpler version, is used by students in my Computation Class at RISD as a way of formulating their perceptions into to execution of their digital visualizations.

Process & Methodology

A critical part of digital (re)creations is the decision process used during the modeling and rendering of *unbuilt* buildings from the architect's original drawings. The original drawings were essential in portraying interior spaces and tectonics. However, they did not address the details of the project nor did the hand drawings describe finishes (i.e. colors, materials and textures). These limitations were overcome through research and the extrapolation of details, materials and furnishings from other buildings built by Alvar Aalto.

A critical part of the success of this project was my methodology. I divided the project into phases. Each phase had its own distinct character and objective: the research phase involved gathering reference materials (e.g. obtaining large scale prints of original drawings from the Aalto's Foundation in Helsinki, Finland) and analysis of the design's final state; the design phase to resolve contradictions and missing elements through the process of extrapolation from built works and archival materials; the modeling phase where 3D digital models were constructed; the visualization phase where materials and lighting simulations were developed, and the presentation phase where various simulation techniques were evaluated to best communicate the experience and the essence of *unbuilt* space.

Figure 5: The unbuilt visualization of Alvar Aalto's Altstetten Church. Computer graphics by Andrzej Zarzycki.
Floor plan rendition with an alternate sunlight scenario.

Not a Single, but All Possible Designs

By going through the process of virtually constructing an *unbuilt* building, one not only gains insight into the designer's thought process, but also gains the ability to recognize all the other possible designs, which could have been realized. This exercise unfolds the pictures of possibilities. Since the reconstructed image is one of many possible, albeit likely the most probable interpretation of *unbuilt* space, the (re)creative process requires us to think about an idea of all possible spaces that can be interpreted from the same set of assumptions. *What ... if* is a constant question. The changing of materials, spatial elements or site orientation would alter the space giving us a new design with different sun exposure. Testing these possible designs against the most probable design would enable us to better judge the original ideas.

While these projects may seem to focus on achieving closure of unrealized designs by resolving and completing an architect's original intentions, more emphasis was placed on posing rather than answering questions. In this kind of investigation, by visualizing designs, we form a proposition about a possible design. While these propositions are important for our understanding of an architect's work, the questions are more important than the answers. This leads to a shift in an investigative process that treats past designs as the building blocks for various scenarios and re-creation of new life rather than a linear, domino effect like design steps.

Finally, the very process of creating virtual worlds and imagery provokes new and interesting questions, which may be utilized to guide young designers' future efforts. This connection between the study of architectural history and testing design possibilities is a promising example of synthesis between academic research and teaching.

Where to Go From Here?

As educators and designers we tend to focus on creating forms and spaces. In result, we emphasize the creative aspect of tools, often ignoring the experiential and emotional connections that are formed as a result of interfacing with virtual environments. In the case of *unbuilt* projects, this latter component is critical, since the purpose of digitally resurrecting *unbuilt* designs is to increase public awareness and to bring them into general consumption. As such, presentation of work and an ability to connect to it is critical. In this particular case, due to the printed medium, the images are presented as still-life pictures. If you were to view a video of an *unbuilt* project, your experiential aspect would increase due to the nature of moving pictures. An ability to navigate the space, not unlike a video game, is the next level to develop and would address the experiential differences between physical and digital models.

The navigability of digital models and environments is a critical element of the successful design interaction between the designer and the design. While there is space for improvement in these areas, there is also a constant progress as well. An example going in this direction is a MRI (*Multi Reality Interface*) approach, where the user or a designer would interact with a computer through physical objects. Another example is a 3D mouse-input device such as a SpaceNavigator, a device with higher levels of navigational freedom than a typical computer mouse. **form•Z** is one software that supports these devices, thereby increasing productivity. However, in the context of this article, the use of 3D mouse devices is critical from the navigational perspective. With their use, users can gain a real and intimate access to virtual space. This increased access translates quickly into democratization of virtual environments.

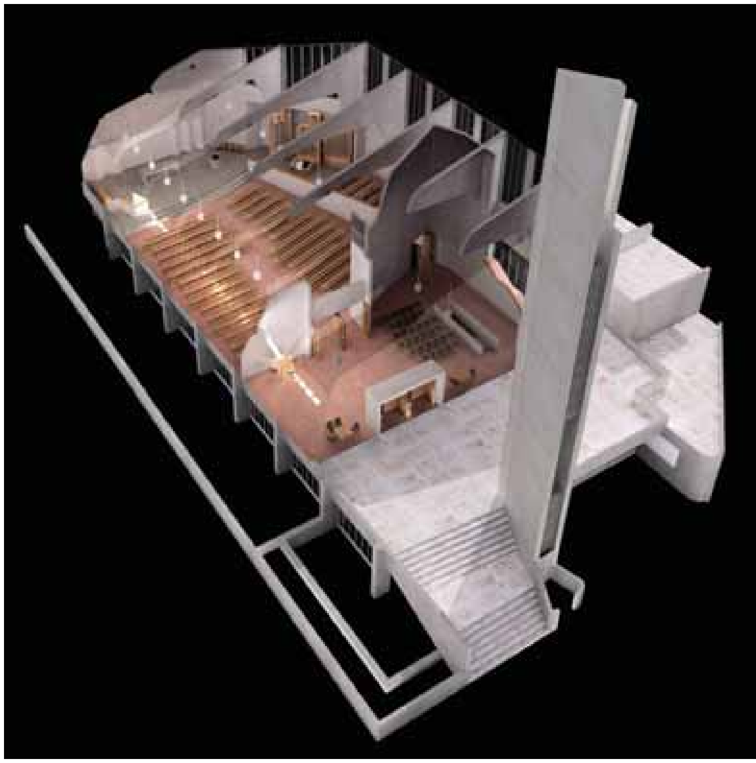


Figure 6: (Left) The overall perspective illustrating a progression sequence.

Figure 7: (Above) View toward the altar.

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Alvar Aalto, Richard Weston, Phaidon Press, 1995.

Note: *The two student examples discussed following this article were developed during routine digital courses in the Interior Architecture Department at RISD. The quality of these examples speaks about a great fit between the new generation of students embracing technology and software with advanced capabilities, which promotes visual thinking and creativity. In essays below, students discuss their hands-on experience with* ***form•Z****. The Relativity visualization by Sophia Chan was recognized with an Honorable Mention award by* AutoDesSys *in 2007.*

For a biographical summary of Andrzej Zarzycki please see page 67.

Rhode Island School of Design
Providence, Rhode Island

The Affects of Virtual Light in Aalto's Tallinn Art Museum

by Aaron Lehr

The Tallinn Art Museum by Alvar Aalto builds upon previously completed projects such as the Viipuri Library and Helsinki Institute [1]. The luminous interaction of light and space is an important design aspect in these projects. Consequently, my digital representations of the Tallinn Art Museum narrate this unbuilt space by using a play of light and architectural detailing. An unbuilt project is always difficult to imagine and discuss in a realistic situation. To mitigate this situation, I created a virtual building that allows one to see how light affects the internal and external spaces. A physical model is less capable of displaying effects of realistic lighting. The addition of light allows a person to see how walls, windows and doors create a realistic space by representing light traveling through the interior space. By using 3D rendering software such as **form•Z**, I am able to pinpoint the natural lighting of the sun and artificial lighting of incandescent lights to visually express the architect's intent.

The software tools allow for a precise positioning of light sources to represent a variety of lighting situations within a building. In a natural setting, there is a dominant light source, the sun, as well as smaller and less powerful artificial light. In a physical model, one cannot see the changes in illuminations during the different times of day. However, the virtual model allows me to use geo positioning of the site to accurately identify the effects of sunlight throughout the day. This gives me an advantage over traditional physical models by allowing me to know where the sunlight will enter the building and illuminate the interior space.

When I produced lighting scenarios for Aalto's Tallinn Art Museum, I used dark and light areas to move the viewer's eye through the building. In the image of the main lobby, I used an omni light in the back of the courtyard to create a bright area where the second floor courtyard meets the solid wall of the lobby; this effect creates an area of contrast leading one's eye to the rear of the picture.

Another effect that can be created with light is laying different shadows over each other. In the lobby image (Figures 1, 2), I used a less intense omni light behind the support columns, which casts light shadows down the stairs and along the lobby floor. The lobby floor is a unique woven brick pattern, sometimes described as a beehive brick pattern (Figure 1) shown in Aalto's perspective drawings [1]. I used another artificial light to accent the architectural details of the columned wall producing shadows that mim-

Figure 1: An entrance hall with a view of a courtyard.

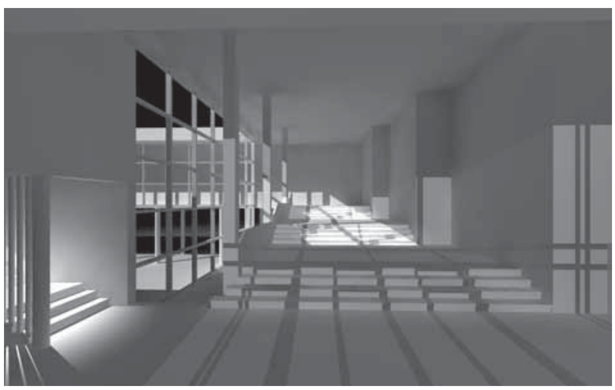


Figure 2: An entry sequence. The image matches Alvar Aalto's original design sketch.

icked those on the lobby floor. This columned wall detail can be seen in Aalto's built projects, such as Villa Mairea and the Technical University of Helsinki [2]. Using a different intensity and amount of light brings the viewer into the space and creates dynamic lighting situations accenting the architectural details. Aalto did not provide information in which I could base the placements of lighting fixtures; therefore, I used lighting that would explain the physical space of the building rather than placing actual lighting fixtures distracting from the building's architecture.

Within Aalto's concept design of the Tallinn Art Museum, there are several different ways in which natural light enters the building. The sunlight enters through the curtain walls in the courtyard as well as via the front entrance facade. In addition, a significant amount of natural light enters from the round skylights penetrating the roof, creating a play of shadow and light in the courtyard image. One can see the combination of the light, which enters through the circular skylights and the curtain walls. The skylights and curtain wall were design ideas that can be traced through Aalto's built projects from the Viipuri Library to Helsinki Institute [2].

Along the courtyard, the bright lights of the curtain walls create a lively contrast between light and dark areas in the interior spaces. The doorway also frames the viewer's eye to be pulled down the stairs into the entrance lobby (Figure 4). I created this focal point by using a series of lights combined with Aalto's architecture.

In effect, my renderings are produced to display a variety of dynamic light conditions to show the Tallinn Art Museum concept as a physical space (Figure 3). The unbuilt Tallinn Art Museum provided an opportunity to study the effects of sunlight and artificial light on a building. Aalto's use of light in similar buildings allowed me to imagine how the lights would play in the unbuilt structure; whereas, the 3D rendering software allowed me to provide an image for others to view how I imagined the effect of light within the virtual building.

Figure 3: A museum hallway focusing on an interior courtyard.

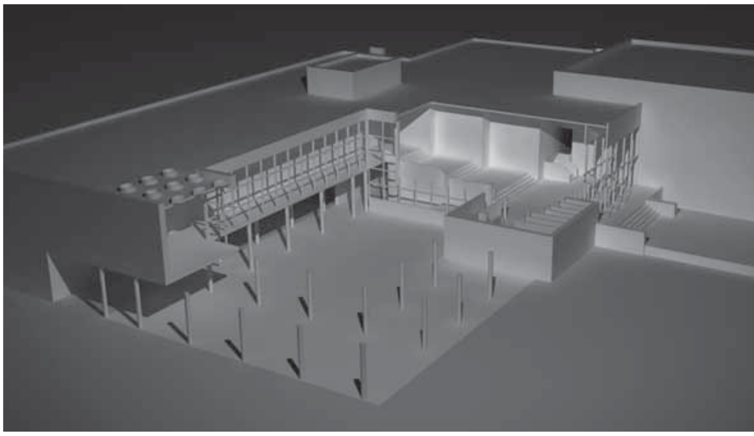


Figure 4: The sectional perspective illustrating the building's circulation and organization.

References

[1] Paul David Pearson, *Alvar Aalto and the International Style* (New York: Whitney Library of Design, 1978).

2] Richard Weston, *Alvar Aalto* (London: Phaidon Press Limited, 1995).

Aaron Lehr is a sophomore majoring in interior architecture at Rhode Island School of Design, refining his basic architectural ideas. Beginning in preschool, he built factories, houses or other buildings out of every cardboard box available. Today, he continues to enjoy the idea of adapted reuse and is fascinated with the idea of recycling a structure and site to produce a new project. Before entering RISD, Lehr attended a performing arts high school in Wilmington, Delaware, where he concentrated in Studio Art. Although he would have preferred to work in three dimensions, studying drawing, painting and the use of color provided a necessary base to enhance his architectural studies today. While in high school, a number of Lehr's sculptures received both local and national art awards and recognitions. Since studying at RISD, he has only been working with computer-aided design programs for a year. Lehr admits the use of digital tools intrigues him as it helps with his design work. His hope is to continue to learn how to refine his design ideas in a digital environment.

Rhode Island School of Design
Providence, Rhode Island

Danteum & Escher: Two (Un)Realized Visions

by Sophia Chan

Danteum: *The Digital Construction of Heaven through Glass and Light*

Danteum is one of the most famous architectural projects never constructed. In 1938, architects Giuseppe Terragni and Pietro Lingero designed the building as a structural interpretation of Dante's Divine Comedy. Proposed during Mussolini's rule in Italy, however, the project was not seen as being supportive of Mussolini's political ambitions and never came to fruition.

Terragni and Lingero used Dante's work and the mathematical rule of the golden rectangle ratio to design Danteum. The architects also used symmetry and specific materials to construct different structural representations of each of the stages in the Divine Comedy. While one room would be a library that would house a collection of Dante's works, other rooms would draw inspiration from Dante's literary themes of "Paradiso" (heaven), "Inferno" (hell), or "Purgatorio" (purgatory). The architects' concept and design transformed Dante's two-dimensional Divine Comedy into a three-dimensional structure full of illusions.

For example, "Paradiso" would be a room located on the uppermost level of the structure and would consist of 38 glass columns arranged symmetrically around a central point (Figures 1,2). The nine central glass columns would represent the nine spheres of heaven as described in Dante's poem. The positioning of the columns would force the viewer to circle the room and to look upward to the sky, which symbolizes paradise.

After studying the architectural plans and sections, I modeled and demonstrated the essence of the space of "Paradiso" by using digital modeling tools. Several factors contributed to my decision, such as the structure's emphasis on materials and light. The key architectural elements of the space would be the configuration of the glass columns. After careful study of the glass columns and its specific glass properties, the discovery of how the reflections and refractions of the glass would create numerous distorted views of the space were made (Figure 3). The glass would make the group of nine columns and peripheral columns all appear to be in infinite repetition, thereby symbolizing Dante's concept of heaven and never-ending life.

