Architectural Research Centers Consortium

THE REACH OF RESEARCH

ARCC 2005

Spring Research Conference

MISSISSIPPI STATE UNIVERSITY
COLLEGE OF ARCHITECTURE, ART AND DESIGN - JACKSON, MISSISSIPPI

2005 ARCC Spring Research Conference

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Architectural Research Centers Consortium
Purpose and Mission

Architectural Research Centers Consortium, Inc. is an international consortium committed to the expansion of the research culture and infrastructure in architecture, planning and related disciplines. Since its founding as a nonprofit corporation in 1976, ARCC has represented a concerned commitment to the improvement of the physical environment and the quality of life.

As an organization of researchers and research centers, ARCC sponsors workshops, sustains networks and exchanges information and experiences intended to help build a research culture and infrastructure – in architecture schools and beyond.

2005 ARCC spring Research Conference
The Reach of Research

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David Perkes, Mississippi State University

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ARCC Research Conference 2005 Best Paper Award

The Board of the Architectural Research Centers Consortium designates one conference paper as the recipient of the Best Paper Award.

The 2005 Best Paper Award is:

"Material Matters: Seeking Collaborations Between the Building Industry and Innovative Architectural Practices" by *Franca Trubiano, College of Architecture, Georgia Institute of Technology.*

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Former Dean and Professor
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Senior Director, Grants & Development
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Keynote Address:
Research in environmental design is at the core of great architecture

Donald Watson, FAIA
Dean and Professor Emeritus
Rensselaer Polytechnic Institute

In the past 100 years, architecture has been advanced by research by architects, educators, scholars and researchers. Research has created the knowledge base of architectural professional practice.

The term "research" here is defined broadly, as an analytic habit of mind undertaken to establish knowledge that informs the design of the built environment. It encompasses many ways to develop architectural knowledge, including scientific and applied research, scholarship argued from evidence, and systematic design studies that explore alternative possibilities. Villecco and Brill (1981) offer a similar definition, describing *environmental design research* to include development of rigorous theories and principles, evaluation and documentation of findings, translation into policy design guidelines and/or creation and critical analysis of design alternatives.

This tradition of research in environmental design needs to be better recognized and honored. The multifaceted methods and venues that contribute to this tradition have been diffuse and ill defined. This may have advantages of encouraging wide latitude for creative forms of research, adaptable to a creative and dynamic profession. A disadvantage is that the vital role of research and its contributions to architecture have been undervalued and—one might speculate that as a result—have been underfunded.

The following commentary presents an overview of the past century of contributions to architecture and environmental design research. Far from a complete inventory, it is sufficient I hope to offer evidence of the rich tradition of environmental design research.

******

About one hundred years ago, Frank Lloyd Wright published *Organic Architecture*, proclaiming that design of "furniture, building, setting and environment" should be conceived as an organic unity, "all things together at work as one thing," anticipating by fifty years the definition of environmental design. Early in his career, Wright published portfolios of drawings and designs. At the same time in Europe, Sant'Elia and Marinetti published the *Futurist Manifesto* and Tony Garnier published *Cite Industrielle*. Each exemplified the **architectural portfolio** as a means to advance ideas through drawing and publication of visionary plans and projects.

In the 1920s, a profusion of **architectural manifestos** inaugurated the modern movement (Conrads 1984). Every architect, it would seem, set forth a list of design principles, anticipating research topics of ensuing decades: function, technology, health ("hygiene"), solar design and climate. Hannes Meyer, appointed by Gropius as the first "head" of architecture" at the Bauhaus, established a curriculum of design as "systematic research," giving emphasis to predesign investigation of context and conditions. Although controversial for not giving intuitive art exploration its due, he was considered the first to grasp the importance of science in the education of a designer (Schnaidt 1965).

The **study tour** was part of every architect's education from the time of the Renaissance, including aspiring architects of the new modernism. C. Londberg-Holm, who later was to formulate the Sweets catalog, photographed wheat storage buildings from the American farmland which reportedly influenced aspiring modernists of the Bauhaus. Alvar Aalto began his career with a European study tour with particular interest in hospital design. His travel studies informed his early masterworks, including the Tubercular Sanatorium at Piemo (1929). Aalto wrote of the architect's obligation to "do no harm," anticipating by more than a half century the current interest in environmental ethics (Ventre 1990).

Le Corbusier documented his wide-ranging study tours in sketchbooks. He described the design process as a "patient search," similar to what Donald Schon would much later define as "design as inquiry" (Schon 1983). Aalto, Le Corbusier, Gropius and Breuer included analysis of sun angles, climate and daylighting in their designs. Richard Stein, author of one of the signal books of the 1970s, *Architecture and Energy*, told of working in the Gropius office in Cambridge, drawing hour-by-hour sun angles to fine-tune the shading trellis of the Gropius home in Lincoln, MA. The interest in sun and climate was continued in the 1930s by Richard Neutra in California (Neutra's "Health House" designed for Philip Lowell dates from 1929). George and William Keck's work began as model houses built as **demonstration prototypes** for several Chicago expositions (Crystal House 1932 and House of Tomorrow, 1933), a mode of innovative practice exemplified by Paxton's Crystal Palace at the Great World Exposition of 1851. The Crystal House was warmed by the sun, an unanticipated result that began a series of investigations by the Keck Brothers in the pre-WWII era of what became popularly described as "solar houses."

The 1930s also saw interest in new materials and "prefabrication," exploring factory production. Among the most original innovators of these and ensuing WWII era, R. Buckminster Fuller developed radically new concepts of structures and fabrication for housing, transportation and urban structures. The geodesic dome and lightweight tensile structures were developed with support of the U.S. Army during WWII, and subsequently by industrial sponsors. Fuller, calling design "anticipatory science," reached post-WWII generations of architects through seemingly indefatigable visits to schools of architecture throughout the world.

After WWII, John Entenza, editor of *Arts & Architecture,* initiated a program to promote modernism in house design through Case Study Houses, a multiyear program of demonstration prototypes. From 1945 to 1966, twenty-six Case Study houses were built, including designs of Pierre Koenig, Charles and Ray Eames, and Eero Saarinen, among others, who contributed to mid-century innovations in architectural structures and materials technology. In the 1950s, Saarinen's office undertook ambitious investigations of materials such Core-Ten Steel (John Deere Headquarters) and of structures (Yale Hockey Rink and TWA Terminal, New York).

These were significant commissions, where the importance of the project was extended by research and development in architecture and engineering, essentially creating **large-scale architectural prototypes.** Not unlike the great works of public and private architecture of other historical periods, this exploration benefited from a confluence of ample budgets, willing clients, and significant collaboration of manufacturers and contractors. In this same spirit, Roche and Dinkerloo, Saarinen's inheritor firm, designed the 1950s Ford Foundation Headquarters Building in New York City with its garden atrium designed by Dan Kiley to replicate healthy growing conditions for major indoor planting….a full-scale research prototype, which became a precedent-setting model and provided lessons for current-day applications. The Saarinen office provided formative professional experience for younger architects, including James Bradburn, designer of Denver Airport suspension-cable roofed terminal, and Cesar Pelli, architect of many of the world's tallest skyscrapers.

The 1950s also saw formation of **research centers in Schools of Architecture,** including University of Michigan, Princeton, and University of Texas, where Bill Caudill founded the Research Unit that undertook research in daylighting and ventilation. Caudill later founded the firm of CRS, adopting the same proactive approach to design innovation, in this case through practice. At University of Michigan, the research center headed by Ted Larsen took a special interest in the multidisciplinary approaches required in environmental design. At Princeton, the Olgyay Brothers established the architectural research laboratory, focussing upon building climatology.

In the 1950s and '60s, many Schools of Architecture initiated **research in the design studio**, often with guest instructors from other academic and professional disciplines. Examples, to name only a few that resulted in publications of academic research, include Serge Chermayeff at Yale, Shadrach Woods at Harvard, Louis Kahn and Richard Le Ricolais at U. Pennsylvania, Konrad Wachsman at University of Southern California (USC), and Ralph Knowles, first at Auburn and later at USC.

In the 1960s, architectural practices responded to government funding and industrialization opportunities, including Operation Breakthrough of U.S. Department of Housing and Urban Development. Government sponsored research and demonstration (R&D) programs supported **construction product innovations,** by aggregating market demand sufficient to provide incentive for industry investment in R&D of new products and processes. This model was later used in the 1970s with funding from the U.S. Department of Energy to encourage early utilization of solar end energy efficient technologies.

In the 1960s, significant research was undertaken by some **architectural practices that specialized in research**. Building Systems Development (BSD) founded by Ezra Ehrenkrantz and Christopher Arnold exemplified this model of practice. Among its innovative efforts of the era, was the Schools Construction Systems Development (SCSD) project for the State of California. It sought to encourage industry research and development of new products for better schools by issuing performance-based specifications (after research to establish criteria) and by aggregating markets, selecting the same product for multiple schools. Over 80% of construction products used for school construction in the ensuing decades were introduced to respond to this program, a result of what Ehrenkrantz described as **innovation in processes** of construction procurement.

In the 1970s and 1980s, **government-sponsored R&D funding** supported research in architecture and benefited schools with research centers and some professional offices with research capacity. Challenged by national energy conservation goals in late 1970s, the then newly authorized U.S. Department of Energy sponsored a multi-year research program in building design and construction. The American Institute of Architecture established the AIA Research Corporation, directed by John Eberhard. The multiyear funding support and research focus enabled advances in integration of research and design practice, e.g., the DOE code for simulation of building energy use. There was also significant product innovation as a result of research partnerships. For example, MIT School of Architecture Construction Research Center received government "seed funding" to develop high performance glazing. The effort was picked up by industry partners, and ultimately resulted in significant innovations, such as low-e argon filled windows. As a result of this substantial focus of program goals and funding in the late 1970s and early 1980s, U.S. government laboratories, schools of architecture and professional practices produced work that became front rank in international advances in building design and construction.

In the 1990s, new ways to integrate research and architecture became evident in international professional practices. Absent large government funding, private firms in architecture, engineering and construction began undertaking their own research and development. Richard Rittelmann of BHKR helped established that firm's significant role in partnering **advanced building research consortia,** focussing upon very specific innovations for the health and the housing industries. Frank Ghery's office helped in development of CAD modeling with cathode-ray pens, enabling structural computation and manufacturing templates sufficient to analyze and to fabricate complex shapes and spaces, unique to each site and program. Bechtel Corporation, with substantial engineering and construction investments, developed virtual reality modeling of construction process, enabling "4-D" (time sequenced) modeling of a construction project and site. Computer visualization of complex considerations of airflow, light, temperature, fire spread, developed by consulting groups such as Arup Associates, demonstrate that technical analysis and rapid prototyping is possible instantaneous with the point of design conception, so that schematic design can be eat once technically sound and exploratory. These expanded capacities allow architects to integrate environmental design research and design more easily than at any prior time.

Also in the 1990s, new approaches to regional and urban development were prototyped and refined through built work of professionals based both in practice and in academia, resulting in contributions to **theory advanced through practice.** Calthorpe and Partners, and Andres Duany and Elizabeth Plater-Zyberk, are representative of a broad and open collaboration of practitioners, academic-based scholars and researchers focussing upon themes of new urbanism, recalling themes of early twentieth century visionaries.

There remains, however, a gap in finding and accessing knowledge relevant to practice within the same timeframe as afforded by computer aided design tools and within other time and financial constraints of practice. There needs to be more accessible documentation and archiving of what is known and learned (Watson 1999). With broad access to this rich tradition, every building designed today can fulfil the challenge proposed by the title of this talk, that "research in environmental design is at the core of great architecture."

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Productive Accident in Student Analysis of Urban Form and Space

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ABSTRACT

If as educators we are to expect our students to act with confidence within the city as context, we must define and develop modes of inquiry which directly and successfully enable students to engage and understand multilayered, accidental, and experientially superimposed urban relationships. For without such modes of inquiry, we run the risk that our students will fail to appreciate the accidental relationships which are so central to the American urban experience as sources of profound understanding and inspiration. In this paper, I consider successful methods and techniques which my students in two separate courses presently use to analyze accidental relationships which exist in the American city. One of these courses is the first semester of our institution’s undergraduate architectural design studio sequence; the other is a seminar course on visual communication techniques which I offer to graduate and undergraduate students. In both courses, I propose specific modes of inquiry which the students use to make sense of accidental relationships and juxtaposed observations within the city. The techniques invoke structured photography, layered mapping, and multimedia collaging. In presenting each of these modes of inquiry to students, I attempt to frame the acts of gathering and organizing information in support of urban site research so as to heighten the likelihood of productive accident.

1. PURPOSE AND RESULTS

The purpose of this paper is to discuss a specific methodology for urban research and analysis dealing with accidental relationships in the American city. Results of the methods proposed here consist of successful student work completed in two courses taught during the 2003-2004 and 2004-2005 academic years.

2. THE IDEA OF PRODUCTIVE ACCIDENT

As an architectural educator at the University of Minnesota, I have found that many successful architectural design students engage in processes characterized by *productive accident:* the discernment of value from unintended visual relationships within evolving work. Among the examples of this phenomenon which I cite in my paper titled Promoting Conditions for Productive Accident (1) is *superimposition:* for example, two drawings completed to satisfy different or competing agendas may reveal through superimposition new and unintended spatial relationships; or models constructed at a certain scale may be placed into other models built at a different scale, revealing surprising and unanticipated relationships between part and whole.

In urban analysis and research of urban forms and spaces, I believe that productive accident can become critical to the process of making sense of observations. This is because cities are shaped over time in response to multiple, persistent, but often unrelated forces; as a consequence, built urban form may appear strongly accidental in character. I contend here that our responsibility as educators to assist our students in understanding this experience can be met through the *definition of specific modes of inquiry* which engage multilayered, accidental, and experientially superimposed visual relationships.

3. DESCRIPTION OF COURSE STRUCTURE AND FORMAT

3.1 Visual Communication Techniques in Architecture

Visual Communication Techniques in Architecture (ARCH 5313) is an elective seminar course offered to students from all levels of the University of Minnesota's graduate and undergraduate programs in architecture. The course provides an opportunity for students to develop confidence in judging the usefulness of specific representational media in their design processes. I developed this course with the belief that the ability to make such judgments is a necessary precondition to producing deeply felt and convincing architectural design work.

The fifteen-week course is structured around a series of cumulative exercises, formulated in response to two subject-themes: analysis of the local environment and analysis of the remote environment. Students proceed from analyzing the shared experience of the University of Minnesota's Architecture Building to the remote experience of buildings in Switzerland, Japan, and India. At the end of the semester, students submit a portfolio of work arguing a point of view regarding the role of media in shaping their perception.

3.2 Architectural Design Studio

Undergraduate Studio I (ARCH 5281) is the first of a series of required architectural design studio courses for Minnesota students pursuing either a Bachelor of Arts or a Bachelor of Science degree in architecture. The course is instructed collaboratively: as many as six instructors in a given semester take responsibility for groups of as many as eighteen students each.[1] The overall curriculum is established at the departmental level, and the individual instructors provide individual interpretation of the curriculum on a daily operational level.

The studio addresses *modes of gathering* through a concentration on persistent history, social ethics, and material philosophy. Students explore the architectural ramifications of these issues through local precedent studies, full-size investigations of material, and the production of iterative scale models and drawings. Students complete the semester by synthesizing study work into a comprehensive design for a shelter or "gathering space" constructed of stone. The component of this course most relevant to the subject of this paper is the two-week phase titled Landscape, in which students are introduced to the complex urban site within which they are ultimately responsible for proposing the comprehensive design.

3.3 Modes of Inquiry

In both courses (ARCH 5313 and ARCH 5281), I propose specific modes of inquiry which the students use to make sense of accidental relationships and juxtaposed observations within the directly experienced urban environment. The techniques include *structured photography*, *layered mapping*, and *multimedia collaging*. In presenting each of these modes of inquiry to students, I attempt to frame the acts of gathering and organizing information in support of urban site research so as to heighten the likelihood of productive accident.

4. EXAMPLES OF WORK

A project in the Landscape phase of ARCH 5281 requires students to define a path through a selected urban space. At equally-spaced points along the path, each student photographs their surroundings according to precisely defined rules: looking straight down at their own feet, directly to the left and to the right. The resulting photographs are assembled as a collage, which is itself subsequently used as the basis for analytical models. The methodically produced and assembled photographs create opportunities for students to observe unintended spatial and temporal relationships within a relatively abstract graphic composition. Patterns of light and shadow might emphasize, for example, the relatively strong presence of a visible horizon line in one area compared to another; otherwise unobserved symmetries and order might become apparent when the work is considered as a whole. Provided that the students remain alert to possibility, the exercise provides a fresh look at familiar ground.

In Tamer Azazzi's work at Minneapolis's Riverside Plaza housing complex (Fig. 1), several unanticipated relationships became evident: the gridded floor serves as an orientation device (made apparent by the juxtaposition of "straight-down" views showing a rotating grid); bright white columns against a complex visual background recall bright white vertical strips of sky between buildings; facades organized in grids repeat themselves at smaller scales in entrances; and the continuous presence of the walking surface becomes comparable to the continuous presence of strong vertical elements.

Fig. 1

David Wilson, at a site in Minneapolis's Milling District, responds to his initial series of photographs with a figure-ground collage tracing the visible contours of buildings, bridges, railings, and other elements of the built environment which operate to shape space and experience (Fig. 2). The work is remarkable for its direct engagement with the cacophonous silhouette of the urban landscape, as David allows his explorations to be guided in part by deliberate intent (attempting to categorize solid separately from void) and in part by the accidental collisions between adjacent images. The resulting collage is no longer immediately discernible as a composite of several images, but instead becomes legible as a whole, reading strongly as a single continuous reflection upon his urban surroundings. Accidental relationships which emerged from his structured photographs become a jumping-off point for a new and specific understanding of the site.

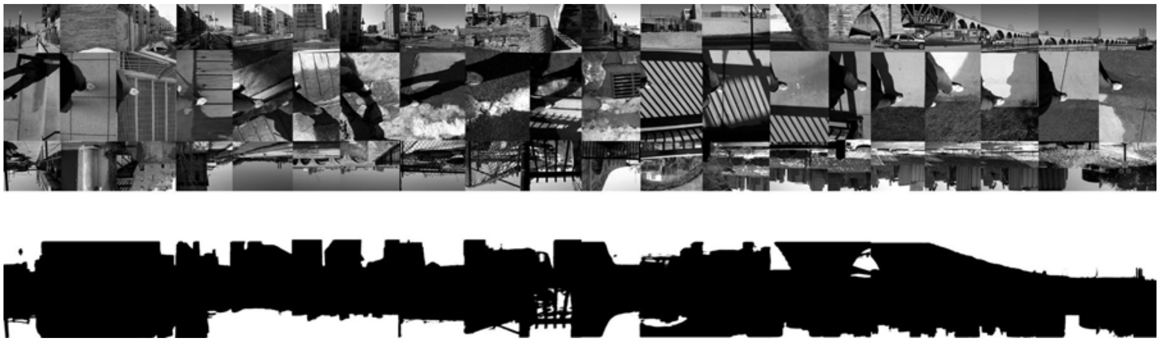

Fig. 2

As another component of the Landscape phase in ARCH 5281, each student conducts on-site reconnaissance in response to which they produce a series of maps at uniform scale. Each map is composed of multiple sheets of translucent paper, and each sheet of paper contains information corresponding to an observation or set of observations. The observations may consist of categorized built phenomena (e. g. constructed streets and paths, building volumes, overhead wires), or perhaps of aspects of experience more difficult to quantify, such as perceived horizons which change over time, perceptions of boundary along a path, and memory evoked by sound and silence.

After her first visit to the site, Laura Malwitz identified a unique location at the river shoreline, at which point the complexity of the site was to her somehow more apprehensible than elsewhere. Her maps (Fig. 3) overlay the presence of built structures and surfaces with speculative drawings having to do with sensory perception. The act of separating observations into translucent layers and then rearranging them heightens the possibility of productive accident: by rearranging the layers, it became possible for her to discuss why and how her perceptions were shaped, and even to speculate as to the possibility of similar experiences elsewhere within the site. The productivity of accident is seen to enable confidence in establishing position and relation to urban surroundings.

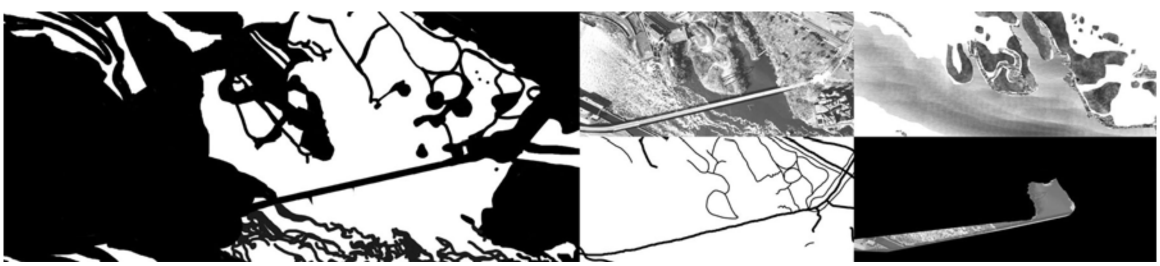

Fig. 3

An exercise in ARCH 5313 asks students to consider the architectural elements which define, frame, and interfere with the perception of horizon, where *horizon* is initially defined to mean a perceptible and continuous line which separates ground from observable sky. Superimpositions of text, color, line, tone, and photograph – some of them deliberate, others accidental – enable the students to address their place in the city while being specific about how the built environment shapes their understanding of relationships between themselves and their surroundings.

Will Spencer's work (Fig. 4) begins with a composite photograph of an urban site in Minneapolis. In an initial image-manipulation, he identifies and categorizes multiple intersecting horizons corresponding to foreground, middle ground, and background; in two subsequent images, he addresses the horizon as the imaginary line of convergence for all other “horizontals” and as the position of a vanishing point. The work is a convincing illustration of productive accident: recognitions of irregular shape, contour traces, shifts in color, and overlays of tone combine to draw straightforward value from complex urban surroundings.

Fig. 4

Nathan Zook begins his analysis (Fig. 5) with a composite photograph of an urban street in downtown Minneapolis. He immediately recognizes and chooses to emphasize through tracing the irregular, accidental shape of the sky. From this recognition, he puts forward (in superimposed text) the suggestion that horizon ceases to operate the way he expected it to and instead becomes something like a vertical horizon. Again, the work is distinguished by its ability to discern value from the unintended.

Fig. 5

5. CONCLUSIONS

As students study the city through artifact collection and production, the graphic arrangement of their findings (whether photographs, maps, or text) will initially suggest importance, prioritization, presence, and memory. But if the students graphically arrange their findings in a way to promote juxtaposition and superimposition of information (e. g. photographs placed adjacent to each other, or atop each other, or overlays of tone and text atop image), the possibilities for unintended relationships to develop are increased and the opportunities for students to learn – *not simply to re-present found content devoid of a contextual understanding* – are immeasurably strengthened. Research findings arranged graphically are collage-like, in that they deliberately superimpose and juxtapose information from different sources, although they possess additional formality and order demonstrating the thoughtfulness and care inherent in research endeavors. This strong combination of formality and order enabling the bringing-into-being of accidental relationships convincingly parallels the evolution of the city and enables students to act with well-grounded confidence.

Sources

(1) Christenson, Mike (2005): Promoting Conditions for Productive Accident. Unpublished (scheduled for presentation at ASCA International 2005).

Endnotes

[1] ARCH 5281 exercises for Spring Semester 2005 developed by Mike Christenson and Kathy Olmstead, based on previous semester work and contributions by Mike Christenson, Naoto Sekiguchi, Ralph Nelson, Mary DeLaittre, Benjamin Ibarra-Sevilla, Jeanne Sterner, Mary Springer, and Malini Srivastava.

STRUCTURAL APPRAISAL: A CLASSICAL WAY FOR LEARNING

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ABSTRACT

Structural Analysis is an important subject in the Architecture curriculum at Temple University. **Structural appraisal projects help a student understand architectural and structural integration, construction and technology, and address practitioners concerns for preparing students for practice.** Projects incorporated in the Structural Analysis course typically focus on the documentation of historic structures. Students survey neglected and/or abandoned historic buildings that are in danger of collapse or demolition. The students are encouraged to appreciate the beauty in abandoned structures rather than view them as eyesores. They are required to integrate sustainable design and building conservation approaches in their solutions. On specific projects, they are required to 1) visually inspect the building and note damage, deficiencies and overall condition; 2) perform analysis of the existing structural system; 3) identify necessary repairs; 4) perform analysis of the building for varying stages of conservation, including associated cost estimates; and 5) determine a new use for the building. The students are encouraged to follow both the intuitive and mathematical paths in their analysis. Example projects include the historic Baptist Temple (from which Temple University is named), farmhouses, greenhouses, warehouses, barns and bridges. The goal of the projects is to illustrate the significant impact of the integration of structure and architecture and educating students about the significant contribution they can make to protect historic structures.

1. PURPOSE OF THE WORK

Teaching structural analysis to architecture students is simply not easy. The concepts are often hard for the student to understand and there is often no simple solution. To help the students learn these concepts, they are assigned a research project to provide a structural appraisal report on a historical structure at the beginning of the semester. Structural appraisal is the procedure of evaluating the capability of the structure for sustained use.[1] The students in the class learn to efficiently organize, coordinate and communicate information in order to convey data necessary for structural analysis. In the field of architecture it is difficult to teach structural analysis where the groundwork consists exclusively of a system of theoretical concepts. Structural analysis is a problem solving activity. Authentic problems are abundant in historic buildings to provide examples. Teaching structural analysis to architecture students requires that the students must develop the aptitude to deal effectively with problems, which occur in real circumstances. A historic building with an exposed structure system provides an excellent case study to directly involve the student in this learning experience. The course emphasis is based on the concept of "how to learn how to learn" from abandoned historic buildings in the built environment of Philadelphia. Temple University architecture students are exposure to of the subject of structural analysis through the class lectures, assignments and structural appraisal project. The purpose of a building's structure is to offer a safe and strong method of sustaining the loads imposed by the

[1] P.F.G. Banfill. Structural Engineering for Building Conservation; Heriot-Watt University, Edinburgh, 2003

building's composition, the building's occupants and their property, and the forces of nature, through a series of load paths down to a sturdy foundation.[I] The subject content addressed in the course include loading determination and evaluation; resolution and equilibrium of force systems; truss analysis, etc. The students learn how to calculate centroids, moment of inertia, and shear and bending moment diagrams. In addition, the students are taught basic beam, column and system design. The course builds on the awareness of the theory of force equilibrium. Force equilibrium stands for one of the most influential concepts in the field of structures for architects, and is the starting point for the learning of structural behavior.[II] For equilibrium in a beam, the externally applied bending moment has to be resisted by the internally produced moment between the tension force and the compression force.[I] The students gain first hand experience about force equilibrium while examining a historic building. At the completion of this course, the students generally have a sound understanding of this concept and are able to utilize it in analyzing statically determinate force systems.

The course is divided into two parts consisting of statics and strength of materials. A principal intention of strength of materials is to acquire an effective connection between applied loads on a non-rigid body and the resulting internal forces and deformations induced in the body. The properties of a variety of structural materials in resisting the applied forces are addressed. Upon completion of the strength of materials section, students gain an understanding of the correct relationship of material strength, stresses, section properties, and deformation derived from the analysis of the load and different support conditions of the structural member.[III] The field observations conducted by students deal with the likely causes of structural failure in the building under investigation and ways of strengthen and repairing walls, piers, arches, roofs, etc.

2. STRUCTURAL DOCUMENTATION

A structure being appraised is by description able to maintain the loads at the moment of assessment.[I] At the beginning of the semester the students do not have the knowledge or ability to undertake the structural investigation work. However, as the semester progressives and the students learn the basics of structural analysis, they gain confidence in their abilities to carry out the appraisal. Particularly important is the introduction of load tracing and how tributary loads act on structural members. The field report is required and is to be supported by many annotated sketches and calculations. The final documentation is approximately 2000 words in length, excluding appendices. The students are taught in the weekly lectures that as future architects they should be taking a leading role in sustainable design, green architecture and building conservation. Through the lectures they start to see the potential beauty in abandon structures that others see as eyesores.

In summary, the scope of the students' research investigation includes 1) visually inspecting the building documenting any damage, deficiencies and overall condition; 2) analyzing the existing structural system to determine code compliance; 3) recognize vital repairs to the existing building; 4) examine the building for varying stages of conservation including associated cost estimates; and 5) determining a new use for the building. The report is to clearly explain the structural system of the building and the way loads, and forces are distributed through the building to the ground. Using the extent and probable weights of the building materials being supported, the students are required to estimate the stress level in one element in each of the following categories: 1) a load bearing wall; 2) a floor system, including joists, boards, any secondary materials; 3) a structural component in the roof, such as a connection, rafter, ridge beam or

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[II] P. Beckmann. Structural Aspects of Building Conservation; McGraw-Hill, London, 1995

[III] B. Onouye and K. Kane. Statics and Strength of Materials for Architecture and Building Construction; Prentice Hall, New Jersey, 2002 purlin; or 4) the foundations at one point where loads reach the ground. Foundation performance is important to all buildings and the students gain knowledge about the basic principles of soil and foundation behavior, outline possible causes of problems including differential settlement. They summarize alternative strengthening procedures in the report. The students are asked to compare the stress level with the likely loadbearing ability of the member concerned and comment on the occurrence of any visible deflection, deformation, cracking or settlement, which might confirm the successful operation of the existing structural system.

3. WORK ACCOMPLISHED

The structural appraisal project is primarily about recognizing how the structural system of the building works.[IV] The project includes field sketches representing elevations, sections, important architectural/structural details, connections, roof framing, ceiling framing, floor framing and foundation layout. Both transverse and longitudinal sections through the structure are sketched, etc. All sketches are to be clearly documented to show all necessary load paths and how loads transfer from point to point. An understanding of the types of loads and forces and the behavior of materials and components is a necessary prerequisite for assessment of a building's present condition and for consideration of engineering alternatives.[V] Therefore, the students report on all structural items and conditions that concerns them and makes suggestions for repair. This process allowed the 2002 class to save two historic buildings scheduled for demolition after presenting their report to administrative officials. The 2003 class analyzed and built two replica trusses of the transept trusses in the historical Baptist Temple. As the contractor was making the field repairs, students gained first hand experience by site visits. The students are encouraged to follow both the intuitive and mathematical paths in their analysis. Each student normally has to make several trips to the site to document and study the structure. They are required to visit the library, city or county building permitting office to obtain the history of the structure and other related information. They are encouraged to obtain advice from consultants when required (i.e., from students in landscape architecture, construction engineering technology, engineering, architecture, etc.). In the fieldwork they utilize digital cameras, levels, lasers, etc. as required. They are required to use structural terminology learned in class when discussing the project and to explain that terminology in their report or when called upon in class. Students take the assignment seriously and gain a general understanding of the integration of architecture and engineering in the process.

4. CONCLUSION

Structural appraisal projects can be used to motivate students to learn about building structures. By researching and investigating a historic building the students have a means to assess what they have learned in the classroom and apply their knowledge to a real project. They learn more through this case study teaching and learning approach than in the traditional lecture course. It is evident that significant progress was made through the course of the semester. This observation prompts the question: how does a student learn to bridge the gap between academics and practice?

5. VISUAL MATERIAL

5.1 Photographs

[IV] P. Robinson. Structural Repair of Traditional Buildings; Donhead Publishing Company, Dorset, 1999

[V] F. Moore. Understanding Structure; McGraw Hill, New York, 1999

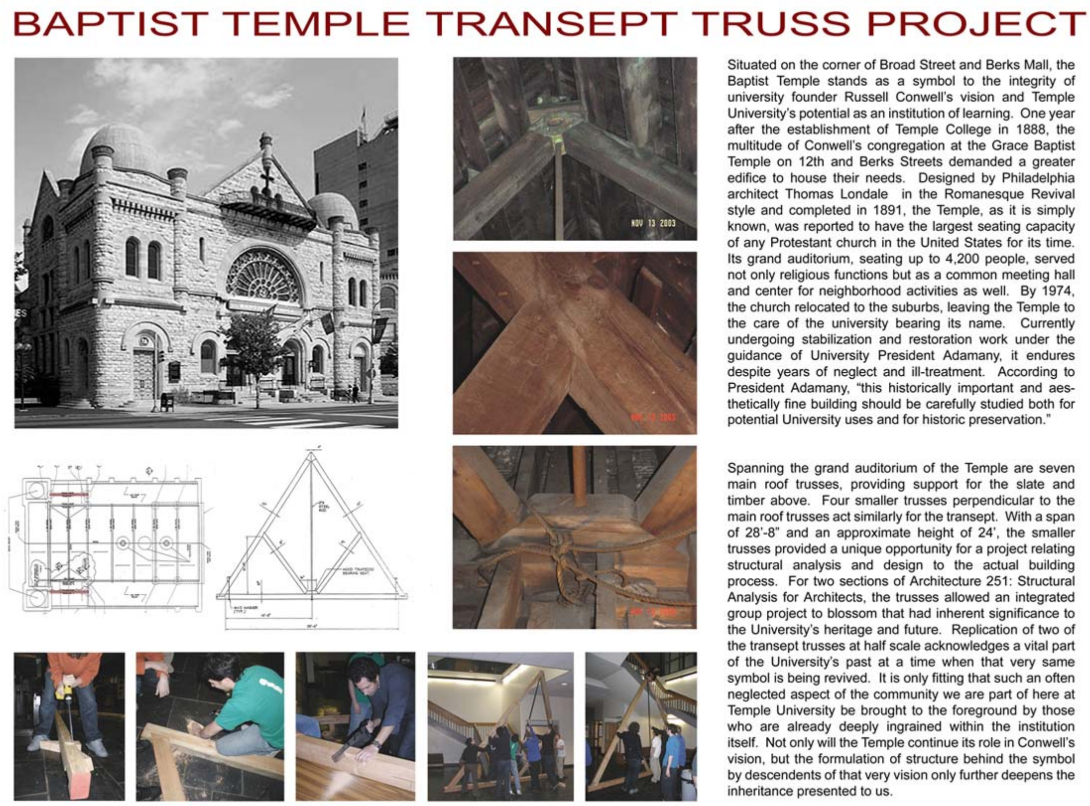

Fig. 1 Baptist Temple Transept Truss Project

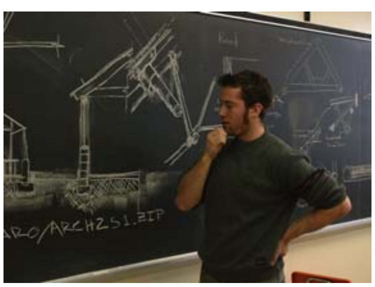

Fig. 2 Ambler Greenhouse Project **Fig. 3 Ambler Greenhouse Project**

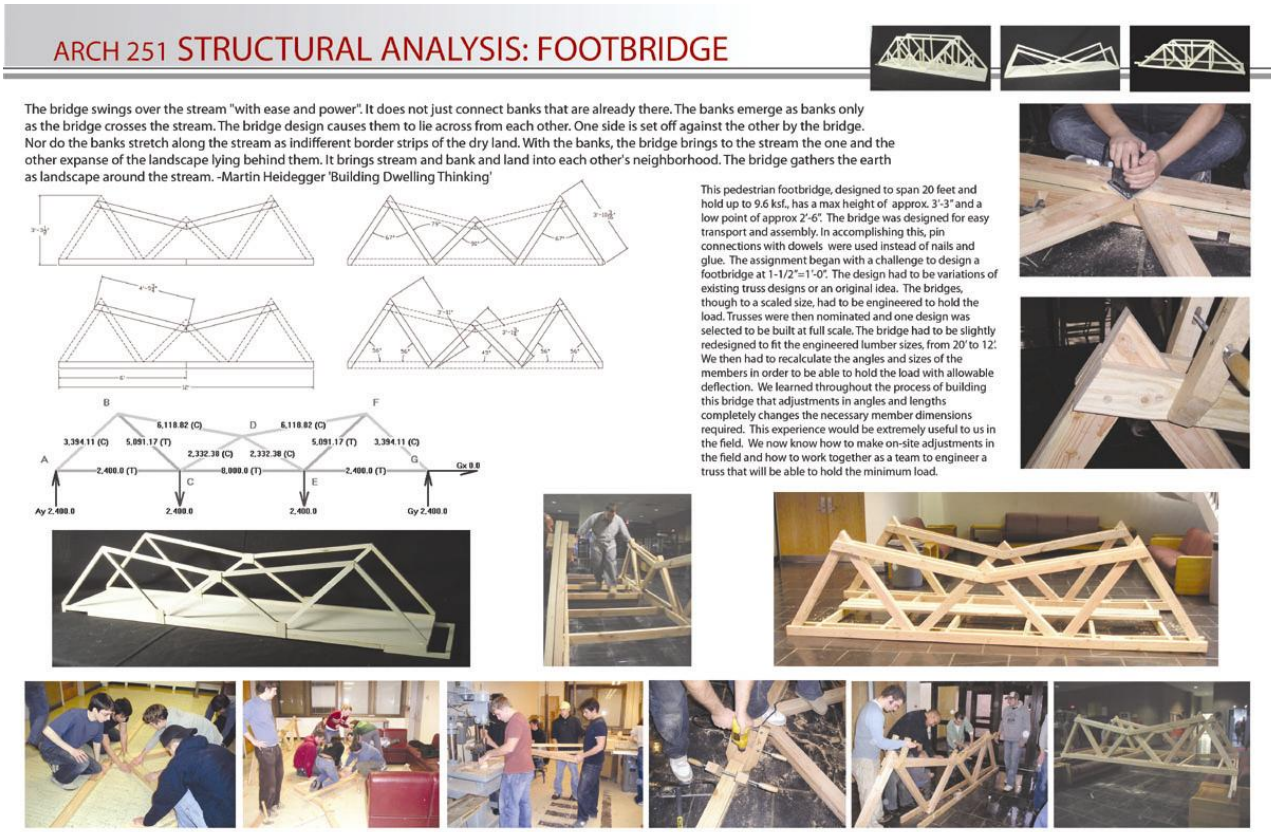

Fig. 4 Footbridge Project

Fig. 5 Spring House Project

Fig. 6 Spring House Project

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Regulating Student Achievement and Learning in Design Studios:
The Goal Regulation Model

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ABSTRACT

Existing models of learning in design studios fail to explain learning or predict achievement in ways that effectively guide pedagogic decision-making. This paper discusses an alternative model of learning in design studios known as the *Goal Regulation Model (GRM)*. The GRM supports the commonly held belief that students learn by doing; however, it extends this idea by integrating it with two educational theories, social learning theory and self-regulated learning, in order to provide a stronger theoretical basis for decision-making. The GRM was derived by combining these two theories, interviewing a range of students, and applying the results in design studio settings. The underlying belief of the GRM is that goals drive a student's learning while self-regulation directs it. The GRM supports this belief and explains its reciprocal effects on teaching and learning. This paper: 1) summarizes the GRM's theoretical framework, 2) describes the GRM's interdependent phases and processes, and 3) presents several guidelines for improving student learning and achievement.

1. INTRODUCTION

Educators will often adopt and utilize a particular teaching approach without necessarily considering the theory that underlies their actions. In landscape architecture education, specifically studios, teachers typically theorize that students learn to design through the process of doing consecutive, increasingly complex projects. In this commonly held view, learning occurs as students gain experience (i.e. knowledge) through the practice of doing (e.g. making mistakes, achieving success, etc.). While theorizing learning as a process of doing is broadly accurate, it does not provide a strong enough basis for guiding the daily actions of studio teachers nor does it adequately explain the fundamental interaction between motivation and achievement. Without a strong theoretical foundation underpinning studio teaching, it is difficult for teachers to justify their practices, measure learning outcomes, and evaluate teaching effectiveness.

This paper offers a new framework for thinking about learning in design studios known as the *Goal Regulation Model (GRM)*. The GRM fits within the notion that students learn by doing; however, it also extends this commonly held belief to include a stronger theoretical foundation for pedagogic decision making and establishes a model for predicting learning outcomes. Two educational theories, social learning theory and self-regulated learning (SRL) provide a basis for the GRM. By combining these two theories, interviewing a range of students, and applying the results to studio settings, a new view into the processes associated with studio teaching and learning emerges.

2. LITERATURE REVIEW

The following sections discuss literature associated with social cognitive learning theory, self-regulated learning and goals in order to develop a theoretical framework for investigating the relationships between student goal use, learning, and achievement. In addition, the literature serves as a foundation for constructing the GRM.

2.1 Social Cognitive Learning Theory

Social cognitive learning theory emphasizes the belief that most learning occurs socially by observing other people. Through social learning, people acquire knowledge, rules, skills, strategies, beliefs, and attitudes (Schunk 2001). Three assumptions of social cognitive learning theory that are relevant to this study include: 1) self-efficacy, 2) learning and performance orientations, and 3) sub-processes including a) self-observation, b) self-judgment, & c) self-reaction (Figure 1).

Theoretical Assumptions of Social Learning Theory	**Descriptions**
Self-Efficacy	Self-efficacy refers to the judgments of one's own ability to perform specific behaviors and attain desired levels of performance (i.e. goals). Self-efficacy is an underlying belief that strongly influences a student's choices and behaviors. It is modified by many factors, such as previous successes and failures at attaining goals (Bandura 1977).
Learning & Performance Orientations	A performance orientation focuses on grades, rewards, and approval while a learning orientation stresses mental challenge, thought development, and metacognition. These two orientations determine the types of goals students will set for themselves with each orientation exerting different effects on a student's self-regulatory activities (Schunk 1996).
Three Sub-Processes: • Self-Observation • Self-Judgment • Self-Reaction	These three sub-processes of social learning begin with a student observing himself or herself in light of goals. Then, the student will judge their own progress, again with respect to their goals and based upon their self-observations. Next, a student will react according to the judgments that they make about what caused, or failed to cause, their progress towards goals (Schunk 1996).

Fig. 1: This chart briefly describes three different features of social learning theory applicable to student goal use and self-regulation.

One distinguishing feature of social cognitive learning theory is the prominent role it assigns to self-regulatory capacities. "By arranging environmental inducements, generating cognitive supports, and producing consequences for their own actions, people are able to exercise some measure of control over their own learning" (Bandura 1977, pg. 13). From a social cognitive perspective, "self-regulated learning involves a sense of personal agency to regulate other influences, such as emotional processes, as well as behavioral and social-environmental sources of influence" (Zimmerman 1995, p.218).

2.2 Self-Regulated Learning

For over 20 years, researchers have studied student ability, motivation, and quality of instruction in an effort to better explain student learning and achievement. During this time, numerous empirical studies focusing on the role of students' personal attributes and the psychological processes underlying their academic learning and performance have increasingly emerged (Schunk and Zimmerman 1994). These studies have led to a growing interest in the concept of self-regulated learning (SRL) as an important variable that interacts with achievement (Zimmerman, 1989). Barry J. Zimmerman (2000), a leading SRL authority, defines the construct of SRL as the self-generated thoughts, feelings, and behaviors oriented toward attaining goals. While conceptualizations of SRL vary, most researchers agree that SRL involves learners: a) having a purpose or goal, b) employing goal-directed actions, c) monitoring their own behaviors, and d) adjusting their learning to ensure success (Schunk 1996).

A critical aspect of SRL is that learners have some choice in the learning situation since SRL varies from high to low depending on the amount of choice learners have and what they choose to do (Schunk 1996). The greater the degree of choice a learner has, the stronger the effects of SRL on learning and achievement. Researchers have been exploring SRL's pedagogic implications through both experiments (Schunk and Zimmerman 1994) and intervention studies (Schunk and Zimmerman 1998) and report compelling results in improving students academic functioning. The last two decades of research has clearly established the validity of SRL as a predictor of students' motivation, achievement, and learning (Zimmerman 2000). Since SRL is especially influential where students have a high degree of choice in their learning outcomes, as they do in design studios, and since a growing body of literature supports the notion that optimal academic achievement is strongly tied to the degree of SRL the learner is capable of exercising (Zimmerman and Martinez-Pons 1986, Zimmerman 1990) it seems reasonable for design educators to consider exploring SRL for its capability of explaining differences in students' learning and achievement in design studios.

2.3 Goals

Success at mastering cognitively complex tasks, like a design project, requires remaining focused and efficient in the face of obstacles and changing circumstances (Barone, Maddux, and Snyder 1997). It is on complex tasks that self-regulatory skills are most important in ensuring success. Goals are the foundation of self-regulation in that we attempt to regulate our actions, thoughts, and behaviors to achieve some desired outcome. Goals provide the standards or reference criteria against which progress is monitored and abilities are judged (Barone, Maddux, and Snyder 1997). When a student's goals are specific but too easy, or when their goals are too vague (e.g. "Just do your best") students fail to perform at their finest (Locke and Latham 1990). Learners that set general goals, distant goals, absolute (unchanging) goals, or nonhierarchical goals will typically become less motivated and successful (Barone, Maddux, and Snyder 1997). These particular properties of goals detract from efforts to self-regulate because: "a) learners who lack specific goals are often unsure about what to do next, b) learners who set distant goals must wait long periods for corrective feedback, c) learners who set absolute goals are often discouraged about their seemingly slow progress, and d) learners who fail to discriminate strategy processes from performance outcomes hierarchically seldom develop high quality technique" (Zimmerman & Schunk, 2001 pg. 295). Regardless of their specificity, difficulty, and proximity, goals will not influence motivation and behavior unless the learner receives feedback concerning how well they're progressing toward their goals (Locke and Latham 1990). When students have goals and are provided goal-based feedback on their progress, then they will perform better than when they have only goals or only performance-based feedback (Locke & Latham 1990).

3. THE GOAL REGULATION MODEL

The GRM is an analytic framework, developed by the author, to help in understanding student learning and achievement in landscape architecture design studios. Since the GRM attempts to show process and predict how learning occurs, it acts as a working model. It is referred to as a *working* model because it's testing and application is ongoing. Essentially, the GRM creates a frame that informs and guides teaching practices while explaining the reciprocal effects of teaching on student learning and achievement.

The GRM shows how a student, through a series of interdependent and reoccurring processes, executes a studio project (Figure 2). Three phases including: 1) planning, 2) performance, and 3) reflection, organize the processes sequentially. At the beginning and throughout each project, a student engages in processes depicted in the model. Figures 3, 4, and 5 below, explain each of the phases and their components in detail. The GRM, like other models of self-regulated learning, predicts a direct correlation between a student's degree of self-regulating behavior while engaging in the processes, and the extents of that student's learning and achievement. In other words, as a student's self-regulating behavior increases in frequency, sophistication, and self-efficacy by becoming a proactive, goal-oriented learner so does their achievement and learning.

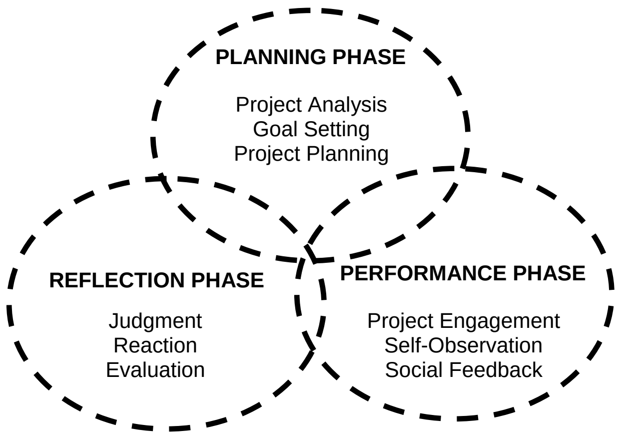

Fig. 2 Shown are the three interdependent phases (Planning, Performance, Reflection) of the GRM, including the major sub-processes associated with each phase.

PLANNING PHASE		
SUB-PROCESSES	COMPONENTS	DESCRIPTIONS
Project Analysis	Project Diagnosis	Student examines the project for requirements, freedoms, opportunities, barriers, and other such information to use in helping set, organize and plan future goals.
	Initial Motivation	Student's level of motivation during the planning phase / beginning of the project. This corresponds to the thoroughness of the project diagnosis, intrinsic interest of the project, perceived relevance, and student self-efficacy.
Goal Setting	Goal Origination	The student's utilization of self-set or teacher-set goals will influence behavior and outcomes. Student-set goals tend to increase motivation and project engagement.
	Goal Motivation	The student's satisfaction and rationale for choosing one goal over another will influence behavior and outcomes.
	Goal Orientation	The student's tendency toward setting predominately cognitive/learning type goals compared to performance/show-off type goals will influence behavior and outcomes. Learning goals tend to lead to lasting improvements in achievement.
Project Planning	Goal Completion	The student's degree of articulation in measuring when and how a goal will be attained will influence behavior and outcomes. The clearer the plan the better.
	Strategic Planning	Student's overall plan for project completion, including time, resources, direction, etc. integrated with and driven by goals.

Fig. 3 Chart showing the Planning Phase and descriptions of the Phase sub-processes.

PERFORMANCE PHASE		
SUB-PROCESSES	COMPONENTS	DESCRIPTIONS
Project Engagement	Self-Efficacy	A student's situation-specific beliefs about their capability to execute successful behaviors. Self-efficacy influences a student's choice of activities and effort, profoundly influencing learning and achievement.
	Design Process	Student's choice of studio-related and project-related behaviors such

	Behaviors	as site analysis, sketching, etc. Efforts should be tied to goals and strategic plans.
Self-Observation	Monitoring	Student's observations of themselves compared to standards (goals) derived from the profession, peers, and other sources. Self-monitoring involves several techniques and influences decision-making. It should be regular and recorded.
	Metacognition	Student's thinking about their own thinking and how this influences decision-making. Helps students evaluate results of monitoring and subsequent reactions.
Social Feedback	Modeling	Learning from other people, or modeling, helps students establish standards, learn skills, and attain knowledge. Encourage modeling of successful behaviors.
	Feedback	The feedback students get from their peers and professors reinforces a student's adoption of certain behaviors that influence learning and/or performance. Timely feedback related to goals is most effective.

Fig. 4 Chart showing the Performance Phase and descriptions of the Phase sub-processes.

REFLECTION PHASE		
SUB-PROCESSES	COMPONENTS	DESCRIPTIONS
Judgment	Self-Judgment	Self- judgment refers to comparing present performance with one's goal and making a judgment as to one's progress. Self-judgments, especially favorable ones, cause reactions that help sustain motivation on future performances.
	Progress Outcomes	The assessment of progress as it relates to goal attainment. The outcomes lead to a student's behavioral reaction.
Reaction	Self-Reaction	Self-reactions to goal progress motivate self-regulated learning. If a student believes they are accomplishing goals and progressing, their positive reaction boosts self-efficacy and increases motivation.
	Sentencing	Consequences and rewards established by students and based on progress outcomes. Includes consequences like staying up late, rewards like taking a day off, or the establishment of sub-goals.
Evaluation	Self-Evaluation	The value a student attributes to their progress towards goals. Students tend to have higher achievement when evaluations suggest that efforts were worthwhile.
	Constructive Preparations	Student develops new knowledge constructions and experiences a change in their self-efficacy that translates into a student's motives and goal orientations for the next project.

Fig. 5 Chart showing the Reflection Phase and descriptions of the Phase sub-processes.

4. GUIDELINES FOR IMPROVING STUDENT LEARNING AND ACHIEVEMENT

The following guidelines are based upon preliminary findings from an ongoing study of the GRM. The guidelines focus on goal use since goals are the primary factor influencing student self-regulation. In addition, goals are the driving force carrying students through the design project as explained in the GRM. Therefore, implementing these suggestions should lead to higher student learning and achievement results.

1. Promote goal setting and strategic planning, then, use these goals and plans as a point of departure for discussion and feedback.
2. Ensure that each student sets a range of goals including those that are specific, hierarchical, reasonably difficult, flexible, and learning-oriented.
3. Encourage students to write their goals down so that they can reference and monitor them later during the project.
4. Suggest that each student post their goals for other students to see in order to enhance opportunities for social modeling and to advance accountability.
5. Support group discussions and feedback that focus on goals by utilizing the social setting of studios to help students evaluate each other's progress.
6. Establish lists of goals related to completing the project (i.e. project performance) and lists related to developing conceptual knowledge (i.e. skills and knowledge not

necessarily demonstrated in the project drawings). Use the lists as an organizer for teaching and learning and as a reference point for assessing learning outcomes.

7. Find ways to give students ownership of projects and the goals associated with them in order to elevate motivation by increasing goal relevance and intrinsic interest.

5. CONCLUSIONS

Currently, the GRM provides a framework situated within current research in educational psychology that helps design faculty to reflect upon and consider revisions to their current teaching beliefs and practices. This alone is a significant development in the effort to redesign studios to facilitate maximized student learning and achievement. In the future, the GRM will need more examination and study in studio settings in order to determine its validity and ability to predict student achievement and learning. Design instructors interested in enriching their students' academic accomplishments are encouraged to find ways of applying the GRM in their studios and report their findings back to the author.

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A New Form of Architectural Surface Material

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ABSTRACT

This paper presents an ongoing research project about the development of the materials and fabrication techniques for a fundamentally new class of architectural composite. This type of composite, which is a representative example of an even broader class of smart architectural material, has the potential to change the design and function of an architectural structure or living environment. As of today, this kind of composite does not exist. Once completed, this will be the first technology on its own. We believe this study will lay the fundamental groundwork for a new paradigm in surface engineering that may be of considerable significance in architecture, building and construction industry, and materials science.

INTRODUCTION

Recent developments in digital technologies and smart materials have created new opportunities and are suggesting significant changes in the way we design and build architecture. Traditionally, however, there has always been a gap between the new technologies and their applications into other areas. Even though, most technological innovations hold the promise to transform the building industry and the architecture within, and although, there have been some limited attempts in this area recently; to date architecture has failed to utilize the vast amount of accumulated technological knowledge and innovations to significantly transform the industry. Consequently, the applications of new technologies to architecture remain remote and inadequate. Although, there have been some adaptations in this area recently, the improvements in architecture reflect only incremental progress, not the significant discoveries needed to transform the industry.

However, architectural innovations and movements have often been generated by the advances of building materials, such as the impact of steel in the last and reinforced concrete in this century. This relationship –between new technologies and 'new architecture' is very significant and has always played a significant role in architectural field so that architecture in modern times is characterized by its capacity to take advantage of the scientific developments and technological innovations (Morales 1997).

Based on the digital and technological advancements and the introduction of new design and fabrication tools to architecture, a new way of design thinking has emerged –ways to express an idea as well as ways to create –fabricate and manufacture- usable and meaningful designed environments. These developments are seen as mind-extending or as a catalyst to stimulate designers, to facilitate new problem structuring and construction activities, such as conception, representation, reflection, and production. As a result, a new architectural formal language and grammar, where structure and skin form a new kind of composite materiality, has been emerging. Consequently, an interesting relationship is established between the new geometries and "new materials where new architectural geometries opened up a quest for new materials and vice versa" (Kolarevic 2003).

The composite nature of these new materials is created by the combination of multiple separate layers of different materials into a single material. Certain cognition-driven terms, such as 'smart' and 'intelligent' are started to be used to describe the interactive and built-in programming nature of the composites. There are some scattered attempts of the creation of these materials but currently they are mainly used for limited applications and mostly for aesthetic purposes. A new architectural composite is needed which will merge digital and material technologies, embedded in architectural spaces and play a significant role in the way we use and experience architecture.

This paper introduces an innovative architectural composite material, the digital wallpaper, that will be part of the architectural space and will include circuit elements – transistors, resistors, capacitors, diodes, etc. -- equipped with sensing and computational capabilities in the form of a lightweight, flexible thin film laminate that can be either be applied on top of the wall surface or used as a partition-wall element in itself. This new material is capable of displaying different visual properties on demand. Our approach uses three major pertinent domains in this area: architecture and design; engineering and material science; and construction technology. Together, this confluence will produce an innovative surface material that lies at the intersection of the involved domains. See Fig. 1.

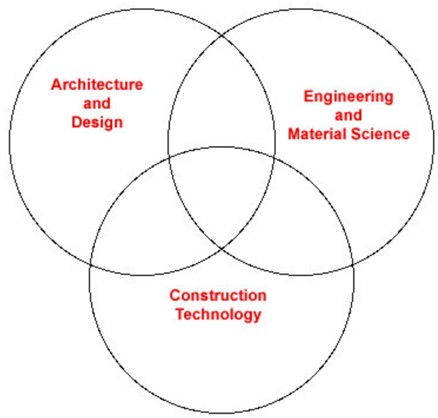

Fig. 1: Converging Domains: Architecture and Design; Engineering and Material Science; and Construction Technology

APPROACH

This new 'smart material' reversibly switches its properties in response to an external demand. On this 'digital wallpaper', colors, patterns can be set, changed, and adjusted to different tastes, furniture, mood and design trends. Various visual projections –or presentations- would be available, too. For example, picture frames can be created on defined areas on demand and in theory every wall could become a TV screen, including the ceiling! Figures 2 and 3 illustrate concept drawings and actual prototypes (Rogers 2001; Rogers, Bao et al. 2001) of the types of systems that we are utilizing.

Fig. 2 Living space enhanced with thin, wall mountable large area displays. Adapted from a presentation by Philips.

The crucial element for these types of systems is the ultralow cost distributed electronics that can control the colors of the pixel elements. We are designing these circuits to have layouts and performance comparable to the circuits that are used in liquid crystal computer displays. Static

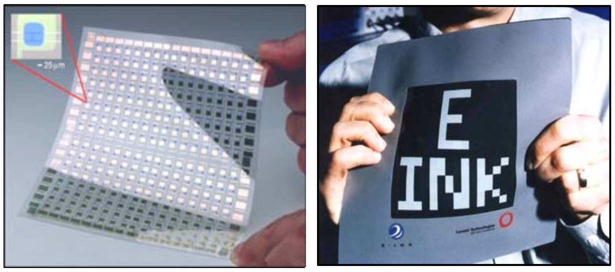

Fig. 3 Flexible electronic circuit (left) and paperlike display system constructed with it (right).

images as well as full motion video will be possible. For digital wallpaper, it must be possible to build the circuits at a small fraction of the cost of those that use conventional silicon on glass.

In addition, due to considerations of weight and installation, they must be constructed on lightweight, flexible, rugged substrates such as plastic rather than traditional electronic substrates such as glass or silicon. The materials and engineering technologies that can enable circuits of this type do not currently exist. Therefore, one of our primary goals is to develop and demonstrate the necessary materials and fabrication techniques.

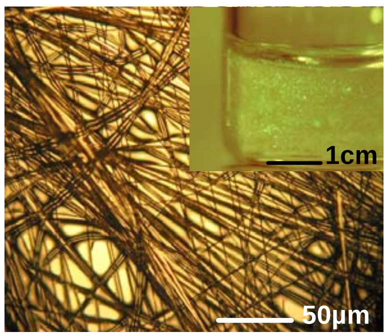

Fig. 4. Microstructured silicon, in the form of long narrow ribbons. The inset shows a solution suspension of this material.

We believe that the most promising material for the semiconductor component of these circuits is a printable form of single crystal silicon, which we refer to as microstructured silicon (μs -Si) (Menard, Lee et al. 2004). This new material is just now emerging from our labs. The basic approach in this case is to use specialized etching procedures to slice a standard silicon wafer into microscopic pieces – ribbons, wires, platelets, disks, etc. depending on the application. These pieces can then be dispersed in a liquid solvent from which they can be cast onto nearly any substrate, including low cost plastics. The necessary circuits can then be constructed out of the μs -Si material. The advantages of this approach are: (i) it enables a high quality semiconductor to be integrated onto a wide range of substrates at room temperature and in open air, (ii) it relies on very well developed materials technology – single crystal silicon wafers, (iii) it exploits all of the knowledge of how to build circuits out of silicon, and (iv) it is compatible with printing techniques and other low cost, non-cleanroom based methods for making the circuits. Figure 4 shows an image of some of this material, in the form of collections of microscopic ribbons (Menard, Lee et al. 2004)

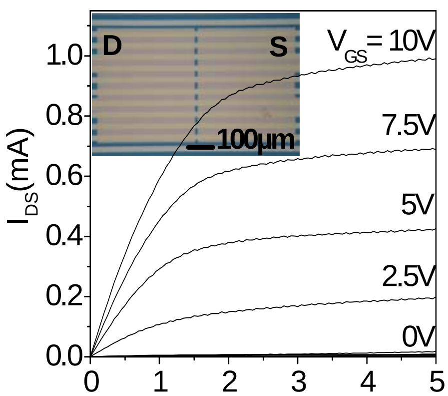

Fig.5. Current-voltage characteristics of a device that uses μs -Si as the semiconductor.

Figure 5 illustrates an array of such ribbons integrated into a device that operates like a high performance, conventional transistor(Menard, Lee et al. 2004). The switching characteristics of devices such as these are almost as good as well engineered transistors on silicon substrates. They are considerably better than those of conventional silicon transistors on glass. This new μs -Si technology allows one to consider, in a realistic way, the types of smart architectural surface materials described in this paper.

CHARACTERISTICS

In order to identify and define the main properties, various layers of audio-visual components are identified; their functions are defined and pressed together into a single composite 'smart' material. This new polymer composite has its own sensors, printed speakers, and computation firmware built-in in its layers. Based on this integration, this new composite perform multiple functions by changing its properties dynamically in direct response to user's preferences and demands (see Figure 6).

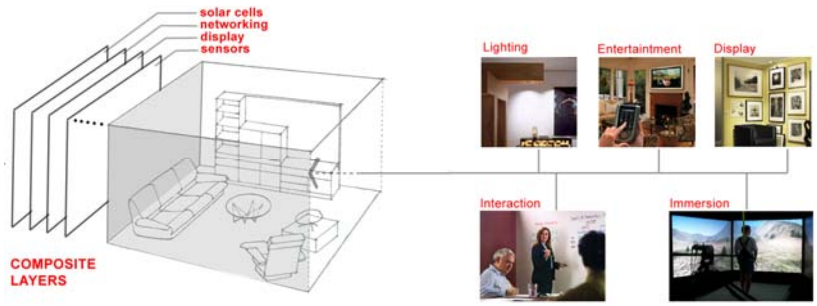

Figure 6: Digital Wallpaper is designed to respond to multi-modal design demands by simple property changes to the material with control systems

METHOD

The "Digital Wallpaper" prototype is initially applied as an external sheet on top of the existing wall surface. At its technology base, it relies on innovative ways to build circuits out of the µs -Si material described previously. We are developing these concepts and applying them to large area circuits on plastic substrates with designs that specifically address the digital wallpaper application.

We are adapting for use with µs -Si the printing techniques and circuit designs that we developed in the past for organic semiconductor based circuits (Rogers, Bao et al. 2001; Blanchet, Loo et al. 2003). Figure 7 shows an example of a 50x50 cm flexible active matrix circuit that we formed by printing(Blanchet, Loo et al. 2003). New methods must be invented to deposit and pattern the µs -Si to yield similar circuits for digital wallpaper. We are pursuing approaches based on silk screen printing and ink jet printing for this purpose. We are also developing methods for integrating other components of the circuits (e.g. dielectrics and electrodes) directly onto the µs -Si before this material is printed onto the final devices substrates. We believe that these strategies will enable high performance circuits to be formed directly on conventional building materials such as paper and polished stone or wood.

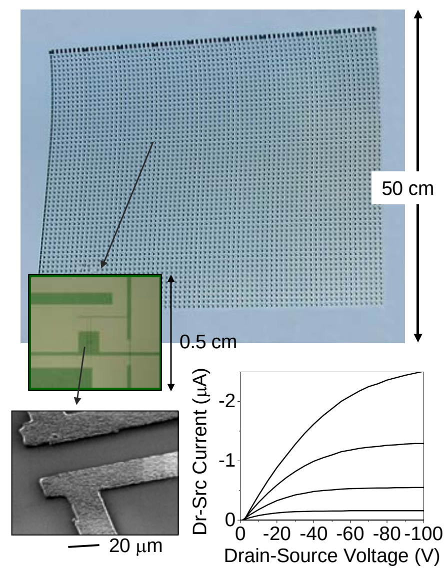

Fig. 7. Large area printed circuit that uses organic semiconductors. Similar systems that use µs-Si will enable high performance, robust operation.

CONCLUSION

This is an ongoing study partially funded by the Research Board at the University of Illinois at Urbana-Champaign. The current challenge is to develop the first phase of the prototype and test it in a non-clean-room based environment. As of today, large scale, flexible display material does not exist. Once completed, this will be the first technology on its own. Next step is the addition of the structural stability to the material and use it as a 'digital' wall which we believe will replace the interior partitions in the near future. In architecture and construction industry, this material can make significant changes in building design, especially in wall-systems and enclosures.

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Collaborative Research, Development, and Patent Licensing for an Energy-Saving Roofing System

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ABSTRACT

This paper describes the process and preliminary results of a collaborative research and development project for an energy-saving ventilating roofing tile system intended for market introduction. The project also served to apply an interdisciplinary design approach to the fields of architecture and civil engineering similar to that used in many high-tech industries.

I began the project seeking to develop a marketable high slope roofing system having: (a) an internal ventilation system to mitigate solar heat transfer, (b) a partial composition of recycled material, (c) durability and resistance to stresses including transport, impact, and natural forces (freeze/thaw, fire, insects, precipitation, earthquake, etc.). Interlocking roofing tile geometries were explored producing a series of contiguous channels running from eave to ridge. These geometries suggested using non-conventional roofing materials. Asst. Professor Gregor Fischer, Univ. of Hawaii at Manoa (UHM), Dept. of Civil and Environmental Engineering, who specializes in Engineered Cementitious Composites (ECC) and I discussed the project, and we decided to collaborate. We evaluated the potential of ECC for forming the roof tiles. ECC appeared promising for this application as it: (a) can be molded using common mass-production methods, (b) can be made with recycled or waste materials, (c) has a high strength-to-weight ratio, and can withstand bending stress without steel reinforcement, (d) is crack and weather resistant, (e) is fire resistive, (f) can be formed with various shapes, textures, and colors.

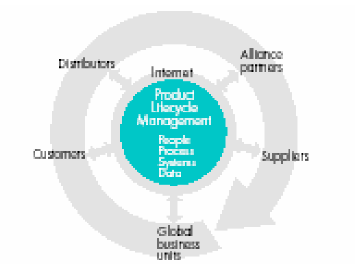
Computer and physical models were used to achieve a design synthesizing form, material, and function in the system. This synthesis was achieved due to our combined expertise in construction methods, building systems, material science, and structural analysis. Prototype tiles were molded of ECC, and were evaluated for dimensional tolerance and impact and bending stress resistance.

To secure intellectual property protection for the ventilating roofing system, we conducted a patent search and co-authored a Provisional Patent Application which was filed with the U.S. Patent and Trademark Office through UHM's Office of Technology Transfer and Economic Development (OTTED). An OTTED development award allowed thermal testing of the system. As of this writing, testing is starting and is scheduled to conclude in June 2005. Test results hope to show that the ventilating roofing system will reduce heat transfer from the roof to underlying interior spaces vs. existing methods. Prototype molding techniques were successful, and these appear adaptable to roof tile industry practices. Due to the promising indicators of commercial viability, OTTED has indicated interest in filing a utility patent on the invention, and negotiating patent licenses with manufacturers.

1.0 BACKGROUND

Tombesi argues that fundamental changes have occurred recently in building design and construction operational structures. He argues that increased project complexity has necessitated new non-linear processes which blur conventional distinctions between architects, consultants, contractors and suppliers. [1] Such a condition may cause architects to play a more significant role in the development of building components and systems. One result of this new role may be that buildings would be more contextually responsive. Frampton suggests “tectonic culture” may be achieved in complex modern projects by architects investing greater care in the work and collaborating with specialists using computerized network- based collaboration technologies.[2] Such arrangements may augment research and development activities occurring within typical building design and construction processes.