The open grid work in the ceiling would also exhibit a repetitive ribbon effect due to the glass' cylindrical shape. The transparency of the glass columns would skew the perception of the room to generate an illusion of infinite space. This illusion could only be achieved using rendering programs that could create a representation of the properties of glass instead of a traditional, physical modeling of the space. Information about the materials could be found from the architects' original descriptions of the project, but details of the specific properties of the stone floors or other textures were not clear. The opacity of the glass and the amount of refraction were also factored into

Figure 1: The colonnade; the Paradiso Space, Danteum.

Figure 2: The colonnade; the Paradiso Space, Danteum.

Figure 3: Distortion in a glass column; the Paradiso Space, Danteum.

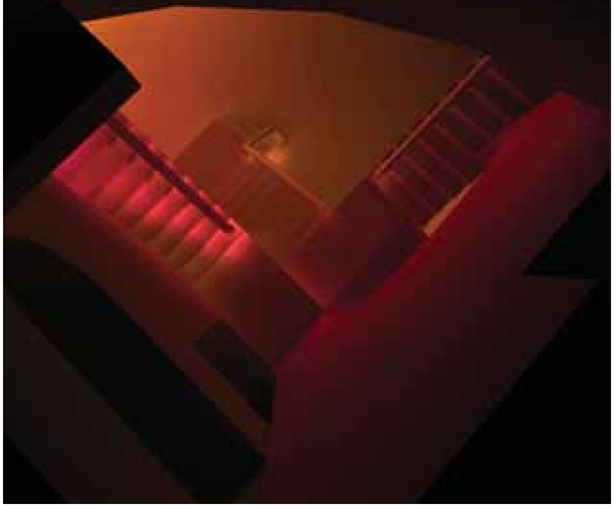


Figure 4: An artificial light study for the Relativity space.

Figure 5: A 3D interpretation of M. C. Escher's "Relativity."

the considerations about the design, as this was an unbuilt project. The final decisions thus included a series of images of the space.

Using digital tools, I also created different views that represented each of the daytime and nighttime lighting scenarios for the structure. Depending on the time of day, the amount of light in the room would vary and yield a room that changes both contrast and luminosity. The closely paneled walls would allow only a sliver of light to pass from the exterior to interior space and would thus enhance the light and shadows of the space itself. The combination of the glass columns and variable light supply would also cause the lower half of the room to be more enclosed than the upper skyline. Various degrees of distortion would emerge, such as a mirage of endless glass columns reflected in the space's walls. In comparison, the square apertures in the ceiling and open-ended sky would jointly create an illusion of freedom as one ascends to heaven.

Terragni and Lingero's decision to use glass columns in the structure and to include a variable light supply in the room would have consequently transformed a two-dimensional piece of literature into a three-dimensional structure of heaven, or "Paradiso." The three-dimensional structure could only have been possible using digital tools that could interpret the architects' original intent through different materials and lighting scenarios.

2D to 3D Relativity by Escher

"2D to 3D Relativity by Escher" posed a design challenge of extrapolating a two-dimensional drawing into a three-dimensional construct. Since the original two-dimensional floor plan was created on a skewed perspective, there were no basic floor plans that could facilitate the creation of six spatial sections in three-dimensional space. Numerous estimated measurements would thus be needed to create the details of this project. **form•Z**'s functions and capabilities were ideally suited for accomplishing such an endeavor.

In two dimensions, **form•Z** allowed the architect to draw continuous lines and curves without any breaks to create closed shapes that could be transformed into three dimensions. The options of retaining or deleting objects in an operation were also useful in both two and three-dimensions. Given its ability to retain an original two-dimensional drawing throughout the design process, **form•Z** easily facilitated the conversion from two to three dimensions.

In three dimensions, the program's lofting tools were essential to constructing circular objects from various directions with different gravities—indeed, the circular stair railings were illustrated using this exact program function. **form•Z**'s catalogue menus were also more useful than other drafting programs in allowing Boolean operations and additional commands for constructing three-dimensional objects to be performed in different layers and thus preserved. Finally, **form•Z**'s rendering capabilities offered a final check on both the faces and the solid objects in the interior space of the structure.

By transforming a two-dimensional drawing into a three-dimensional space with three different gravities, **form•Z** not only simplified the design process, but also enabled this architect to study interior spatial relationships with precision and in detail (Figures 4,5).

Sophia Chan is a second year graduate student in Rhode Island School of Design's Interior Architecture department. She has recently received an honorable mention in **form•Z**'s Joint Study Program on her work "2D to 3D Relativity by Escher." Prior to graduate school, she earned her B.F.A. from Parsons School of Design in 1999 and has worked in the fashion industry in New York for more than eight years. She has been published in Women's Wear Daily and more recently served as the design director for Perry Ellis dresses and separates. She seeks to use her experiences in design to broaden and develop her knowledge of interior architecture. She perceives interior architecture as a study of the relationship between people and their surroundings. Sophia intends to become an interior architect in New York after she obtains her M.I.A. in 2009.

University of North Carolina at Greensboro
Greensboro, North Carolina

Making Virtual Real

by Tina Sarawgi
Student projects: Julie Barghout and Michelle Herrera

When a design studio extends itself into the real world, it starts to offer unique learning opportunities to the students. Studio projects grounded in reality can enable students to understand the complexities of real-life projects through a learning-by-doing paradigm. However, in projects of such scope, it is important to be able to convey the proposed design solution to the clients such that it makes them excited about the space they are about to inhabit.

Over the past two years, dialogues with Gensler at Charlotte, NC, led to the integration of real-life projects into the 3rd/ 4th year digital design studio at The University of North Carolina at Greensboro. The projects included an 18,500 sq. ft. fabric showroom for Culp Inc. at High Point, NC, and a 13,000 sq. ft. workplace environment for Mullen Advertising Agency in Winston-Salem. Both projects were completed by Gensler, Charlotte a few months before the students started working on them in a design studio environment. The studio challenge was to develop comprehensive design solutions in conjunction with regular discussions with the clients and site visits. Two studio projects by Michelle Herrera and Julie Barghout are featured here outlining their digital explorations with materials and lighting.

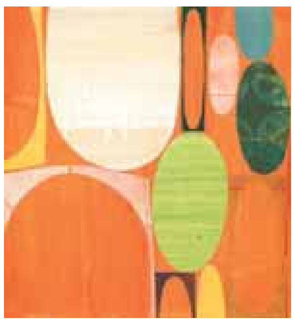
The Process

Designers at Gensler provided information on the site and program, the scope and size of which were adapted to fit the academic curriculum parameters so that the project could be completed within a semester. The real clients: VP of Human Resources and Sales in Culp, and the VP of Human Resources and Creative Services Director in Mullen interacted regularly with the students over the semester, providing them an in-depth insight into the spaces, activities, and experience desired by the clients. Having a real client to talk to, understand the needs of, and then respond to, not only placed a sense of responsibility on the students, but also steered them toward making their design decisions relevant to the users of the space. In the same vein, visiting a real site to experience, assess, and understand opportunities and constraints of, provided a deeper insight into the design problem at hand.

Digital Explorations

Our perception of space results from a combination of the shape and reflectance of surfaces, the distribution of lights in the environment, and the observer's point of view (Vangorp et al., 2007; Adelson, 2001). The intrinsic mechanics of the material (such as elasticity, viscosity, etc.) acted upon by outside forces leaves it in a certain shape. For example, a fabric drapes and folds in different ways depending on how thick or stiff or elastic it is. The intrinsic optics of the material (such as reflection, refraction, transmittance, and absorption of light) determines the way it is illuminated by the lights in the scene. And finally, the position of the observer (or camera) at some viewing point in space, looking in a certain direction with a certain focus apparatus combines with the material's intrinsic mechanics and optics to form an image (Adelson, 2001). Visual observation of the everyday world conditions us into doing a good job of guessing the intrinsic mechanics and optics of materials.

Knowledge of these physics-based properties of materials and lights can help one make a rendered space look realistic. But to express the immeasurable aspects of architecture, one needs to go beyond form and construction and capture the spirit of a place. This requires understanding and representing the "presence" of materials and light, taking inspiration from its behavior in real-life.



Figures 1, 2: Examples of texture maps used by Michelle Herrera.

Figures 3-6: (3) Views of the showroom with display boards and shelving to display the Culp Inc. fabrics; (4) the waiting area; (5) the fabric bolts along the hallway; and (6) the café. Models and images by Michelle Herrera.

form•Z was chosen over other programs [1] as the *virtual* tool to develop the final visualizations of the real projects because of its user-friendly options available to evoke the intrinsic mechanics and optics of materials, and lighting in the space. The intention was not photorealism but to express the essence of something that was not yet built. The material and lighting explorations in the spirit of this view are discussed below.

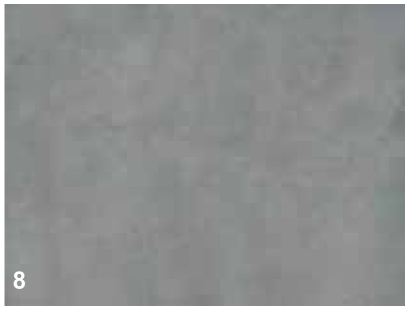
Materials

In the Culp Inc. fabric showroom design project, Michelle's goal was to achieve a comfortable atmosphere that would encourage the visitors to occupy the space for a longer period so that they would possibly end up buying the fabrics on display. She achieved this goal through the use of warm colors (accents of burgundy) and soft materials (plush fabrics) to make the clients feel relaxed, thereby spending more time in the space.

Texture mapping was used to wrap the material image around the objects (Spalter, 2000). Michelle chose to go with images gathered from various resources such as photos, scanned images, or Web sites to define the materials in her project (Figures 1, 2). The images were adjusted in Photoshop to avoid tiling before they were imported into **form•Z**.

Object reflectance played a key role in developing the renderings. The reflectance of an object consists of three components: ambient, diffuse, and specular. The ambient color does not vary across an object. The diffuse color varies according to the Lambertian law. The illumination component that changes the fastest is specular. Specular highlights can help illustrate object detail in an object with high curvature (Lee et al., 2004) as seen in the chairs and the pendant lights in Figures 4 and 6. It is important to consider the viewing direction, surface normal and/ or light direction for specular highlights on a shiny surface.

By adding a combination of ambient, diffuse and specular reflectance properties to surfaces, light bounces off of surfaces simulating the effect of real environments. Notice the reflectivity added to the textures, especially on the wood ceiling and the concrete floor surfaces in Figures 3 through 6. Michelle also found that white objects often



Figures 7, 8: The tiling seams of the concrete texture above is reduced by increasing the reflectivity of the surface; and the texture for concrete mapped in the project. By Julie Barghout.

appear gray when rendered in **form•Z**. A small amount of glow added to the surface properties renders it white. Reflectance, glow and transparency options were adjusted in **form•Z**'s surface style settings to achieve the overall appearance of materials.

In the Mullen Advertising office space, Julie's project's central theme was to create "a space to see and be seen." This was emphasized through the use of transparent and translucent materials. Julie also found an unlikely application of material reflectance. She tweaked the reflectivity of materials to camouflage the flaws in the texture, which would otherwise be apparent and distract the reviewers (Figures 7,8).

Lighting

Lighting is an equally important part of the perception of objects in space. Materials alone cannot make a virtual space look convincing without appropriate illumination. A shiny object will not look very shiny if seen in an environment with broad diffuse illumination (Adelson, 2001). When placing lights in a scene, it is also important to keep the layers of lighting, which include ambient, focal, task and decorative, in mind (Benya, 2001).

Although **form•Z** offers radiosity-based rendering options capable of achieving photorealistic renderings, they were not used by the students. Lights were used in both projects to approximate the properties of real lights. Instead of faithful visual reproduction, lights were used in both projects to suggest and at times exaggerate the experience in the space, whether it was warm and inviting in the Culp Inc. showroom space or transparent and creative in the Mullen Advertising Agency office space.

For the most part, Michelle used point lights for both ambient and focal lighting within the space. She used the lights in combination with reflective surfaces to create images that emphasize light and shadow. Point lights were used predominantly because they give the most reasonable results, while area and line lights slow down rendering time significantly.

In Julie's project, point lights were employed for ambient illumination and cone lights for focal lighting. Direct lights were used at places to add dynamism to the space (Figures 9, 10). Color was used as a wayfinding element by defining the various departments of the advertising agency in different colors. Lighting was used to further highlight the color scheme of each department.

The final renderings seemed to convey the representation of the place as a multilayered integrated experience of the senses. Compelling results achieved in **form•Z** required little or no post-processing in Photoshop.

Conclusion

In the words of Peter Zumthor, "the best images of something not yet built are the ones that give you a broad, open feeling, like a promise" (Melvin, 2006). This would not have been possible with photorealistic representation. The final images created by students in both projects are not exactly true to the physics of light or materials, but they take inspiration from their properties in real-life and use it to create something that inspires and stimulates imagination, thus going beyond creating a visual likeness alone. These images spread the enthusiasm for the projects amongst the clients, conveying to them the essence of the space. This was recognized and appreciated during the final critiques.

Figures 9, 10: The images above show the cone light used in the linear light fixtures; point lights for general illumination; and direct light for creating a dynamic imagery (by Julie Barghout). The account services department is color-coded green, while the creative department is color-coded red.

Another noteworthy aspect of the project stemming from the academia and professional alliance was that the projects were worked out to a greater level of detail than is usually found in studio projects (Wood and Oxley, 2007). Faced with responding to the aspirations of real clients and seeing that their design decisions affected the lives of people whom they were interacting with, the students went beyond meeting the project requirements as a checklist.

In conclusion, these projects demonstrate a way of bridging between the academia and the profession, made possible with the use of robust digital rendering tools which fuel imagination and convey the ‘atmosphere” of a place (Zumthor, 2006).

Notes

[1] The students in the design studio, in addition to **form•Z**, worked with a variety of other software programs such as SketchUp, AutoCAD, etc. The former was used for its quick modeling capabilities. AutoCAD was used to convey the construction and millwork details two-dimensionally. However, when it came to the depiction of lighting and materials in the space, **form•Z** was selected.

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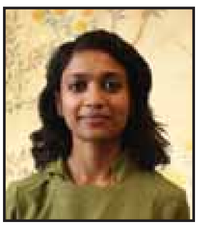


Tina Sarawgi is an associate professor in the Department of Interior Architecture at the University of North Carolina at Greensboro. She holds a Masters of Architecture from Miami University in Oxford, Ohio and Bachelors of Architecture from the School of Planning and Architecture, New Delhi. Her teaching areas are interior lighting design and digital design. In her interior architecture design studios, ranging from second to fifth-year level, she encourages the integration of digital media with design explorations. Her research investigations include the exploration of digital tools in lighting simulation for which she has received several grant awards including the Graham Foundation for Advanced Studies in the Visual Arts.