Architects have recently adopted Building Information Technology (BIM) to manage complexity though collaboration. BIM is based on Product Lifecycle Management (PLM), a type of computer software used by major manufacturers since the late 1970’s allowing simultaneous sharing of product data by all concerned parties including marketing, engineering, manufacturing, and suppliers. PLM allows better and faster communication, thus shortening the time to bring high value products to market. In contrast to a typical architecture project using only extant building technology, high tech product development may involve basic scientific research, applied engineering analysis, prototyping, testing, and a tight integration of physical form, user interface design, hardware, software, and manufacturing processes. Seen in this context, the present project served the dual purpose of developing a marketable building system, and to test a simple application of interdisciplinary collaboration used in high-tech industry.



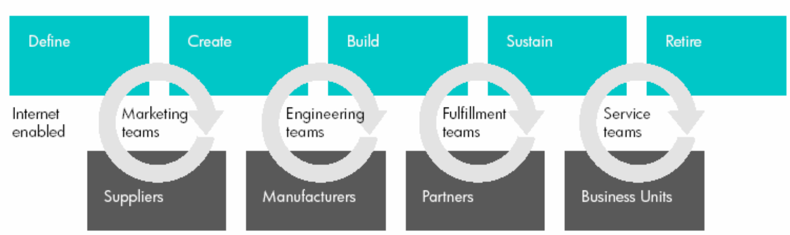


Fig. 1 (left) and Fig. 2 (right). Diagrams of PLM System as used at Hewlett-Packard Corporation (from HP corporation’s brochure entitled, “Product Lifecycle Management for the Adaptive Enterprise – The story, success, and the vision of the HP/Compaq merger”)

2.0 METHODOLOGY

2.1 Design

The ventilating roofing system project began in September of 2003 with the objective of reducing solar heat transfer. Solar roof loads contribute around 30% of the total heat gain in most houses; thus, reducing this load could have significant impact in energy consumption.[3] Common heat gain mitigation strategies work to counteract radiation, conduction, and convection effects. Reflective roofing surfaces and barriers reflect solar radiation. Insulation materials reduce convection and conduction.[4] Roof ventilation removes heat and moisture from roof spaces and assemblies. Roof shading can significantly reduce heating loads. When typical shading elements (e.g., trees, adjacent buildings) are not present, shading may be provided with a double layer roof. However, the additional cost and space requirements of double layer roofs prevent their widespread use. Therefore, a solution was sought to provide the benefits of a ventilated shaded roof in a compact space, and to dissipate heat as near the roofing surface as possible. To mitigate solar heat transfer, a first line of defense is to reflect heat from the roofing surface. A light colored roof may reflect approximately 20-25% of the solar heat energy.[5] Reflection was not pursued as a primary strategy as a reflective surface may be easily added to most roofing materials and as well may often be considered undesirable due to glare or aesthetic concerns. A second line of defense would be to quickly extract heat from the roofing material. The investigation was confined to high slope roofing. Passive ventilation was explored as this appeared the simplest and potentially most effective means of heat extraction. From the outset, the key interest in the project was to develop a cost effective alternative to common roofing systems. Therefore, using mass production techniques, low cost materials, and installation and appearance norms needed to be considered. These factors led to exploration of a modular tile roofing system incorporating contiguous ventilation channels in the assembled tiles to create a passive stack effect.

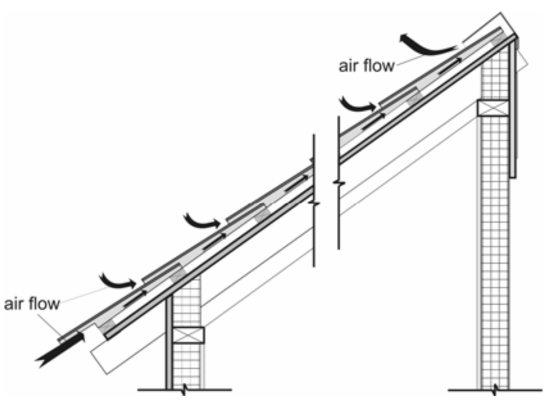


Fig. 3 Ventilating System Diagram
Diagram

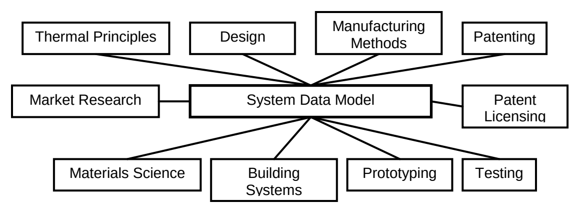


Fig. 4 Rockwood/Fischer Collaboration

Initial tile designs had forms that appeared difficult to manufacture using common shingle or tile roofing materials (e.g., clay, concrete, wood), and I thus considered using Engineered Cementitious Composites (ECC). Given my limited knowledge of ECC, I contacted Asst. Prof. Gregor Fischer of the UHM Dept. of Civil and Environmental Engineering who has particular expertise in this material. We reviewed the roofing system and agreed to collaborate on the project. Fischer and I shared an interest in developing, patenting, and licensing the system. As well, we wished to use the project to explore collaboration techniques. In contrast to the use of PLM in a large enterprise, our work occurred primarily within an academic setting involving fewer parties.

As an initial stage in the collaboration, design criteria was established for the roofing system which included providing: (a) internalized ventilation to reduce solar-induced heat transfer, (b) primary composition of recycled and waste materials, (c) durability including resistance to stress via impacts and natural forces (freeze/thaw, fire, insects, precipitation, earthquake, etc.), (d) moldability using common mass-production techniques, (e) quick installation with moderate-skill labor (f) various shapes, textures, and colors. The primary objective was to mitigate solar heat transfer through the roofing assembly. An additional goal was to improve upon disadvantages in existing wood, concrete, and clay tile roofing systems.

2.2 Patenting

Preliminary ventilating roofing designs were developed and several appeared to meet most design criteria. The intent to market the system necessitated intellectual property protection via patenting. A U.S. patent gives the inventor the exclusive right to make, sell, or use the invention for a period of 17 years.[6] A patented invention must be novel (differs from prior art) and unobvious (synergistic functionality).[7] The patenting process began by conducting a patent search; the review of prior art uncovered extant methods for providing sloped roof ventilation: (a) installing roof tiles over battens and counterbattens, (b) using a double roof structure, (c) ventilating the space below the roof deck, (d) proprietary methods that use special hardware to create a ventilating space between the roof tiles and the roof membrane. No extant method was found in the patent search using a ventilation method similar to ours. Several methods vented the space between the roof tile and the roofing membrane, however, none accomplished this by incorporating ventilation within the roof tile itself. We then elected to co-author a Provisional Patent Application (PPA). The research was conducted in part using University facilities, necessitating invention disclosure to the UHM Office of Technology Transfer and Economic Development (OTTED), who then filed the PPA with the with the U.S. Patent and Trademark Office (USPTO). OTTED deemed the invention commercially viable, and offered development funds for thermal testing of the invention.

The design of the ventilating system proceeded by ensuring the stated design criteria were met while minimizing material use and maximizing overall simplicity and mass-production efficiency. In addition, novel and unobvious features needed to be retained for patenting. Using drawings, computer models, and physical models, design aspects were studied including: (a) interlocking means between adjacent tiles, (b) fastening methods of the tiles to underlying roof construction, (c) structural integrity of the tile, (d) necessary form and dimensional clearances necessary for the molding process. Initial designs were complex, being comprised of multiple pieces or having shapes difficult to mold (see Figs. 5-6). The final design is a one-piece tile (see Fig. 7).

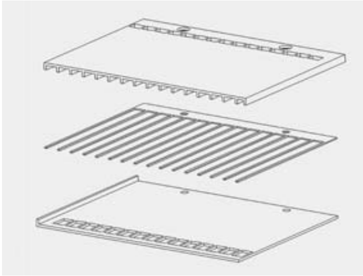


Fig. 5 Roof Tile Design “A”

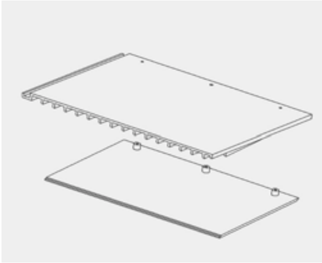


Fig. 6 Roof Tile Design “B”

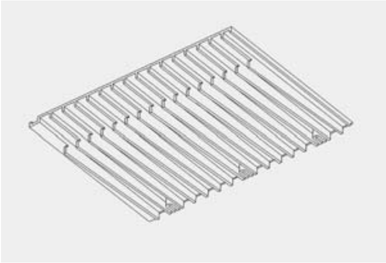


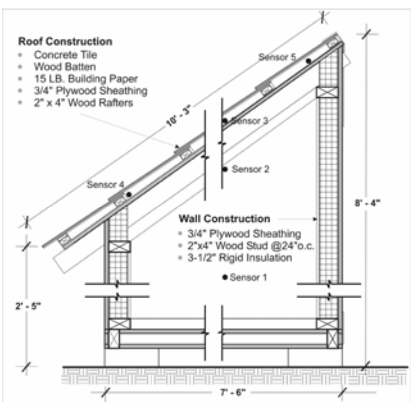
Fig. 7 Roof Tile Design “C”

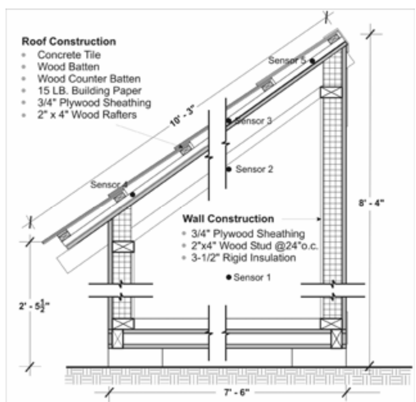
2.3 Prototyping

Clay and concrete roof tiles of complex shapes are now mass-produced using two-piece molds. We reasoned our roof tile could be produced with a two-piece mold and thus be manufactured using common methods. Four different two-piece molds and associated roofing tile prototypes were developed. The first used an extruded profile for the tile such to test the basic molding process. This first casting was acceptable, having few surface flaws, no cracks, and with all features being fully formed. Practical tests on this first tile indicated it sufficiently strong to resist anticipated loads. The ECC mix contained admixtures to provide fast setting time and good flow in the mold. The second and third mold and roofing tile prototypes incorporated a more complex and intricate form. Changes in the third mold were needed to correct needed clearances and geometries. Otherwise, tile quality matched the first prototype. The fourth mold and roofing tile prototype sought to simplify the process for producing the tiles to be used for thermal testing.

2.4 Thermal Testing

Thermal testing will give data useful in marketing the invention. The experimental setup uses 3 identical huts (see Figs. 8-10 for materials, dimensions, and temperature sensor locations). Differences between the huts lie only in the roofing tile type and connection method. A first test without applied roofing materials will establish any thermal resistance variations between huts. A second test with applied roofing materials seeks to establish the effectiveness of the ventilation means in reducing thermal transfer relative to other common concrete roof tile systems. For both tests the huts will be sited on a UHM campus lawn receiving direct sun through most of the day. Huts will be aligned with the sloped roof facing due South and spaced apart to prevent huts from shading each other. For the first test, temperature data from five locations in each hut will collected at 15 minute intervals over the course of one week. For the second test, temperature data will be collected from the same locations and using the same sampling interval, but with the overall test period extended to one month. A weather station installed near the test huts will log climatological data. Collected data will be numerically and graphically analyzed using Boxcar tm software.





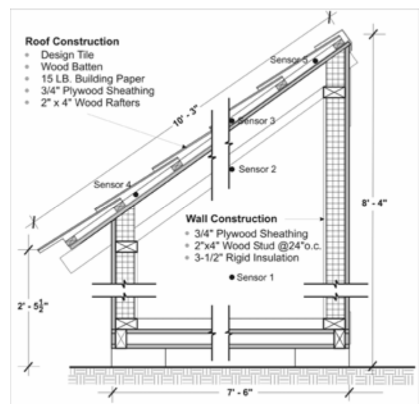


Fig. 8 Hut 1 Cross Section

Fig. 9 Hut 2 Cross Section

Fig. 10 Hut 3 Cross Section

3.0 CONCLUSION

Thermal testing is not complete preventing comparison between our system and typical competitive concrete roof tile systems. However, other project objectives have been investigated sufficiently to allow evaluation. The collaborative methods worked in that Fisher's expertise in ECC materials science, molding, and structures complimented my building systems knowledge. Work was aided my computer modeling and file sharing. We achieved a simple system design by understanding and relating market forces, material, form, manufacturing methods, and natural forces. Informal structural tests indicate sufficient resistance against expected loads may be achieved in a roof tile larger than typical concrete roof tile, yet which is lighter per unit area. Hence, roof structure dead load is reduced, installation is quickened, and resistance to transport, installation, and wind/earthquake stresses is given (via ECC ductility). ECC costs slightly more than conventional concrete, however, less material is needed. Prototype molding techniques were relatively successful. Through our investigations into industry techniques, we believe our roof tiles maybe formed using standard roof tile industry two-piece molds and practices. Due to the promising indicators of commercial viability as documented in our research and outlined here, OTTED has expressed interest in filing a utility patent on our invention, and marketing the patent to manufacturers for sale or licensure.

4.0 ACKNOWLEDGEMENTS

I first thank my collaborator, Asst. Prof. Gregor Fischer, who was essential to the development of the project. I also wish to thank Asst. Prof. Stephen Meder, Director, ECS Lab, UHM, School of Architecture who donated his Lab resources. Thanks go also to UHM student research assistants who contributed to the development of the project: Mujtaba Ashan, Cori Ann Gum, Heidi Newton, Patricia Mills, and Jinghai Yang.

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Web-Based Timesheets for Architecture Design Students

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ABSTRACT

Skills in time management are highly important to professional architects but rarely obtained through an architectural education. A Web-based application for collecting time data from architecture students can achieve multiple benefits to students and educators and perhaps remedy the problem. Several versions of the application have been written and tested. The next phase of research will include a widespread distribution of the Web service to collect data from many schools, courses, and students. Data collected using the software will reveal behavior patterns of architecture students and also provide empirical evidence to validate theories of design process.

1. TIME MANAGEMENT IN ARCHITECTURAL DESIGN

1.1 Motivation

The patterns of student and instructor behavior in architecture schools frequently appear to be a manifestation of a distinctive subculture centered around the design studio space and the courses taught within that space. This "studio culture" is recognized widely by those who are pursuing and have pursued an architectural education. Recently, the American Institute of Architecture Students has initiated an examination of studio culture that includes both high praise and harsh criticism (1). The studio is accepted to be at the core of architectural education and of great value in forging identity, community and lasting friendships. However, it also can engender unintentional and destructive habits and values that can carry over into the profession of architecture. Many of the problems with studio are related to poor and destructive management of time resources. Studio culture can engender overwork, myopic focus upon design at the expense of other courses and social adaptation, procrastination, sleep deprivation, and other destructive practices. A belief that studio culture should be changed to incorporate time management skills appears to be growing among students and educators.

1.2 Overview

Changes to course structure and assignments could have an impact upon studio culture to remedy some of the problems identified by the AIAS. Arguably, there is a need for better understanding of how students use time and also a need to coach them in better use of time. A Web-based approach to collecting time data from students is one way of achieving a better understanding of student's behavior and providing greater guidance in architecture design studios. An implementation of this concept could make use of a database server that is equipped with a Web-based user interface. Such a tool has been demonstrated to be usable and acceptable to students and instructors. Furthermore, the implementation makes a timesheet service universally available to all architecture students who have Internet access and speak English. Thus it could be an effective tool for conducting research in both design process and time management.

2. Background

2.1 Previous Studies of Architecture Studios

In spite of the assessment by the AIAS that studio culture undervalues skills of time management, there hvae been only a few research efforts that have examined how architecture students manage their time. In a study of the design jury system for evaluating the products of studios, the issue of poor work habits and destructive attitudes toward the use of time were identified (2). This qualitative study made use of surveys as well as interviews with students, instructors and practitioners. It found that students often appear unable to plan their work or anticipate how much time tasks will require. Instructors sometimes encourage work patterns that involve major changes very late in the process. In some settings, instructors encourage "all nighters" before a project is due, and, because of sleep deprivation, students are unable to attend carefully to the reviewers comments.

In extensive observations of the interaction between studio students and instructors, similar problems have been identified (3). The intensive dialogue between instructor and student, while modeling a behavior of inquisitiveness and commitment to high quality, may also lead to indecisiveness and a poor valuation of the time that must be devoted to a project.

An informal study required students to keep timesheets of their studio work (4). The study documents several design studio courses and shows that most students exhibit a "fast and binge" pattern in which they work very little until just before the due date and then work extremely hard. Although students perceive that they work hard, their total effort over the course of the semester is no more than what can be achieved through moderate but steady effort each week.

Many educators and practitioners acknowledge the importance of time management skills. However, accreditation standards for architecture schools do not list time management as a necessary skill to be provided in school (5).

2.2 Design Methods

A discussion of time usage in studios immediately leads to the question of "What are the activities undertaken in design?" Numerous authors have suggested models of the design process. One model suggests a cycle of analysis, synthesis and evaluation (6). A model of design focused upon the programming stage also distinguishes sharply between analysis and synthesis (7). Another model suggests that there are eight fundamental design activities: formulation, synthesis, analysis, evaluation, documentation, reformulation of structure, reformulation of behavior, and reformulation of function (8).

Various research projects have attempted to study the design process empirically to explore particular theories of design. Researchers have staged design trials that compare process and products when aided by computers to those when unaided (9). Protocol analysis has employed "talk-aloud" approaches or videotaping of designers interacting on design teams (10, 11). However, there appears to have been no systematic study employing a statistically valid sample of students to allow confirmation of design process theory or establishment of typical patterns of time usage.

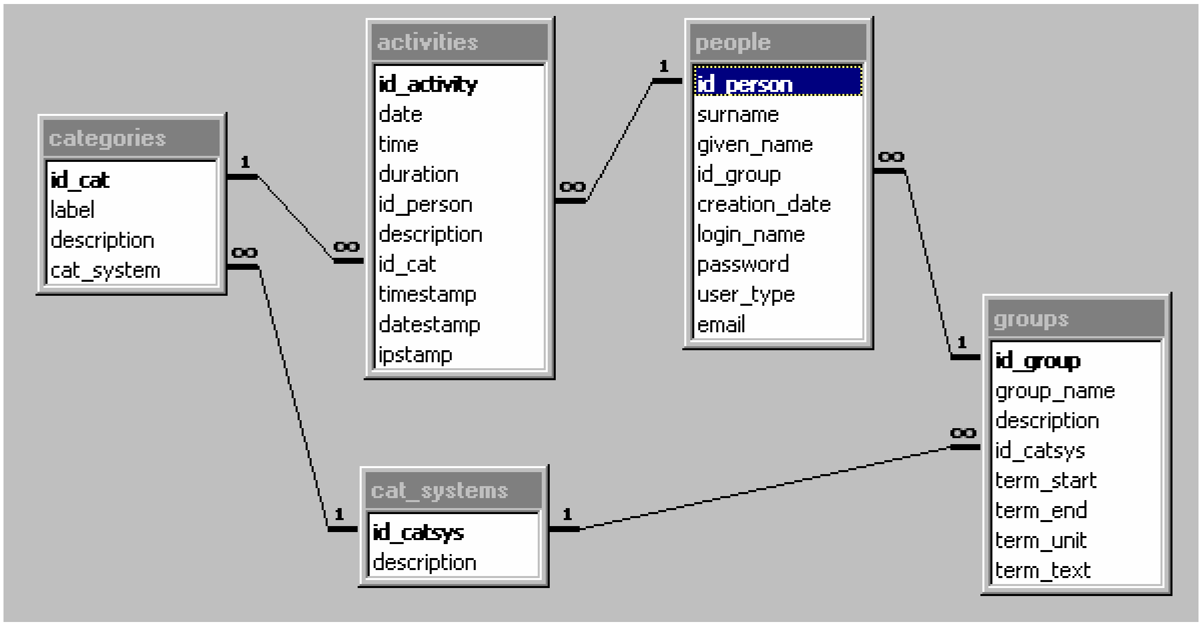
2.2 Web Services

The Internet and the World Wide Web are an extraordinary tool for conducting studies across very large and diverse populations. E-commerce sites such as Yahoo!, Amazon, Expedia and others are capable of collecting large amounts of data about buying and Web surfing habits. They employ technology that has become very accessible and widely understood. Essentially, a Web browser, such as Netscape or Microsoft Internet Explorer, presents a user interface to a customer that consists of forms. Using the form, a customer can submit data to a Web server. The Web server parses the data and provides it to a database server. Scripts that are executed in the browser or on the server compose new forms and reports that can be viewed by the customer using the browser. Software such as Microsoft Internet Information Service and Microsoft SQL Server can handle millions of transactions with no practical limits on the number of users.

Earlier research has tested the concept of a Web site to collect timesheet data from architecture students (12). The concept has been easy to implement and presents no special challenges to students who are typical of the intended customers.

3. CURRENT INVESTIGATIONS

3.1 Implementation



The current state of this research is a new implementation that has been written using Active Server Pages (ASP) Web pages and a SQL Server database. This commercial grade infrastructure is intended to support fielding a timesheet service publicly to any architecture design school in the world. The next stage of investigation involves promoting the use of the service among a moderate number of design studio courses at a diverse set of universities.

The SQL Server implementation employs the five tables shown in Fig. 1. A timesheet itself is made up of records in the *activities* table that are associated with a particular record in the *people* table. A record in the *activities* table is also associated with a record in the *categories* table to express the idea of classifying an activity according to a design method theory. Thus, the *categories* table may include a record for analysis, another for synthesis, and another for evaluation. A record in the *people* table is associated with a record in the *groups* table that is intended to represent a class. A record in the *groups* table is associated with a record in the *cat_systems* that designates a system for categorizing design process, such as Asimow's analysis-synthesis-evaluation theory or Gero's situated function – behavior – structure framework.

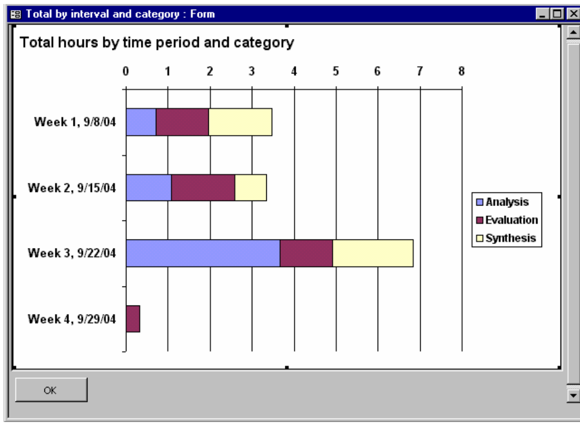
Analysis records are automatically stamped with several data to help record the context of the creation of the record. Timestamps and datestamps record the instant of the transaction. The IPstamp records the Internet Protocol address that identifies the computer being used by the customer. In most cases, because IP addresses are often allocated dynamically to computers as they log onto a network, the IPstamp does not identify the specific computer but does identify the subnet. The time and date information will be used to track the patterns of using the tool, answering questions of whether students diligently keep up with time usage by the hour or record time usage in a batch after longer periods. The IP address may help identify whether students work at home or at school. Both of these examples of "metadata" may help in analyzing the data for reliability and accuracy; one might assume that a customer who creates records frequently is more diligent and accurate than one who puts in many records in quick succession and may be reconstructing or inventing entries in the timesheet.

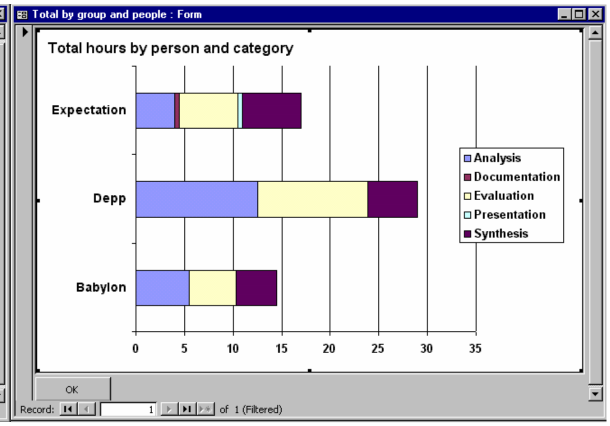
3.2 Demonstration

A customer must first be added as a user by the administrator. Each session requires the customer to login and enter a password to confirm identity. Actions are relatively limited: the customer may add another activity record, review his or her cumulative timesheet and delete or edit records, or examine reports. For adding a timesheet, the customer must enter a description of the activity, a date, a start time, a duration, and a category chosen from a list. The software will add a timestamp, a datestamp, IP stamp, and relation to the customer.

Reports present information about time usage in graphical format. Additional reports are being designed,

Fig. 1. Tables, fields and relations for timesheet application.





but currently four charts are provided. A pie chart shows the proportion of time spent by a particular customer in each category. A second pie chart shows the instructor's expectation for how much time should be spent in each category. A stacked bar chart shows the amount of time spent by a particular customer in each category each week of a project (fig. 2). A final bar chart shows the amount of time spent per week for each student in the group (or class) compared to the instructor's expectations (fig. 3).

3.3 User Trials

Fig. 2 Summary by category and week.

Fig. 3 Comparison of all students' total time usage.

students enrolled in design studios to test the willingness of students to use the system. Thirty-two students and faculty from both undergraduate and graduate courses have tested the system. Although trials have not been long enough to gather usable data, the trials have clearly established that the tool is easy to use, the concepts are easy to understand, and the value of the tool is evident.

For future trials, demographic data about the students will be collected to allow correlation of behavior to grades, year level, experience and other factors.

4. CONCLUSIONS

4.1 Summary of Results

The current research builds incrementally on previous work. The initial trials indicate that a Web-based time management application is easy for students to use. A small sample of students rapidly grasped the value and stated that they would use such software if it was available. The SQL Server implementation appears to be capable of supporting virtually unlimited traffic. The research is ready for the next step of widespread dissemination of the software as an Internet service.

This software can collect extensive data about actual design process and behavior of students. It will enable the collection of data that establishes through empirical evidence the work behavior of students with respect to time utilization. It also may serve as an apparatus for validating design methods theory by documenting the patterns of activities according to theoretical categories.

4.2 Future Work

The method of using a data-driven Web site to collect information about people's behavior is general to many other domains and research questions. In addition to collecting data from many architecture schools in many nations, there are other domains of design that may be amenable to this research method, such as product design, landscape architecture, or engineering. Other non-designerly activities could also be studied, such as construction or management. Indeed, the general question of what is the behavior pattern of any student in a university could be studied with this software. The research topic need not be limited to students, but could also be applied to achieve an understanding of professional behavior. The wide range of potential applications of this research suggest that the method itself is a notable contribution.

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Concept Mapping: A Tool for Improving Teaching, Learning, and Assessment in Landscape Architecture Design Studios

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ABSTRACT

Concept mapping is an educational tool with the capability of transforming teaching, learning, and assessment in design studios. A concept map is a graphic representation or diagram of knowledge that documents how effectively a learner organizes, represents, and understands a concept. Concept maps can be used by faculty members to assess their teaching efficacy and by students to assess their learning comprehension. Concept maps are particularly appropriate for design studios where project-based learning is common and students and faculty are familiar with creating and analyzing graphic representations.

Studio teachers typically assess their students' progress by critiquing drawings, models, and other graphic representations. However, this type of assessment corresponds to what students choose to show in their work and not the full range of what they've learned over the duration of the studio project. This means that teachers often measure improvements in performance and not necessarily changes in cognition. When combined with typical studio assessments, concept maps provide teachers with another layer of evaluative data that they can use to see what their students have and haven't learned. In addition, concept mapping allows a student's misunderstandings to emerge, indicating the need for an instructional intervention or a reevaluation of teaching methods. This paper uses emergent findings from an ongoing study to support the usefulness of concept maps as an alternative assessment method in landscape architecture design studios.

1. INTRODUCTION

In contemporary landscape architecture design studios, there is a degree of difference between teaching and a teacher's observations of what is being learned. Schön (1985) says that it is difficult for studio instructors to assess what a student has learned from the experience of a studio. The predominant use of current assessment methods including critiques, desk reviews, pin-ups, juries, and discussions exacerbate this problem. A wave of literature during the late 1980's and early 1990's has criticized these existing methods for being unfair, time consuming, passive, tense, confusing, and failing to sufficiently measure learning outcomes (Anthony 1991; Frederickson 1991; Dinham 1989). These studies suggest that design faculty regularly use existing assessment methods as an instructional approach, resulting in a lack of structured assessment and evaluation of student learning in studios. Existing methods of assessment are useful for providing instruction, but they are not the only forms of feedback or assessment available to teachers. Concept mapping, an alternative form of assessment, helps teachers assess student learning while providing additional instructional feedback and documentation of educational outcomes.

2. SIGNIFICANCE AND PURPOSE

The purpose of this investigation is to examine the usefulness of concept mapping as an assessment tool in landscape architecture design studio settings. The aim of the study is to assist in the development of alternative assessment techniques and a body of theory applicable to landscape architecture and other related disciplines that emphasize design studios in their curriculums. Landscape architecture faculty and administrators should consider using concept maps in addition to their existing forms of assessment (e.g. desk critiques, pin-ups, juries, discussion) for four reasons including:

1) Concept maps assess different types of student knowledge in design studios that current assessment techniques do not. Cognitive psychologists have delineated knowledge into three discrete types that include: a) declarative knowledge that refers to “knowing that” or knowledge of facts, b) procedural knowledge that refers to “knowing how” or knowledge of processes, c) strategic knowledge that refers to combining declarative and procedural knowledge types to form complex plans (Anderson 2000). Current assessment techniques tend to focus on assessing procedural and strategic knowledge but concept maps also incorporate declarative knowledge.
2) Social learning theory suggests that there is a difference between learning for comprehension and learning for performance and that students don’t always demonstrate all that they have learned in a given performance (Bandura 1977). This means, that critiques don’t always measure what a student has learned from a project but instead what the student wants the professor to see – emphasizing looking good rather than comprehensive learning.
3) Concept maps document and provide evidence of learning. These documents can be saved and referenced by students, teachers, administrators, and outside agencies such as accrediting boards.
4) Concept maps assess prior knowledge (i.e. the knowledge a student has prior to instruction), outcome knowledge (i.e. the knowledge a student has attained as a result of instruction), cognitive growth (i.e. measure of difference between prior knowledge and outcome knowledge), and effectiveness of teaching and learning (i.e. the degree to which a student learned what the teacher wanted the student to learn), while critiques tend to only measure project performance outcomes.

3. LITERATURE REVIEW

This study expands on two key areas of literature and research including: 1) concept maps and 2) social learning theory.

3.1 Concept Maps

As defined by Joseph Novak (1991), “concept maps are tools for organizing and representing knowledge”. They are diagrammatic and hierarchical in their construction. A concept map begins with a central concept or a particular chosen domain of knowledge. This central concept, represented by one or two words, is usually enclosed within a circle or box of some type and typically placed at the top or center of one’s map. What follows is the placement of related concepts below or around the central concept. Cross-links are used to connect concepts and to make propositions, which show interrelationship between concepts (Figure 1).

Ausubel (1978) suggests that the construction of knowledge happens uniquely depending on the individual and that the success of constructing new knowledge is dependent on linkage to preexisting knowledge. Furthermore, the act of making these links will lead to the establishment of meaningful, long-term knowledge, while the act of retrieving this knowledge leads to improved critical thinking (Daley, Shaw, Balistrieri, Glasenapp, and Piacentine 1999). Therefore, the construction of a concept map, with its cross-links and interrelationships, itself assists in the creation of new knowledge.

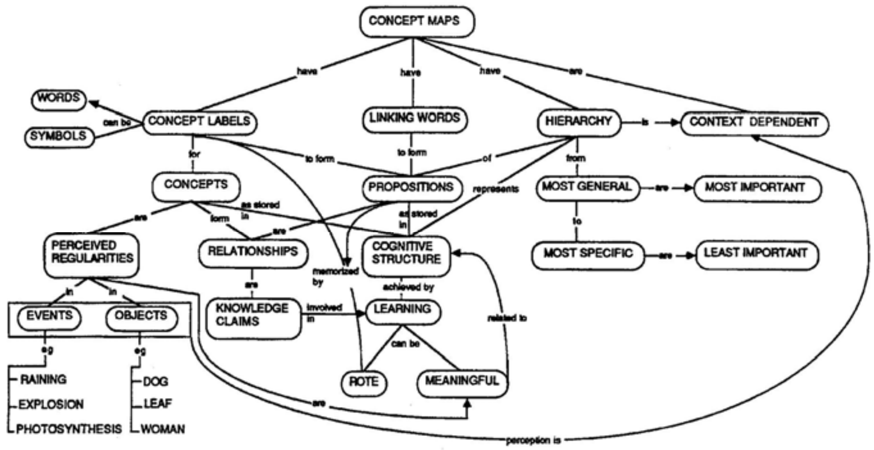

Fig. 1 An example of a basic concept map created by Novak (1991). This particular map also helps explain the theory and structure of concept mapping.

Concept maps help students articulate their knowledge while fostering an understanding of the interconnectedness between concepts. Concept maps provide students a structured format for expressing what they know and connecting it with what they're learning. Research confirms that experts have a strong conceptual understanding of their work and its relationship to other areas of knowledge (Anderson 2000). Helping students make these types of connections accelerates knowledge acquisition while securing it within the learner's mind through meaningful elaboration and critical thought. In addition, concept mapping can lead to increases in a student's self-efficacy by helping students to see their own goal attainment and cognitive growth, which could then lead to a possible change in behavior (Bandura 1977)**.**

3.2 Social Cognitive Theory

Social cognitive learning theory highlights the idea that much human learning occurs in a social environment. By observing others, people can acquire knowledge, rules, skills, strategies, beliefs, and attitudes (Schunk 2001). Social learning theorists argue that because people can learn through observation alone, their learning will not necessarily be reflected in their performance (Ormrod 1999). In other words, something learned at one time may be exhibited at the same time, at a later time, or never. This suggests that a student can learn project-related concepts without necessarily including all that they're learning in a pin-up review. Therefore, when a professor uses an existing studio assessment method such as a pin-up, they neglect to assess the range of student learning and instead assess only what the student has chosen to include.