How Should Digital Media be Taught?

by Kostas Terzidis

Note: The following text is based on an interview conducted on 04.14.07 by Junfeng (Jeff) Ding, Senior Designer at Hillier International Architecture, NY and Xiaojun Bu, MArch student at Graduate School of Design (GSD), Harvard University.

Contrary to common belief, computation is not really a goal, but rather the process of arriving at a potential goal. There is a distinction between the visual appearance versus the essence of something. For example, consider the case of a curve. A curve, of course, is a geometrical object that has a visual manifestation, i.e. it looks round, elastic, and soft. But that is just a phenomenon that appeals to our eyes. Behind a curve lies also the mathematical process that defines, describes, and controls it. That has a certain computational complexity that allows the computer to respond to its real time behavior, so that it will look curvy or flexible to your eyes. So the complexity of the curve is something hidden in the computational process. Yet, there is something even deeper than that. That is, the actual complexity that even though it is based on logical arguments, its quantity and articulation is so extreme that it goes beyond one's ability to understand it. Perhaps because humans have a limitation by nature, they just don't understand immediately the complexities involved. Even if many scientists are gathered, still each one of them is limited and so is the whole group. Even if it is split into smaller pieces it still doesn't get understood.

Occasionally, we comfort ourselves thinking that even though some problems are extremely complicated, they are so only in the sense that it would take us a long time to solve. But then again how can that claim be true when we do not understand the problem in the first place; and who is going to negate that claim when we humans are the only judges. So the complexity referred to here is not something remote or abstract but can be found amply in everyday life; for instance, our own bodies are complex structures that we do not know how they work exactly; and yet we are them. Nature is complex, but it can be argued that its processes happen in a certain computational way. The structures of cells, organs, organisms, or even chemical or social phenomena are dominated by processes the mechanics of which we do not understand. There are levels of complexity that need to be understood through some sort of a methodology. One such methodology is computation. In that sense, computation is actually a means to reach a goal, not the goal itself. So it appears possible that computation can be used as a complement to one's own inability to fathom something that is beyond one's understanding, not to do things one already knows.

In my courses, I am trying to sensitize the students about the possibility that there is more than just application driven processes, that is, processes where somebody already provides us with the tools and we just use them. That is to say that, when one uses **form•Z**, Rhino, 3D MAX, or whatever, in reality one is replicating a set of methods that somebody already has done in advanced. In other words, somebody has already assumed that you are going to make a line, and has customized the line command in a way that it is convenient to you. And that convenience I am afraid you pay later on because you're in a way driven to make a decision that you would not have necessarily made, had the same design be done by paper, or more importantly, had it been done by a truly computational process, such as scripting or programming.

The problem is that that decision was not yours. Perhaps an easy analogy is the paradigm of a pool, i.e., one is given the ability to swim, but in a small pool. And then one is able to write one's own scripts and gets more freedom, perhaps now swimming in a lake. And later on one can go on to the ocean. And then one is faced with infinite freedom. Because there is no constraint on the size of the pool that one has been placed in, when one thought that he or she was free, but really was not. I often use the phrase "form follows software", in the sense that software affects the way one thinks. Unfortunately (or fortunately), different software implicitly enforces one to make stylistic decisions. In that sense, it is easy to distinguish a design made in **form•Z**, because it is possible to discern certain characteristics that are stylistically provided by **form•Z**, which means one is actually abiding, almost as a mannerism, to that particular software that actually in a way manipulates the way one thinks, decides, and designs.

In my GSD classes, we are trying to have the students think in the reverse way. It is a fairly complicated process, because for them it is completely unexpected. Yet it is extremely useful because it becomes the first time that they get acquainted with the computer not in a friendly customizable spoon-fed fashion, as in "do this for me." But it is more along the lines of "I need to first find out the logical and mathematical principles, the computational elements, and the relationships to articulate them into things that could be architectural." As in swimming in the ocean, at the end they cultivate their ability to do the things that they really want. Of course, it is hard and it needs lots of work, but I think the results are truly exceptional because they can design not by nursed copying or imitating but by creating; in the true sense of the word.

Any criticism of the current state of how computers are being used or taught is perhaps premature since my approach is too early to conclude. However, these classes at the GSD are an indirect criticism or comparison to other schools and practices, because as mentioned earlier, when one uses ready-made software, such as in modeling applications, they do things easily and fast, and so one tends to be seduced, drawn into, and follow because it is easy, fascinating, and produces results fast and impressively. So faculty and students like it, because it gets things done faster and more efficiently. Yet, at the end, while they may think that they are designing computationally, in reality they are not. They are not really using their minds, logically speaking. They are not challenging the discrete mathematical entities by manipulating them through logical operations which is what computation is. They are just moving the mouse on the screen, by following a preset process being given to them by the programmers that sell these applications.

It is actually an economic rather than an intellectual relationship. For the price of software there is an

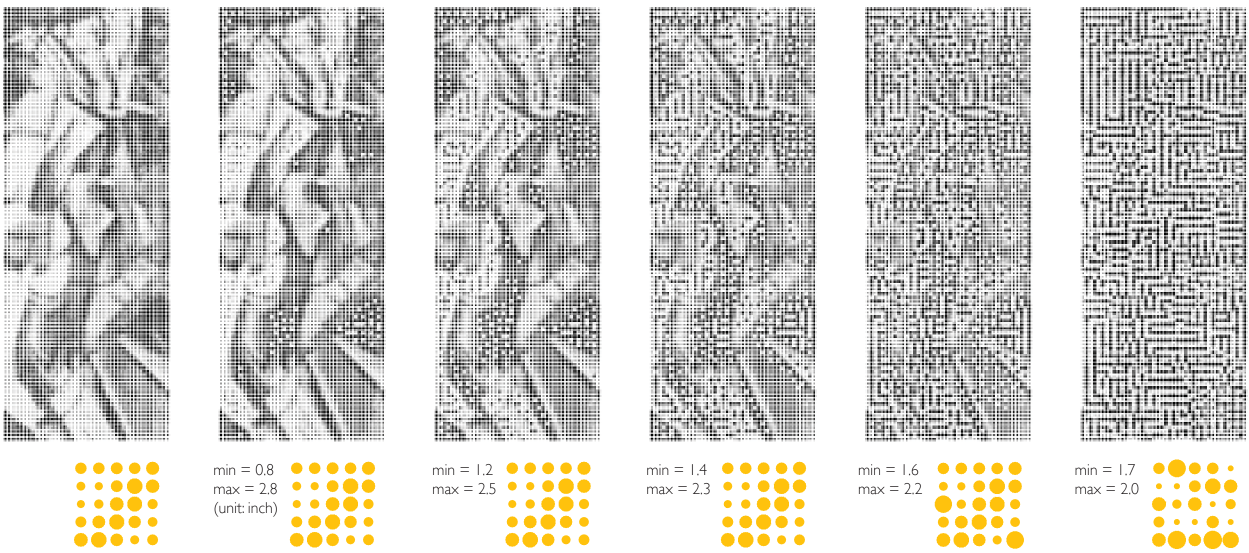


Figure 1: Cellular automata studies by Zhou Xu, MArch II. An array of circles whose radii are based upon the RGB values of pixels from Marcel Duchamp's painting: "nude descending a staircase." Then each circle is judged twice by its eight neighbors' average radius value; if it is less than a designated minimal value, the area can be regarded too light, hence the target circle is replaced by a larger one, reversely, if the area appears to be too dark, then a smaller circle would be the replacement.

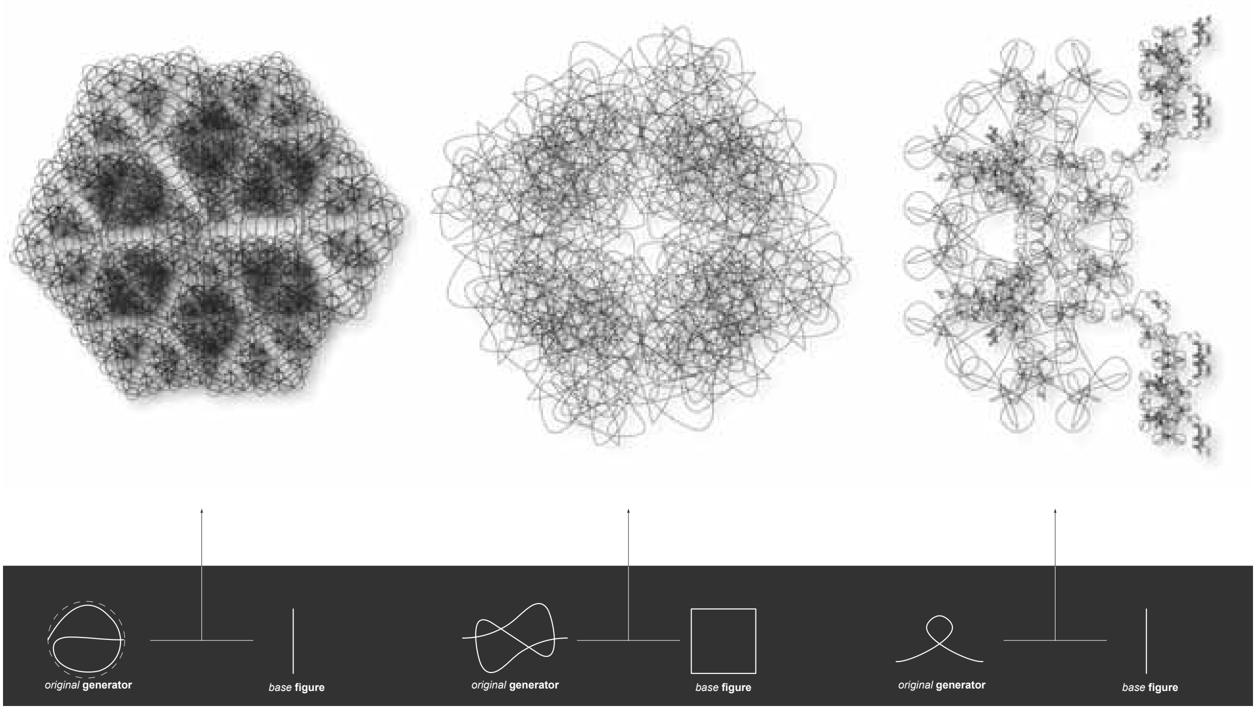


Figure 2: Fractal studies by Kei Takeuchi, MArch I. Each curve segment of a base shape is replaced by a curve called generator. The results are shown above for multiple replacements.

investment return. But in reality they are paying the price of "eye candy" that they get through this kind of process, which I refer to it as computerization. In other words, this relationship reveals that computation is not about the value of a computer and its software, but rather about a mind that thinks using arithmetic and logic as if it is a computer. Of course, when one uses **form•Z**, there is surely a computational process somewhere, but it is not there because of the computer itself. A computational process does not need a computer necessarily. Of course, computers, as data processing machines will help, but it isn't solely the computer itself. It is a logical and arithmetic device, which has nothing to do with the computer the way it is comprehended today. It is not a little gray box with a pixel screen. Rather, it is a flow of immaterial information. There is a distinction. And the problem is that a lot of people don't know it. A lot of people think of the computer itself, as if somewhere inside the computer, something magical is happening. Instead, it is in one's mind. You are the one who makes it. So, in a way, we should be doing design the right way, and not be affected out by software companies. Although I have nothing against them--after all they are doing their job--, and so should we. We can still make parti-design, we can still make diagrams with truly computational methods using numbers and relationships, and then use the computerized techniques for rendering, presentations, etc., which I think they are very good for those purposes. But I don't believe that the pixel-perceived image that one makes moving the mouse is also computational or algorithmic; because it is not. There is no computational process in the way it was designed. That is my distinction.

Kostas Terzidis is an Associate Professor at the Harvard Graduate School of Design. His current GSD courses are Kinetic Architecture, Algorithmic Architecture, Digital Media, Advanced Studies in Architectural Computing, and Design Research Methods. He holds a PhD in Architecture from the University of Michigan (1994), a Masters of Architecture from Ohio State University (1989) and a Diploma of Engineering from the Aristotelion University in Greece (1986). He is a registered architect in Europe where he has designed and built several commercial and residential buildings. His most recent work is in the development of theories and techniques for algorithmic architecture. His book Expressive Form: A Conceptual Approach to Computational Design published by London-based Spon Press (2003) offers a unique perspective on the use of computation as it relates to aesthetics, specifically in architecture and design. His latest book Algorithmic Architecture, (Architectural Press/Elsevier, 2006), provides an ontological investigation into the terms, concepts, and processes of algorithmic architecture and provides a theoretical framework for design implementations.

Tamkang University
Tanshui, Taiwan

Toward Constructive Design

by Chen-Cheng Chen

In traditional architectural education, students employ hand drawings and hand made physical models to represent their designs. Today, thanks to the integration of a variety of digital tools and design processes, drawings made with a computer-aided design (CAD) system can be easily transformed into a physical model using computer-aided manufacturing (CAM) techniques. Consequently, students take advantage of the new CAD/CAM technology when they create their design work. This way, both the design and construction process become reciprocal during a design study. In this paper I present three examples of student projects where today's CAM technology is used to fabricate virtual designs that were first created by the students. The first example is about masonry walls, the second about the construction of a door, and the third about the construction of a small shelter using modular construction units.

The most common way to build a masonry wall when using a 3D CAD program is to draw a single cuboid with proper proportions that correspond to the dimensions of the wall and then use it as the body of the complete wall. After such a cuboid has been created, brick textures preferably with bumps can be mapped onto the wall to complete the appearance of a brick wall. While the digital masonry wall is completed at this point, the tools used hardly suffice for addressing more complex design requirements. For example, using the above method, there is no way to make a masonry wall with void spaces in-between. Needless to say that a computer virtuoso may resort to using image software, such as Photoshop, to generate an image that corresponds to the type of wall he would like to generate. This image is then transferred into the 3D CAD software and is mapped as texture onto the wall cuboid. This appears to have solved the problem, however some masonry designs may be too complicated to be able to represent as an image. What if the void spaces of the masonry wall have different spans? What if the masonry wall layers are not lying horizontally, but are at different angles? What if the bricks are not rectangular? The design specifications of a masonry wall can be even more complicated than these examples. The alternative is, of course, to not represent the wall as a single cuboid, but to build it up with many cuboids that represent the bricks the wall is made of. The first example in this paper is about such explorations of constructing brick walls.