Students choose what to include in their drawings based primarily upon their goal orientation. Social cognitive theory suggests that learners engage in one of two types of goal-related orientations, performance or learning, while working on projects and tasks. A performance orientation focuses on grades, rewards, and approval while a learning orientation, also called a mastery or cognitive orientation, stresses mental challenge, thought development, and metacognition. These two orientations refer to the types of goals students will set for themselves with each orientation exerting different effects on a student's project-related activities and achievement (Schunk 2001). Cognitive maps emphasize assessments of learning orientated behaviors while criticism and pin-ups tend to focus exclusively on performance oriented behavior. When combined, cognitive maps and existing forms of assessment, provide a holistic view of a student's learning and performance.

4. METHODOLOGY[2]

As part of an ongoing study, participating design studio teachers collect two forms of concept maps, the first a pre-test before instruction and the second a post-test after instruction. The data collection instrument is a two-sided 11x17 sheet of paper. One side of the sheet is blank and used by students to create their concept maps. The other side of the sheet contains a brief description of concept mapping with 2 examples of non-related concept maps and a set of instructions. No time limit is given for completing the concept maps.

As students complete their concept maps, the instructor collects and analyzes them. The method of analysis varies depending on the purpose of the particular map. For pre-test concept maps, design teachers analyze each individual's map to determine what a student currently knows and what gaps exist in their understanding of a particular concept. The teacher then compares the analysis of each student's map with those of the other students in the studio and with their own understanding of the concept; this holistic assessment helps the teacher decide where to begin instruction. For post-test concept maps, design teachers again begin with analyzing each individual's map, but this time they're assessing the overall progression of the student's conceptual understanding from pre-test to post-test, essentially measuring cognitive growth. In addition, teachers compare the post-test map with their own *key map* representing the expected learning outcomes in order to assess the effectiveness of their teaching.

The following example (Figure 2) represents a typical concept map created by a student. In this case, the concept was the country of "Panama" – a broad concept that corresponded with a summer studio involving lectures in the United States and a 10-day field study abroad. Each student in the course had very little prior knowledge about Panama before the studio and thus their pre-test concept maps were very similar to the one shown in Figure 2. However, those students that were more engaged in the studio, such as the student in the example, developed a fuller concept of Panama and thus created a fuller post-test concept map. The studio teacher assessed each student's cognitive growth based upon increases in number, relevance, and sophistication of new words, propositions, descriptions, cross-links, and other significant features.

[2] Additional examples of concept maps, including the teacher's concept map key, are not included in this discussion paper; the details of these maps are best viewed at a larger size not appropriate for the length of this paper.

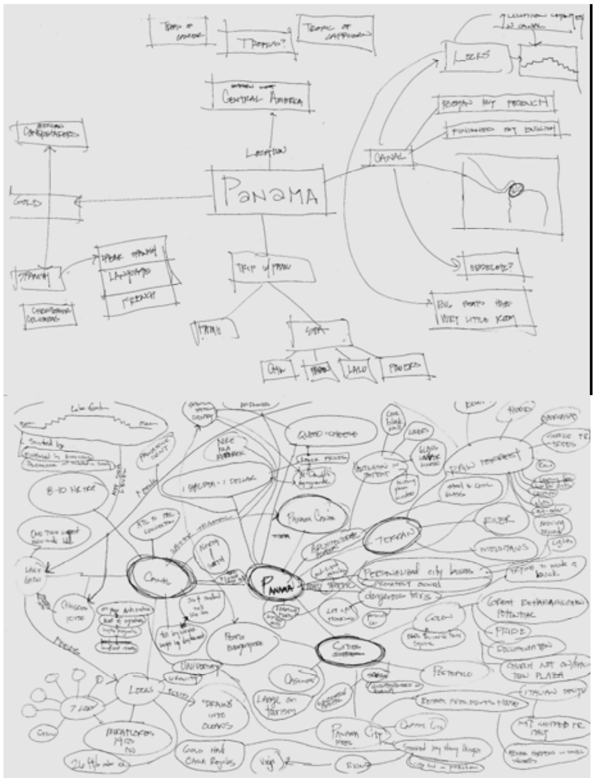

Fig. 2 An example of two concept maps showing a students preexisting knowledge (left) and outcome knowledge (right). Increases in number, relevance, and sophistication of new words, propositions, descriptions, cross-links, and other significant features suggest the degree of cognitive growth.

5. EMERGENT FINDING AND RECOMMENDATIONS FOR DESIGN STUDIO TEACHERS

1. Design studio teachers should not use concept mapping alone, but in addition to their current assessment methods in order to assess the range of student learning, specifically that learning that does not easily appear in the student’s drawings, presentation, or performance.
2. Design studio teachers should create a concept map “key” that represents the outcomes and goals of instruction. This map can guide teaching and serve as a reference for assessing the students’ concept maps.
3. Design studio teachers should be prepared and diligent about administering concept maps in order to avoid biasing the students pre-existing knowledge or distorting the overall assessment.
4. Design studio teachers should share the concept maps with their students and other teachers. For students, this helps increase awareness of conceptual development. For teachers, it helps them to anticipate and prepare a course of instruction specifically oriented for incoming students.
5. Design studio teachers should collaborate with their administrators to maintain an ongoing portfolio of concept maps that demonstrate each student’s growth throughout the curriculum. These kinds of records can assist a program in meeting it’s assessment criteria for accreditation.
6. Design studio instructors should avoid deriving quantitative measurements from the concept maps or applying a rigid preconceived scoring system. Instead, embed assessments in the student’s own maps.

6. RECOMMENDATIONS FOR FUTURE STUDIES

1. Provide students and teachers instruction about how to create, analyze, and improve their concept maps.
2. Conduct interviews with teachers and students to validate the concept maps and to see what actions that they take regarding the information provided by concept mapping.
3. Study the effects of empowering students to make concept maps voluntarily as a means of enhancing their studying and academic achievement.
4. Correlate concept maps with student grades and other achievement measures to check the validity of concept maps as a measure of achievement and tool for grading.
5. Examine the use of concept maps in group situations as means to assessing group thinking and productivity.
6. Study the concept maps of experts, such as well-known designers, to see how they think and how their concepts relate to those of students.

7. CONCLUSIONS

This study shows the usefulness of concept mapping as an alternative assessment technique in landscape architecture design studio settings and contributes to the development of an increasingly needed body of theory related to assessment and evaluation in environmental design disciplines. Faculty and administrators should consider reevaluating their program's current assessment techniques to include concept mapping in order to shed light upon the effectiveness of their teaching and learning ventures.

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Architectural Research as On-Going Group Collaboration

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ABSTRACT

Clarifying the frameworks for the conduct of architectural research can liberate educators and practitioners alike. This paper accepts the premise that modes of research are themselves forms of social communication and that knowledge emerges as a social construct. The publication of work and its presentation in a social setting reinforces the fact that it is only by agreement within the peer group that the new theories are tested, new understandings evaluated, and knowledge legitimized.

Two modes of research are now widely accepted. Mode I research, regarded as the Royal Mode of research, involves the formalized framing of a hypothesis and its testing for proof; Mode II, labeled by some as the Nomad Mode, is transient and highly dependent on context—it is trans-disciplinary, non-hierarchical, and involves many actors. Of the two, Mode II research functions as the research model of significant fit for the architectural community—it obviates competitive peer pressure and instead leverages the role of peers as participants in on-going group collaboration.

1. INTRODUCTION

1.1 Academic Disjunction

Typically, architectural schools have survived in their academic settings by positioning themselves as “professional schools”, highlighting the importance of active practice and community outreach by the faculty as forms of research and as activities integral to their studio teaching. Nonetheless, the schools continue to face a disjunction within their respective academic communities because of the traditional emphasis on the scientific method as “the” research model**—**one that has never provided a broad enough operational fit.

Moreover, as a further complication to the research expectation, architecture schools are also very different from the other “professional schools” found in the university setting. They do not fit the medical school model of a teaching/practice hospital in which research is conducted in a laboratory setting or within the clinical context of the day-to-day patient service; they do not fit the law school model in which new knowledge derives externally**—**from the judicial actions codified in case law; and they do not fit the engineering school model in which research is pursued primarily as a ‘fundamental’ hard science.

1.2 Research Modes

Ernest Boyer (1990) tried to enrich the academic perspective on research by defining types of scholarship. He recognized four: the scholarship of *discovery*, the scholarship of *application*, the scholarship of *integration* and, the scholarship of *teaching*; his subsequent Carnegie Foundation study on architecture schools (1996) expanded on these concepts, arguing further for embracing both practice and outreach as having a double meaning for "building community"—that within the professional discipline and that within the client base served. His studies have assisted schools of architecture, at least in the United States, by providing definitions of research in which professional practice and community outreach are considered to be legitimate forms of research. This is reflected, as well, in the writings of Donald A. Schon (1983, 1987) who contended that the practitioner, by reflective action, can—and does—function as a researcher.

2. THE STRUCTURING OF INFORMATION

A singular observation applicable to all modes of research is that they seek information structure. Whether by extracting that structure from informational content in its raw form as a data set, or by bringing structure to the content so as to order the information to make it usable, it is the singular intent of research to see that structure as the foundation for the formulation of knowledge. Deriving first principles from the observable world or identifying associative orders across disciplinary boundaries can take many operational forms, but each is readily categorized using the "Royal" and "Nomad" descriptors.

Mode I research, the "Royal" Mode, is problem-centered, and seeks to define universal first principles; problem sets are clearly described, and the intent is to arrive at discreet solutions. This form of research is also discipline-centered, and involves usually a single actor/researcher who attends to the hierarchy of disciplinary knowledge and seeks to preserve that form. This research is undertaken with no practical goal in mind; the peer group is competitive and serves to test for "truth" through methodological replication.

Mode II research is characterized as context-dependent, and relies on distributed actors/researchers contributing creatively to the knowledge production. The group seeks to identify the ordering structures which transcend disciplines, reflect heterogeneity, and acknowledge social accountability. This work typically seeks to produce useful knowledge for context-specific application, although it is not, by definition, applied research. Mode II research, as a form of structuring information, is more readily understood in process and as a process is correlated frequently to the process of design.

3. THE ROLE OF NEED

Another singular observation is that the characterization of need—"felt need" or "anticipatory need"—can be used to underscore the distinction of the Mode I from Mode II modalities. "Felt need" is problem-centered and associated with expressions of discomfort or lack of coherence on the part of the potential beneficiaries of the research process. Felt need, as a research seed, is most akin to the operational structure associated with a reductionist design process; it focuses on problem defining—linked to problem solving.

"Anticipatory need" involves a propositional advancement—a set of values, which can be relevant to context, but supersede the details and particularities of that context to address the more substantial structural order within. Anticipatory need aligns best with Mode II research. The structure invites participation by many actors, and recognizes the importance of a socially-distributed contribution of information, reflection, and decision—and can yield the invention or discovery of instrumentation, method and/or new models of process; it focuses on problem making—linked to value-making.

4. THE RELATION OF DESIGN TO RESEARCH

As documented in the writings of Groat and Wang (2002), both design and research involve the structuring of information. Design, by definition, is considered a "generative production of figural schemas that lead to built forms", and research is seen as "an episodic activity" needed to support that generative work. Design is posited as comprising an analysis function on the "front end", an evaluative function on the "back end", and an action function in the "middle zone". Citations from Duerk (1993), Farbstein and Kantrowitz (1991), Jones (1992), Preiser, et al (1988), Susman (1983), and Zimmring and Welch (1988) are used to support this sequencing. Architectural design is described as a learned skill that is largely individual and idiosyncratic; it is not easily open to group collaboration. Architectural research is described as methodologically rooted, and, as a result, more readily open to group collaboration. Given that distinction, seven examples of research are posited as activities independent from, but supportive of, and useful to, design. They are:

- history research
- qualitative research
- experiential research
- correlational research
- simulation research
- logical augmentation
- case study and multi-method research

These types of activity reflect what is described as a reality for architectural research—an interdisciplinary 'screening' that occurs between the analyst/designer/researcher and the generalized topic of inquiry, namely that of "…the built environment" whose purpose is "…to enhance human life". Most importantly, however, these activities, presented as unique to the field of architecture—and linked to, but separate from, the process of design—comprise the essential descriptors of the more universal characterizations of Mode II research, and reflect the nature of collective creativity embedded in that definition.

5. THE CORRELATIONS TO THE BALL STATE EXPERIENCE

5.1 Reframing the Research Definition: A Different Dawn

In 1994 an effort to grapple with "the ambiguities in the university reward structure, and…the external pressures to become more accountable for contributions to the public that provides financial support…" a committee of some 50 faculty from throughout the campus were constituted in workshop format and charged with reviewing the roles of Ball State University faculty as teachers, scholars, professionals, and citizens; the goal was to differentiate more fully the reward system which would account for the university's commitment to being "a premier teaching institution". The committee explored ways to make improvements to the university's policies and reward structures as they pertained to research that would enable faculty to make contributions in wider array of professional engagement. The goal was to introduce a reward system that would be consistent with the university mission, and that would encourage a balance of contributions to the students, the university, the educational profession, and society.

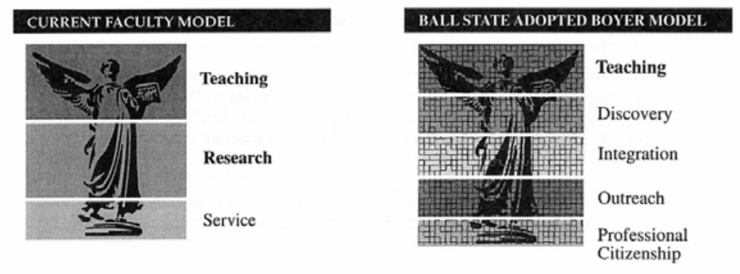

Fig. I A Different Dawn: The BSU Research/Education/Service Model

Significantly, the committee came to rely on the publication of Boyer's *Scholarship Reconsidered* (1990). The committee adopted his four tiers of definition for scholarship: *teaching*, *discovery*, *integration*, and *application*, but went on to broaden these to include a further breakdown of the *application* tier into striations of "*outreach*" and "*professional citizenship*". The emphasis in this last move was to differentiate the role of faculty as good citizens within the external professional community and within the internal university community. *Outreach* activities were defined as "tied directly to one's special field of knowledge and related to, and flowing directly out of, one's professional activity", whereas *professional citizenship* was tied to "internal institutional service performed by faculty…" See Figure 1.

The committee supported Boyer's argument that scholarship of application "nullifies a traditional distinction between "basic" and "applied" knowledge, asserting that "the processes of the mind are more dynamic"— and that the scholarship of outreach can lead to new intellectual understandings. This framework was adopted in principle by departments throughout the institution and has been used differentially ever since.

Building on this framework, the Department of Architecture subsequently embraced the Boyer (1996) study published under the title of "Building Community", in which the work of the school is prominently featured.

5.2 Introducing a Research Program: Vital Signs

To this day faculty and students are engaged in the kind of outreach described in that report; one of the most recent endeavors is our active participation in the national Vital Signs initiative, employing empirical field-based measurement of the performance of signature architecture. We have focused on buildings located in the cities of Columbus, Indianapolis and Muncie. (See: http://www.bsu.edu/vitalsigns)

Although on the face of it, this research would seem to fit a strict application of the Mode I modality, a more significant story lies in the Mode II aspect of the program development, which has been of significant import to the recognition of the "professionalism" of our school. In fact, the Vital Signs program has served as a platform for recent initiatives through the Center for Energy Research/Education/Service to offer Daylighting Research Fellowships for practitioners statewide.

What follows in the paragraphs below is a sampling of the impact of the Vital Signs program—as outreach, and especially as a networking opportunity for constituent faculty nationwide; this is described in three ways: (1) our participation in the Vital Signs education/research initiative, (2) an exemplary research discovery growing out of this participation, and (3) a follow-on transformation resulting from the socially-distributed involvement of participants within the SBSE faculty list serve network.

5.3 Architectural Research as a Group Conversation

Members of our faculty have elected to focus on the use of the Vital Signs field-based research and teaching protocols in the area of *daylighting design and occupant response*. After several years of empirical data gathering and concrete field-based assessment of building performance, methodologies for data manipulation began to emerge. Specifically, the goal of the faculty and professional staff was to find ways to streamline the documentation and interpretation of field-measured data into the useful graphic representation of "glare factor"—if present—within the visual field maps of spaces being examined.

By definition, the participants made use of the so-called "Schiler Spike"—a graphic illustration of glare using an accounting of the brightness factors within the visual field on a pixel-by-pixel basis. When a spike of light intensity occurs as an outrigger above and beyond the boundary of the more general "mound" of illumination levels within the visual field, the spike is considered a clear index of glare factor within that visual field. To simplify such graphing, a methodology was derived by Jeff Culp at CERES; whereby the raw data sets from manipulated digital photographs could be downloaded into a spreadsheet and thereby readily translated into a 2-dimensional graphic plot to reveal the "Schiler Spike". (These materials are available on the following web site: http://www.bsu.edu/classes/culp/litestuff/)

This methodology, which involves several explicit steps, was ultimately posted on our web site as noted and made available to members of the SBSE list serve for use in the schools of architecture throughout the United States. The tool/technique was used subsequently by a faculty member on sabbatical to assess the Arup offices in London. As a refinement to the process, that faculty member using the tool produced a more user-friendly presentation of the interface/access for the procedures of data conversion. Students and faculty can now download that tool interface; clearly the enhanced interface is of benefit to all.

As another instance of adoption, the tool has been used by a faculty member on the West Coast engaged in an assessment of the Disney Concert Hall, which has recently been reported on NPR, as about to undergo external renovation based on the technical analysis performed.

Other examples of research collaboration occur in the day-to-day postings on the SBSE list serve wherein faculty solicit input, critique, and/or help from colleagues throughout the world as they pursue research questions in each of their specific contexts. The speed with which these inquiries yield results and the transformative effect of such input amplifies the importance of the socially-distributed contribution by members of this research/design community.

6. CONCLUSION

Much of the architectural research discussed by Groat and Wang indeed is episodic and, in varying degrees, science-like; it is reductionist in form, directed at solving a problem and subject to validation by replication. The real frontier for research in architecture, however, is in the creative collaboration and contribution of faculty and practitioners of differing capacity and interest focused on research in service to the value-making function of architecture.

The sample story above, at one level, offers a fairly simple, self-evident presentation of the importance of this colleague networking and the opportunity for collaboration in research. More importantly, however, the example argues in favor of schools of architecture using this form of research to reinforce their identity as professional schools—distinct from those other academic units, non-professional and professional alike, that use the Mode I research model.
The value-making enterprise has been the seed bed for great works of design and research in the past, and is reflective of the transformations in design process currently emerging in architectural practice nationwide. As we confront both the "felt" and "anticipated" need for green, sustainable, and regenerative design, we are becoming evermore aware of the import of having at the table—from the beginning—<u>all</u> the players involved in the production of a work of architecture. New models of design process dictate that we engage a kind of "breathing in/breathing out" protocol

for exploring and deducing through multiple cycles of iteration the input of all parties. This new framing of the design function calls for a new framing of the research function. The Mode II research model is a best fit in this case, and will only assist schools of architecture as they continue to hold their position as professional schools operating within the somewhat limiting, tradition-bound disciplinary obsession of the academic context. Mode II research offers a kind of salvation; it cries out for architectural research to be acknowledged as an on-going collaboration.

7. ACKNOWLEDGEMENTS

Colleagues actively involved in the example story of this paper include: Jeff Culp, Adjunct faculty and Operations Manager at BSU/CERES—who created the software routine described; Bruce Hagland, Professor of Architecture at the University of Idaho—who used the tool to analyze work stations at the Arup offices in London; Marc Schiler, Professor of Architecture at the University of Southern California—who used the tool to analyze the Disney Concert Hall; and of course Cris Benton, Professor of Architecture at University of California Berkeley—who initiated the national Vital Signs Program.

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Digital Design-Build

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ABSTRACT

This paper is concerning a new methodology for design-build education based on digital design and fabrication. This is being examined through a recently developed community service learning studio at the University of Utah, College of Architecture + Planning. As digital design processes that lead to digital manufacturing and fabrication become more widely implemented into the making of buildings in standard practice, students who engage in this learning will be better equipped to become leading practitioners in the art of building.

1. INTRODUCTION

Architectural education in many institutions across the country recognize the need for students to develop an awareness of the physical aspects of architecture, that of the making of buildings. Design-build programs in schools of architecture focus on serving communities with student labor by means of recycled, off the shelf or found construction materials. Auburn and more personally Utah's rural programs are some examples. Although these programs are positive in helping student engage in a social act and learn valuable lessons about traditional construction, they do not address the changing nature of architectural design in contemporary practice, that of digital design and off-site fabrication of buildings. The Digital Design-Build Service Learning Studio at the University of Utah, College of Architecture + Planning is therefore, rooted in teaching and researching methods of digital design and construction practice.

Fig.1 University of Utah, College of Architecture + Planning Rural Studio – Bluff, Utah (Professor Hank Louis)

At the foundations of digital design and manufacturing, or CAD/CAM in architecture is the principle of off-site fabrication. Benefits of prefabrication include increased speed of construction, better constructability, liability reduction, increased precision and quality control, as well as increased recyclables. In addition, similar to the focus of the current design-build educational models, this process, by means of digital practice has the potential to put architects back in control of the building process as the master builder. Although computer aided design and manufacturing has primarily been associated with elitist architecture, the implementation of digital design-build has the potential to create a better product for less money than conventional construction in mainstream design and construction practice.

Wherefore, the goal of this research is to investigate the process of digital design and fabrication, its pros and cons with respect to cost, time, constructability, and whether architecture based on this notion is limited in its formal qualities. In addition to practice issues, the studio will be a evaluated in its effectiveness over time as a learning model in architectural education. The process is explored by means of teaching, meaning the students with the aid of professors are developing projects that probe explorations in CAD/CAM. The projects are therefore, real world projects with a client, a site, and a budget. Currently, the Utah Transit Authority (UTA) is funding a project in which students develop designs, drawings, pricing, and lead times for digital manufacturers, in order to build prototypes for construction. The process is documented in preparation for a report that evaluates the project and recommends a design and construction based on the research discoveries. The project will be built in town as the first in a series of shelters for the Bus Rapid Transit (BRT) system. The model will be evaluated and repeated with modifications for a future shelter project for the University of Utah Campus Shuttle system in connection with the Campus Facilities and Planning Department. Additional projects being sought for subsequent years include student union demountable booths, as well as other small pavilions and buildings on campus and in the community. Funding for the program is provided by the client organizations and additional support is being sought from parametric software developers for testing in the digital design-build program and manufacturers who are working to emerge in mainstream building practice. Funding is also being requested from the Lowell Bennion Campus Service Learning Center at the university once service learning designation is awarded to the studio course.

2. CASE EXAMPLE

2.1 Work Description

The work conducted on a project in the Digital Design-Build Studio is broken into the following three phases: Design Competition, Design Development, and Prototype Construction.

For UTA the initial design commenced with a three week design competition. The competition was introduced as an initial meeting with the client representative, a project manager at UTA to establish the goals, expectations, and programmatic requirements for the project. Students worked in teams of three or four with their studio professors on urban analysis and architectural design. A presentation was then made of the schematic designs to a jury consisting of representatives from UTA and the college in order to select teams whose projects respond most appropriately and innovatively to site and program while utilizing a CAD/CAM intention. The top three winning teams are now participating in the following phases of development of the project.

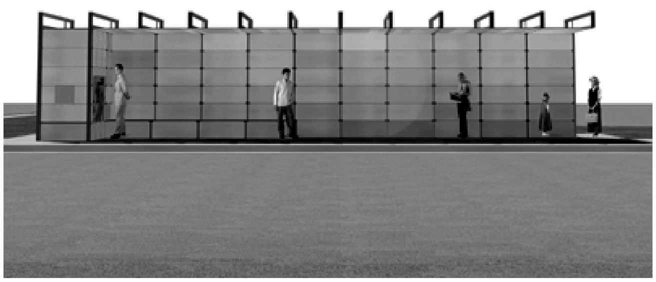

Fig. 2 UTA BRT Winning Schematic Design Scheme (Jensen, Bradford, Newbold, Sumsion)

The students are currently participating in the latter end of the second phase of work consisting of construction documents, pricing, and construction process development and planning. This phase involves meeting bi-monthly with the client representative or group and engaging a structural consultant and other consultants as deemed necessary. The process is lead by a steering team made up of experienced designer/fabricator professors. The student team members have been given responsibilities in conjunction with the roles of the professors, namely: the project leader who acts as a manager of the team by keeping track of responsibilities, maintaining the schedule, interacting with consultants and reporting bi-weekly to the professors; the modeling leader who is primarily responsible for developing the digital models, and the pricing leader who is responsible for interacting with fabricators and contractors. Each group has developed the project including locating fabricators, beginning digital ready files for fabricators, and establishing a construction methodology and associative price in preparation for prototyping. After the pricing data is gathered a decision will be among the teams as to which design responds to the issues budget, speed of construction, durability, and constructability. A design will then be chosen for building the prototype.

Digital ready files are being produced in phase two in preparation for fabrication of parts or wholes for construction. In the third phase, students will observe the fabrication of parts at the fabrication shop. The components will be transported and assembled at a predetermined site. The construction will be supervised by professors. The prototype with its pricing data and lessons learned, will be evaluated in a report as a model for implementation on the 3500 South corridor for design/construction by UTA.

2.2 CAD/CAM

The dialectic of form making to physical making of architecture is explored in this studio. The question of what determines form is difficult to evaluate. In the process of digital design and fabrication projects issues of software platforms capability may determine form. In other projects the manufacturing technology available is only utilized in so far as it is a step in accomplishing the desired design objective. This latter traditional method of producing architecture continues to disassociate design from production. Rather, in the digital design-build studio the goal is to explore the methods of manufacturing and fabricating for building as the impetuous for design and form making. In short, the software and manufacturing technology informs and may even drive the design process. Students therefore learn of the importance of understanding the tools necessary to fabricate and produce buildings. In order to foster this knowledge students are taken to CNC (Computer Numerical Control) fabrication shops including digitally driven laser/water jet cutting, 5-axis milling, tube and pipe bending. These processes are evaluated and explored for their potentials in form making such as testing them against forming surface, plane, and or volume. The design process then yields a product that relies on the technology available.

Students of architecture learn software programs quickly and efficiently. Many students are excellent modelers on the computer, however have not learned to harness the skill into design, having utilizing three dimensional modeling programs for visualization only. The studio presents opportunities to apply specific software applications to the design intention. Many different software packages are available, however vary in their function. There exist 5 general groups of parametric modeling environments in computer aided design, namely, concept renders such as Sketch-up and Form-Z, animation programs such as Maya, entity based programs such as Vectorworks or AutoCAD, component based software otherwise known as building information modelers such as Revit and ArchiCAD, and finally design development modelers such as SolidWorks in the industrial design arena and in architecture, CATIA.[3] The digital-design build studio encourages students to experiment with software applications that meet the design intentions based on the abilities of the fabricators. CATIA is a powerful platform that offers great advantages for integrated design in building information modeling environment that can act as a database of information represented in a variety of mediums, graphically being just one, however is difficult to learn in a short semester-long studio.[4] Proactively, the students will continue to learn software packages in the future, and as the studio evolves year to year, the platforms will become more sophisticated. It is the intention of the studio therefore to utilize and test software capabilities according to design intentions.

[3] Shodek, Bechthold, Griggs, Kao, and Steinberg. Digital Design and Manufacturing. Wiley Publishers 2005. Ch. 10 Fundamentals of Digital Modeling

[4] Ghery Technologies has developed an architectural version of CATIA called Digital Project that offers a more user friendly environment.

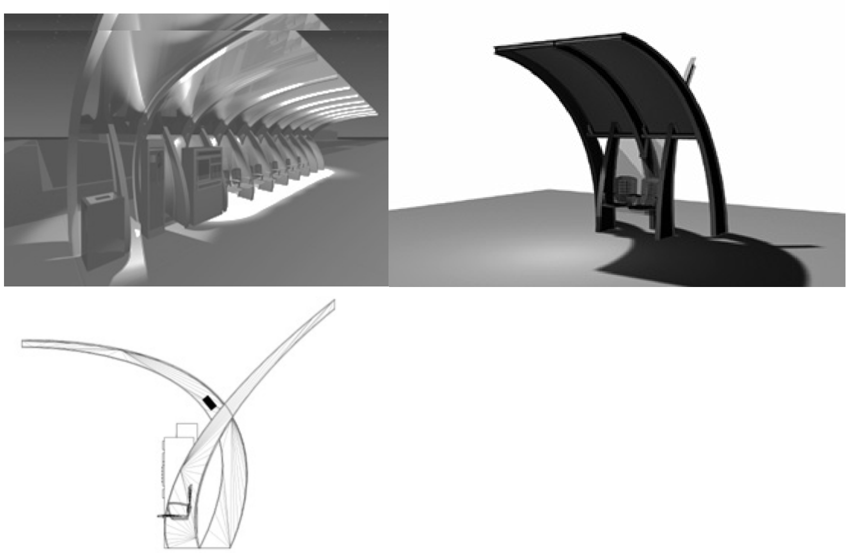

Fig. 3 Initial design concept (concept render), construction module (Entity Based), digital development of steel components for fabrication (Design Development Modeler)

2.4 Practice Training

In addition to learning issues of software and fabrication students also learn real life lessons concerning professional practice such as the realities of client and consultant interaction. For example, in the UTA project, students in meetings with the structural engineer are evaluating issues in relation to design, similar to an office environment. In a recent report from one of the groups, the leader stated after a structural consultant meeting, “We have to make compromises on things that do not matter so much and take a stand with things that do. We have to let go of the randomness of the columns for an ordered chaos of grided columns on angled cants, but we are maintaining their dimension and profile. Although tube steel is not the best profile for making a moment connection, the tube profile happens to be the most economical.” Students are also learning about continued interactions with the client after a schematic design is approved or competition is won through bi-monthly development meetings. On list of things to do before next client meeting, one group noted a task list in their bi-weekly report as follows: “understand what the client ‘needs’, refine lighting scheme/talk to lighting consultant, contact fabricator for fabrication options, work on thermal expansion scheme on glass to frame, rework structural details according to engineer’s suggestions…” Lessons learned concerning practice issues in this experience are invaluable in aiding young architects in becoming leaders in the art of building.

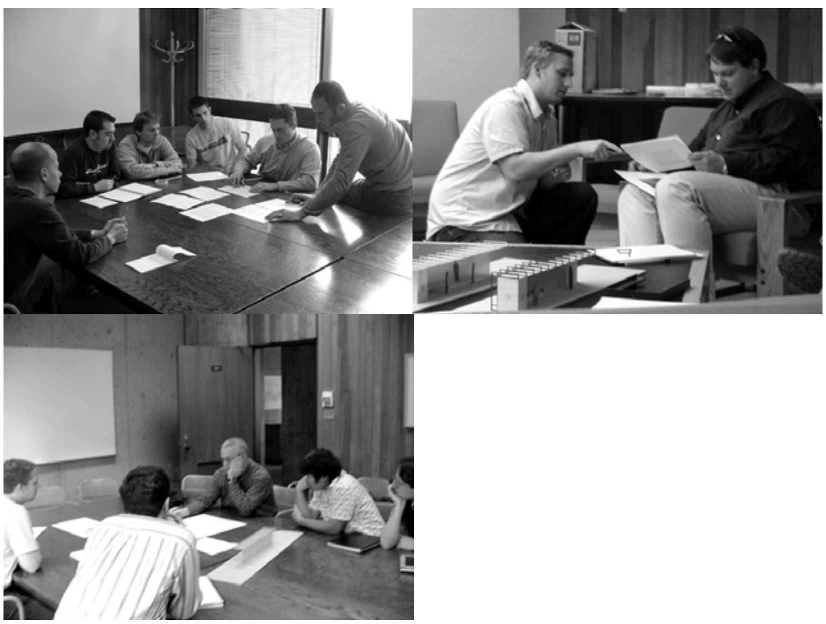

Fig. 4 Student team meeting with professors, student team leader meeting with client, student team meeting with structural consultant.

A vital role of the architect is with respect to serving the community at large. Although the projects in the digital-design build studio are client driven, the design-build projects are also related to important community and civic issues. For example, for the Utah Transit Authority, the design calls not only for a sophisticated shelter design, but one that considers ticketing machines, integral signage, and accommodations for twenty waiting riders per stop. The issues of design range from traffic analysis, urban design, landscape, graphics, and iconology of the bus system itself. The issues addressed through the studio help in teaching students the importance of design as a social and ethical responsibility.

3. LESSONS LEARNED

3.1 Conclusions

The outcomes of the Digital Design-Build Service Learning Studio are beneficial for students, the community, and the profession of architecture. First, students learn about the realities of practice through the lens of a real world project that is built. The scale of the projects is such that students are able to experience similar phases of a design project in the profession at an increased pace. Therefore, the students learn the skills necessary to become instrumental on a design team. Students also develop a sense of obligation to the community as the projects work to foster an attitude of education as part of practice. The community benefits from the service learning class by having their programmatic needs met. In addition, under the digital design-build methodology, community groups have projects built that surpass traditional practice models trough producing a better end product at a potentially lower cost, in a shorter amount of time, while engaging in a process of supporting public education of young architects. The profession benefits from the studio in producing knowledgeable and skilled designers in the digital design and fabrication arena.

Construction in the U.S. is relatively cheap in materials costs and expensive in labor costs. In traditional models of design-build education students are hence often exploited as cheap labor to accomplish construction projects for the benefit of the community. The digital design-build studio utilizes students as a means of education in the manner in which they will be practicing, that of design development. The students then engage in construction by means of development and observation without being used for labor. As a new model for architectural education, the Digital Design-Build Studio address all aspects of architectural education and practice and combines them into one concentrated and integrated experience that teaches client interaction, programming, site planning, consultant interaction, management, and construction administration.

Fabricating – Design – Research: Examining the Integration of Digital Fabrication Technologies into the Architectural Curriculum

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ABSTRACT

This paper examines the roles that Digital Fabrication and Manufacturing technologies can have on the ability to Fabricate Design Research. In particular, it examines the ability of digital fabrication technologies to stimulate, initiate and integrate design research of various areas in the architectural curriculum. The paper explores the inherent relationships between fabricating, design and research and how one should understand their meanings in his/her own design process.