Figures 1(a) through (d) illustrate various methods of generating brick walls with **form•Z**. All these being interesting styles of brick walls, there are also some points that need to be made. Some of the wall designs require bricks with two different shapes in order to allow the bricks to interlock together. This is required in order to achieve basic structural integrity and to make sure that the center of gravity is located in a steady position, or otherwise the wall may easily collapse. While there are additional details that may be critical to the integrity of the wall, working on a computer model that represents the real thing makes it easier for a designer to evaluate a structure. In this study, we may not be able to simulate the brick wall layer by layer, but we have to acknowledge that a computer is a more effective tool to work with than hand drawing would have been. At the same time, it allows us to create wall patterns beyond what we would be able to do with manual means.

It is possible that, in the future, parametric design techniques and even more convenient interfaces may open up additional opportunities for imaginative solutions as well as automatic examination of the structural strength of our masonry walls. Even today there are many more compositional possibilities from what we have shown here. May be even Shape Grammars can be employed for the exploration of additional patterns. It might be fun to see if there is any possibility in taking advantage of the Augmented Reality technology, which may bring our design imagination to the next level. What if the CAD systems become sensitive to gravity? Just as in real life we shall be able to feel the gravity whenever we put down the bricks and even hear the sound of bricks bumping [1],[2]. The software will inform us if the center of gravity is at the proper place, and if not we shall be able to make the necessary adjustments and develop the appropriate details.

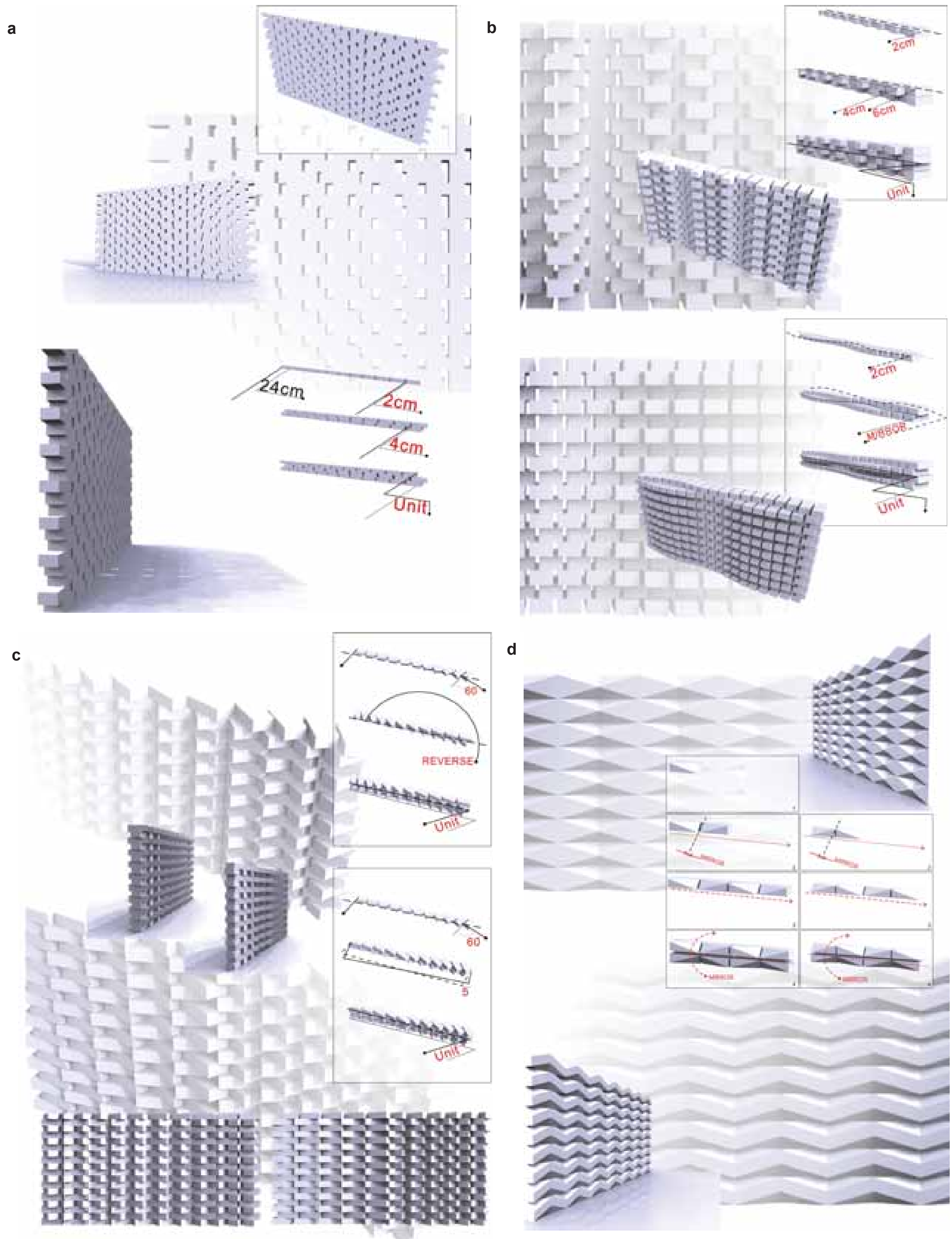
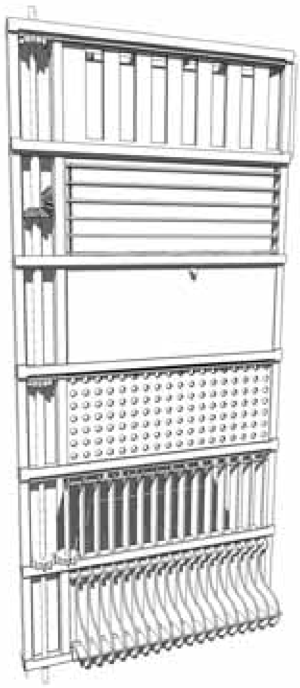


Figure 1: Studies for different masonry walls by Ching-Hang Lee.

a



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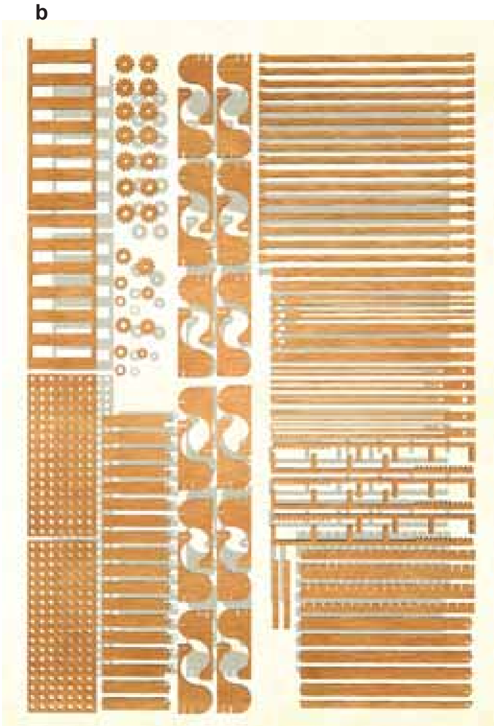

c

Figure 2: The production of a door through a CAD/CAM process, by Ke-Chi Yan.

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The next example deals with the design and construction of a door, which deviates from the common doors that typically consist of leaves, a knob, internal windows, and possibly some decorations. Figure 2(a) shows the creation of a different type of a door, which differs from the typical rather banal architectural door. The door shown is divided into six parts, which are (top to bottom): (1) a part that offers the function of lighting; (2) a part that allows peeping; (3) a part for deliveries; (4) a part with penetrated holes that shed light; (5) a part for ventilation; and (6) the baseboard.

At first, the design of the door was completed with a 3D modeling software (**form•Z**) and the details of the design were reviewed until the designer was satisfied that the door design worked well. Next, the details of the door were unfolded and the composite diagrams shown in Figure 2(b) were made. Next, different components were milled with a CNC (computer numerical control) miller. A full-size mock up with all its components was made from medium density fiberboards, as shown in Figure 2(c).

The complete process went through different stages, starting with a 3D digital model and ending with a CAM produced physical model. The process is fast and precise. The result is persuasive and has allowed us to be quite imaginative with the designs of doors, windows, and other types of components. This design study only required the use of a few simple tools. Most important of all is that this exercise made it possible for students to be both designers and construction workers at the same time. In addition they developed a sense that one can easily construct his/her own design.

The last example, shown in Figure 3, is based on a design idea that comes from potato chips packed inside a cylindrical package (Figure 3(a)). The idea is to take a window frame cross section (Figure 3(b)) and to cut it in slices, which then become modular prototypes with which a variety of structures can be derived. After some module and joint studies in **form•Z**, unit chips are generated by milling 3mm-thick fiberboards. Each of the unit chips are 10cm diagonally and have 8 slots on the surface (Figure 3(c)). A 100x100cm (the size is dictated by the dimensions the CNC miller can accept) fiberboard can generate 169 unit chips (Figure 3(d)) and takes an hour to mill. Using a simple design, unit chips were put together within a short time, as shown in Figure 3(e). Using more unit chips, one can construct a small space structure, as shown in Figure 3(f). By relocating the slots on each unit while retaining the shape of the units, the smaller shelter shown in Figure 3(g) can be created. One can imagine that, if the unit chips have different shapes, then additional possibilities for assembling a variety of forms exist. This is an intriguing topic, which may be appropriate for a future exploration. In addition, if one sprayed mortar on top of the shelter as an exterior finish, the lifetime of the small shelter could be prolonged significantly. Finishing methods are yet another topic for future explorations and discussions.

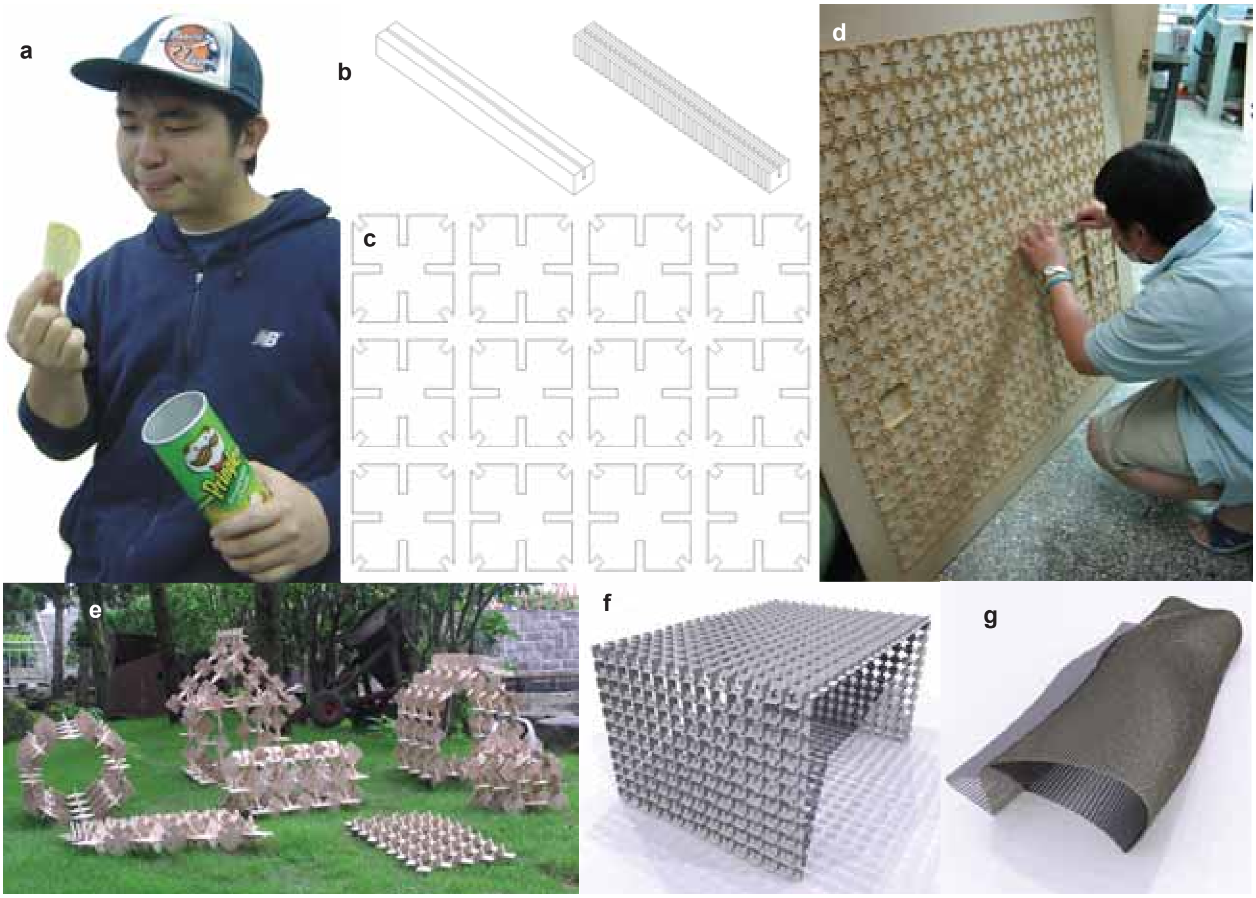

Figure 3: Fabricating unit chips and using them to construct a variety of space structures. (a) through (e) by Chia-Chi Hsieh; (f) and (g) by Ching-Hang Lee.

All the projects that have been presented here can be done easily through the use of a personal computer, a 3D modeling program, and an inexpensive CNC miller. The friendly environments created by today's CAD software benefits the students by allowing them to focus on their design creativity, as it allows them to easily make revision and to verify the validity of their candidate design solutions. Also, in spite of the missing gravity from today's computers, virtual designs can be materialized in the real world using the available CAM devices. We may also take another look at architectural components such as walls, windows, and doors, and be able to uncover more "possibilities" in component based design [3]. The assembly of such "custom design" components may generate different types of architectural designs.

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For a biographical summary of Chen-Cheng Chen please see page 108.

form•Z in Digital Design at the University of Waterloo

by Thomas Seebohm and John Cirka

Foundation Course

Currently, we use **form•Z** to build a strong foundation in three-dimensional, digital design and modeling with a required course in the second term of the first year in the four-year undergraduate, pre-professional program. This year we increased the emphasis on design eliminating a project, without a design component, that required modeling, interpretation and presentation of an existing house, from the recent past, featuring design excellence. As in previous years, the final term project that was an entry to the 2007 Steel Structures Education Foundation Design Competition. In addition, there were exercises intended, in each case, not only to impart basic modeling skills, but also to facilitate design skills using three-dimensional modeling.

New this year is an adaptation of John Hejduk's nine square plan design exercise adapted to three dimensions by adding two floors to make a three-dimensional grid of 27 cells. The intention of this first exercise was to ease the students into three-dimensional modeling with transformation operations only: primarily move, and navigating around the virtual model/ virtual space. Other constraints such as snapping were also included. Additionally, they were asked to output using traditional architectural drawing representations: axonometric (plan oblique), orthogonal views, cavalier projections (elevation oblique), which **form•Z** can provide (and no other three-dimensional modeling package as far as we know).