As a primary case study, the paper will present student work from a course titled "Introduction to Techniques in Rapid Prototyping", in which students were introduced to various digital fabrication tools and software. The student work demonstrates the interactive design process in which fabrication, design and research are interwoven in order to investigate new design methodologies based on new technologies.

1. INTRODUCTION AND HISTORY

In 2001, The Catholic University of America's (CUA) School of Architecture and Planning (in Washington, D.C.) began an initiative that examines Computer-Aided Design and Manufacturing (CAD/CAM) in architectural education and the profession. The intent was to integrate notions of building technologies, digital media and material imagination in a progressive and innovative way. Since the inception of the initiative, CUA's architecture program, already nationally recognized for design education and physical model making[5], passed a resolution that would require all incoming freshman to purchase a laptop computer and appropriate software. This requirement would, in turn, require numerous revisions to the existing curriculum, including the introduction of various digital media courses at the entry level, coupled with additional advanced seminars and graduate concentrations in Digital Media and Digital Fabrication. In addition, the requirement would foster the development of higher-end output and peripheral labs to augment the increase and interest in the area of computers in architectural design.

The school initially purchased a Universal X-660 45-watt CO2 laser cutter and engraving system, a Microscribe 3D digitizer, and a vacuum-forming system. In addition, the School made a number of software purchases, including Rhinoceros 3.0 (NURBS modeling) and Solidworks (parametric modeling). During summer 2005, a 4'x8' Techno-Isel 3-axis milling machine, as well as Mastercam (CAM software), will be purchased. Together, these tools will make up the Digital

[5] The Catholic University of America School of Architecture and Planning was featured in an exhibit entitled "Modeled Space, Space Modeled" held at the National Building Museum, Washington, D.C. (2002). The exhibit demonstrated how the process of architecture advances through various stages, from recording and analysis of existing conditions through presentation of a design proposal.

Fabrication Lab, an annex to the existing Wood & Metals shop. The intent of these labs will be to support student design work and research, as well a foster a renewed interest in the culture of making.

In order to support and introduce students to the concept of digital fabrication, an undergraduate seminar entitled “Introduction to Techniques in Rapid Prototyping” was introduced. There were three goals for the course. The first was to teach the techniques and processes associated with the design and fabrication tools. The second goal was to educate students on how to integrate digital design and fabrication tools into their own design methodology. It was crucial that the course require students to learn by making through a process which would consistently provide feedback, thus informing the development of a design. Thirdly, to produce work that generated interest and excitement about the potential of Digital Fabrication and to communicate the notion of how digital tools are beginning to redefine existing conventions of building technology, material understandings and professional practices. The ability for the subject to spawn new avenues of research for students to pursue is critical for the ongoing success of the initiative.

2.0 COURSE CONCEPTION: FABRICATING – DESIGN – RESEARCH

In the introduction to “Versioning: Evolutionary Techniques in Architecture,” Sharples Holden Pasquarelli (SHoP) uses the term *“versioning”* as an operative term that describes “the way in which architects and designers are using technology to expand the potential effects of design.” Versioning implies that emphasis is placed on technique rather than image. The technique advocates an iterative process of design in which the computer becomes an indispensable tool that provides feedback during the design and fabrication phases. It becomes an attitude rather than an ideology, which allows the designer to think “across practices” as a way of problem solving.[6] The notion of “versioning,” coupled with the ability of digital fabrication technologies to quickly test and re-test a design scheme, creates a more methodical design process that is more closely aligned with established scientific, historical and statistical methods of research. In turn, the design process becomes an iterative research process, creating a case study or default test case and constant testing procedure. (Fig.1)

We can say that the above-mentioned process consists of three parts: fabricating, design & research. The *Oxford English Dictionary* defines fabricating as the act of “constructing, or manufacturing.” It defines research as “the act of searching (closely or carefully); to search again or repeatedly,” and design as a method of “form(ing) a plan or scheme; to conceive and arrange in the mind; to originate mentally, plan out, contrive,” as well as “to have in view, to contemplate.”

The three words become descriptive of a design methodology in which new technologies are integrated as a means of generating both design and production data. The designer mediates between the virtual world of the computer and the physical world of the artifact, learning from each successive phase. The process is by no means linear; it can be described as a continually narrowing cycle as the designer begins to question relations between the three. How does one fabricate a design and what is its relationship to designing the fabrication technique? How does one design his/her research versus researching his/her design? And ultimately, how does one research fabrication and what avenues of research are fabricated given this process? By asking these important questions during the design phase, not only does a design develop, but it also enables one to generate avenues of research for further study, within the original scheme or outside of it.

The relationships between fabrication, design and research became the framework for the development of the course. (Fig.2) This framework would require students to continuously and iteratively make associations between design and fabrication, between fabrication and research,

[6] Sharples, Holden, Pasquarelli (SHoP), *Versioning: Evolutionary Techniques in Architecture*, AD Architectural Design, Vol. 72, No 5 September/October 2002, Wiley-Academy.

and between research and design. The intent was to provide a methodology in which students could question their work in a productive fashion for design development, but also allow students to consider areas of research that could be applied to other courses, studio work and/or graduate studies.

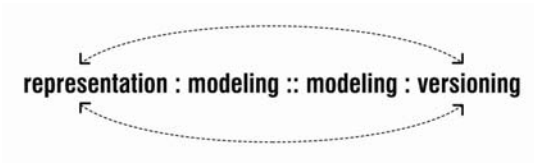


Fig. 1 SHoP's diagram of "Versioning"

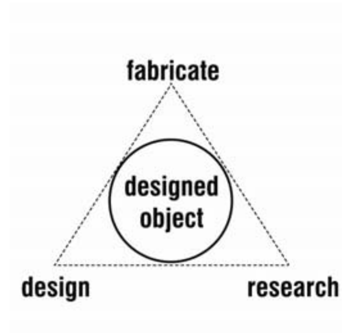


Fig. 2 Fabricating Design Research Diagram

3.0 COURSE DESCRIPTION

Given the above-mentioned notions of fabricating, design and research, the course outline for "Introduction to Techniques in Rapid Prototyping" was developed that addressed three objectives; technique and process, thought through making and research development.

Rather than continuing the centuries-old process of distancing the architect from the physical construction site, CAD/CAM and Rapid Prototyping applications demand that architects immediately participate in very real issues of material manipulation, fabrication and assembly. Rather that liberating the architect or allowing for ever-greater degrees of abstraction in design, CAD/CAM places necessary limitations and makes demands on the designer to clearly think about construction issues during the design process. The interplay between digital tools, virtual and physical models and their applications represent very rich opportunities for architectural development. This course serves as an introduction to issues as they relate to design processes, materials, fabrication and architecture.

Students were introduced to Rhinoceros, a 3-D NURBS modeling program. In addition, students learned the use of a 3D Digitizer as an input device and a CO2 Laser Cutter as an output device.

A total of five projects were assigned during the course of the semester. A number of design problems were assigned in which students investigated the potential of the computer's ability to rapid-prototype assemblies in quick succession. The first four projects were designed in a way to teach the software and tools, as well as technique. During project five, students were asked to further develop their schemes by proposing avenues of research, supplemented with precedent studies in fabrication and design. Students focused on how this process can inform the design and construction of architectural elements.

Although this class is a 3-credit seminar for 2nd and 3rd year architecture students, the mode of instruction more closely resembles a design studio. This allows a student to follow through with a semester-long design investigation fully engaging the software and equipment, honing his/her skills and knowledge to develop a project that he/she can become passionate about.

4.0 PROCEDURE / INTEGRATION / APPLICATION

4.1 Project 1: Base Prototype 3D Model

During the Project One, students were asked to select an object from a provided list made up of architectural objects or products, such as bricks, shingles or joints, as well as door knobs and pulls, light diffusers and containers. Students were asked to create a virtual model of their chosen object using Rhinoceros. This exercise served as a means of introducing the software to the students. The objects were modeled in great detail and the students created high quality rendering that represents existing characteristics they observed.

For the purposes of this paper, the work of two students will be presented. They will be referred to as Student A and B. Their designs will be used as examples of the methodology followed during the course.

Student A chose a lamp with a carved wooden base and a traditional fabric lamp shade. (Fig.3,4) Student B chose a cast metal cabinet pull with a curved form. (Fig.5,6)

Fig. 3 Student A

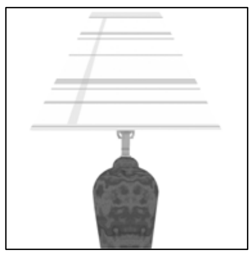


Fig. 4 Student A

Fig. 5 Student B

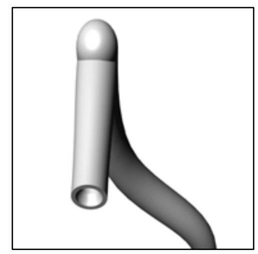


Fig. 6 Student B

4.2 Project 2: Digitizing Physical Qualities

In Project Two, students were introduced to the Microscribe 3D Digitzer. 3D scanning (or 3D digitizing) involves the creation of a digital model by translating points in physical space into virtual 3D space, in turn creating a digital version of a physical object.

Instead of digitizing the objects chosen in project one, students were asked to create an "analogue object model," which became a physical representation of a characteristic or quality inherent in the original object. This exercise forced the students to look at their objects in a new way. Students considered notions of materiality, translucency, opaqueness, weight and form. The intent of the analogue object model was to physically capture these qualities to serve as a transformative tool given the 3D digitizer. In other words, with the use of the digitizer, students were asked to capture the physical properties of an object that were next to impossible to model virtually. Digitizing allowed a copy of the physical object to be represented electronically and eventually allowed the electronic version to be manipulated in ways the physical version cannot.

4.2.1 Student A: Material and Gravity

After discussing the initial object with Student A, he chose to investigate how the formal properties of one material can translate to another material. In the initial object (the lamp), the fabric material was considered to be a fluid, dynamic material with light-filtering characteristics. In contrast, the base of the material, a solid, carved-form of wood, was considered to be static and heavy. For his analogue object model, Student A chose to represent the idea of a solid material, which will respond or transform its formal properties relative to an applied force and gravity. Student A chose acrylic as the default material that would be deformed. Prior to deforming the material, he drew a reference grid over the surface. Using a heat gun, the sheet of acrylic was melted over a form. (Fig.7) The resulting form was an extremely complex geometric form that was directly related to the process by which it was created. (Fig.8) This object was then digitized by plotting the points along the reference grid in order to create a virtual model. (Fig. 9,10)

Fig. 7 Production of model Model

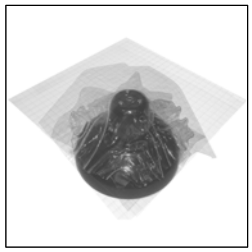


Fig. 8 Analogue Model

Fig. 9 Digitizing Process

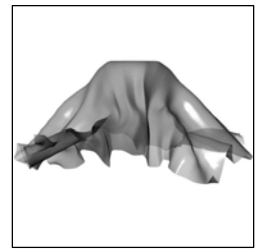


Fig. 10 Virtual

4.2.1 Student B: Form & The Human Touch

The door pull which Student B selected during the first phase suggested the idea of the human touch. The form of the door pull made a weak attempt to respond to the human hand. Student B pursued an investigation into customizing architectural components based on user specifications, or the human form. In order to create his analogue object model, Student B produced a casting of his hand in the position in which it would grasp a door pull. (Fig. 11,12) This object was then digitized to create a virtual model. (Fig. 13,14)

Fig. 11 Production of model Model

Fig. 12 Analogue Model

Fig. 13 Digitizing Process

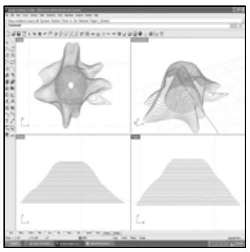
Fig. 14 Virtual

4.3 Project 3: Fabrication Drawings

During Project Three, students developed their virtual models from the previous exercise into fully constructible virtual assemblies that considered all details, connections and materials. In addition, fabrication drawings were created from which the physical model would be cut using the Universal CO2 Laser Cutter. The drawings were created directly from the 3D virtual model.

The process in which the students disassembled their virtual models required them to envision the final form of the object. To create the drawings, a thorough understanding of the assembly process was required prior to disassembling the model. This thought process required students to revise their constructs as necessary. Students began to understand the notion of how CAD/CAM processes place necessary limitations and make demands on a designer to think clearly about construction and assembly issues during the design process.

For the fabrication drawing portion of the course, Student A chose to create a light-filtering device. In order to create the fabrication drawings, a series of contours were cut through the object that allowed for alternating materials to create areas of translucency and opaqueness. (Fig.15) Cut templates were nested and prepared for cutting. (Fig.16). Student B produced a virtual model of a schematic door pull that would be incorporated into a stock cabinet door and/or drawer. (Fig.17) The solid wood insert would serve as formwork for a finish veneer to give the impression of a continuously curving wood surface. The object was then contoured to provide cut templates for wood to be cut and stacked together to imply the form. (Fig.18)



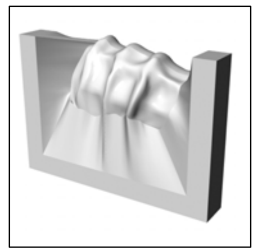
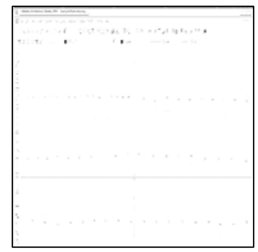



Fig. 15 Student A: Contours Fig. 16 Student A: Templates Fig. 17 Student B: Solid Model Fig. 18 Student B: Templates

4.4 Project 4: Laser Cut Model

During Project Four, students were introduced to the Universal CO2 Laser Cutting machine. Components of each design were cut and assembled into the final proposed fabrications.

4.4.1 Student A: Light Diffuser

Using the CO2 laser cutter, Student A cut multiple layers from wood and acrylic. (Fig.19) The layers were then assembled by stacking them about a center reference point. (Fig 20,21) When a light was placed below the object, the form glowed with a soft light. (Fig.22) Due to the undulating form of the object, the light was brighter at areas where the perimeter of the acrylic layer was closer to the light and was dimmer as the acrylic layer distanced itself from the light. Although the object, produced an interesting effect, the means of disassembly was simple a result of cutting multiple plan cuts through the form. Critiques of Project Four suggested a departure from the light filtering properties in order to focus on technique rather than effect.



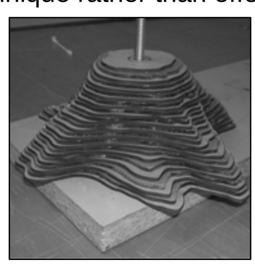
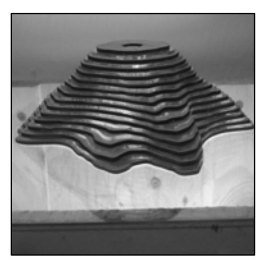



Fig. 19 Student A: Laser Cutting Fig. 20 Student A: Assembly Fig. 21 Student A: Model Fig. 22 Student A: Model

4.4.2 Student B: Door Pull

During Project 4, Student B fabricated the door pull insert using the CO2 laser cutter. A mock-up revealed that the expansion and contraction of the material produced an undesirable warping of the veneer over time. This unexpected result led Student B to think about how he may integrate the pull into the drawer/door itself. By prototyping the object, Student B was informed about his design in a way that would not have been possible in its virtual state. Design began on the next iteration; the integration of a customized handle into the face of a cabinet door and/or drawer. (Fig. 23-26)

Fig. 23 Student B: Sketchbook

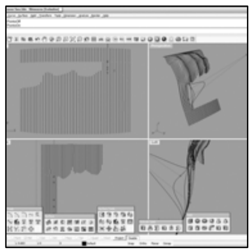


Fig. 24 Student B: Virtual Model

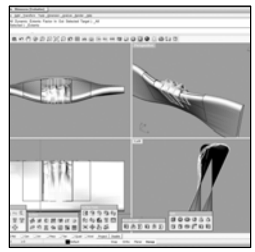


Fig. 25 Student B: Virtual Model

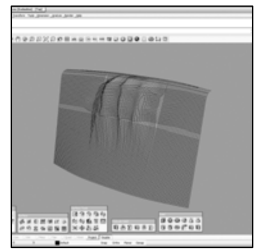


Fig. 26 Student B: Virtual Model

4.5 Project 5: Final Project "Fabricate-Design-Research"

During project five, students were asked to revisit their design schemes given their newly found knowledge of digital design and fabrication. Students then proposed avenues of research that were generated as by-products of the preliminary design process. To support their research, students investigated precedents into their chosen topics providing necessary information that would be folded into the development of the final scheme.

It is important to note that during this phase an emphasis on the cyclical nature of design was stressed. Students were encouraged to move freely in the design process, between all phases of the previous exercises, allowing the processes to inform the design. Given the ability to rapidly prototype assemblies, the students employed a design methodology that allowed them to quickly test and re-test their design scheme while asking the questions related fabrication, design and research.

4.4.1 Student A: Technique and Craft

Referring back to the analogue object model, Student A became interested in the reference grid applied to the flat acrylic sheet prior to deformation occurred. These lines, once straight, now appeared to be warped, twisted, and random. Student A chose to explore how these lines could be fabricated rather that replicating the form of the object itself.

The avenue of research that Student A chose to pursue had to do with issues of "craft." He began to look into traditional means of wood bending. Charles and Ray Eames' work provided valuable insight to use of a form onto which a wood member is shaped.

Prior to fabrication of a physical form / bending armature, a "trench" was subtracted form the virtual object along the grid lines that had been digitized in Project Two. (Fig. 27) This model was then contoured, fabrication drawings were generated, and a physical model was produced. (Fig. 28) Once the physical model was ready, Student A soaked a number of wood members in water. The members were then fit snuggly into the trenches along the bending armature. After the wood members had dried, the wood was removed from the form and studied. (Fig. 29,30) Although, the members did not entirely keep the form of the object, the ability to control and predict the three dimensional curvature of a line-like member in space was successful.

Many often criticize CAD/CAM technologies by stating that they erase traditional notions of craft. What was interesting about Student A's project was that it attempted to use technology to inform a traditional craft. This overlap became very exciting area to investigate. Critics of this project directed Student A to look into other crafts which allow thin members to retain their shape. The craft of weaving was proposed. Although the final project did not address notion of weaving fully, Student A became interested the ability to form wood while applying the techniques and patterns of weaving to help the material keep its shape while gaining strength.

Student A is currently in his second semester, fourth year. He had indicated that he is extremely interested in pursuing further research into notions of craft and materially as related to CAD/CAM technologies.

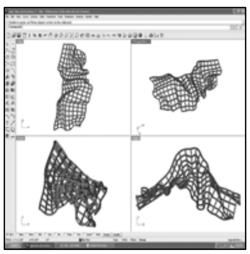


Fig. 27 Virtual Model Wood Model

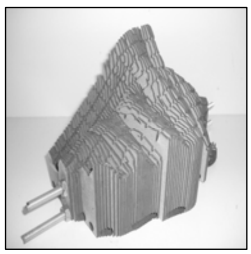


Fig. 28 Bending Armature

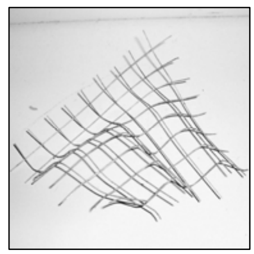


Fig. 29 Final Wood Model

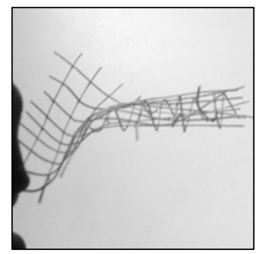


Fig. 30 Final

4.4.2 Student B: Integration of Product

For the final project, Student B chose to examine how the integration of an accessory product into the form of, in this case, a cabinet door could create new possibilities or programmatic uses. Student B researched the Harvard University Graduate School of Design admissions office millwork design by Office dA (Boston, MA). In this project, layers of medium density fiber board were stacked together and sanded in order to create the desired, undulating form. The form was then veneered using a vacuum-forming bag. Cabinet pulls were integrated into the undulating form, thus disguising the required pull and push locations. Student B examined the potential to take this idea a step further. He became interested in adding value to the form by allowing one piece to affect the piece above and/or below by serving as a locking device. Student B began to research millwork hardware systems and components from manufacturers like Hafele. For this design, the idea was to eliminate the application of hardware but to integrate it into the design, in turn informing and legitimizing the form. (Fig.31,32)

Although the final design was not physically mocked, the ability of the computer to animate the movement of the pieces suggested how the pieces would work. Student B plans to continue the development of this system during independent research course over the summer. He plans to spend the time fabricating full scale working prototypes.

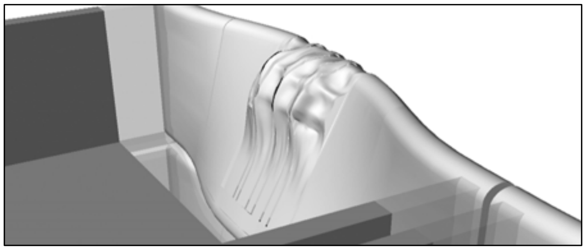


Fig. 31 Student B: Virtual Model of Drawer

Fig. 32 Student B: Elevation of Drawer Front

5.0 SUMMARY AND CONCLUSIONS

“Introduction to Techniques in Rapid Prototyping” stressed ideas of fabrication, design and research by focusing on technology and technique in order to develop a design methodology. It focused itself squarely on these issues without being tied to the development of program. The work presented was successful in that the participating students have proceeded to pursue areas of study at the graduate level that require more detailed, rigorous investigation related to issues in CAD/CAM processes. The intent of the course was achieved in that the students have taken the knowledge gained directly from the course back to their studios and continue to synthesize their modes of working, the techniques and the technology by questioning the relationships between fabrication, design and research.

6.0 FUTURE DEVELOPMENTS

As of the fall semester (2005), The Catholic University of America’s School of Architecture and Planning will be offering a graduate level concentration in Digital Fabrication. Courses in this concentration will include studios dedicated to the investigation of CAD/CAM processes in the design and construction of architecture and architectural projects. Through a design-build model, students will gain first hand experiences of real world issues when constructing and/or fabricating building scale structures. In addition, students will be required to take a number of concentration electives. These electives will range from instruction of various software platforms and CAD/CAM machining processes, to architectural theory (in digital design and computation) and professional practice. The intent is to provide students with a well rounded Master’s level education while allowing them to pursue thesis research and design work in the specific area of digital fabrication.

“Introduction to Techniques in Rapid Prototyping” has been successful in the way that it has generated much interest in the subject. Given this success, the course will remain at the undergraduate level. Its position in the undergraduate curriculum is intentional and will serve as a feeder to the graduate level digital fabrication concentration. As of March 2005, approximately 10 students have registered for the graduate level concentration, all of which had been enrolled in “Introduction to Techniques in Rapid Prototyping.”

Having explored this teaching model for the last two years with the limited resources available at the time, the instructors can speculate that the model will need be to be revised as new tools and resources become available.

Next steps in the integration of digital fabrication technologies into the architectural curriculum will investigate larger scales of design and production to engage building-sized proposals while exploring more complex assemblies made from component parts. The instruction of parametric modeling will be an important inclusion as the software allows students to rethink and revise his/her design process based on production techniques and constraints, providing a more efficient way of moving between design and fabrication. Other areas of investigation will include more thorough research of manufacturing methods in other industries.

Although the content of “Introduction to Techniques in Rapid Prototyping” will require revision as new tools become available, the basic notion of “fabricating design research” will continue to be a framework for future iterations of this introductory course. The subject continues to generate a high level of work and thought, which the is filtered out to design studios for all to learn from.

30 Pieces of Plywood: exploring digital processes of making

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ABSTRACT

This paper describes the process and findings related to the implementation of a digitally fabricated installation within the context of an undergraduate third-year architectural design studio, entitled "Thirty Pieces of Plywood." This title referred not only to the material under consideration, (plywood), but the scope, (thirty pieces), of the installation as well. The installation served as the final four-week project in the fall term for a group of 15 students exploring the potential of using a digital "medium" for design, collaboration and construction. This project required the design teams to tangibly realize a digital form, understand the material nature of architecture in both a digital and material realm and interrogate digital fabrication of a process of design. Fabricating reality became the process of reconciling the digital and the material. The focus of this investigation was to understand a method of digital exchanged afforded by a digital medium, allowing the digital model to become the vehicle for design, fabrication and assembly and in doing so explore the use of the computer in making.

1. Introduction

For the past three decades, the integration of digital technology has evolved from the replacement of the drafting board with an emphasis on production and efficiency to an essential tool for visualization. It is at this point that the practice of architecture is beginning to critically examine the implications and opportunities that digital design and fabrication technologies offer in contrast to the established method of architectural design, production, and delivery. Within academia, schools across the country and abroad are beginning to recognize the need redefine the "woodshop" to include CNC devices, i.e., CNC routers, laser-cutters and 3D printers. It will be implementation and application of the "digital fabrication shops" that will define the next step for computers in a digital era. Investigating the relationship between architectural design and a digital means of production will provide a material understanding to a new digital practice of architecture. Alicia Imperiale describes in her book New Surface Flatness that, "Digital technology has not only ubiquitized media, image and communication. It also poses a radical shift in the material, technology and communications involved in the construction industry." This has lead architects to search outside their own discipline for inspiration. (Imperiale 2001)

This renewed interest in understanding building materials and assemblage methods coupled with the digitally facile designer will challenge the traditional role of the architect and the project delivery process. Establishing a relationship between the designer and fabricator will allow for new avenues of collaboration. Exploiting the opportunities inherent in a digital design process, whereby information can be exchanged between collaborators from conceptual design to fabrication, allows the architect once again to be immersed in making. Understanding of the fabrication process and the translation of digital design models to the Computer-Aided Manufacturing (CAM) software for the generation of control data to drive numerically controlled fabrication equipment will allow designers to be part of a feedback loop that can now inform the design process. Where once the computer provided solely a digital representation of the design intent, it now provides instructional data sets for CNC fabrication.

This paper describes the process and conclusions related to the implementation of a digitally fabricated installation within the context of an undergraduate third-year architectural design studio, entitled "Thirty Pieces of Plywood." The "thirty pieces of plywood" referred not only to the material (plywood) under consideration but the scope of the installation (30 pieces) as well. The installation served as the final four-week project in the fall term for a group of 15 students exploring the potential of using a digital "medium" for design, collaboration and construction. Various components of the project were divided among teams in the studio that became responsible for design, coordination and the fabrication of their respective components of the installation planned for the courtyard space adjacent to the architecture building. The "thirty pieces of plywood" installation required the design teams to tangibly realize a digital form, understand the material nature of architecture in both a digital and material realm and interrogate digital fabrication of a process of design. Fabricating reality became the process of reconciling the digital and the material. Students sought to exploit the exchange of information afforded by a digital medium, allowing the digital model to become the vehicle for design, fabrication and assembly.

Fig. 1 Completed Installation in the Courtyard.

2. Digital

2.1 Digital Process

The representation of materials in the immaterial realm of the computer has brought about a fixation on image over that of an object's true physical properties. This fixation on image limits the role of the computer as merely a tool for visualization. Advances in software technology have provided the designer with the ability to accurately represent a material in an immaterial digital world. Material properties in the digital world are assigned, characteristics such as reflectivity, incandescence, transparency, diffuse, specular, shinyness, eccentricity, and color all of which represent a visual component of a physical object. The true properties of a material like strength, stress, and texture can only be experienced in the physical realm. Digital design has also taken on a new vocabulary and method of form making. As Joseph Rosa describes in Folds, Blobs and Boxes: Architecture in the Digital Era the differences in vocabulary in contemporary architecture verses that of a pre-digital era where "beauty, scale and proportion… have given way to adjectives like smooth, supple, and morphed." (Rosa 2001)

Figure 2. Design Intent: Surface Model.

Digital media has brought about a blurring between what is real and what is virtual. Due to this blurring between the digital and the real, designers are becoming further removed from the material, that which is physical, to explore the intangible, ephemeral accepts of virtual space. This project seeks to bring a material understanding to a digital design process and allow a digital craft to emerge. The blending of design and fabrication via the computer is providing opportunities for architects to return to a previous era of the "master builder".(Cheng 2000) Computer-numerically controlled devices allow architects to share in the process with fabricators and to understand more the act of assemblage and fabrication.

2.2 Digital Design

This project began as a digital exploration investigating the process of translating a digital representation into the realm of real materials. The studio was provided with a digital surface that served as the design intent for the project and became the standard by which each of the teams would generate their respective components. The teams were divided into the various structural components; the primary structure of the ribs, secondary structure of the slats, and the final component of the skin. The digital process was centered on the ability to exchange data between individuals within each team and between teams. Using the digital model as the single source for design and construction allows one to visualize potential areas of conflict. The intent of the project was to translate a "digitally born" surface into a materially analog equivalent. (Kolarevic 2003) The benefit of a digital medium is that the process of moving from conceptual design to fabrication, through a “file-to-factory” process, is collapsed and the time allotted to design is extended into the fabrication process. (Kolarevic 2003)

2.3 Coordination

The ability to coordinate between the teams quickly became critical to success of the project. Teams could not work within a vacuum as is sometimes the case when working independently as the sole author. Within the first week of working together the coordination between the rib team and slat team began to breakdown due to a lack of communication. The digital data shared between the teams needed to be coordinated. Simple naming conventions and common areas on the network made accessible to all teams and team members needed to be established. Work schedules between the teams and among the team members varied leaving the most current file hidden within a field of data. As the week progressed, certain students from each of the respective groups emerged as a point of contact and the responsibility of coordination fell on their shoulders. Miscommunication between the teams demonstrated the need for a project manager. By the end of the second week, one student took on the responsibility to ensure the coordination between teams, final fabrication instructions and final assembly.

2.4 Digital Design Development

Design development takes place within any project and the “Thirty Pieces” project was no different. As the “surface” began to be realized materially, the teams needed to understand the limitations of the selected final material, plywood, and the limitations of the 2D cutting process. Once the final shape had been established for each individual component, whether part of the ribs or the slats, further analysis of how the component would be fabricated from a 4’x8’ sheet of plywood needed to be explored. In many cases the component at full scale would be greater than the length of the plywood. The design development needed to materially explore each of the components at full within the model space of screen.

For example, the primary structure of the ribs was created by slicing the surface at regular intervals. This slicing method produced the desired profile but not the actual material component needed to support the structure. The fabrication of each rib would require three layers of the plywood to ensure the seams or joints would be staggered over the length of the rib. This staggering of smaller pieces to construct a larger member had an added benefit in that it conserved the number of plywood sheets for the project. Reducing the radius of the components allowed the pieces to be nested more closely together thereby reducing waste. “Nesting” is the process of closely compacting items together. The nesting required some forethought as well. The 2D Cutting process using a CNC router with a ½” router required the students to consider a 1/2” kurf to compensate for the amount the bit would remove around the boundary of each component. Once each of the components had been successfully broken down into its respective smaller elements the task of nesting multiple pieces on to one sheet of plywood and labeling each of the components to ensure coordination was the task at hand.

Fig. 3 Digital Design Development Model.

2.5 Collaborative Process

The success of any collaborative project hinges around the ability to share knowledge and communicate it well. Whether using a digital medium or implementing a more traditional method of design, students needed to find a way to communicate with one another. This would require each of the students to develop the ability to understand and work with the dynamics of a group. Unlike many of their previous studio projects, ownership was not entitled to any one student. Design decisions were made collectively and the original design intent served to focus discussions and parameters for the project. By focusing on the common problem, resolving the surface in a material sense, the mentality shifted from the individual to the collective.

The use of digital media did in fact change the design process and impact the collaborative nature of the project. The exchange of digital information meant that each team did not have to redraw the previous team's components. Through the use of the digital model teams could freely share their respective components and provide the needed updates to the other teams. In many cases the members of the same team needed to be able to share a master file and distribute the work load.

The exploration of the digital to the real became apparent after the more forty slats had been modeled and ready to be transferred to the ribs team for coordinating their location at each rib. This presented a problem after the students realized the actual size of ½" plywood is 15/32". The slats' location and dimensions needed to be exact to provide the needed friction joints between each of the ribs. The coordination between teams became a skill that holds as much value as did knowing the 3D modeling software. In some cases there seem to be an unwillingness to collaborate due to the time constraint of the project. This unwillingness to take the time to stop working and ensure that everyone was up to date and each of the components were coordinated as the design developed manifested itself in the final product.

3. Analog

3.1 Fabrication Process

As the complexity of architecture increases the need for collaboration between designer and fabricator becomes more apparent. Exploring new design and fabrication methods will lead to a fundamental understanding of their implication on revising traditional design processes. The "30 pieces of plywood" project served as an introduction to 2D Cutting method of fabrication. Prior to this project the only experience with digital to analog method was using a laser cutter. The laser cutter provides the ability to construct small scale models from basswood, chipboard and acrylic within a limited range of sizes and thicknesses. The small scale models, while valuable, do not accurately convey the real-world conditions of building at full-scale. The process of fabrication began by using the two-dimensional information created in AutoCAD. This 2D data was then assigned a tool-path that would direct the CNC router to cut along a designated line or curve at the appropriate depth. This direct link to fabrication allows the students extent the use of their digital design data.

The 2D cutting process was not without its share of problems. Due to the humidity, the ½" plywood began to warp, in some cases as much as 4" in four feet. Attaching the material to the CNC router bed would mean using a mechanical fastener. This presented a problem by placing screws in the potential path of the cutter. The warping problem arose again as the individual components were in the process of being cut. As the cutter began to release the component from the stock, the internal pressures of the plywood cause each of the individual components to warp and curl. This presented a problem for the router as it moved across the bed. To resolve this problem, students fastened each individual component prior to the final cutting pass that released it from the material.

The final task in the 2D cutting process was the annotating the pieces as they were removed from the table for final assembly. Due to the nesting process, the components on one individual sheet of plywood did not necessarily correspond to the adjacent pieces. This required a level of coordination and a method of marking the material prior to be removed from the table. Establishing an annotation system allowed multiple students to assist during the 2D cutting process and extend the cutting times based on student availability outside of class.