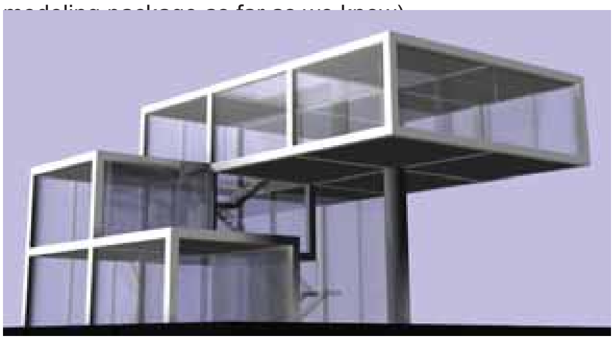


Figure 1: 3D Nine square grid design, Richard Kim.

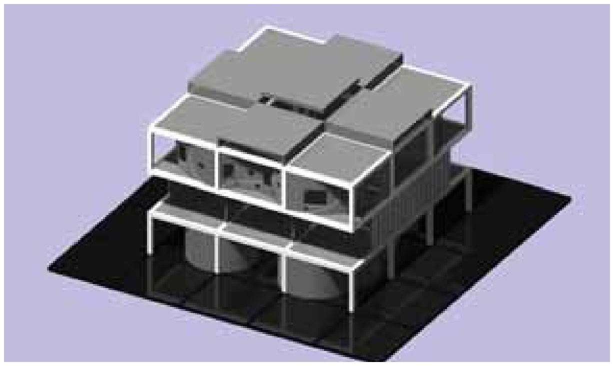


Figure 2: 3D Nine square grid design, Richard Lam.

At the same time, this exercise is a design exercise in the spirit of Hejduk's original exercise introducing students to the idea of an abstract architectural language of elements, relationships between the elements and the grid with powerful precedents in architectural discourse such as the famous essay by Rowe on the "Mathematics of the Ideal Villa" (Rowe, 1995). Although, as has since been remarked, this exercise deemphasizes material and program, these omissions can be justified in considering the limited time available in an introductory course (Love, 2003). That is not to say that other elements such as furnishings, lighting and materials cannot be added in later exercises. Some examples of the nine square grids are shown in Figures 1-3. Somewhat later in the course another exercise focuses on detailed design of a structural steel connection thereby addressing the structural issue also glossed over in the nine square grid exercise. Figures 4-6 show some examples.

Some submissions for the final term project are shown in Figures 7-10. At the level of three-dimensional modeling skills, the intention of the course is that the principles of three-dimensional modeling and dexterity in their use are sufficiently strengthened with the design exercises and the final project that the students will readily be able to learn other three-dimensional modeling software or use what they have learned to advantage on their co-op work terms that all Waterloo architectures students participate in every four months.

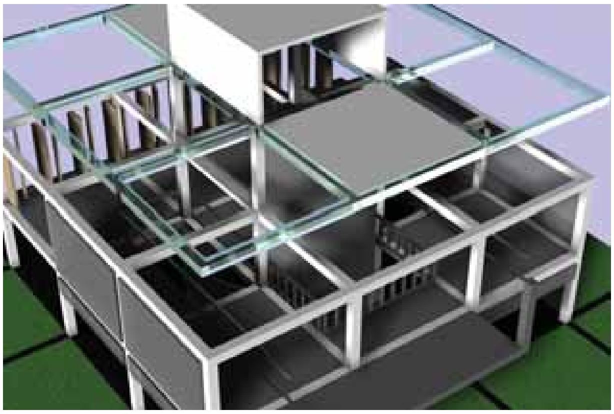


Figure 3: 3D Nine square grid design, Chris Mosiadz.

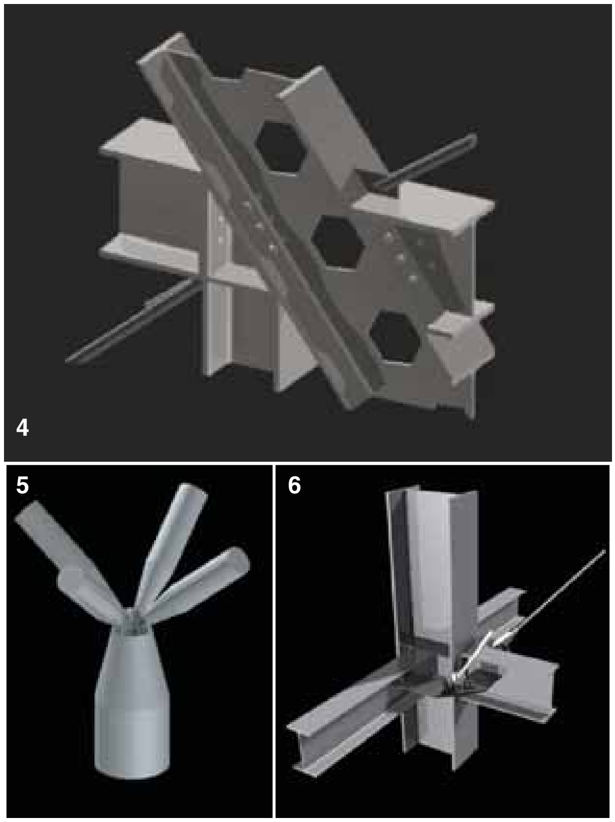
Beyond the Foundation

We realize that this one required course, though a strong foundation, is no longer sufficient to adequately train students in the diversity of digital tools that are available and new design methodologies that are being developed in academia and practice. On the one hand there is a need to simply introduce students to more software including presentation software such as advanced Photoshop, Illustrator and InDesign and other three-dimensional modeling software and rendering software, while on the other, there is a need to advance the theoretical underpinnings of digital design and new methods of design.

What are these theoretical underpinnings? As will be explored further below, fundamental is the understanding that digital design is a process of human-computer interaction based on an understanding of the human design process and how digital processes can support and expand design capability. Also fundamental is that digital design is a three-dimensional process involving the assembly of three-dimensional components rather than drawing two-dimensional representations such as plan, section and elevation. Digital design is an iterative process (as is the traditional manual process) where alternatives are generated and selection is made of the most appropriate design. Digital design opens the possibility to more complex geometrical design and hence the principles of geometric constructions, of proportion, and of constructing curvilinear shapes, including the use of scripting to form a basis of digital design. Digital design allows selection of the most appropriate design alternatives by testing with simulation software for such aspects such as lighting and energy consumption.

The solution to the dilemma of the seemingly conflicting demands to introduce more software packages and to teach the underpinnings of design is to teach both in one course using various design exercises. This solution also avoids the problem that teaching the use of new software packages is generally not considered adequate subject matter for a university course (just as learning a specific programming language is not in a computer science curriculum) because it is vendor specific and not focused on general principles underlying the software. Some examples illustrating the principles underlying three-dimensional modeling software are: polygonal model representation in terms of object, faces, edges and vertices; basic modify operations such as move, copy, mirror; solid modeling with Boolean operations; the concept of nested symbols, instances or blocks; and curvilinear modeling with Non-Uniform Rational B-Spline (NURBS) surfaces and other surfaces.

Given that digital design tools, particularly as they become more sophisticated, should be seen as untrained design assistants who have to have everything explained to them, it is clear that the more we ask these assistants to become involved in the design process the more we have to be able to articulate what the process is. The problem, therefore, is that design as currently taught in design studios is based on critiques of the final product rather than on the process. We must therefore learn to make the design process more explicit in studio teaching in order to provide the theoretical underpinnings of digital design and new methods of design.



Figures 4-6: Structural steel details, by (4) Chris Mosiadz, (5) Shane Neill, and (6) Eric Tai.

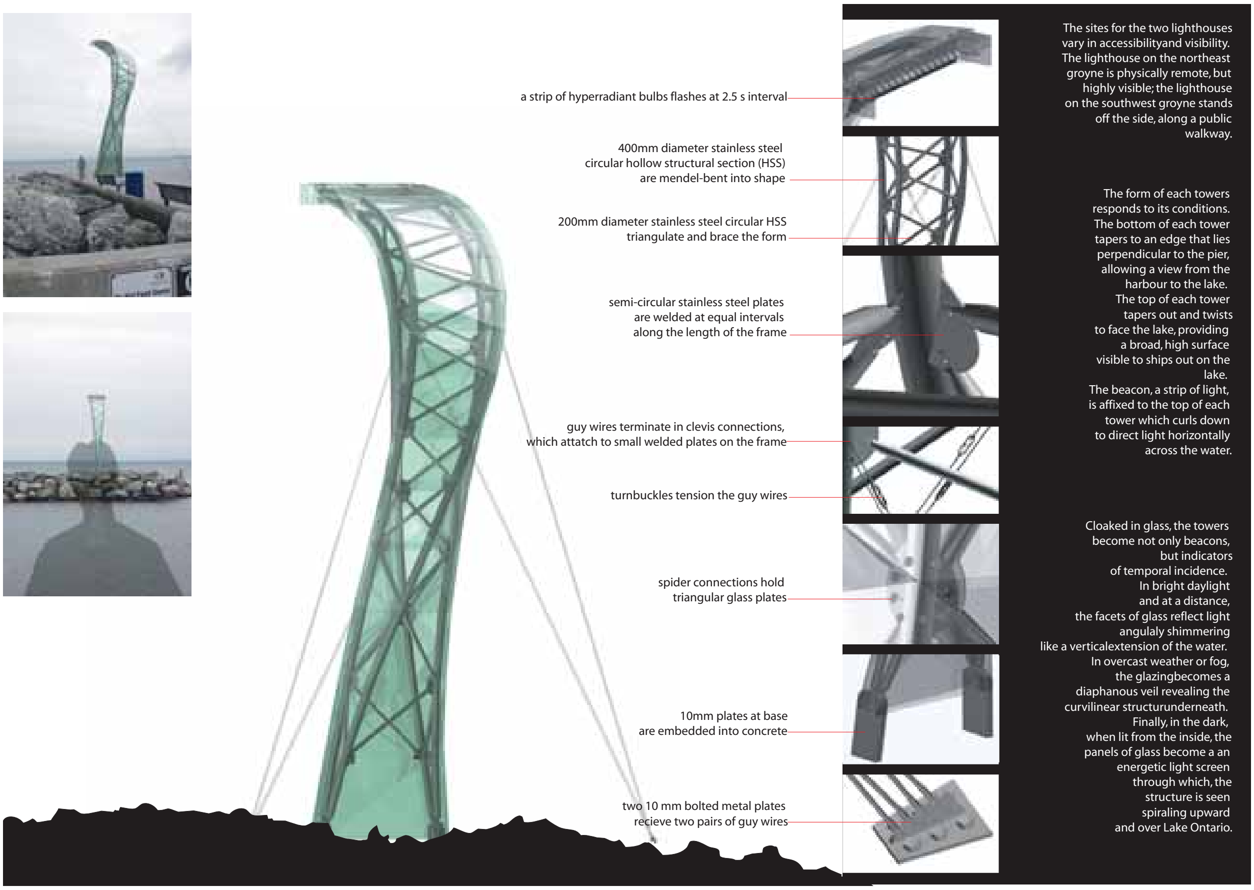


Figure 7: Final Tower Project, Neill, Bragg and Manchester.

Three areas of design teaching that can be made more explicit and supported by digital processes are: visual reasoning including the iterative design process, characterized so well by Archea as puzzlemaking in his memorable paper entitled: “Puzzlemaking: What architects do when no one is looking” (Archea, 1986, Seebohm 2007); learning of domain design content; and conceptual reasoning leading from design issues (requirements) through design concepts to the form of a design (Oxman, 1999, 2003). To clarify what each of these three areas are, consider each in turn. By describing visual reasoning as puzzle-making, what Archea essentially said is that architects proceed in a trial and error fashion, where they behave as if they are designing a puzzle in which neither the puzzle pieces (architectural components) nor the way the puzzle pieces are to fit together (the combinatorial rules describing the formal design language) are known. Architects behave this way at the outset of a design process because they do not know what solutions they are seeking, given that architectural design problems are not completely defined and allow many possible solutions. The search is for a puzzle that will have desirable effects and meets design requirements. Learning design domain content includes knowledge pertaining to the building type being designed and its context. For example, for multiple-unit housing design there are housing typologies, unit typologies, entrance lobby typologies, fire exiting requirements, social issues, sustainability issues and structural design considerations. In addition, domain content should include much knowledge that is often considered inexpressible and left to intuition but of which much can be stated explicitly and tested as Christopher Alexander has shown with “A Pattern Language” (Alexander, 1977).

Conceptual reasoning leading from design issues though design concepts and finally design form focuses on the linkage between “visual reasoning and conceptual processes” (Oxman, 1999a). These processes can be made explicit and knowable by constructing knowledge structures (diagrams of nodes and links showing relationships between issues, concepts and forms and the many stages in-between) to make explicit “the structures of knowledge employed in design thinking” (Oxman, 1999b). Oxman and collaborators are exploring digital tools to support the learning and use of knowledge structures in design.

In addition to making design processes more explicit in design teaching in order to make it possible to support these processes with digital tools currently used, being developed or yet to be invented, there are also explicit new methods that are enabled when designing digitally in three-dimensions. Among these methods is a current flourishing of parametric design alone or in combination with scripting that promises to dramatically extend the capabilities of the designer.