The off-site assembly process required the careful coordination of all the individual pieces that made up each of the seven ribs and forty slats. The assemblage of the ribs and slats began by distributing each of the necessary parts for each component. This became an interesting task even with the annotated pieces and required consulting the original digital model when clarification was needed.

Fig. 4 2D Cutting.

Due to the large number of individual components comprising the slats, the coordination of each of the horizontal members became difficult to layout. While each of the slats had been marked as they were removed from the table, identifying the adjoining ends and their respective orientations became problematic. The slight curvature of each of the slats in the 8' dimension compounded the problem making it difficult to visually layout the components end to end.

Fig. 5 Off-site Assembly.

3.2 On-Site Fabrication

The on-site fabrication process became just as challenging as the previous design and off-site fabrication processes. While all of the components had been assembled and hand-delivered to the site, the location and method of erection was still to be determined. During the shakeout phase, understanding the numbering system at the site and the physical location of the individual components became problematic. Locating the exact location for the ribs to be erected presented a problem until the courtyard site had been marked and annotated for the task. It seemed that there was difficulty understanding the construction sequencing from the scale of a table top laser cut model to the full-scale installation on site.

After the layout work was complete, thoughts turned to how the ribs would be lifted into place and anchored without mechanical fasteners. This was resolved not by using temporary bracing by the solicitation and employing of the student bystanders who had gathered. Once the ribs were aligned, the four slotted slats were lifted into place that corresponded to their respective rib slots. This created a connection that would lock the ribs and slats together without the use of fasteners between the components. Once the four slats were in place the installation began to take shape and stabilize the structure while the remaining slats were installed. As the remaining slats were put into place, it became evident that without the use of a mechanical fastener to hold the ribs to the ground plane, the internal stress of the plywood would create torque in the tale portion of the installation. The smallest rib of the project required 20 slats of plywood to mate in a relatively small radius creating uplift on the rib. An on-site decision was made to cut the project length back to reduce the torque on the remaining structure. After cutting the slats back to the next rib and pressure was reduced and structure gained stability.

It became evident during the construction process that there was an error or an omission in the measuring of one of the brick seating areas. The design and fabrication of the installation was based on the assumption that the measuring of the existing conditions was correct. Where in fact the measuring was erroneous in one area and led the group to field modify the one of the ribs by attaching a portion of the rib removed from the tale. Until that point a folding chair had served as a prop for rib. The students also learned about the precision and levels tolerance required when linking digital design and numerically controlled cutting. This became evident in the field when it became clear the some of the slot dimensions had not been revised in the digital model and not adjusted prior to writing the tool-paths. Those slots then needed to be resized and cut by hand in the field with a jigsaw.

Fig. 6 On-Site Fabrication.

Another area where the collaboration between teams needed to have been more closely aligned is in the connection between the slats and the ribs. The ends of each of the slats needed to align to one of rib bays to ensure that each end of the slats were held in place by one of the ribs. The slat team worked from the original surface model and the rib locations provided by the rib team. During the design phase, the rib team determined it was necessary to revise the spacing of the ribs. This change was not communicated to the slat team and did not become evident until the construction phase. Had each of the teams re-assembled their respective models back into the final construction model, this error would have been seen before the components were fabricated and delivered to the site.

4. Conclusions

The role of digital technology needs to re-define itself, returning to a notion of craft and a material understanding within a medium that is inherently not material. Computers have evolved from production devices to conceptual modelers to exploratory tools and now a tool for fabrication. This early investigation has allowed students to understand the translation from digital to physical and the limitations of materials and fabrication processes. During the "30 pieces of Plywood" project, students were required to engage the computer as a tool for making. The pedagogical implication for introducing CADCAM to architecture design students creates not only an interesting challenge but an opportunity as well. That opportunity seeks to merge the digital facilities of today's students with a true material understanding of architecture. The blending of the digital and real or the material and the virtual holds the potential for the future of designing in a digital world. The creation of digital information, i.e. our digital models, no longer have to be relegated to a representative images but can offer a material understanding that can instruct in its own making.

Fig. 7 Completed Installation

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Studies of Early Representations of Balkan Vernacular Architecture

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ABSTRACT

This research involves the exploration of the earliest graphic and sculptural representations of simple architectural forms (dwellings and working buildings) found through a variety of sources and investigations, and the comparison of the buildings with contemporary examples of vernacular architecture of the Balkans. The work includes investigations from libraries, institutes, museums and on-site recording of building forms through photographic and digital means. The investigations have taken place over fifteen years in Austria, Hungary, Italy, former Yugoslavia and its Republics and Provinces, Roumania, Bulgaria and Turkey, as well as through contemporary research in important libraries and sites in Italy, Turkey, Greece, FYR Macedonia, and institutions and libraries in the United States, Europe and Asia.
The materials recently gathered include reproductions of images and on-site photographs of drawings, etchings, frescos, mosaics, sarcophagus reliefs, and building elements of early vernacular architecture of the lands of the Balkans. The results of these investigations are yielding representations of a complex set of morphological and typological building expressions that expose strong relationships with the remaining early traditional buildings of the Balkans. The materials reveal a variety of representational devices from iconographic or symbolic representation to more factual and accurate illustrative devices.
The analysis and understanding of where these device limits exist become part of an on-going work to better understand the roots of Balkan vernacular architecture. Another part of this investigation is to build, from the partial views provided, a logical and whole view of the elements and buildings represented and to compare these with the building technologies, morphologies and typologies that have been observed and known to exist for the last two hundred years in the Balkan peninsula and Turkey.
The presentation will include preliminary analysis of a number of early representations of Balkan vernacular architecture and comparative analysis of these with examples of remaining vernacular architecture that can be found on the Balkan peninsula today.

1. FRAMING THE STUDIES

For many years our studies have focused on the vernacular architecture of the Balkans, beginning in 1987 with studies in Yugoslavia and spreading throughout the rest of the Balkan peninsula and parts of Anatolia. Over the last year we have extended our research through explorations of the earliest representations of simple architectural forms found through a variety of sources including libraries, institutes, museums, and on-site recording of building forms through photographic and digital means. The investigations have taken place over the years in former Yugoslavia and its Republics and provinces, and most recently in important libraries and sites in Italy, Turkey, Greece, FYR Macedonia and institutions and libraries in the United States. The materials gathered include reproductions of images and on-site photographs of drawings, etchings, frescos, mosaics, sarcophagi reliefs, and building elements. The results are yielding illustrations of a complex set of building morphological and typological expressions that expose strong relationships to the remaining early traditional buildings of the Balkans.

The materials that we have examined reveal a variety of illustrative devices from iconographic or symbolic representation to more factual and precise depiction devices. The analysis and understanding of where these conflicts and dilemas exist becomes a major part of the on-going work. Another is to build, from the partial views provided, a logical and whole view of the elements and buildings represented and to compare these with the building technologies, morphologies and typologies that have been personally observed and known to exist for the last two hundred years.

2. THE QUESTION OF REPRESENTATION

A number of important questions had to be addressed before this study began. Initial questions dealt with the accuracy of representations found. Representation, as we often define it, must accurately depict the physical environment and context as we would perceive it first-hand if we were present in the place being represented. Yet representations by their nature transform wholly three-dimensional environments into two dimensional (or reliefed two dimensional) abstractions for others to view. Beyond this representations exhibit symbolism, technique and craftsmanship. The earliest examples are dominated by symbolic and iconographic issues that demand a grasp of cultures and cosmological views of the time. The viewpoint of the author (artist) and often the patron or supporter may dominate the work. And finally, artistic techniques and craftsmanship intervene. These issues demand that each representation be viewed within its context. The degree of realism in the representation can only be validated by other supporting information or findings. Thus the premise of the research demands a highly critical approach and a realization that the investigation must be understood as speculative and theoretical in nature.

The artifacts found include elements from periods that span over eight centuries. These represent items on archeological sites and documents from archeological sites, artifacts in academic institutions and museums, and in preserved buildings of the last four hundred years. The artifacts and documents reflect the sense of the ideal and the real that were of sufficient value to generate or commission the work of art, calligraphy or architecture that remains. The variety of techniques of representation that deal with the establishment of rules of orthogonal and axonometric projection, and perspective illustration influence greatly the study of the items that have come to light.

3. EARLIEST PERIODS

The earliest periods of Balkan life involve two areas; the cultures bordering on the Mediterranean Sea and those that existed on the Danube River basin. The *megaron house* found in Sesklo (near Thessaly, Greece and dating to approximately 5700 BC) has been found in many places on the Balkan Peninsula and throughout the islands of the Mediterranean and Aegean Seas as well as in Anatolia. This rectangular house with its columned portico and single interior room with a central hearth can be found as a prototype for many of the simple traditional Balkan houses that exist today. The second dwelling type is found in the Iron Gates region of the Danube at Lepenski Vir (in Serbia and dates from approximately 6500-5500 BC). The dwellings in this region are based on isosceles triangle geometries and are built into the terraced banks of the river with entries typically facing the river. Research about these dwellings is still evolving since their discovery in 1965[7]. Scholars agree that before this time inhabitants of the area lived in cave dwellings in this mountainous area where the Balkan (Dinaric) Alps and Transylvanian Alps meet at the Danube. Little has been found to show that the traditional dwellings of today reflect the influence of the dwellings and tombs of this early culture.

Maps of the transformation and the growth of civilization on the Balkan Peninsula and Anatolia indicate overlaps of the cultures of the Indo-European, Hittite, and Persian cultures as time passed.[8] By 1850 BC the Illyrians, Thraco-Cimmerians, Greeks, Minoans, Livians and Hittites were major influences in the area. In 1000 BC the Illyrians, Thracians, Greeks, Ionian Greeks, Phrygians and Neo-Hittites were present. Xerxes, of the Persian Empire, captured Macedon and Thessaly in 480 BC and moved to occupy Athens. Alexander the Great extended the Macedonian Empire by 323 BC east to Indus River. By 145 BC the Roman Empire gained control of the lower Balkan Peninsula and allied itself with the powers in Anatolia. At Caesar's death in 44 BC the Roman Empire had control of the lower Balkan Peninsula, Anatolia, the eastern Mediterranean and Egypt. The movements of armies and peoples in the expansions of empires brought with them the evolution and transformation of dwelling and other building types.

[7] Dragoslav Srejovic, *Lepenski Vir National Museum*, Beograd 1983
[8] Colin McEvedy, *The Penguin Atlas of Ancient History*, London 1967

Typological expressions and variations of the early megaron house, the courtyard house, terraced housing and many of the techniques employed in the buildings of the Hittites of central Anatolia have been found in numerous archeological sites in these regions. These developments remain as principal bases of traditional dwellings that are represented and found in remaining dwellings of the last three hundred years.

4. ROMAN RECORDS AND IMPRINTS

The Roman Empire initially developed a number of outposts in the lower Balkan peninsula and then extended its control up to the Danube River and beyond to what is now Romania and the perimeter of the Black Sea. The exploits of the wars with Dacia and Thrace in 100-04 AD are memorialized on Trajan's Column. The column today remains an important record of not only the battles but also of the representations of the artists' interpretations of the village and town buildings of the cities of ancient Dacia and Thrace. The column has been studied by scholars for its rich detail. In addition to the column itself (estimated to be constructed in 110 AD) there is a portfolio of drawings produced in the 1660s[9], a set of castings of the column panels created in the beginning of the twentieth century that are in the Museo della Civilta Romana, and a number of sets of photographs of the castings. These will be discussed later.

The presence of the Roman Empire in the Balkans and Anatolia cannot be understated since the Romans brought another culture to the landscape and built up areas that previously had been sparsely occupied. The buildings of the new governors and the development of roads and other infrastructure promoted trade as social and economic stability were established. For these reasons, we studied the representation of the Roman rural landscape and its buildings to understand whether (and to what degree) the traditional buildings of the Balkans were extensions of Roman prototypes. We sought illustrations of common rural and urban settings found in paintings, mosaics and sculptural reliefs and recording the most compelling examples. The time span and geographical distances covered by these examples is large since the Empire survived across a millennium and spread across Europe and a portion of Asia. The Empire’s influence was tempered by the inclusion of many peoples, even by elevation of foreigners to the position of ‘Caesar’.

The earliest notable examples of Roman urban buildings come from the frescoes of Boscoreale from a noble’s dwelling in Pompeii (circa 100 BC). Their complexity and asymmetrical overlays display a great divergence from the dominant symmetry normally associated with typical Roman courtyard dwellings. The scenes are fanciful and yet display, through cantilevered elements, a freedom of building form and structural expectations. Sensitivity to the creation of mock symmetry and arrangement of shading and shadows reveal a playful look at the moods that can be created by the use of shifting light patterns.

An important Roman example depicting an idealized scene of rural village life was found on one sarcophagus for a child (circa 300 AD). The relief on this small marble sarcophagus depicts Eros playfully accompanying a boat passing small dwellings with cantilevered balconies on the upper levels. The peaceful and pleasant setting is in contrast to the multitude of sarcophagi that depict struggles of heroic men in battle with one another, or lions, predators and preys in deadly struggles, or men in the context of their work. The scene of the child passing to another world accompanied by the Eros is a scene that evokes sympathy for a life cut short. We encountered a number of other reliefs that illustrate the settings of town and village life, but these are rare in the vast collections in Rome.

The mosaics of Pompeii and Rome are exquisitely made and serve as excellent vehicles to illustrate people, events and buildings. But rarely is the subject the common life of rural or urban settings (in the Eastern Empire more examples appear). Within the churches of Rome, Venice and Constantinople some of the most famous mosaics depict critical Christian religious events. However, in such instances the settings most often complete the scene and buildings are highly abstracted to frame focus upon the central figures of the events. The early mosaics of Pompeii, Ostia and southern Italy often address the creatures of the sea and the gods of Roman mythology

[9] Bartoli, Petro Santi, 1635-1700 Colonna Traiana eretta dal Senato, e populo romano all'imperatore Traiano augusto nel suo foro in Roma.

but a few touch on rural life. Those that do describe economic buildings (stables, grain storage buildings, etc.) as secondary parts of the theme.

The Column of Trajan is a chronicle of the war years in Dacia and Thrace. The artists created a series of relief panels that spiral up the shaft and depict battles, places, armies (both adversaries and allies) and travels. The Column still stands at the edge of Trajan's market. The castings in the Museo della Civilta Romana allow people to view each part closely. For the purposes of this paper I will discuss just one relief panel. Panel XX/XXV shows Roman soldiers setting Dacian town buildings on fire. The buildings are wooden plank structures of simple construction. Today on the column itself, the building in the foreground is clearly shown as supported on piles, however the area below is void of treatment. In the drawing of the same building done in the seventeenth century the base of the building is shown as enclosed and constructed using the same plank construction as the upper storey. The casting of the scene, as one might expect, is in agreement with this column panel as it now exists. This conflict brings into question whether the buildings in panel XX/XXV are pile structures (common along the Danube) or two storey structures (also common along the Danube and Sava Rivers).

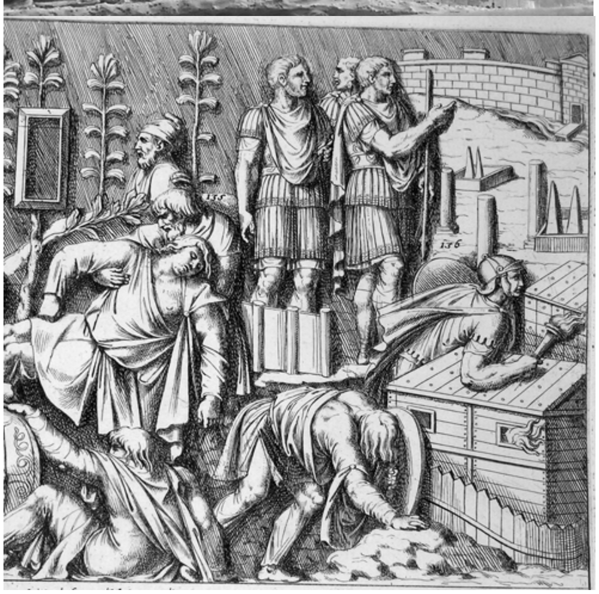

Fig. 1 Trajan's Column, Dacian Building (panel XXV)

Fig. 2 Bartoli Drawings, portion of panel XXV

There are many images of buildings and fortresses on the column that need close review and analysis. The dilemma of this one example points to the need to carefully inspect not only the artifacts as primary sources but also the historic records in order to understand the representations that occur.

Many churches in Rome contain important mosaics that span over five hundred years, and the images of towns within Christian religious scenes offer images of both heavenly cities, Jerusalem, and other biblical cities. These images are highly interpretive yet exhibit some knowledge of building groupings, often with proper relationships between known and archeologically confirmed building sites. The majority of these images display only masonry and prominent buildings of the times. These images were noted and recorded for comparison with those of later images in Roman Catholic and Eastern Orthodox mosaics and frescoes in the churches of the Balkans.

5. BYZANTIUM AND THE EASTERN ROMAN EMPIRE

After the decline of the Western Roman Empire, the Eastern Empire retained control of much of the Balkans, Anatolia and parts of the Eastern Mediterranean for over six hundred years. The contractions and re-expansion of the Eastern Roman Empire allowed for the joining of Eastern and Roman traditions and building types. The division of Christianity into Roman Catholic and Eastern Orthodox through the late Roman Empire reflected important divisions of the cultures of the Empire. The Eastern Roman Empire and Byzantine Empire adopted the Cyrillic alphabet and Greek and Slavonic languages. This separation in religious liturgies impacted greatly on the way representations evolved. During this broad period, Antioch and Damascus became major cities in the Eastern Mediterranean and were major centers of populations and trade. While Rome and Venice were struggling, these cities were flourishing. In Constantinople, Antioch, Damascus and even Jerusalem one finds significant mosaic representations of buildings and town plans of the time. These representations often incorporate names written in Greek Cyrillic alphabet. The building types, most often grand in nature, show the range of forms and porticoes, masonry pattern relationships that one can find in towns and villages of the late medieval period.

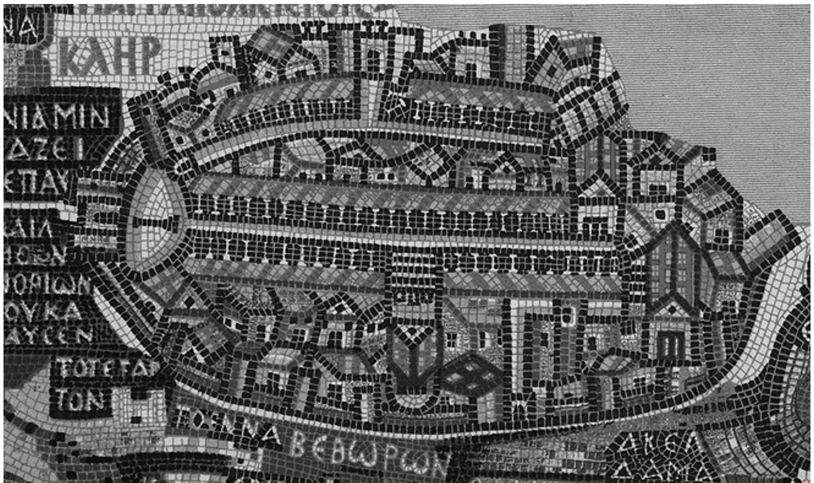

Fig. 3 The Madaba Mosaic in Jerusalem

Fig.4 Mosaic in Great Mosque, Damascus

The mosaics of the Eastern Mediterranean are representations of the Byzantine era, but incorporate elements of Persian as well as western design. The exchanges of power during struggles over the sacred cities of the East gave rise to blended techniques of the artistic heritages of those who worked in these settings. The buildings even changed hands from Christian to Islamic but often the themes of the art maintained the traditional expressions of the common culture (Persian versus Arabic or Greek Christian versus Islamic). Enclosed ground levels and open upper levels of the dwellings and other buildings are common attributes of the structures of these times. Few examples of wooden buildings are depicted but extended roof profiles hint that these are wooden caps to the buildings.

6. THE OTTOMAN EMPIRE

One of the most difficult aspects of this study is a recurring insistence among certain scholars that there is no such thing as a Byzantine house, and that the predominant dwelling forms of the southern Balkans are direct expressions or derivations of Ottoman architecture. These issues are most strongly contested by Turkish and Greek scholars. To this end we searched through the works of deBeylie and Choisy from the beginning of the twentieth century and found that many of the primary sources of later authors were also the bases of the theories of these scholars. Fortunately there are etchings and drawings that have survived and serve to describe the landscape and city views of major trade cities, and depict the dwellings in question.

Fig.5 Istanbul Image (inverted) Melchior Lorichs, 1559

Fig. 6 Ancient House in Fenner, Istanbul, c. 1500

7. POST-BYZANTINE STUDIES AND SUMMARY

In Italy, Turkey, Greece and other Balkan countries, the mosaics and frescoes of the Christian churches (some converted to mosques) provide images of buildings that begin to further define the built landscape of the period since the Ottoman Empire collapsed. In the acropolis district of Thessaloniki, Diocletian's Palace district of Split, and numerous villages of the Balkans one can still find the urban fabric of much older times.

During the eighteenth and nineteenth centuries travel accounts by diplomats, writers and artists have provided views of the cities and landscapes of the Balkans and Anatolia that form a rich set of documents from which to study the traditional buildings and landscape of these lands. These demonstrate that the simple houses of the country and village are consistent with the early dwellings of more ancient times. These comparisons are being formed into a document that is currently under development by the authors.

Weissenhofsiedlung, Stuttgart, 1925: The Initial Scheme

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ABSTRACT

Mies van der Rohe viewed his first proposal for the Stuttgart Weissenhofsiedlung as "artistically right." Despite this conviction, he guided the project through a series of design iterations that had the effect of radically transforming the project.

The origin of the initial scheme has been a matter of some speculation among historians. Most believe that the initial project was a result of collaboration between Mies and Hugo Häring. There has also been some speculation on the intentions behind the initial project. Both discussions have been thwarted by the presumed lack of documentation.

This paper will present a partial reconstruction of the first scheme, based on historical documents. Rather than trying to assign authorship, it will speculate on the origins of the scheme, some reasons for the abrupt change in design direction, and reaching implications for the understanding of the later work and thinking of the later work of Mies van der Rohe.

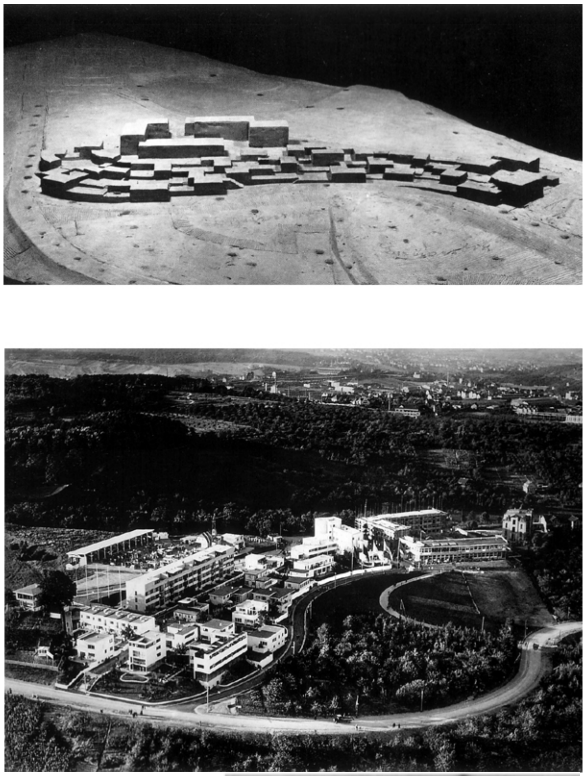
Collaboration or Dialog

Several scholars agree that the first scheme for the Stuttgart Weissenhofsiedlung was probably not designed by Mies van der Rohe alone, but was the product of a of a collaboration between Mies and Hugo Häring. Circumstances suggest this could likely have been the case. Mies had divorced shortly before 1925 and when Häring arrived in Berlin, Mies offered him a work-space. "We talked more than we worked," Mies later said of these times. Both the talk and the work proved productive. The discussion evidently focused on the nature of the new building; their projects show a degree of cross-fertilization in terms of conception and form.[10] Time has shown their dialog to be one of the most characteristic breaks in modernism, a split that divides proponents of the organ-like building (Häring) from those of universal space (Mies) or, changing the terms, expressionism from rigorous formal and material resolve. This dialog has persisted in various forms throughout modernist and contemporary discourse. Although Häring built little himself, he was a mentor to Hans Scharoun. The debate has therefore been read into the development of the Berlin Cultural Forum, a sort of face-off between Scharoun's Philharmonic and Library and Mies's New National Gallery. It is also possible to read the legacy of the debate into our contemporary context. It suggests a means of understanding the rift in concurrent ideologies of practice—between (say) Frank Gehry and Zaha Hadid on the one hand and Herzog and de Meuron and Rem Koolhaas on the other.

If the Weissenhofsiedlung project of 1925 was the product of collaboration, it stands as a marker in a common road, just before a significant fork. As it appeared in the preliminary site plan and clay model, the proposal was based on the extensive terracing of the site and had the effect of suggesting a continuous built fabric. The project was clearly something new: the Stuttgart building authorities, unable to relate the project to any reassuring precedent, were frankly aghast. So

[10] See for example the discussion of the Friedrichstraase skyscraper competition in Peter Blundell-Jones, *Hugo Häring: the organic versus the geometric*. (Stuttgart: Ed. Axel Menges.Jones, 1999), 40-42.

strong was the impression of continuity that the authorities suggested that the proposal neglected the needs of light, ventilation, and vehicular access (they also objected to excessive wall-work and the apparent lack of basements). After surviving a good deal of controversy, including attacks on his competence, Mies submitted a revised plan in July of 1926. Although similar to the 1925 proposal, elevations and plans from 1926 already show less the character of the terrace scheme than the discrete masses of the final project (Figure 1, 2).



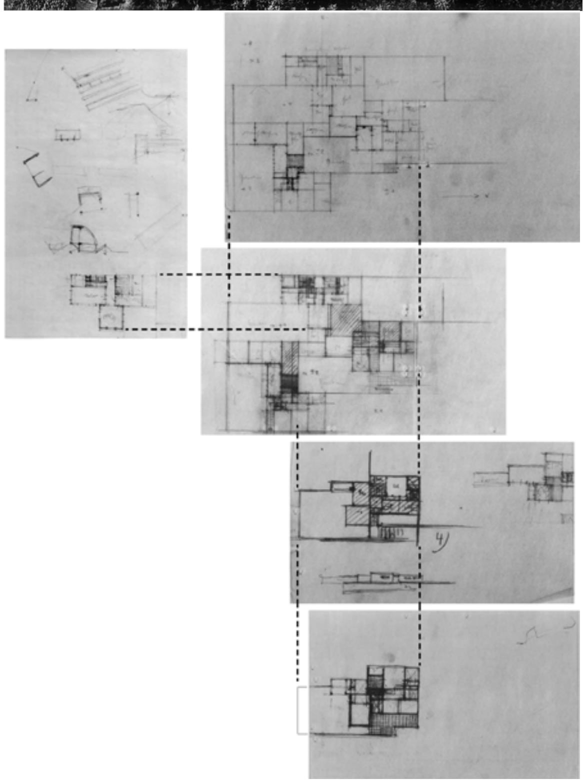
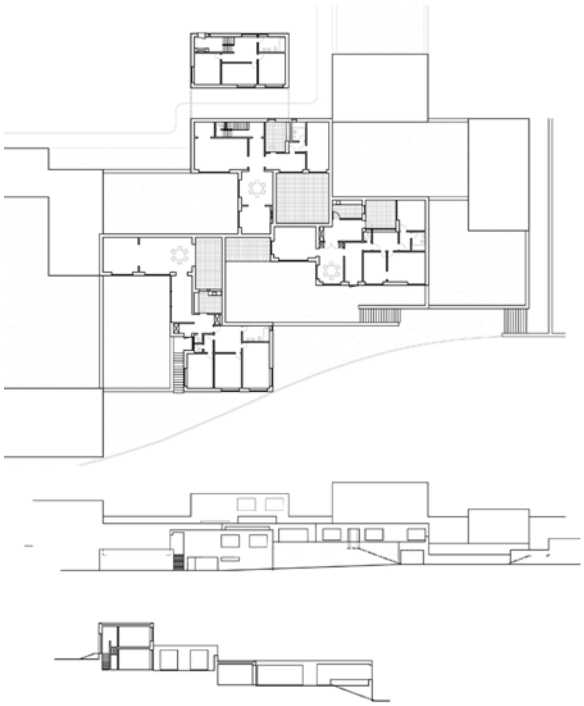


Fig. 1 Weissenhofsiedlung, 1925. (clay model, above) and an aerial view of the exhibition, 1927 (below).

Fig. 2 Sketch plans attributed to Mies van der Rohe.

Drawings published as part of the Museum of Modern Art's *Mies van der Rohe Archive* indicate that more has survived from the original scheme than was previously thought.[11] In addition to the site plan study and model photographs there is a series of plan sketches that can be mapped to specific locations on the initial plan (Figure 2). This paper focuses on the development of 3 buildings at the center of the project. The Weissenhof site was located in the countryside surrounding of Stuttgart; the complex was to straddle a local high in a rising slope. Plans were drawn with north to the right. The 3 dwellings that are the focus of this study were to be located near the inflection point in the eastern bounding street, on the low side of the site. Although sketches for other buildings exist, the drawings for these buildings are the most developed, including two drawings of the grouping (drawing numbers 4.168 and 4.170) as well as supplemental sketches. Many of these drawings include annotations, including room names and relative grade elevations. Examination of the original drawings at the Museum's archive greatly facilitated the understanding of marks and notations. In the following descriptions, the equivalent lot locations from the final project have been used to distinguish between the buildings. The plans and sections resulting from the reconstruction by the author are shown in Figures 3 and 4.

[11] Mies van der Rohe, Ludwig. *The Mies van der Rohe Archive, Vols. 2*. Arthur Drexler, ed., with introductory notes by Franz Schulze. (New York: Garland Pub, 1986), 178-210. Handwriting analysis should help with establishing the providence of these drawings, however this is beyond my expertise.



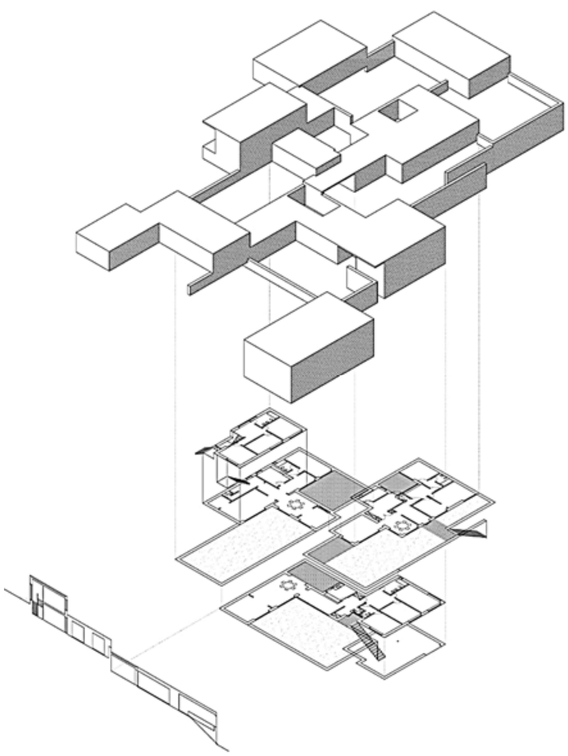


Fig. 3 Plans and sections of dwellings on lots 18, 19, & 20 (clockwise from lower left)

Fig. 4 Axonometric of units 18, 19, 20 & neighbors

Lot 18 (dwelling at southeast/lower left, drawings 4.168, 4.170)

The initial site plan indicates that this building was a L-shaped volume, with the vertical leg of the L backing up to large courtyard to the south. As developed in plan, the building became a Z-shape (again with the vertical backing up to a large court). According to the site plan and model, the lower leg of the Z was to be two stories tall to accommodate the change in grade between the street and the level of the courtyard. There is a stair indicated between the street and the main living level. The drawings indicate that area of the street was assumed to be at level +0 and the court at level +2[m].

Plans 4.168 and 4.170 indicate a similar arrangement of rooms at the living level. In the east wing, 3 spaces nominally labeled “z[immer]” (room) face the street. In the west wing, the rooms are apparently living spaces, opening on the large court. The center part of the building seems to be the focus of the sketches, with the draftsman testing the location of circulation, kitchen, and toilet areas. Sketch 4.170 seems to be the layout drawing, and shows a relatively small kitchen area centrally located and opening onto a rectangular “wirtshaft hof” (housework court) to its north. Toilet rooms are located near the entry as is characteristic of the plans of the time, including those of Mies’s. The bedroom closest to the entry seems well suited to domestic help.

Plan 4.168 is a less tentative drawing, and perhaps represents an advance over 4.170. Along the large court, sketch lines indicate that the stair is to be open and that the south facing room (labeled, but unintelligible) may have an overhanging eave, or area of terrace paving. Marks on the plan indicate that this room, as well as the living room, may have been intended to open on both courts. The drawing also explores a different arrangement of service spaces in the east wing. Although no lower level plan seems to exist, the circle with a “X” at its center may indicate the thought of a spiral stair connecting to the lower level.

Lot 19 (dwelling at west/top center, drawings 4.168, 4.170, 4.176)

This building was to be T-shaped in plan, with relatively large courts to each side of the east-west (vertical) stem of the T. As in Lot 19, the large court was located to the south. Its level is indicated to be +4[m]. The smaller court is almost square and labeled simply “hof” (court). The top of the T lies along the street to the west is divided by an entry hall, which lies on axis with the center of the T-stem. The south wing seems to be dedicated to living spaces. The north wing contains the kitchen and service spaces. These remain constant in the three plans. A space labeled “wirtshaft” (housework) lies along and opens onto the court. To the extreme north is a large rectangular room that also opens on the court. Notations indicate that an internal area that shares a common wall with the kitchen may have been intended to include a bath.

In the area of the south wing, both drawings 4.170 and 4.176 contain a single large space labeled “Wo[hnzimmer]” (livingroom). Drawing 4.170 indicates that the first spaces in the east wing (the stem of the T) was to be a the es[zimmer] (dinning area) and the east-most room the “lib[rary ?].” Drawings 4.168 and 4.176 show similar forms for these spaces but drawing 4.168 seems to be a more exploratory version of the plan. It indicates both the overall subdivision of this living space, including the presence of a dining table, a corridor, and perhaps a circular stair—none of which seems to work.

Although the site plan indicates that this unit was to be one story, all 3 plans indicate the presence of a stair in the south wing, along the street wall to the west. All plans also seem to indicate a toilet room beneath the stair. Grade elevations in the final project suggest that the street level would have been about 1.5-1.7 m above the living level. A second level above this wing would have not only facilitated entry, but provided the space to for bedrooms not shown on the main floor plan.

Lot 20 (dwelling at north/right, drawings 4.168, 4.170, 4.174, 4.180)

This building is the most unusual in terms of typology: a U-shaped volume around a central court, with a wing attached to the middle of the south side of the U. In drawings 4.168 and 4.170 this wing is occupied by a square-ish living room near to the center of the U and further to the south, a small rectilinear volume marked “loggia”. Drawings 4.168 and 4.170 also show similar arrangements for the main part of the dwelling, including the kitchen to the south side of the inner court, joined by a buffer-like space marked “wirtshaft.” This space extends from the entry hall to the north toward the internal courtyard. To the south of the entry hall is a prominently-scaled room marked “es[zimmer]” in drawing 4.168. To the north of the entry hall are the private spaces of the house. These rooms face east, but are planned en suite around a room to the east side of the court. The development of the plan in drawing 4.168 indicates the consideration of corridor planning, to both the north and south of the entry, considered perhaps to allow immediate connections from the entry to living room and to the room on the north side of the interior court. It faces south and is marked “sol[arium].”

Dwelling 20 is located in adjacent to a prominent stair in the site plan. Annotations on the plan indicate the elevation of the courtyard as “ca (circa) +2m”. Annotations on drawing 4.170 also indicate a “garage,” apparently at the lower level. Based on the final grading of the street and the need for a garage, the court level would in fact have been closer to 3 meters above level 0, placing each dwelling in the cluster at distinctly different grade elevations.

Drawings 4.173 and 4.180 are similar and show developments on this plan. Both exchange the housekeeping and kitchen areas and the living and dining areas, an apparent improvement in circulation and adjacencies. Marginalia on 4.173 indicates an intermediate state in the development of the plan, showing only revisions to the kitchen area, and clarifying circulation from the entryway to both the north and south wings of the plan. This circulation scheme seems to have been adopted in the later sketches. A more heavily drawn configuration on the same sheet shows a corridor along the east side of the inner court providing equal access to all rooms in this wing, including the solarium.

These drawings show a revised location of the living room, an arrangement that extends a prominent volume towards the east boundary of the lot, bifurcating the mass and effectively forming a third court overlooking the street. This configuration, sketched in elevation on drawing 4.173, is clearly more dramatic in massing than any of the individual volumes indicated on the initial site plan.

The building on Lot 20 is located adjacent to a stair so prominent that in the massing model it seems to indicate the presence of a public passage. Unfortunately there is no passage at this location, and the stair leads only to a single dwelling (lot 20). The prominence of the site may well have been the motivation behind the study of the buildings in this area, but the public passage was, in both the initial and final schemes, located further to the north. The false importance of the stair can be understood as a mere semantic error in a development sketch. Or it may have been representative of the confusion between public and private space, one of the larger contradictions within the project.

1925 vs. 1927

Each revision in the plan after 1925 brought the Weissenhof further from the initial conception, and closer to a conventional arrangement of isolated volumes. Increasingly the land was marked by a conventional rectangular partitioning. The building masses reached for near-prismatic simplicity; they seem destined to be centered on their lots. In fact, this is more of a formal logic than a strictly typological one. The project did mix row-house and apartment types with house types. Apartment and semi-detached aggregates were, however, treated as autonomous and units, consistent within themselves, separate and distinct from all other units. In the absence of commercial and public amenities, and in relative isolation from the city of Stuttgart, the Siedlung was closer to a garden suburb than an extension of the city.

With the reconstruction of a few of the buildings, it can now be seen that the first scheme was different in a number of ways. The model reflected the complicated rhythms of massing and an intriguing ambiguity between building and terraced landscape. In the site plan drawing the distinction between the built and the un-built was more clear. Surprisingly, the development sketches went in the opposite direction. Rather than simplifying the relationships between the dwelling units or between the units and the land, the architect's development of the house types seems to have complicated these relationships. In addition to the courtyards formed by the terraces, courts were added internal to the building masses. Instead of isolated prisms, these masses were composed of apparently primary forms, combined to make L-, T-, U- and Z-shaped assemblages. Instead of isolation, each building merged not only with the site walls but also with its neighbors.

The result was a near-reversal of the conventional figure/ground relationship of the house type, a conception that seems to have been an uneasy fit with the conception of the European landscape. This analysis suggests that the complexity of the project—including property arrangements, the coordination of the building techniques, and the integration of distinct (and therefore discontinuous) formal systems within a technically indistinct (and continuous) building fabric—created significant obstacles, perhaps too many obstacles to be overcome in the short time frame allowed by the exhibition.

What was lost when the scheme was transformed? A comparison between the first and final schemes indicates that the 1925 project truly was more dense. While the number of units is nominally the same, the average unit size, as well as the overall floor area ratio (FAR), would have been about 20% higher than the final scheme (0.59 vs. 0.47) and, for the developed plans (presented here) the FAR is greater than the average (0.66 vs. 0.59).

More suggestive than the quantitative increase in the density was the discovery of a spatial strategy for urban housing. To be sure, the idea of the court-type space appears in Mies's architecture before 1925 and in many projects thereafter. In 1933-34 Häring used the type to design a small group of buildings at the Kochenhof, a small un-built extension to the Weissenhof.[12] But the most powerful implications of the first project for Stuttgart lie in the conception of the living-court as an urban type. In both personal and student projects between 1931 and 1940, Mies pursued the courthouse motif time and again. As Terrence Riley has said, Mies used the courthouse type as a demonstration of "...a house that could create a city...".[13] It was a strategy that, without ignoring a dwelling's formative connection to the environment, offered the potential to be *scaled*.

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[12] See Jones, *Hugo Häring* and *Modern Architecture Through Case Studies*. (New York: Architectural Press, 2002), 14.
[13] Terence Riley, "From Bauhaus to Court-House," in Terence Riley and Barry Bergdoll, eds., *Mies in Berlin*. (New York: The Museum of Modern Art, distributed by Harry N. Abrams, 2001), 337.

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“What’s a nice architectural historian like you doing in a truck stop like this?”

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ABSTRACT

Along almost every interstate highway off-ramp are the much-maligned places where the everyday rituals of the road are practiced. The truck stop is an integral part of this American scene; yet its mystique is distinct from other vernaculars of roadside architecture, for the expansive domain of the truck stop is a hybrid place that straddles the borders between a protected private precinct and a contested public realm. This paper investigates the socio-spatial order of the truck stop, by engaging interdisciplinary frameworks of the history of architecture and cultural studies, including the theories of Michael Foucault, Edward Soja, and Henry Lefebvre concerning the production and socialization of space. In addition, the study employs a phenomenological inquiry based on the author’s experiences in the long-haul trucking industry. This research argues that the truck stop, both a spatial “in between” and a point of destination in the cultural landscape of the highway, is not a neutral local in which social relations unfold. Instead, it operates as a spatio-temporal structure that materially constitutes and makes concrete the social actions, relationships, and ordinary practices of the road.

1. INTRODUCTION

At the end of almost every interstate highway off-ramp fast food places, gas stations, cheap motels, and outlet malls greet the curious tourist and the weary traveler alike. They weave an architectural welcome mat stitched of flimsy drivet walls and familiar corporate logos. The sceneographic clutter marks the oft-times maligned places where the everyday rituals of the road are practiced. The truck stop is an integral part of this American scene; yet its mystique is as distinct from that of other vernaculars of roadside architecture as the eighteen-wheel constituency the truck stop was created to serve differs from a fleet of soccer-mom piloted SUVs. With approximately 87% of American freight transported by truck, the interstates that carry watermelons from fields in Georgia to A& Ps in New Jersey and ferry lettuce from coolers in California to the WalMart distribution centers across North America are well traveled. Somewhere between the garden of America and the neighborhood superstore, to be assured, the truck and its driver will need fuel, food and facilities with plumbing. For them, Loves, Flying Js, Pilots, and Petros line the interstate corridor. The truck stops here.

In contrast to its enduring love affair with the automobile, American popular culture exhibits ambivalence in its regard for the big truck. While the automobile became an emblem of the American dream of freedom and prosperity, the truck, born to move heavy loads, represented a less alluring world of work and menial labor. Research and scholarship about the trucking industry reflects this bias: ample studies investigate the economic dynamics of the industry and the regulatory climate that controls it, anthropological and sociological inquiries explore matters of driver identity and ideology, but the cultural landscape of trucking, which necessarily involves issues of the design, production, and negotiation of space, at the unwieldy scale of the highway has been largely ignored. On the subject of the truck stop, Chester Lieb’s *Main Street to Miracle Mile,* a veritable primer for studying roadside architecture is silent. J. B. Jackson’s 1988 essay, “Truck City,” remains the single authoritative commentary on the truck in the domain of architectural research. Similarly, with the exception of Marc Wise’s critical photo essay, *Truck Stop*, this ever-present landmark of the highway has drawn little attention beyond quirky articles in the popular press, erotic short stories, and a handful of undergraduate design theses.

This investigation of the socio-spatial order of the truck stop, through the interdisciplinary lenses of architectural history and cultural studies, is part of a book-length project, “18 Wheels and the American Dream.” What takes a “nice architectural historian” out of the archives and into the truck stop? For three years, I was part owner of a long-haul trucking company and had many opportunities to view the cultural landscape of trucking from the front seat of a Kenworth T-600. Consequently, research of this paper blends an experiential body of knowledge—acquired dining at truck stops, doing laundry at truck stops, Christmas shopping at truck stops, and, even being solicited for “favors” at truck stops, with the more traditional domains of the architectural historian’s knowledge. The larger project, from which this paper derives, seeks to make the cultural landscape of trucking more central to the discourses of American architecture and cultural studies, for it engenders issues of domesticity, work and commerce relative to place-making that, this research asserts, reflect overarching transformations of late twentieth-century and twenty-first-century cultural practices.

2. SITUATING THE TRUCK STOP IN HISTORY: A GLIMPSE AT ITS PAST AND PRESENT

The truck stop, inevitably, evolved in concert with the ascension of the long-haul trucking industry. During the years that followed the First World War, the truck became an important part of American life and a keystone in a seemingly boundless consumer revolution.[1] By the early 1920s, dedicated truck routes were established and, in the tradition of the stagecoach stop relay station where horses and drivers were changed and passengers refreshed, the truck stop was born. It was, however, a typology that grew up haphazardly, and out of necessity when service stations, initially devoted to the needs of long distance automobile and bus travelers, realized the revenue potential of filling the big truck’s big tank. Gradually, savvy station owners added lodging, lounges, and the all-important showers to their emporiums; houses, gas stations, and garages were handily adapted to serve the burgeoning business of providing food and mechanical services to truckers. The Dixie Trucker’s Home, a Route 66 landmark, offers a model of this evolution. Opened in McLean, Illinois in 1928 and recognized as one of North America’s first truck stops, it grew from unassuming beginnings when its founders (John Geske and J. P. Walters) rented one-half of a mechanic’s garage to sell sandwiches to truckers. Within a decade, the Dixie added a counter fitted with six stools where grilled burgers and 10-cent milk shakes were available continuously, 24-hours a day. Behind the restaurant, there were cabins for road-worn drivers and a cattle pen where live stock in transit could exercise while their chauffeurs enjoyed dinner. From the windscreen view, the Dixie Trucker’s Home differed little from ordinary filling stations of the period: a box of a building with a four-pump fuel island and an overhanging canopy facing the iconic roadside.

Although built in 1955, Meridian, Mississippi’s Red Hot Truck Stop echoed the modest program and small town scale of the early truck stop. Its architectural expression, however, resonated with the modernity of 1950s car culture and a trucking industry that was modernizing incrementally with the progress of the interstate highway system. So too, the building reflects the oil industry’s desire to make their invisible liquid products appear as modern as postwar consumer culture demanded by giving a new look to the facilities that dispensed them.[2] Designed by architect Chris Risher, Sr., the compact and concrete framed Red Hot translated International Style modernism into the syntax of the American roadside. A state-of-the-art curtain wall capped with a broad, overhanging flat roof wrapped around its restaurant. Signage that rivaled early Las Vegas super-graphics announced “Red Hot Truck Stop Good Food” to drivers approaching from a new four-lane section of Route 80. Legend had it that Red Hot coffee had the power “to reveal things about Hattiesburg and New Orleans that even the natural light of day overshadows.”[3] Sinclair diesel flowed from 6 pumps that stood on an island in front of the building; truck service was relegated to an attached garage at the rear of the remarkably unified structure. Outside, the Red Hot displayed the conventions of the typical postwar gas station, an oblong white box with grand display windows pioneered in Water Dorwin Teague's prototype designs for Texaco (1937-48).[4] Inside, however, its modernity was articulated with a sinuously curved counter, which swept across two discrete dining rooms. Although drivers reminisced about rubbing shoulder with "Fats Domino and Percy Sledge's valet" at the Red Hot, others speculated that the bi-partite plan was a tacit tool of segregation.[5]

Period photographs and oral histories that chronicle the Dixie Trucker's Home and the Red Hot Truck Stop fuel nostalgia for a lost highway landscape of White Castles, Howard Johnson's and drive-in movie screens. Architecturally, they are as closely connected to these icons of modern vernacular building as they are to truck stop myths of comely, yet maternal, waitresses and mouth-watering, biscuits and gravy. Regrettably, the original Dixie Trucker's Home burned in 1967, to be replaced by a barren box with false parapets and mansard-inspired awnings. The Red Hot's demise was more carefully calculated; in 2000, it was torn down to facilitate construction of a Wal-Mart supercenter. The irony of the transition is stunning, for the contemporary truck stop, born of familiar and deeply engrained meta-narratives of postwar America's economic prosperity and corporate prowess, owes far more to the model of the superstore's promises of "one shop fits all" than to the fine balance of machinic utility and cozy domesticity associated with its earliest exemplars.

By the end of the 1950s, bigger trucks, an expanding trucking industry and the Federal Highway Act conspired to render the traditional truck stop obsolete. No longer was the truck stop a two pump or six pump affair; truck stops had grown to 2 acre-6 acre properties, often owned and operated by major oil companies. The Pure Oil Company, the operators of more than ten per cent of American truck stops in 1960, appealed to drivers with promises of "Pure's blue ribbon cup of coffee" and air-conditioned "roomettes." The self declared "crown jewel of the Pure system" was The Detroiter, situated on I-75 south of the "motor city." Pure was a descriptive nomenclature for the coffee, the diesel and the building: white, planar and unornamented in the high modern spirit of its age. With service bays discreetly situated at the rear of the building, the Detroiter façade could easily be mistaken for that of an early Holiday Inn. These spaces, however, were only a small part of the truck stop ensemble that also included restaurant accommodations for 112 drivers, scales, 2 lube bays, tire service, a store, and 10-paved acres of parking. Simply stated, the truck stop was fast assuming the proportions of postwar suburban shopping centers

The Detroiter is still a feature of the I-75 corridor, but its postwar "purity" has not remained unaltered. The original building is much renovated, reconceived as "a mall within a truck stop." Situated on the edge of an urban center transformed and stereotyped by its history of civil unrest, "secure and guarded" parking is even more seductive to the long-haul driver than the blue ribbon cup of coffee. Comfortable sleeper berths in big trucks have made its carpeted roomettes obsolete, but private showers, washing machines, shoe shine stands, a barber shop, and the services of a massage therapist enhance the Detroiter's aura of domesticity. So too do parking space hookups for cable TV, phone, fax, and the Internet bring the comforts of the late-modern home to acres of blacktop, while TV lounges, movie theaters, and video-games rooms offer public entertainment, traditionally associated with pleasure palaces found only in the center of the city. So too, fax machines, FedEx drops, internet kiosks and ATM machines constitute an information age agora of commercial services drawn from the downtown. Fast food carryout and the Sara Lee Bakeshop, the stuff of the suburban strip, complement the time-tied full service restaurant. The amenities available at the renovated Detroiter are hardly extraordinary. They are standard spatial and functional fare at the myriad Petros, Pilots, Flying Js and Travel Centers of America—the corporate giants of the truck stop industry.

3. NEGOTIATING SPACE AT THE TRUCK STOP: AT WORK, AT HOME, OR IN BETWEEN

> Like the paradigmatic shopping mall, the expansive domain of the truck stop has become a hybrid place that straddles the borders between a protected private precinct and a contested public domain. As a self-contained community, the truck stop embodies layers of transience and permanence and strata of social organization that reveal the complexities of more ancient models of community life. In its conceptual frameworks and spatial order, the truck stop recalls the socialization and discourse of the Roman bath, the hierarchical ordering of labor, prayer and dwelling of the monastery, and the power to practice one's trade of Godin's Familistère. Equally compelling in their intricacies is the interface of the truck stop's two dominant mythologies: the spheres of domesticity and labor.

With its clientele of long-haul drivers, who may be away from home for weeks at a time, much is made of the institutionalization of domesticity at the truck stop. An architectural rhetoric of gabled entrance bays, dormer windows, and enormous front porches masks many contemporary truck stops. The façade of domestic order is deceptive, for psychically, the big truck is the driver's dwelling, and domesticity is hardly authentic in a placeless sea of asphalt with as many as 100 other rigs constituting a very extended family. Parked at the truck stop, however, the machine enters the domestic garden—or more correctly, the back yard, for, typically, truck parking is situated at the rear of the truck stop. Outside and inside form a "dialectic of division," analogous to that of the suburban house on its ubiquitous front yard, that makes them both isolated and penetrable.[6] Only within the confines of the truck stop interior, where drivers pass through the same spaces, performing the same rituals—dining, grooming, shopping, engaging in discourse, does a phantasm of domesticity become possible. In other words, the truck stop is a space of sociality that alludes to, but hardly defines, domestic relations, in the widest sense of the term.

The illusion of domesticity, however, is not sufficiently palpable to erase from the truck stop the residue of work and its traditionally masculine telos. As an institution and practice, trucking involves physical labor, which recent scholarship in masculine studies suggests is necessarily connected to the semiotic construction of working man's bodies as their primary economic asset.[7] In this connection, maintenance and repair of equipment at the truck stop are self-evident extensions of the active labor of driving. Documenting logbooks, scheduling deliveries, and faxing load confirmations are equally critical to the work of trucking, yet reflect modern accounts that organize and rationalize masculinity around "technical knowledge." As a domain of work, the truck stop blurs the clear economic circumstances, institutional structures, and spatial domains of the blue-collared factory floor and the white-collared office.

In spite of the rigors of trucking and the pragmatic concerns of the driver, the male telos of the truck stop cemented its identity as a "grimy asphalt jungle crawling with hot-pants clad lot lizards and amphetamine pushers."[8] The stereotype fast diminished when the industry, anxious to expand, aggressively changed its image to attract a four-wheel driving clientele, a marketing strategy analogous to Las Vegas's self-referential reinvention of itself as a family destination. A critical mass of news articles, including a *National Geographic* profile of the Giant Truck Stop in Jamestown, New Mexico; chronicles on "best of" series on the discovery channel and the food network, and the publication of an *All American Truck Stop Cookbook* make clear that the truck stop no longer evokes images of "greasy spoons catering to rough clientele."[12] Popular travel literature notes with awe that the Lodi Travel Center (near Cleveland) features a Starbucks café; 260 slot machines energize the Alamo Truck Stop at Sparks, Nevada; and travelers in range of Salisbury South Carolina's Derrick Plaza Truck can tune in the CB to hear Sunday morning services broadcast from its chapel. The Iowa 80, the largest truck stop in the world, boasts a food court filled with fast food nation staples Wendy's, Dairy Queen and Blimpie, and a well-stocked Trucker's Warehouse Store. Noteworthy for its selection of chrome items, the boutique affords opportunities to dress up the Peterbilt just as the Home Depot markets Ralph Lauren paint to embellish any suburban tract house. The appearance of chiropractor offices, clinics for sex workers, and permanent ministries housed in abandoned trailers, however, transcend the culture of late-capitalism and underscore the degree to which the truck stop has evolved from a modest arena of roadside commerce to an expansive ex-urban community. Consequently, neither the gas station, the fast food restaurant, nor the shopping mall—where Sears long ago conquered the dilemma of harmoniously intermingling tire sales, oil changes, and ladies lingerie—offer satisfying models for making cultural or architectural sense of the truck stop, both a space of transience that marks the "in between places" of the highway and a destination in and of itself.

4. CONCLUSIONS

In its emulation of domesticity, the truck stop advertises a hegemenous model of domestic bliss that enforces precise orders of sleeping, eating, and bathing that are requisite for conducting a life in common. Along its restaurant counters, in carpeted lounges that lead to shower halls, and, on the blacktop of its parking lots, quasi-public places of encounter, discourse, and occasionally, sexual concourse locate a sociality that is bound, concomitantly by the mystique of the road and the rigors of the trucking industry. For all the designer coffee, home-style fried chicken, and chrome ladies that can be bought at the Detroiter or the Tucson Truck Terminal, the truck stop cannot be dismissed as just another landmark of late-capitalism. Each truck stop has a significance that transcends its physical character and architectural situation. The truck stop is not a neutral local in which social relations unfold; it is a spatio-temporal structure of social life that defines how social action and relationships are materially constituted and made concrete not merely in built form but always in space. Like the liminal edges and decentered slums of late-capitalist cities, truck stops are heterotopias, which are, according to Michel Foucault's formative discourse, "those singular spaces to be found in some given social spaces whose functions are different, or even the opposite of others.[10] Understanding the truck stop as a heterotopia, thus, recognizes how it juxtaposes in one real place several different spaces, incorporating several sites that are in themselves incompatible with or foreign to one another.[11]

In conclusion, the banal commercial façade of the truck stop belies its intricacy as a self-contained community. The twenty-first century truck stop is nothing like its antecedents of the 1920s or the 1950s; neither are the cities linked to the interstate much like those of thirty years ago. After one-half century of the suburbanizing and malling of America, the big truck driver is hardly alone when he plots a route that patently avoids the old city center. Perhaps the truck stop appeals to such a large audience of consumers because it is painfully akin to the new setting for urban life in which they increasingly dwell—new edge cities called superburbias, suburban activity centers, and pepperoni pizza cities.[12] For a night or two at a time, the truck stop has all the functions these new sort-of cities have, and just like them, spaces and places are spread out in a form that only the road can recognize.

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[2]See John A. Jakle, "The American Gasoline Station, 1920-1970," *Journal of American Culture* 1 (Spring 1978): 529-31.
[3] Marty Stuart, "Truck Stop Heaven," *The Oxford American*, March-April 2001,unpaginated.
[4]See Chester Liebs, *From Main Street to Miracle Mile*, *American roadside architecture* (Boston: Little, Brown, 1985), 104-105; see also "Standardized Service Stations Designed by Walter Dorwin Teague," *Architectural Record* 82 (September 1937): 69-72.
[5]Stuart, "Truck Stop Heaven." Meridian architect Ed Welles argues that the arrangement was simply the product of Risher's exploration of modern space relative to the program (telephone interview, 14 September 2003). See also "Red Hot Truck Stop," http://members.tripod.com/redhottruckstop/Index.htm.
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[7]See especially R. W. Connell, *Masculinities* (Berkeley: University of California Press, 1995), 36, 55.
[8] Kitty Bean Yancey, "Truck Stops Pump Up Image," *USA Today,* August 31, 2001, 8D.
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Accident and Predictability: An Analytical Methodology for Persistent Forces in the American City

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ABSTRACT

American cities are a curious blend of strongly predictable and profoundly accidental relationships, built consequences of persistent forces, the presence of which may be either visible or hidden. Observed urban form and space can be understood as resulting from decisions taken within a specific, but evolving, spatial and temporal context. The contextual elements which remain the same for the longest time are defined as being the most persistent forces of urban form-giving. I propose a methodology which seeks to identify instances of persistent forces, to discern their collisions in space and over time, and to understand observable built form and space as evidence of those forces. Results consist of completed case studies of the freeway system and instances of accidental urban relationships within Minneapolis, Minnesota.

1. INTRODUCTION AND STATEMENT OF PURPOSE

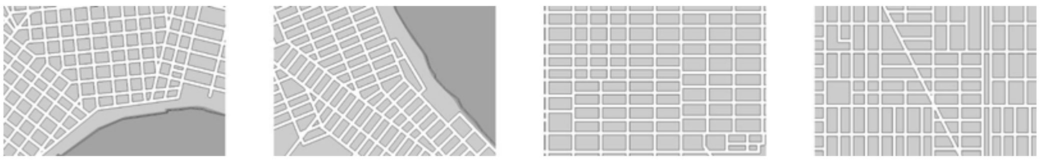
This paper proposes a research methodology for understanding the American city which seeks to identify and analyze the built evidence of *persistent forces* as manifest in accidental and predictable urban form. The purpose of the methodology is not to provide a universally applicable means of categorizing every possible observation of the urban environment; but is rather to suggest a productive means of *asking questions visually* as an aid toward understanding and acting within the city.

The difficulty of analyzing the idiosyncratic form of cities may be defined as one of separating cities into discernible systems, or of identifying a set of forces or ideas which have the power to guide or shape the creation of cities over time. While I believe that it is possible to identify forces behind the development of the city, and that an act of separating observations into discernible subsystems or layers is critical to an understanding of the city, I am not convinced that these forces are fundamentally deterministic in nature: but rather, that their intersection and overlap at specific localities results in urban form accidental or chaotic in appearance.

I argue that the difficulty of analyzing urban form can be defined as one of executing an iterative process of seeing, describing, internalizing, and proposing a specific set of actions upon images, resulting in graphically discernible layers. These layers may not relate directly to nameable urban subsystems, but they may, when reorganized and recombined, enable the identification and analysis of persistent forces in urban development. This happens because the production of layers involves abstraction away from the original image and opens up possibilities of observing and interpreting fundamental patterns in the urban landscape. The successful description of these patterns is equivalent to identifying persistent force.

2. ACCIDENTAL APPEARANCE IN AMERICAN CITIES

American cities are particularly characterized by idiosyncratic and apparently accidental relationships in urban form and patterns of use – for example, as interruptions to a street grid, or as apparent disregard to local topography within a planned grid, or a collision of uses in partially reclaimed abandoned industrial districts. These relationships may be observed at multiple and simultaneously overlapping scales: examining the city or its wider region as a whole through maps or aerial photographs may reveal interruptions to the grid, while observing the city from a ground- or building-level scale, or at a scale of the human body, may reveal surprising or odd relationships between and among individual buildings whose use and purpose has changed over time.



Figs. 1, 2, 3, 4.

At a scale apprehensible in city maps, apparently accidental relationships in American cities are generally visible as interruptions to a ubiquitous city grid.[1] These occur in various manifestations in response to distinct and specific overlapping forces. *Colliding grids* are visible in places like New Orleans and Cairo, Illinois (Figs. 1, 2), where land-speculation grids trace their origin to early patterns of settlement adjacent to landings along a meandering river, resulting in oddly shaped street corners or irregularly shaped or triangular blocks. Milder, less obvious versions of colliding grids occur in flat cities where surveyor's adjustments or the vagaries of speculative land development cause adjacent grids to misalign, as in St. Paul, Minnesota (Fig. 3). Also, *sliced grids*, such as in Chicago (Fig. 4), Washington, New York, or Philadelphia are not uncommon, whether due to deliberate planning or the persistence of a pre-urban intercity road.

Examples of apparently accidental relationships in American urban form apprehensible at ground level include *collisions between street plans and topography* and juxtaposed mixed-use structures within reclaimed industrial districts.[2]

3. A DEFINITION OF PERSISTENT FORCE

I assert that instances of apparently accidental relationships in urban form as cited above are the consequence of collisions between and among persistent forces. By persistent force, I mean something like *causalities* as described in Kostof (7) or *design ideas* in Bacon (2): concepts which posit the existence of forces or ideas, either deliberately formulated or inherited from established convention, which surround and guide the multiplicity of decisions composing urban form over time.[3] My definition maintains a specific identity distinct from Kostof and Bacon: I define those city-shaping forces or ideas which possess persistence over time or persistence through space as persistent forces.

An example of a force persistent over time is *the navigable river:* the establishment and continuing development of American cities such as Minneapolis, Cincinnati, St. Louis, New Orleans, and dozens of others owes much to specific physical relationships to rivers, waterfalls, crossings, or landing places; most such cities have struggled with their river-relationship throughout their existence.[4]

An example of a force persistent through space, one which is typical of mid- and large-sized American cities, is the national freeway system. By spatial persistence, I mean that a force or idea takes its physical form at large scale and in precedence to pre-existing physical forms.[5] The freeway system is unique among the persistent forces affecting the development of American cities because it is designed to be deliberately predictable: it rigorously conforms to a set of guidelines and rules which regulate its design, its construction, and its continued use. Local, particular, unusual, and exceptional features, when encountered, are dealt with predictably: when drivers engage the system, they can expect that any curves and inclines which they encounter will exist within a defined range; that any features outside of the normal range of acceptability will be adequately and consistently identified in advance of encountering them; and that their ability to adapt to these local, surprising conditions can be safely assumed to operate within a given speed.[6]

The graphic analysis of the freeway system has the potential of significant promise precisely because of the consistency and predictability of the system. Every interruption in predictability has the potential to indicate some locally powerful and intersecting persistent (spatial or temporal) force.

4. THE DIFFICULTY OF URBAN ANALYSIS

"The principal difficulty most students of the city face is that of ordering the entire urban area into spatial subsystems due to the extreme multiplicity of such subsystems and the complex interrelationships within and between them." – Bourne (4)

Bourne's spatial subsystems (of which he cites for possible inclusion on a potentially "infinite list" transportation networks, social communities, and industrial linkages), whether seen as the physical traces of forces such as Kostof's *causalities* or Bacon's *design ideas*, are subject to identification, ordering, and analysis. Bourne suggests that the difficulty of this process is due first of all to *multiplicity* and secondly to *complexity* of interrelationship. If a list of such systems is potentially infinite, it will never be possible to identify every system. I propose instead that the difficulty exists not in an attempt to do so but rather in the selection of a mode of inquiry (e. g. of identification, ordering, or analysis) which is most likely to productively enable the discernment and description of patterns in the landscape. Specifically in response to this idea, I propose an iterative method of seeing, describing, internalizing, and proposing specific actions on images, described in detail below.

5. PROPOSAL AND EXAMPLES OF METHOD

I propose a method of urban analysis which begins with an image (e. g. a map, or an aerial or ground-level photograph), and the production through pseudo-automatic digital means of clear and separable graphic layers in response to this image.

The purpose of proposing pseudo-automatic digital means (such as auto-tracing of image contours, stratification or posterizing of images into distinct tones, blurring, inverting, or pixellating) is specifically to promote an analytical shift away from a deliberate statement of hypothesis and to instead open the possibility of accident in observation. As I argue in my paper titled Productive Accident in Student Analysis of Urban Form and Space (5), the deliberate pushing of creative and analytical processes into places where accident is likely to happen convincingly parallels the evolution of the city itself.

Such graphic layers, if produced on translucent paper or its digital equivalent, may be recombined or superimposed upon each other or upon the original image, as seen in the following examples. The act of superimposition further removes the resulting document from a predefined hypothesis and heightens the possibility of discovery from accidental graphic relationships.

A successful method for making sense of a set of such overlaid layers depends first on one's ability to describe, in precise terms, exactly what is seen (in terms of tone, line, texture); second, on internalization, that is, an ability to describe how what is seen defines a structure for thought; and third, most critically, on an ability to propose a very specific action (e. g. a new layer, or a reconfiguration of layers) which strengthens a particular reading of the evolving document.

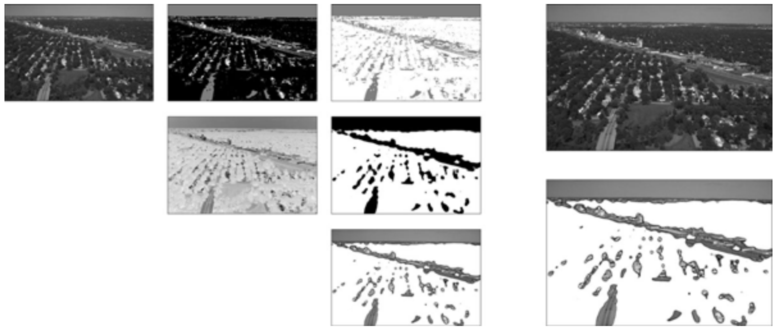


Fig. 5. (Original image copyright Regents of the University of Minnesota. Used with the permission of Metropolitan Design Center.)

Fig. 5 illustrates the graphic analysis of a mid-level aerial photograph of Hiawatha Avenue in Minneapolis; the original image is at top left. The street (the diagonal running across the image) is a pre-urban artifact connecting two significant points along the Mississippi River (visible at the horizon in the original image): to the southeast, the ca. 1820s Fort Snelling, built at the confluence of the Minnesota and Mississippi Rivers, and to the northwest, the Falls of St. Anthony, which as a natural source of power became the nucleus for downtown Minneapolis. The street forms a supporting component of the citywide freeway system, connecting to Interstate 94 at the downtown end and reaching to the Interstate 494 end past Fort Snelling.