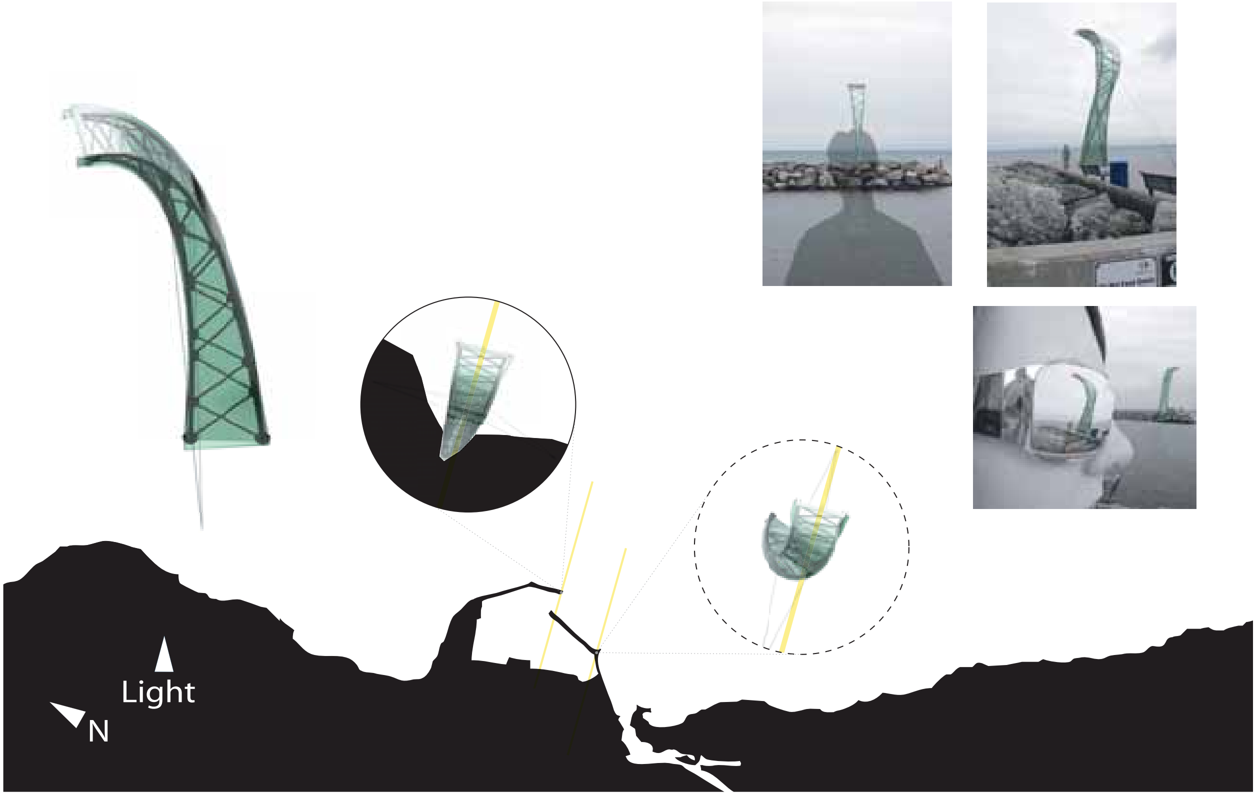


Figure 8: Final Tower Project, Neill, Bragg and Manchester.

Recent explorations in parametric design in the area of urban design by the Berlage Institute are particularly convincing (Berlage, 2007) while Generative Components from Bentley has been used to make systematic inroads on parametric curvilinear design with an innovative teaching approach based on snippets of scripts documented as patterns that are archived as web pages created with Wiki (a server program that allows users to collaborate in creating web content) with clearly stated objectives that others can learn from by adapting the scripts to their uses (Woodbury, 2007, Qian, 2007).

A Course Building on the Foundation

To extend the computing skills of all architecture students as well as going part way to providing a more explicit theoretical basis, we offer an elective course, Digital Design, that will soon become a required course (Seebohm, 2007). This course capitalizes on the strengths of digital tools for which there are no traditional hand-drawn equivalents such as an iterative, three-dimensional design process, curvilinear design and simulation of lighting performance. Moreover, the course provides digital methods that enhance traditional design approaches as in the use of color, proportion, and the use of grids.

While **form•Z** forms part of this course including providing experience in advanced curvilinear design, other software packages are also used to extend digital design experience. Some examples of other software packages and the design skills they can be used to teach are: Sketchup for quick preliminary design exploration, Carrara for fast global illumination making possible lighting studies of interiors including color studies; Ecotect in combination with Radiance for more accurate quantitative and qualitative lighting design studies of interiors; and ArchiCAD for an introduction to Building Information Modeling and its use in design development (not just construction documentation).

Conclusion

To summarize, **form•Z** is currently the foundation upon which our digital design teaching is based, but our digital design teaching is being extended by other software to complement the strengths of **form•Z**. That is, **form•Z** must now be seen in a larger evolving context of digital tools and methods. The reason **form•Z** provides such a good foundation is that it allows one to teach all the principles underlying three-dimensional modeling noted earlier (polygonal structure of objects in terms of faces, edges and vertices, solid modeling with Boolean operations, hierarchical symbols etc.), as well as rendering principles including the concept of shaders and even scripting.

Figure 9: Final Tower Project, Dong and Dabov.

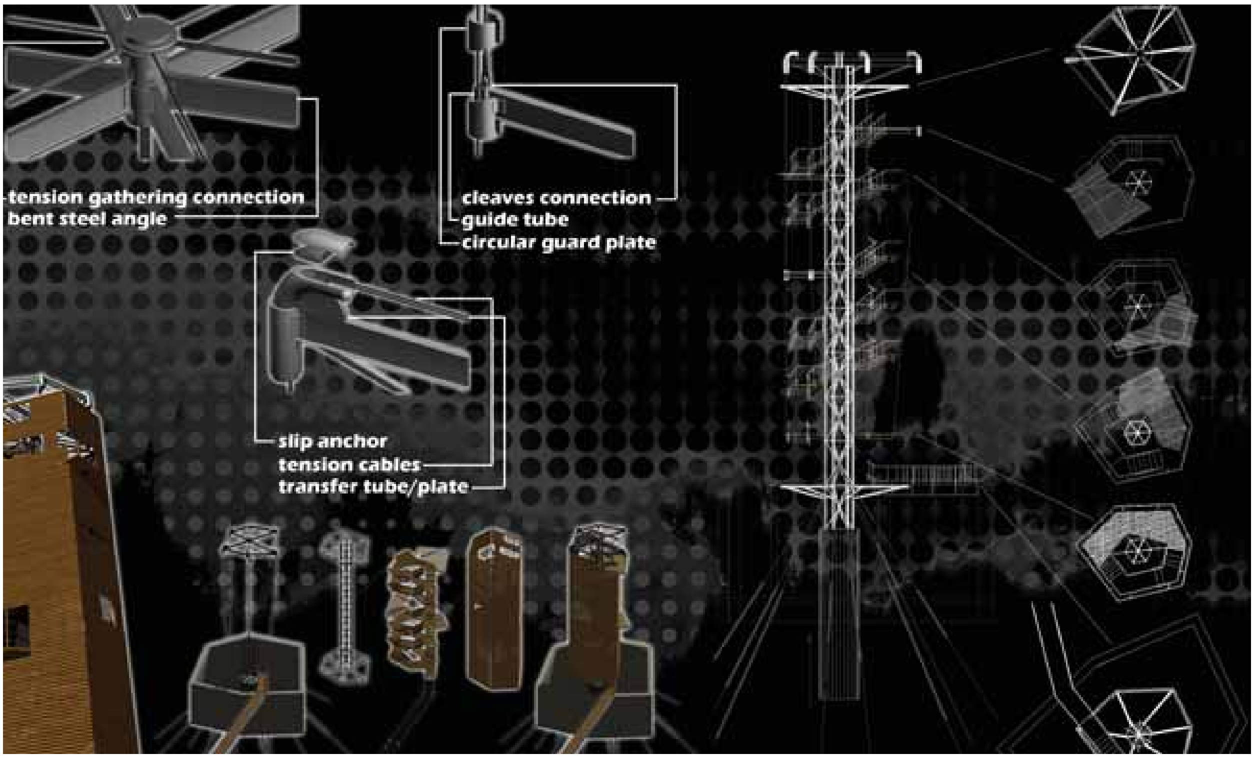


Figure 10: Final Tower Project, Dong and Dabov.

While expanding our teaching, we are formulating a theoretical armature to structure this teaching that will allow incorporation of future developments in digital design software. In this paper we have sketched out the theoretical principles in three groups. The first group consists of the principles underlying digital design, namely that digital design is a process of human-computer interaction, that digital design is primarily an iterative, three-dimensional process, that digital design is founded on rigorous geometric principles allowing complex geometric forms, that digital design allows design to be tested in many ways not possible otherwise and that it makes possible the generation of designs with scripting charting completely new territory. The second group concerns the three areas of the design process that need to be made more explicit to allow support by digital assistants, namely visual reasoning, acquisition of domain knowledge and the linking of conceptual and visual reasoning by the process of issue-concept-form (ICF) pioneered by Oxman. The third group is concerned with the principles underlying current digital design software. As this mostly concerns the use of three-dimensional modeling and simulation software, it consists of the principles underlying three-dimensional modeling software as embodied in **form•Z** and of various types of simulation software (energy, lighting, acoustics, structure etc.). To this third group one should add the principles of computer programming as the foundation for scripting in the different scripting languages offered by various three-dimensional modeling programs.

As a conclusion regarding whether of not the foundation course with **form•Z** can be considered a success, we are pleased to point out that this year's edition of the course led to an award of excellence and an award of merit in the steel tower design competition with which we started this paper, not to mention similar awards in previous years.

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Thomas Seebohm's research interests involve digital technology to design a more holistically conceived architecture and urban environment as is necessary for a more sustainable future. His current research foci are 1) digital architectural design, including digital design in academic studios and practice 2) digital lighting design using physically accurate lighting simulation and rendering software 3) rule-based form generation 4) double shell tensegrity structures including their form generation, stability, visual qualities (when supporting light filtering panels) 5) digital urban design with a special interest in the use of 3D, real time, virtual city models for designing, sustainable, livable cities with community participation. Given the importance of natural lighting in sustainable architecture, Thomas Seebohm's current focus is on designing sustainable buildings and cities using digital energy simulation software taking as input 3D digital representations of buildings and urban fabrics. Dr. Seebohm is a registered architect and professional engineer.

John Cirka is an Assistant Professor in the Department of Architectural Science, Ryerson University. He graduated from Carleton University with a B. Arch. and from Columbia University with an M.Sc. Arch. During more than two decades in architectural practice, John advanced architectural design production with the introduction of digital technologies. He has won awards for his design visualization work. His areas of teaching include digital design theory and practice, history and theory of architecture, and materiality and detail design. John's areas of research include advanced digital design techniques, building simulation and time-based studies. Of particular interest is the intersection of complex geometries, phenomena and temporal experience, and the materiality and methods of building. He is currently conducting research for his dissertation in architecture and philosophy.

Kanto-Gakuin University
Yokohama, Japan

Fields of Study in the Department of Human Environmental Design (HED)

by Takashi Nakajima

The Department of Human Environmental Design in Kanto-Gakuin University aims at educating professionals who are capable of creating and/or organizing human lives and living spaces in ways that are sensitive to the environment and respectful of every individual, especially those that may be weak.

There are approximately 100 students enrolled in the department and our four-year curriculum leads to a Bachelor's degree in Human Environmental Design (HED). The students are grouped in three fields of study according to their interests; these are Life Design, Residential Environmental Design, and Environmental Conservation Design. A goal of the students in the Residential Environmental Design, both Architects and Planners, is to pass the Governmental Qualification Exams within a few years after graduation and after they complete the required practical experience. In addition, there are also several students who complete their training as industrial designers, costume designers, and display designers.

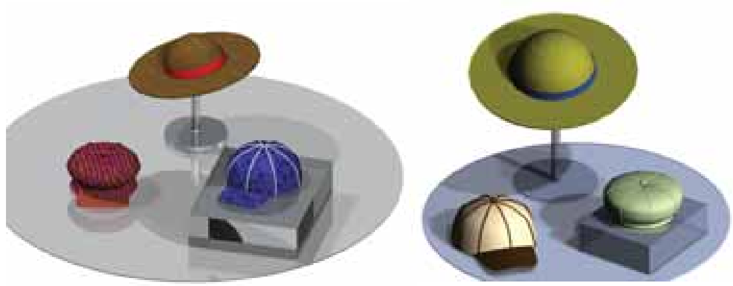
Due to the diversity of career interests among the students, the three digital and eight non-digital design studios deal with a wide variety of design projects whose focus range from toy design to landscape design. In our eight paper studios, students begin with hand drawing techniques and they also learn to do need analysis and architectural programming. They go through the traditional design process step-by-step, and toward the end, they are also trained in design production management.

Digital Studio Orientation

The digital studios place emphasis on teaching computer techniques, which, by today's standards, help produce successful and efficient design solutions. In practice, a most important skill is communication. In Japan, the need for a designer to be able to communicate properly is two-fold: he needs to communicate with professionals at manufacturing and construction sites, and he also needs to communicate with non-professionals, such as the clients and/or the future users of a building. In regards to professionals, one of the most important communication documents is 2D drawings. Also, 3D digital models (either in axonometric or perspective) are considered more important than physical models in Japan. A second very important consideration is participation of all the concerned parties in the design decision-making process aimed at forming a consensus. One of the most efficient methods to achieve this consensus is through the use of digital models that allow evaluation of the various alternative possibilities.

To develop the students' abilities to communicate their designs and to reach consensus, the department offers three digital studios. The first studio (CAD I) teaches 2D CAD software, specifically AutoCAD. This course is considered an introduction to computer usage in architecture. Studio courses are taken in the second semester of the freshmen year. The introductory architectural drawing course taken in the very first semester after enrollment is intended to teach how to use CAD programs for drawing plans and elevations of a single story residential unit.

The second studio (CAD II) is taken during the first semester of the sophomore year and covers 3D modeling with **form•Z**. In this course, the first exercise is to design and model a die placing polygonal blocks on the die's faces. This allows students to practice visualizing objects in a 3D space through a 2D display screen and how to manipulate the views. Then students further develop their 3D skills by modeling objects from our daily life, such as toys, cups, clocks, lamps, chairs, tables, houses, etc. Designing these types of small objects does not necessarily require significant computer skills, as they are relatively simple objects to design.



Figures 1, 2: Different forms, colors, and textures for hats and caps.

Figures 3, 4: Different colors and textures for a house in an environment, by Yoshioki Kambayashiand Sanae Ishii.

Figure 6: Interior design simulation: No2 case, Kenichi Nakano.

Figure 7: Interior design simulation: No3 case, by Yuko Otaki.

The emphasis in these exercises is on visual simulation. The choice of form, materials, colors, and fitness to the environment are judged through accurate renderings (see Figures 1-4). That is, when a particular design project is given, students are also expected to decide on an environment where to place their object. Using rendered images as backgrounds in 3D space, they try and evaluate different volumetric solutions that include color and textures. Through these exercises, students learn how to use the computer for conceptual design.

The third studio (CG•Rendering) is offered in the second semester of the sophomore year and helps students strengthen their 3D presentation skills. In this studio, in addition to **form•Z**, Photoshop is taught and is used to refine the renderings produced by **form•Z**. Specifically, Photoshop's masking techniques are utilized often, which helps reduce both the modeling time and file size that are normally required by **form•Z**. The final project of the studio also requires interior renderings of a commercial unit, including materials, colors, textures, and lighting. These are intended to provide a rather complete feel of the interior space (Figures 5-7).

Figure 5: Interior design simulation: No1 case, by Takahisa Morisaki.

Frequently Used form•Z Functions

In CADII, a chair model and a house model are used to evaluate both the interior and the exterior, as they relate to the surrounding environment. Students select and scan a photograph and then use it as a background environment. When inserting the 3D object in the photograph, the 3D viewpoint is determined using the Match View operation (Figure 8).

In these types of visual exercises, the ability to cast shadows is one of the most important features. An invisible object is placed on the background photo and receives shadows, which appear to be part of the environment (Figure 9). This shadow casting technique is particularly important for freshmen students who typically have difficulty perceiving 3D space. In general, architectural spaces are initially conceived as 2D layout plans. A 3D digital model with shadows is then placed onto a 2D background image, and this is the moment when students' visualization of 3D space typically begins to improve. This perceptual experience of reading 3D through 2D represents a positive moment within the evolution of a student's learning.

Figure 8: The Y chair and the coffee table are placed by using Match View, by Ayaka Kitajima.

Figure 10: A BMP file with an alpha channel is attatched on the glass to draw a figure on it, by Minori Goto.

Figure 12: **form•Z** lighting function Projector simulates a large TV screen, by Kaoru Hirabayashi.

Figure 9: The 3D Y chair casts its shadow in the 2D photo, by Takahisa Morisaki.

Figure 11: A BMP file with an alpha channel is attatched on the glass to write letters on it, by Takahisa Morisaki.

Figure 13: **form•Z** lighting function “glare” simulates spot lights on the counter, by Minori Goto.

In professional interior design practices, figures and letters often decorate glazed doors and windows. To achieve the same effects in the virtual world, color images are mapped with alpha channel (Figures 10, 11). Lighting design is also as important as interior finishes and for some types of commercial buildings even more important. The light modeling tools in **form•Z** are quite effective for simulating various lighting effects. For example, Light Glow and Projector are features that provide visually interesting modeling possibilities (Figures 12, 13).

To place a building next to a group of existing buildings, which is useful when wanting to evaluate the impact of the new building on the environment, the surrounding buildings are modeled as volumes and, for the details, photos of the façades are mapped as decals, which reduces the modeling time required significantly (Figure 14).

Figure 14: The new building (the tallest) is modelled in detail in 3D, while the others are simply decaled with facade photos, by Takahisa Morisaki and Azuma Seki.

Research Projects

One of the oldest and largest Buddhist temples in Kamakura City is Kenchouji Temple. In 2003, we attempted to model its entrance gate (Sanmon) for an exhibition on Kenchouji Temple at Tokyo National Museum (Figures 15,16). The intent was to visualize its very complex wood structure, particularly the joint systems. Thousands of pieces modeled with texture, as well as relief patterns were assembled together. Part of this process was presented as a **form•Z** animation (Figure 17) with finely-rendered images that were very effective.

Another research project dealing with the evaluations of the landscape of an urban waterway bank wall was also produced with **form•Z**. One-hundred-and-eighty-degree panoramic photos were taken around a target point, which corresponded to the landscape of both sides of the waterway, and modified walls were inserted, intended to improve the landscape (Figure 18). The evaluators navigate around the landscape and observe the effects of the modifications in color, form, and texture. Since its initial completion in 2003, this simulation system has been further refined and is now significantly more accurate.

Buildings and other structures tend to remain in our physical environment for a very long time. Consequently, a designer has the responsibility to deal with design sustainability considerations in several different ways. In particular, new landscape designs should be examined thoroughly for their suitability, with the understanding that the urban landscape belongs to all the people that live in the area. This is where highly accurate and detailed digital models are required before the construction of a new design in order to be able to evaluate the impact. Consequently, it is important that universities offer their design students opportunities to learn accurate 3D modeling techniques.

We have also spent time modeling the Kanto-Gakuin School campus, which consists of approximately 50 buildings. This was intended for the evaluation of the impact of a proposed new building. As was mentioned earlier, while the new building was modeled in detail, the elevations of all the existing buildings were modeled by mapping photos of their façades as decals.

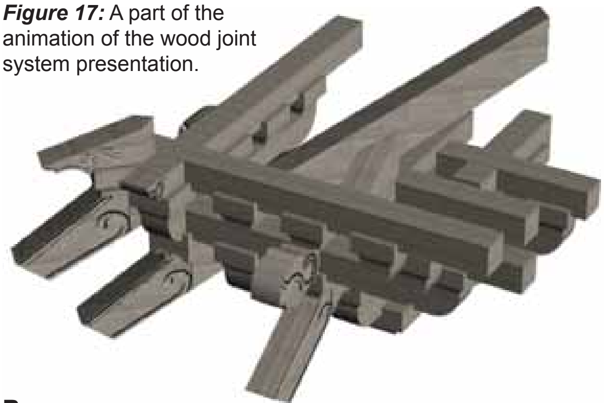
Figure 15: Gate of Kenchouji Temple.

Figure 16: A close view of the gate of Kenchouji Temple.

Figure 18: Panoramic view of CG animation using VR to evaluate landscape design of water way bank walls.

Figure 19: Analysis of the urban profile with the new proposed building (the tallest on the left side) in the university.

Figure 17: A part of the animation of the wood joint system presentation.



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Takashi Nakajima is a graduate from the Department of Architecture, Waseda University of Japan '68, PhD in CE from UIUC '72, Taught architectural design studios and CAD courses at School of Architecture, Laval University, Quebec,'71-'99. Nakajima is now teaching CG and CAD courses as well as Residential Environment courses at the Department of Human Environmental Design, Kanto-Gakuin University, Japan, 00~. He worked as a staff member of CAD divisions in Construction Companies for many years. Research topics include the following; Simulation of human behavior in architectural spaces; Landscape evaluation by CG simulations and 3D model construction of Japanese traditional buildings; The most recent topic deals with evaluations of environmental aspects of Japanese traditional building materials.

Architecture for Zero-Gravity: A Habitat Orbiting the Earth

A Masters Thesis Project

by Zachary Meade

Architecture can be defined as the manipulation and organization of materials to delineate specific spaces that allow for new realities. These spaces spawn new sensory perceptions and emotions. They allow us to experience views, light, and the earth through a new perspective. A simple tree house allows a child to see her own backyard from a new height. She is able to experience the leaves of the tree, the shade it casts, and the light as it trickles through the entanglement of branches and foliage. The tree house allows the child to experience what she has only aspired to experience before its existence. Such is the nature of architecture; it is an apparatus that allows for new perceptions of physical surroundings, a manipulation of form that exalts and expands the mind of the user, and a catalyst for an expansion of awareness.

Gravity is a prerequisite that has always been an influence in architectural design. Architecture has evolved over thousands of years as a resistance to the force of gravity. Gravity determines what we are capable of. It determines form, and it determines the nature of architectural space, as we know it. If we take away this assumption, then it can be argued that we are able to study architecture in a more pure form, this being a series of spaces in a three-dimensional environment. This project is a study of the nature of architectural space in an idealized and pure form.

This project is a hybrid between realistic limitations and conceptual ideals. It partly lends itself to both, but it is not entirely restricted to either. The goal of the project was to prove that conceptions of zero-gravity habitats built for users that wish to experience life in Earth's orbit can be realistically designed to enhance the experiences of these users. These conceptions are meant to grow beyond contemporary technological constraints that restrict existing space stations to the engineering limitations that govern them. These conceptions should be based on the needs of inhabitants instead of the limits of engineering. In the future, as technological implications allow, these conceptions will give us a basis from which design implementations can occur.

Figure 1: The proposed habitat orbits the Earth.

In the early conceptual stages of the design process, three-dimensional modeling techniques were used to explore the notion of organic growth in a zero-gravity environment. These explorations allowed for a documentation of one of many explored design strategies. Because there are no limitations on growth in a zero-gravity environment, form is determined by the movement of inhabitants, the organization of spaces, and the management of daylighting among other variables. Zero-gravity habitats are allowed to respond to these variables more directly without spatial limitation. The resulting forms could conceptually become organic in nature, resulting from a more direct response to these design variables (Figure 2). The virtual explorations of this kind of growth were made to represent the movement of users in organic arrangements of form. Virtual modeling allowed for varied conceptual notions of how these forms may evolve.

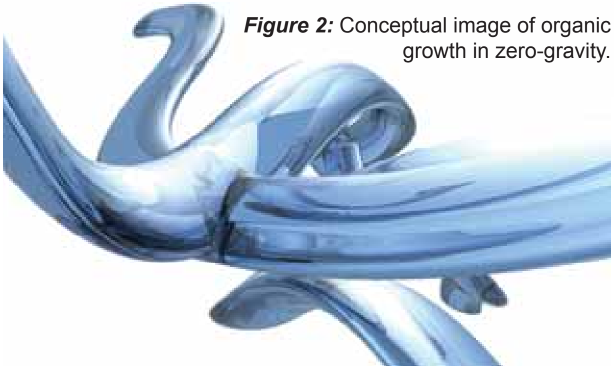


Figure 2: Conceptual image of organic growth in zero-gravity.

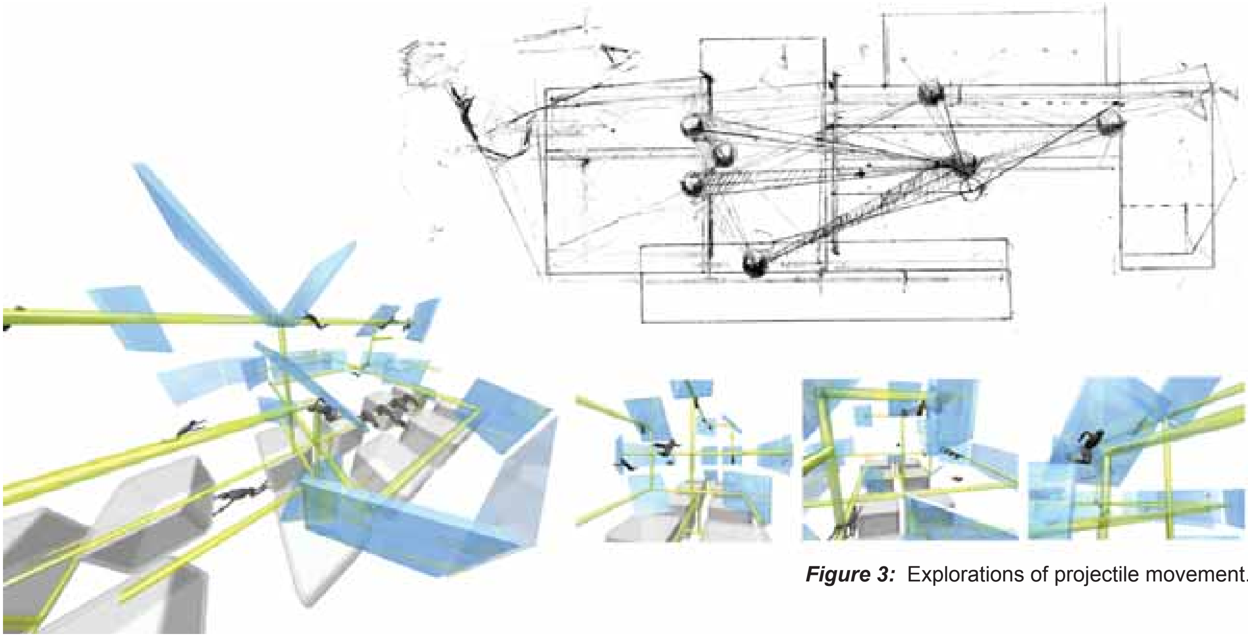


Figure 3: Explorations of projectile movement.

Following these explorations came the identification and mapping of movement the inhabitants of a conceptual zero-gravity environment. A simple program was developed both in a physical model and a computer generated three-dimensional model. The projectile movement of users was proposed and mapped throughout the environment in both models (Figure 3). Nodes of projection were identified and delineated with planes. These planes began to develop into a larger form, which became the basis for the final design (Figure 4). This three-dimensional mapping was essential for the development of this particular design strategy. Specific determinations of the implementation of projectile movement became apparent in the computer model and the advantages, and accordingly disadvantages, of this strategy were revealed. In the virtual realm, the paths of the users took life in all dimensions. They were able to grow out of two-dimensional sketches and take on actual form.

Figure 4: The explorations began to develop form.

The final design project (Figure 5) was completely developed in computer-generated three-dimensional space. The design consists of a 20-person habitat orbiting the Earth at a determined inclination with spaces for living, working, relaxing, and recreation. The habitat was developed in a virtual environment to help eliminate preconceived notions of a ground plane from which structure must grow. The three-dimensional model has no absolute “top” or “bottom”. Instead, it simply has a side facing the Earth and one that faces away. The interior orientation of the users is not constant throughout the habitat. It skews and manipulates to best facilitate user utilization, proper adjacencies of spaces, and the shielding and filtering of light. Accordingly, a virtual three-dimensional model was needed to fully explore what the experiences of the users would be in specific spaces with varying local orientations.

The form of the habitat is directly related to the site variables discussed. Spaces are organized around two main circulation corridors. Particular arrangements of form allow for views to Earth or stars depending on the use of space. View corridors were established and subjected to a layering technique of spatial arrangement that filters light throughout the habitat from active to more private spaces. The result is a varied and complex arrangement of forms that directly relates to the comfort and well-being of the user. Virtual modeling techniques of extrusion were used to explore and refine the varied spaces throughout the habitat. They allowed for quick tests and studies of how the implementation of adjacencies affected user experience.

Of particular interest was the development of the residential nodes that rest along the Earth-facing side of the habitat. A form was developed for these nodes that allows

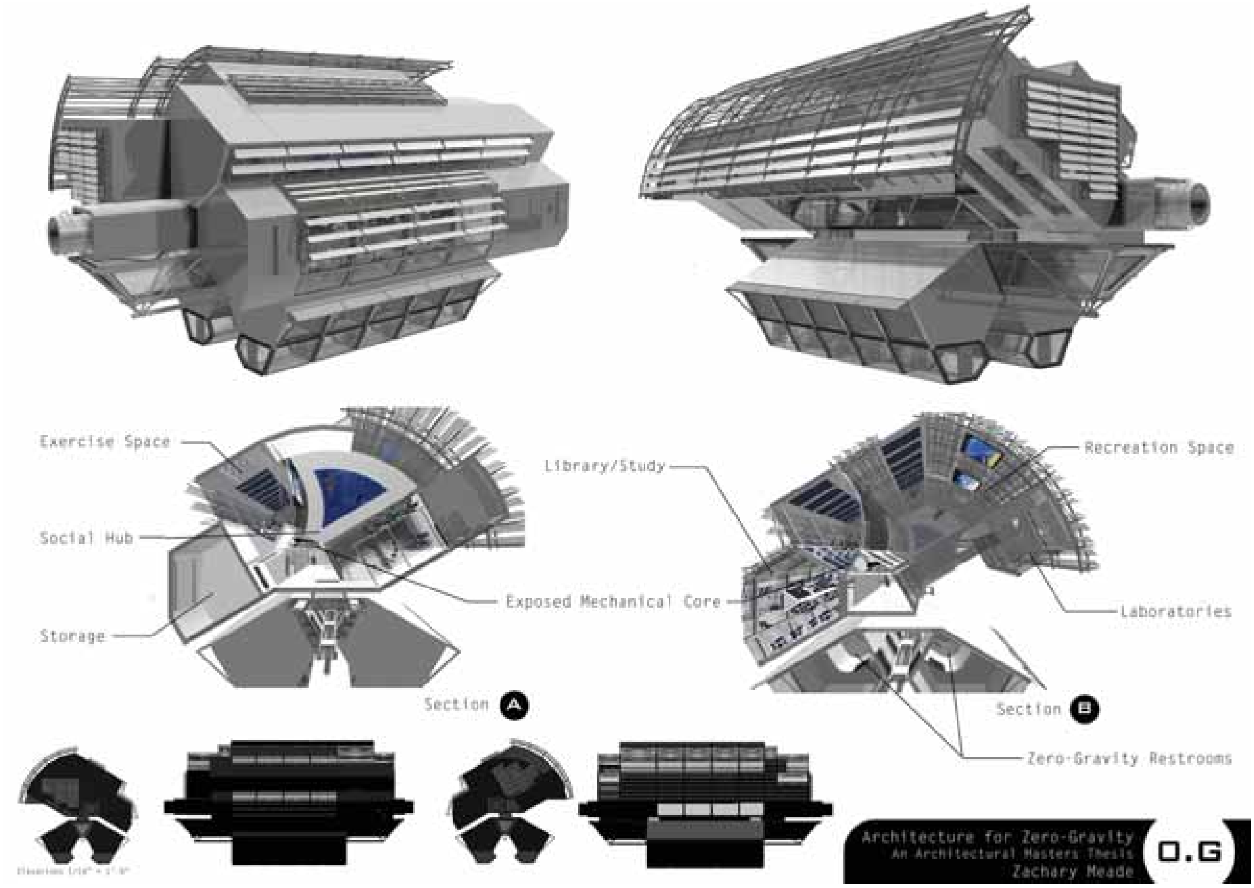


Figure 5: The final design of the habitat.

the users to determine individual orientation within the space. This form can be utilized in a minimum of three different orientations. Users are able to personalize these spaces and create individual environments that best suit their living habits. These forms were developed in the virtual realm and duplicated. By rotating different versions of the same form, multiple perceptions of orientation were explored.

In addition, three-dimensional modeling allowed for the exploration of the nature of interior space in the habitat. Several spaces were developed to the extent of imagined habitation. These renderings illustrate specific examples of the implemented design strategies and the design intent. Without interior exploration, the habitat appears simply to be an odd arrangement of forms without defined meaning. By developing interior spaces, meaning and explanation of form is clearly illustrated.

This project was realized to its full potential only because of the use of computer generated three-dimensional modeling. From conception to final design, techniques and strategies were explored using this medium that would otherwise have been either ignored or developed only to a limited potential. These design strategies became an integral part of the design process. The nature of the project itself demanded a mastery of the relationship of form and the elimination of an absolute orientation. The virtual explorations allowed for the successful implementation of these.

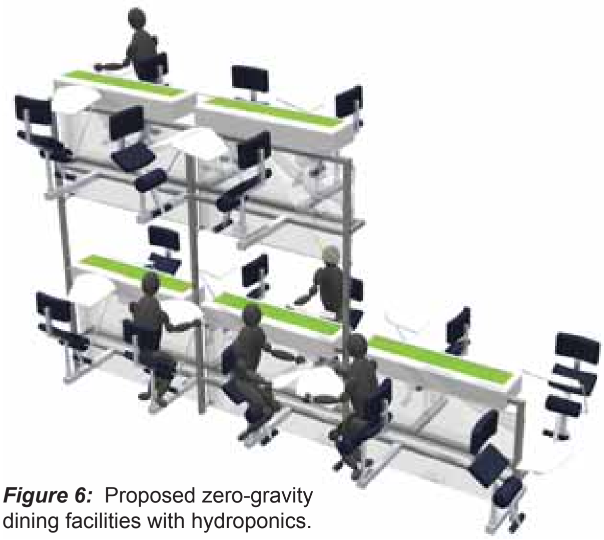


Figure 6: Proposed zero-gravity dining facilities with hydroponics.

The project is a response to the site; it acknowledges and reacts to it. Though no soil and topography exist from which the structure must grow, less tangible site variables produced a very tangible and ultimately intriguing design. With the absence of gravity, the additional design variables become exaggerated. The user is enhanced and the architecture is allowed to better suit her needs. The form in itself becomes more pure and more responsive to utilization. This project was a study of the basic principles, which guide the manipulation and delineation of space.

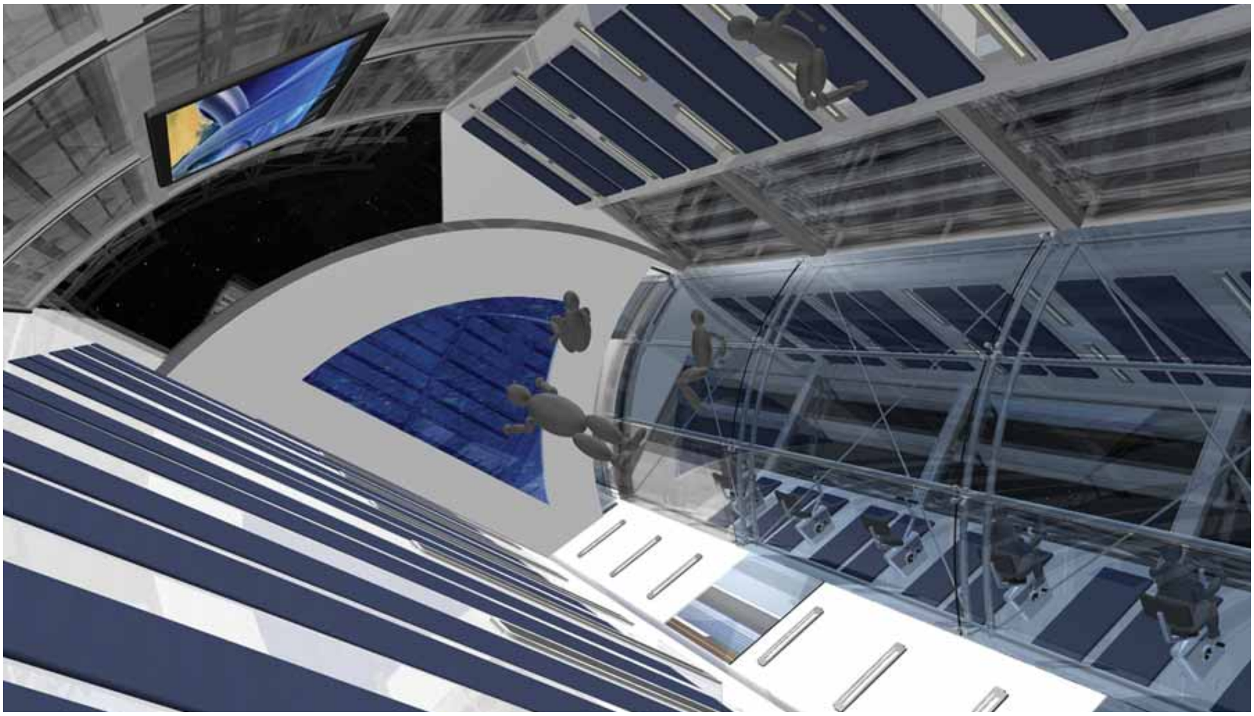


Figure 7: Recreational Facilitiy.

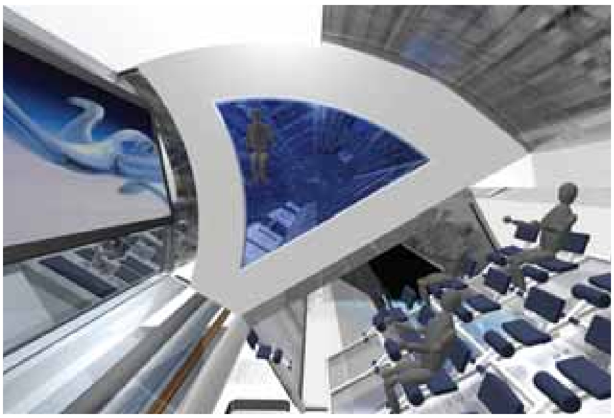


Figure 8: Social Hub with water wall.

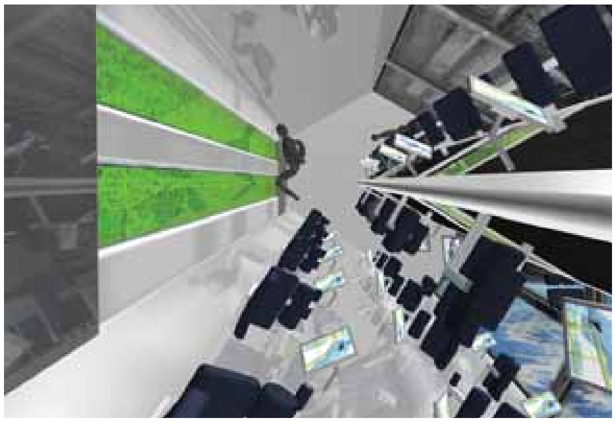
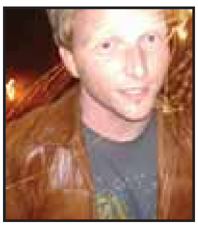


Figure 9: Library with hydroponics.



Zachary Meade received a Masters of Architecture degree in 2007 from the Newschool of Architecture and Design in San Diego, California. His architectural education began in 2003, when he studied architectural history and participated in an advanced urban architectural studio for a semester at Lund University in Lund, Sweden. He is currently working in Wellington, New Zealand pursuing his goal of becoming an architect and learning varying design methods and construction techniques across the world. He actively engages in virtual modeling in his spare time, and is seeking to advance the practice of utilizing virtual techniques in conjunction with photography and two-dimensional graphic media to produce works of art. It is his hope that virtual technology will eventually be recognized as both a practical and inspirational method in all areas of design.

form•Z

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University of North Carolina at Greensboro
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Rhode Island School of Design
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• Clemson Architecture Center
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University of Tennessee
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University of Wisconsin at Milwaukee
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University of Wisconsin, Marathon County
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• Sydney College of the Arts, PI: Andrew Speirs

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Universidade de Brasilia
• Faculdade de Arquitetura e Urbanismo PI: Neander F. Silva

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CEGEP de Saint-Laurent
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Université Laval
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University of Manitoba
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University of Waterloo
• School of Architecture, PI: Thomas Seebohm

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Universidad Nacional de Columbia
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Denmark's International Study Program
• Architecture and Design Department, PI: Anna Yust
The Royal Academy of Fine Arts
• School of Architecture, PI: Henning Orbak

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Germany
Deignlabor Bremerhaven
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Fachhochschule, Potsdam
• School of Architecture, PI: Bettina Dittemer
Staatliche Hochschule für Gestaltung Karlsruhe
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Technische Universität Darmstadt
PI: Asterios Agkathidis
Universität der Künste Berlin
• Department of Architecture, PI: David Steiner

Greece
National Technical University of Athens
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Guatemala
Universidad Francisco Marroquin
• Facultad de Arquitectura, PI: Hector A. Santamarina

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Holon Academic Institute of Technology
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Istituto Statale D'Arte
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Kokushikan University
• Department of Environmental and Civil Engineering PI: Yoshihiro Kitagawa
Nishinippon University
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Tokyo Kogakuin College of Technology
• Architecture Department, PI: John F. Leaver III

Latvia
Riga Technical University
• Division of Descriptive Geometry and Engineering Computer Graphics, PI: Modris Dobelis

Mexico
Universidad Iberoamericana
• Departamento de Arquitectura, PI: Irma Soler

Netherlands
Gerrit Rietveld Academie
PI: Christiaan Thiel
Hogeschool voor de Kunsten, Utrecht
• Product Design, PI: Jan Harm ter Brugge
Koninklijke Akademie van Beeldende Kunsten
• Interieur Architectuur, PI: Frans Willingers

Norway
Kusthøgskolen, Oslo
• IT Department, PI: Trine Wester
Norwegian University of Science and Technology
• Faculty of Architecture and Fine Arts, PI: Knut Rø

Saudi Arabia
King Fahd University of Petroleum & Minerals
• Department of Architecture, PI: Yahya Al-Najjar

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Dankook University
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Hongik University
• College of Architecture, PI: Uk Kim
Kookmin University
• Department of Architecture, PI: Kyung H. Lee
Namseoul University
• Department of Architecture, PI: Kun-Soo Oh
SungKyunKwan University
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Switzerland
EPFL Lausanne
PI: Michel Herzen
Haute Ecole d'Arts Appliqués
• Department of Interior Architecture, PI: Rémy Bochet
Hochschule fürTechnik
• Architektur, PI: Peter Weber
Swiss Federal Institute of Technology Zürich
• Department of Architecture
PIs: Serge Bilgeri, Marc Angélil, Dirk Hebel
Universitá della Svizzera Italiana
• Accademia di Architectura, PI: Enrico Sassi
University of Applied Sciences and Arts Zürich
• Departments of Interior Design and Product Design PI: Barbara Berger
Zürich Hochschule Winterthur
• Department of Architecture, PI: Amadeo Sarbach

Taiwan
Tamkang University
• Department of Architecture, PI: Chen-Cheng Chen

Thailand
International School Bangkok
• IT Department, PI: Larry Maddams

Turkey
Mimar Sinan Fine Arts University
• Department of Informatics, PI: Salin Ofluoglu

Uganda
Uganda Martyrs University
• Faculty of Building Technology and Architecture PI: Mark Olweny

United Arab Emirates
American University of Sharjah
• School of Architecture and Design, PI: George Katodrytis

United Kingdom
Architectural Association School of Architecture
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PIs: Michael Weinstock, Julia Frazer
Bath Spa University College
• Bath School of Art and Design, PI: Roger Clarke
Glasgow Caledonian University
• Department of Engineering, Science and Design PI: Philip Orme
Leeds Metropolitan University
• School of Architecture, Landscape & Design
PIs: Rupert Bozeat, Andrew de Feu
Ravensbourne College of Design and Communication
• Interior Design Environmental Architectures Program, PI: Layton Reid
Royal College of Art
• School of Architecture and Design, PI: Hilary French
University College of London
• The Bartlett School of Architecture, PI: Jean Garrett
University of Edinburgh
• Architecture; School of Arts, Culture and Environment PI: Richard Coyne
University of Strathclyde
• Department of Architecture, PI: Scott Chase
University of Wales Institute, Cardiff
• School of Art and Design, PI: Jonathan Brake

2011 Riverside Drive • Columbus, Ohio 43221
phone: (614) 488-8838 • fax: (614) 488-0848
e-mail: formz@autodessys.com • www.formz.com