The graphic analysis shown here begins with the original image and proceeds through a series of digital manipulations including contrast adjustment and inversion in the middle column and blurring in the right column. The large images on the right are the original image and a “masked” image resulting from superimposing an inverted contrast-adjusted image atop a blurred copy of the original (e. g. two specific pseudo-automated image manipulations). While no longer perceived directly as an aerial photograph, the final image contains distinctly discernible patterns: a continuous gray bar across the top one-fifth of the image, white space in the lower four-fifths, these two areas separated by a narrow graphically animated area; the white space is interrupted by a prominent and blurred diagonal (itself sharing much of the graphic characteristics of the narrow graphically animated area), and by smaller, discontinuous, though still apparently directional and convergent gray shapes. A careful graphic description of this final image may be used in turn as an aid to read the original image, as it serves to structure thought in particular ways: the diagonal strip of Hiawatha Avenue is seen to have characteristics in common with the Mississippi River at the horizon; the small gray clumps in the foreground, while like Hiawatha, clearly appear as subsidiary. The image could be read as suggesting the persistent force of the grid subsumed by the persistent force of the diagonal road.

Fig. 6 illustrates the graphic analysis of a government-produced high-level aerial photograph of downtown Minneapolis; again, the original image is at top left. Downtown is visible at the lower left of the original image and the Mississippi River is the dark patch at upper right. The analysis includes a range of manipulations: the first two rows of images include adjustments of tones, from high-contrast dark to high-contrast light; in the next row, stratified selections of dark tones, midtones, and highlights; the fourth row is a graphic inversion of the third row. The image at lower right “masks” the original image using a combination of images from the second and fourth rows. At least three of the images (particularly the middle image in the third row) suggest a visual affinity between a solid area of color at upper right, interrupted by thin lines of opposite color, with smaller areas of solid color at lower left, themselves also interrupted by thin lines of opposite color. Could such a reading suggest spatial or systemic affinity between the *river*, crossed and divided into segments by bridges, with the overall mass of *downtown*, divided into segments by thin streets? Which takes precedence in such a reading: the volume/mass of the river and the city, or the circulation systems which penetrate and cross those volumes and masses? Other images perhaps more strongly suggest the persistence of the river as a city-shaping force, as they repeatedly emphasize the connection between the grid shift and the shape of the river.

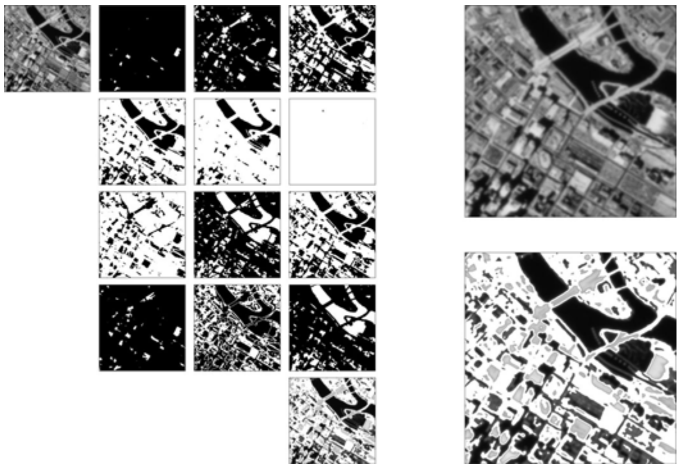


Fig. 6

6. SUMMARY AND CONCLUSIONS

As we as designers seek to act within cities, a graphic analysis of images as described here is seen to generate promising questions about urban form and relationships, questions which are invigorated by accidental relationships yet are clearly bounded by the capabilities and limitations of media (in particular, by maps, photographs, and digital manipulation).

Questions which emerge from a careful description of abstract graphic pattern are seen to productively inform interpretation of an original image of specific form or place; patterns within a composite image, or within a series of images placed in juxtaposition, are seen to hint at the presence and interrelationship of persistent city-making forces. The purpose of defining this methodology is reiterated: it does not promise an everywhere- applicable means of categorizing every possible observation; instead, it suggests a productive means of *asking questions visually* as an aid toward understanding and acting within the city. As we seek to understand the city through image, the approach outlined here proposes a way to extend the range of observations we can draw from images.

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Endnotes

[1] Here, I make exception for pre-nineteenth century central cities which assume forms more typical of European cities; such places may be said to owe their seemingly idiosyncratic forms to forces such as those described by Kostof.

[2] Examples of the first are observed in Manhattan, San Francisco or Salt Lake City. When viewed at the map-scale, these cities can appear uniform and indiscriminate as to topography, but the ground-level view (as of San Francisco's Lombard Street) strongly suggests the imposition of one system atop another. Examples of the second include Minneapolis's historic Milling District, St. Louis's Laclede's Landing, and other areas in which fragments of abandoned structures built to serve expired purposes compete for attention with newer systems, efficiently designed for new purposes (e. g. tourism and entertainment).

[3] See Kostof (7) and Bacon (2). Kostof and other authors in the *systemic* stance as defined by Attoe & Logan (1) have attempted formulations for urban analysis which attempt to determine causal foundations for urban subsystems after the fact. Kostof writes of *causalities* – i. e. the natural landscape, pre-urban land division, synoecism, and social order; Bacon attempts to define a methodology of motivations or *design ideas* (his term) which guide and shape the development of cities.

[4] See, for example, Kane (6) on Minneapolis, Bone (3) on New York, or Attoe & Logan (1) on Milwaukee and others.

[5] Other examples might include Rome's arterials under Pope Sixtus V or Baron Hausmann's reinventing of Paris.

[6] The persistence as a force of the national freeway system is due in part to the circumstances surrounding its origin in a time of perceived national crisis as a federally funded and mandated public works project with ostensible ties to national defense, and in perhaps larger part due to its enabling of out-migration from the central cities at a time when existing housing stock was available at a premium relative to newer housing in outlying areas.

Research, Design and Construction Technologies in Affordable Housing

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ABSTRACT

This paper documents the process and outcomes of a two-year effort at the University to research, design, and build innovative affordable housing. Issues explored in the paper include developing design through research, testing the design through actual construction, applying lessons learned to future projects, and disseminating knowledge into practice. The broad objective of this research is the design and construction of affordable, healthy, socially and culturally appropriate, energy efficient, attractive and sustainable housing. The interdisciplinary team included architects, architecture faculty, contractors and researchers with expertise in design, social and cultural factors, and sustainable building technology. The project is done in collaboration with a local non-profit organization and community development corporation. Phase one of the project was the design and construction of a 996 square-foot (92.5 square-meters) affordable house utilizing innovative construction and enveloping systems. The engineered wood structural system being tested combines un-insulated 11/8-inch (3.8 cm) OSB structural engineered wall panels (oriented strand board) with I-joist floor and roof framing diaphragms. This structural system was combined with the PERSIST (Pressure Equalized Rain Screen Insulated Structure Technique) system of self-healing waterproof membranes adhered to the panel and sheathed by 3" rigid insulating sheets to create a weather tight thermal envelope. One intent of these systems is to reduce material and construction costs by minimizing and eliminating construction steps, such as applying rigid insulation board with embedded furring strips or the direct application of finishes to the panel. Additional intentions are to improve energy efficiency and indoor air quality by increased air tightness and inhibiting mold growth due to moisture infiltration, which has become common in tightly sealed conventional residential construction in the United States. A target cost of $85,000 (US) or less for construction was established.

Phase Two of the project focuses on further development, testing, and evaluation of the design, technologies, and production of two successive Case Study Houses, each bringing forward lessons from the previous case studies. House Two has been completed and House Three will break ground for construction in December 2004. Continuing research efforts include on-site evaluation of construction management, documentation by video and photography and comparison between baseline conventional construction and the PERSIST system applied to the structural engineered panel. This paper will discuss the research project's documentation and critiques and the relative successes of applying lessons learned that modified each successive house in the following areas; energy performance, construction performance and staging, contractor training, interactive education and community input.

1.0 PROJECT GOALS AND OBJECTIVES

The subject of this paper is the design and research of several small affordable, sustainable, and healthy single family houses (House One, Two and Three), constructed in the Frogtown neighborhood of St. Paul, Minnesota, U.S.A on 40 ft by 120 ft lots. This paper discusses the research challenge - providing affordable, attractive, socially acceptable, culturally appropriate, energy efficient, healthy, and sustainable housing - of designing and constructing several single family home using an experimental construction method. The single family home was selected as a building type, because neighborhood infill sites are common to the area and would benefit from alternative low cost solutions. The design would incorporate the social and cultural requirements of predominately Vietnamese and Hmong immigrants, ecological implications of material and design decisions, foundation and moisture mitigation strategies with emerging construction and enveloping technologies.

Beginning in 2001, the Amherst H. Wilder Foundation (a nonprofit social welfare institution with a broad array of work-force housing programs in St. Paul) teamed with the Greater Frogtown Community Development Corporation (GFCDC), the Department of Architecture and the Metropolitan Design Center at the University of Minnesota's College of Architecture and Landscape Architecture to develop designs and construction drawings for one to three prototype houses that integrate affordability with sustainable design, healthy construction, social and cultural responsiveness, and design excellence. The Wilder Foundation and GFCDC coordinated the construction of the first Pilot House with a certified general contractor. The construction documentation and evaluation of House One, completed in Fall 2003, produced construction and detail revisions for the next two houses, House Two and House Three (see Fig. 1).

2.0 DESIGN-RESEARCH TEAM

The design team for the project consisted of university researchers in design, social and cultural issues, sustainable buildings systems, wood building technology, indoor air quality, and moisture control. The research collaborators sought to design prototypes that would test high performance and healthy features in new constructions while still maintaining affordability. The selected building system, *Structural Engineered Panel (SEP)* is a large panel stud-less wall structure made of 1 1/8" OSB panels. The inspiration for this system came from work done in the 1990s by Rob Leslie, who developed a low-tech, low-cost solution for housing needs in third world countries using a system of 3⁄4-inch OSB as both house envelope and structure. The targeted construction cost for the house was between $85,000-$100,000 and mortgages affordable for people at 40-60% of the Twin Cities Median Income. The developer is the Greater Frogtown Community Development Corporation (GFCDC).

In Fall, 2003, after construction had started on the second house, the research project was awarded a $400,000 Housing and Urban Development grant for Community Outreach Partnership Center. The research team renamed *The Affordable Housing Initiative* continue the design-research collaboration just as House Two was under construction. The team's mission enlarged in scope to include affordable housing curriculum development of architects/designers, outreach programs and expanded community participation to further ensure stability and improve the quality of life in low-income communities.

3.0 DESIGN AND CONSTRUCTION

The Pilot Project coupled the stud-free *Structural Engineered Panel (SEP)* building system with the modified PERSIST system. The *SEP* building system consists of a weather envelope constructed of $1^{1/8}$” x 8’ x 24’ OSB panel walls, engineered wood I-joists and rafters. The PERSIST (Pressure Equalized Rain Screen Insulated Structure Technique) system, developed in Canada, provides the moisture barrier, vapor retarder and air barrier as well as the insulation for the wall and roof assemblies. The entire OSB wall and roof structure is encased with self-adhesive, self-healing 60-mil membrane, applied directly to the primed OSB, in a flat as possible (no wrinkles or air pockets) shingle fashion with overlaps the between the wall and roof sheathing. It can be applied vertically or horizontally but the vertical application is preferable. Rigid 4’ x 8’ insulation boards, embedded with treated furring strips at 2’-0” intervals, are then placed over the membrane using adhesive and mechanical fasteners, 2-inches on the walls and 4-inches on the roof. Each surface is then sheathed with siding or roofing. The OSB panels employed serves as the structural component and the interior wall finish (gypsum board is eliminated since the OSB panels may be faced with paper or sanded and painted as the final interior finish of the house). The *SEP* technology and the modified PERSIST or *External Thermal Moisture Management System* (ETMMS) promises a reduction in construction costs, a more energy efficient building envelope, and retarding the mold growth.

Fig 1. House One on the right and House Two on the left

The typical $1^{1/8}$” OSB Huber Corporation panel was originally designed for use as industrial flooring resisting extreme wetting conditions. It is manufactured of Southern Yellow Pine chips (other manufacturers typically use poplar) bonded with an ecologically friendly polyurethane resin that can be sanded to a very smooth surface or imbedded with paper in one surface that; when painted, becomes a suitable interior finish. The panel must be buttressed at 12-foot (3.65 m) intervals to maintain lateral stiffness

By combining the systems (SEP and ETMMS) the design promised a reduction material and construction costs by minimizing steps, optimize space use and flexibility, improve energy efficiency and indoor air quality by increased air tightness and eliminate the inhabitation of mold growth due to moisture infiltration. Each successive prototype (House Two and House Three) incorporated design changes and modified construction protocols in order for the designs to be replicated in the marketplace.

4.0 THE DESIGN

The design of each house sought to negotiate among the social, technical, and construction issues of the project by optimizing the whole design rather than focusing on any one of its specific issues and promote a series of small design ideas rather than achieve a universal solution. The 1 1/8" inch-thick Huber panels required a shift in design conception since the wall became an assembly of sheet goods; the OSB behaves like a continuous beam so joist hangers for floors and a roof can be directly attached to the surface or openings can be cut out with no additional framing. The weather envelope performs best as a simple four-cornered box to minimize cost and permit easy installation of the SEP panels and the PERSIST system. Contextual features such as porches are 'attachments' to the basic box. Open plans and large kitchens provided for flexible family functions as well as assisted in ventilation and thermal performance.

The elimination of the stud cavity found in vernacular construction methods, often a source for mold or deterioration in the tighter insulated walls, also meant the elimination of the traditional distribution network of electricity, plumbing, or heating equipment. Areas for plumbing risers and runs, radon and HVAC distribution are carefully planned near the center of the house. Electrical raceways are incorporated in an extended baseboard trim designed specifically for this task. Vertical trim around doors houses electrical switches. Interior trim is also employ to joints in the interior an important issue since there is no secondary interior finish throughout most of the house.

House One is a 24x24, one-and-a-half story one bedroom 1000 sq feet house, with a single bathroom ('visitable') on the main floor and a full basement that could be remodeled as additional bathroom, bedroom and family room. The main floor was relatively open, given the side entry and stair alignment across the width of the house The second story had one bedroom, a wider open room adjacent to a rough-in bathroom, which served as the master bedroom's walk-in closet. The stick-framed 12:12 pitch roof rests on a girder beam supported on a central column. Details include a slatted stair grill, an OSB pedestal sink, a wrap-around front porch and back stoop, thin-profile alternating siding and wide trim that reflects neighborhood scale.

Fig. 2 Pilot House (House One) Lifting the gable end wall

Fig. 3 Placing OSB panel floor between wall panels

House Two, the 'Narrow Lot House', immediately adjacent to House One (see fig. 1), is a 18 x 32, one-and-a-half story two bedroom 1200 sq. ft. house elevated five feet off grade to provide more security on the corner lot. It has a centrally positioned u-shaped kitchen, eating bar and nook below table height windows. A compartmented bathroom, laundry and mechanical room divide the two generous lower level bedrooms, one facing the facing the rear yard the other the street, all accessed by the straight-run stair behind the kitchen. The living room, entered from the side, across an ell-shaped two-tired porch, is open to the rear yard, and a windowed loft nestles above the kitchen under the cathedral ceiling, overlooking both living and dining spaces, I-joist rafters 24” o.c. span the 18’ between the gable ends. The 1/2 bath on the main floor, accessible from the rear entry, is off the family/dining room (see Fig. 4 for construction sequence).

Fig. 4 house Two: corner panels and one joist ; all panel, windows and rafters in place membrane and windows await insulation

<u>House Three</u> is a 24 x 28 one-and-a-half story three bedroom1280 sq ft, house, again with a full-unfinished basement, but one-and-a-half bathrooms. This plan has a smaller entry front porch, a living room across the street façade separated from a broad family - kitchen area that opens onto a wide deck overlooking the rear yard by a center u-stair opposite a 1/2 bathroom and plumbing-mechanical core backed-up to the kitchen plumbing wall. 85% of the interior bearing walls are $1^{1/8}$” OSB panels supporting the stairs and the floor I-joists. The floor is also $1^{1/8}$” OSB panels and the roof is a custom A-frame truss accessible for storage (see Fig. 5).

Fig. 5 House Three first panels w/ 4x4 corners panel shell w/ partial membrane insulation over wall and roof membrane

6.0 CONSTRUCTION SEQUENCE

Major soil conditions and site-availability schedules modified the original shallow foundation design to a poured concrete basement construction for all three Houses; soils remediation, special foundation waterproofing, extensive insulation, egress windows and large window wells were added to make the basement habitable. Because the standard panels were not available for House One, each wall was fabricated from two offset 3⁄4” OSB panels, glued and screwed together, to make 12 foot-high x $1^{1/2}$” -inch-thick side wall panel’s and the entire gable end panels with all window openings. These were lifted off the floor cap in sequence until all four sides were locked together. Floor joists supporting 3/4” OSB panels serve as both underlayment and finished floor, although sanding improves the durability and finish quality of the floor. On House Three, the $1^{1/8}$” x 8’ x 24’ OSB panel was installed as the finished floor deck requiring the I-joists to be spaced @ 19” o.c. rather than 24” o.c.

House Three exploited the delivery of Huber panels to a local wood fabricator for precutting prior to site delivery. On site, a crane sequentially placed each pre-cut $1^{1/8}$” x 8’ panel (bearing height 17’) with pre-attached 4x4 corner posts. All panel connections were made as 8” wide OSB battens. House Three’s panel fabrication, floor and roof erection, appearing in all respects like a “house of cards” (see Fig. 5), had to be conventionally braced until second floor I-joists were anchored into their plate hangers; erection time was reduced to three days (4 person/day) rather than 12 days on House One (2 person/day).

All Three Houses required care in squaring to properly align the roof ridge, the second floor I-joist and rafter framing. The roof was difficult to sheath, insulate and shingle because of the steep 12/12 pitch and worker safety became an overriding concern. Application of the exterior moisture and vapor membrane was more difficult than anticipated mostly due to uncommon practices.

8.0 CONCLUSION

There is no single design and construction solution to the problem of affordable housing. Incremental improvements have been made in a variety of areas that result in an affordable house that is also more sustainable, healthy, and livable. A few notable results learned from the prior two houses have been incorporated as House Three begins construction.

- The type, size and handling of the $1^{1/8}$” x 8’ x 24’ OSB panels has improved the quality, strength and efficiency of construction: crane lifts are sequenced, interior panels are sequenced with structural stair elements, to name a few.
- Labor costs have been reduced as contractor and client learning curve has improved.
- Preliminary data suggests moisture intrusion has been controlled better than hypothesized.
- The building envelope has performed higher than expected; the airtight system has produced very high ventilation control measurements..
- Energy efficiency goals will be met but % of improvement is yet to be measured.
- Sub-contractor training and quality assurance has improved beyond expectation.
- The cost of high performance systems is offset by cost reductions in areas such as quantity purchases of building materials (panels) to keep costs on a par with conventional construction.

However, to bring this new building system to scale, there will need to be additional research and development in three areas.

First, the SEP system will require code and regulatory testing to achieve broader acceptance by municipalities as well as the design and construction communities. Testing will primarily focus on identifying problems or opportunities in building codes and standards and other regulations affecting the technology; developing new structural engineering standards and fire regulations; and documentation showing how SEP technology complies with the intent of proposed energy regulations. Each house will be tested and monitored for a variety of performance measures, including energy performance, air tightness and air quality. The Huber OSB panel is undergoing moisture and thermal performance testing.

Second, the mechanical systems integration design must be refined since the ETMMS system supports greater innovation than currently being specified. HVAC, plumbing and electrical systems designs need to be integrated with the manufacturing and panel assembly methods as well as systematized to make them easy to modify, maintain and most importantly function predictably and efficiently.

Finally, building the SEP homes requires education and training of: builders to become familiar with manufactured panel systems; education of architecture students and architects in affordable housing design as well as emerging digital manufacturing document production methods; and building system fabricators organized to work from digital manufacturing tools to pre-fabricate panels and components.

The overarching objective is not the production of a significant number of affordable dwellings but, rather, a set of dependable construction details and specifications that can be used by any contractor wishing to use this construction system. The obvious conclusion to this demonstration culminates in producing affordable, energy efficient, sustainable and healthy homes to the marketplace at a reasonable scale throughout the State of Minnesota.

ACKNOWLEDGMENTS

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The Center for Sustainable Building research has incorporated the SEP building systems research with its Minnesota Green Affordable Housing Guide The Guide is a web-based resource to assist designers, contractors, and housing agencies integrate affordability and sustainability for cold climate housing. Separate strategies are developed for Homeowners, Developers, Policy and Decision Makers and Designers and Builders, (http://www.csbr.umn.edu/housing_guide.html).

Mitigating the Effects of Hurricanes in Florida: The Challenges of Upgrading Mobile Home Parks

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ABSTRACT

For the past four years, several universities have been involved in a multi-disciplinary study on how to mitigate the effects of hurricanes on residences in Florida, particularly mobile homes, which constitute a substantial portion of affordable housing in the state. The research has involved several academic disciplines, including engineering, construction, sociology, geography, landscape architecture, and architecture.

The purpose of this track was to analyze issues relative to the upgrading of mobile home communities. The team looked at existing mobile home parks in west central Florida that are economically marginal to assess the feasibility of their redevelopment into zoning-conforming lots that would be appropriate to other types of affordable housing. The intent was to identify potential impediments to the redevelopment of the parks as affordable single-family subdivisions. The work was to build on earlier studies that looked at the physical implications of re-platting existing mobile home parks.

The research focused primarily on west central Florida in the analysis of barriers to upgrading mobile home parks. Team members met with developers, real estate consultants who were familiar with issues related to developing and upgrading mobile home parks. The team also developed case studies on other mobile home communities, related to the issue of upgrading. The importance of this research was made obvious by the 2004 hurricane season, and which four major storms created significant damage to Florida's housing stock, particularly mobile homes.

1. BACKGROUND

Florida leads the nation in the number of mobile homes. Some 2 million residents of Florida, or about 12.5% of the total population, live in mobile homes. The Tampa Bay area, with more than 3 million people, has the heaviest concentration of mobile homes in the state. In many communities, it is the only form of affordable housing. The state does not have rules to keep mobile homes from being placed in high-danger areas: hurricane wind and flood zones in coastal communities.

The potential for damage to this housing stock from hurricane impact is real and of the utmost importance to Florida policy-makers, public officials and a host of stakeholders including, the residents, but also mobile home manufacturers, housing developers and builders as well as design and engineering professionals. The largest numbers of mobile homes are found West Central Florida.

In the Tampa Bay area's five counties — Hillsborough, Pinellas, Pasco, Polk and Manatee —there are more than 134,000 mobile homes. Polk County, crossed by three hurricanes in 2004, has the highest number of mobile homes of any county in the state: 38,748. Pinellas County ranks second, with 35,544. Pasco County ranks fourth with 20,742; Hillsborough County is fifth with 20,726; and Manatee sixth with 18,805. Lee County is third with 26,802 mobile homes. Charlotte County officials expect to spend millions cleaning up the 12,000 mobile homes Charley destroyed or severely damaged. (Helgeson)

A report in November from the Florida Bureau of Mobile Home and RV Construction, which surveyed hurricane damage to mobile homes in 14 counties, says mobile homes built after 1994 stood up fairly well, though some suffered serious damage. Homes manufactured before 1994, however, were found to have sustained extensive damage. For instance, Charley destroyed 93 percent of the 140 mobile homes in Pine Acres mobile home park in Punta Gorda. Only seven of the homes in the park were built by 1994 standards. (Helgeson)

Any issue that affects such a large segment of the population becomes a very important one not only for the residents themselves, but also for state legislators, policy-makers and others. The demographics of mobile homes residents are quite different than those of the total population of the state. These characteristics include the following: Slightly more than 36% of the households consisted entirely of elderly persons (65 and older); an additional 49.1% of the households included members 65 years of age or older; about 15.4% of the population are widowers living alone. These are segments of the population that could be categorized as having *special needs* especially during emergencies.

There are three distinct generations of mobile homes based on their year of manufacture. Roughly these generations can be identified as: Pre-1976, 1976 to 1994, and Post-1994. The Pre-1976 units are those that were built when there were no manufacturing/design standards. Those of the 1976-1994 generation were built under HUD standards. Because of the dismal performance of mobile homes in Hurricane Andrew, new wind standards went into effect in the HUD Code in July 1994-- manufactured homes placed in high-risk hurricane areas now must be designed to withstand approximately 100 mile per-hour winds. The Post-1994 generation incorporates stricter design and manufacturing standards including wind load standards based on ASCE specifications.

Throughout the state of Florida, and particularly in the west central Florida region, there are significant numbers of older mobile homes in use today. Only about 14% of units in service have been built to the strictest wind standards while approximately 29% belong to the "no-standards" pre-1976 generation. This category of mobile home tends to be the most vulnerable under adverse weather conditions. A combination of factors-- age, sustained use, inability to be upgraded or renovated to comply with current codes and standards, substandard modifications-- contribute to unsafe and hazardous conditions. The fact that most of these structures were built under less stringent regulations, using construction methods that would be considered “outdated” today, suggests that many of these mobile homes should be retired from further use. Most of these mobile home structures are of the “singlewide” configuration and were installed on either leased or purchased lots. Invariably, these structures incorporated approximately 500 to 700 square feet of floor area in a rectangular unit, and occupied regular-shaped parcels - some with typical dimensions as small as 25 feet by 40 feet.

It is unlikely that the manufactured housing industry will implement significant new changes in the foreseeable future, to further minimize the risk of property loss and damage due to hurricanes or other severe weather conditions. While modest improvements have been made in enhancing the structural integrity of mobile homes over the last two decades, current trends in this type of construction appear to be focused on increased space, the inclusion of more amenity features and enhanced curb appeal or character. Newer mobile homes have become much more appealing and marketable to that segment of the general public that will consider this form of housing as a first choice, or as an alternative to conventional site-built houses. As the inventory of newer, mostly doublewide mobile homes are purchased and installed; there is an increasing supply of older ones that remain on the market and in continuous use.

In coastal areas, storm surges during hurricane events can be devastating to mobile homes. Floods can cause strong pressures on foundations or piers, and floating debris can cause further damage to the exterior. Interior damage to the structure can be extensive. Some wind and flood damage can be avoided by proper installation, by raised installations using properly designed fill and/or posts, and by using tie-down. However, local building inspectors may be unfamiliar with the particular needs of manufactured houses. This may be especially true in small communities where inspectors do not specialize. Also, inspectors or inspection agencies may easily miss resold manufactured/mobile homes.

2. PROJECT

Because of the growth of the west central Florida, there is no lack of new residential developments at all but the very lowest economic level. These include manufactured home communities, several of which were visited by the research team. While the layout of mobile home parks is in general very tight, this is a factor of the affordability of manufactured houses, and appears to foster a positive sense of community among the residents as many observers have noted. These newer communities appear to be meeting the demand for HUD certified manufactured housing for newcomers or for those who can afford to move and have become aware of the deficit of the older, grandfathered parks and housing stock. Nevertheless, this older stock is serving a vital function in housing the poorest segment of the population.

Most mobile home parks resemble each other more than they differ. Generally the lots are configured for single unit homes and are closely spaced, with minimal side yards. Their roads are typically narrow, more along the lines of driveways [technically *easements*], and are minimally improved. Densities are as high as 50 units per acre. The typical mobile home dweller feels a degree of autonomy afforded by the freestanding home.

Individual sites in a licensed mobile home park are not legally described parcels. The entire mobile home park is a single parcel. Internal lot lines and setbacks in a community are features of landowner policy. Some local governments or similar entities of jurisdiction impose setback standards to effectively reduce the number of usable lots and consequently the number of homes in the community. “This practice discourages homeowners from upgrading and promotes sprawl.” (Governor’s Blue Ribbon)

Park owners that are tying to improve the distressed appearance of their parks are often hampered by the lack of available and affordable rehabilitated mobile home units. Therefore, the park needs to bring in upgraded older homes that are appropriate for the park and the incomes of the persons demanding this product. Older parks are further limited by lot dimensions that cannot accommodate the newer wider and generally larger units.

Manufactured home size trends mirror those in site-built homes; they are getting larger. Even in cases where new homes are only slightly larger, the original layout and existing setback allowances between homes and from homes to roadways make retrofitting older parks with new homes difficult or impossible. An option in this case could be to request a variance, but the granting of such a variance could cause concerns in terms of access for emergency vehicles (if roadways are infringed upon by the new homes) as well as represent a higher risk of fires spreading (if homes are located closer together).

Another possible option to adapt to larger homes would be to reduce the number of sites in the park. In addition to being logistically difficult (since neighboring sites would need to be vacant at the same time to implement such a strategy), this activity would tend to reduce the cash flows associated with ownership of the park. Though rents for larger sites will tend to be higher, it is unlikely that they could be increased sufficiently to compensate for the sites lost in the renovation (including the loss of use of electrical, water, and sewer infrastructure which was already in place to the removed sites). (*Taking Stock*)

A similar issue of concern is the number of single-wide manufactured homes that are being replaced by double-wide homes in mobile home parks. The industry claims the double-wide homes are more marketable, but from the perspective of the residents they can be seen as reducing the affordable housing options that the single-wide units provide.

In addition to the affordability issue, a preponderance of double-wide units can quickly change the character of a mobile home park by reducing available open space. Privacy is also affected by the reduced separation between units. The majority of the open space that is available on a mobile home lot is within a single side yard between two homes. While most lots within a park can accommodate a doublewide, the substitution comes at the expense of outdoor living areas (decks, patios, carports, etc) within these side-yard setbacks. The local codes require a minimum of fifteen feet of separation between homes and a minimum of ten feet between an adjacent home and an accessory structure. For the purpose of the mobile home regulations, accessory structures include decks, patios, carports, sheds, etc. In a majority of situations, a single-wide lot includes an outdoor deck within the side yard and also accommodates the required separation from the deck to the adjacent home within the same area. When a doublewide is placed on the same lot, the ability to have the outdoor living area or carport is sacrificed to meet the minimum separation requirements. (de Raismes)

The team developed the following case studies, relevant to the barriers in upgrading mobile home parks:

2.1. Yachthaven

Yachthaven Estates community area was developed as mobile home subdivision in unincorporated Pinellas County in the 1950s and through resident petition annexed into Largo in 1966 by referendum. There are currently a total of 73 lots that were created through metes-and-bounds lot splits and the dedication of additional right-of-way to access the lots. The area was originally platted as a two-phase, 34-lot single-family subdivision. Since its inception, the property has been developed with mobile homes. Residents discovered that they were in difficult position of being unable to replace their mobile homes (because they were in a flood zone) or construct site built houses (because lot sizes were too small). Thus the neighborhood was unable to upgrade the deteriorating mobile home stock.

> “[A home owner] discovered, at the worst possible time, that she and the other residents in the Yachthaven Estates mobile home community are stuck in a web of city, state and federal regulations, unable to replace their homes even if they are damaged or destroyed by hazards. They can't replace them with mobile homes because their community is in a flood zone and coastal high hazard area, and because it is not legally described as a mobile home park. So when their old, 1950s-era, mobile homes deteriorate to the point of needing replacement the only option is to build houses on site. But other laws require site-built houses have to be on minimum lots of 5,808 square feet. Almost all the lots in Yachthaven are smaller than that. Some are half that size. Factor in required city setbacks of up to 20 feet, and that doesn't leave room for much of a house, even if a house were allowed. (Benham, “Neighborhood”)

In June 2003, the City Commission of Largo approved a neighborhood plan that made all the lots legal, creating an exception to city codes. Mobile homes are still not being allowed, but modular, wood, masonry or any other construction that meets Florida Building Codes is approved. The plan also would reduce the required front setback from 20 feet to 10 feet. The smaller lots (e.g., 40 ft. x 60 ft. and 45 ft. x 90 ft.) are allowed to redevelop in one of three ways:

- Individually as single-family residences following the same standards applied to the other lots;
- "Together" as two single-family attached (zero lot line) residences with a single-family appearance. Each unit must be maintained on as a separately deeded parcel capable of being independently owned and sold;

• Be combined into one lot (without requiring replat), allowing them to be returned to the same size as the other surrounding lots.
(*Yachthaven Estates Neighborhood Plan*)

2.2. Affordable Residential Communities

Affordable Residential Communities (ARC) is a Colorado-based company that buys distressed mobile home parks throughout the country, performs some upgrades, and manages the parks. It is one of the largest mobile home park owners in the country, with over 200 parks and 50,000 spaces.

In 1999, the company bought a mobile home park in Manhattan, Kansas. John Brown, ARC public relations official, “residents who own a 1982 manufactured home or older model, and want to sell their home, will have to make changes meeting the U.S. Department of Housing and Urban Development standards.” Homes built prior to 1982 will be able to remain in Blue Valley," Brown said. "Should they decide to sell their older homes, they would have to be brought up to HUD 1976 standards." (Kistner)

The team met with David Prejean and Mike Proulx, from ARC, in June, and visited two of the company’s mobile home parks in Broward County. In choosing a new community to invest in, ARC establishes a budget and evaluates the due diligence of the property. In most cases, old sewer systems are the most common factor that deters the company from investment in a park. The established budget is then used to improve the infrastructure, do extensive clean up and add amenities to the community.

3. FINDINGS

For most mobile home parks an upgrade in the housing stock to better resist hurricane force winds is the obvious needed change. Replacing older mobile homes, especially those manufactured prior to 1976, with newer post-1994 manufactured homes would be a desirable upgrade. Unfortunately the newer units are typically wider than older mobile homes they would replace. In consequence the team’s initial exploration was to determine ways to re-plat existing parks to accommodate either the newer and larger (wider) manufacture housing units or perhaps even site-built housing.

Typically, the oldest and most decrepit mobile homes are occupied by the least advantaged members of society. The occupants cannot afford to pay for the newer, better and safer units. To the extent that the mobile home market operates like the automotive market it accommodates all comers – but the fundamental notion of upgrading mobile home parks by re-platting and installing newer and larger manufactured homes contains a fallacy: the poorest segment of the existing mobile home parks will be squeezed out, and will be left homeless. Also, manufactured units that would fit on many existing lots are available, but typically are not promoted by the industry, according to some sources, which prefers to sell double-wide units.

Land-tenure must be addressed, since the incremental increase in value of the homes is in fact typically tied up in the increase in value of the land, which the land-tenant doesn’t benefit from. Where parks are failing or have failed the change of land ownership should be pursued both for humanitarian reasons and for the benefit of the larger community. Education has been given insufficient attention, but must be linked to the land-tenure conclusion. It is clear that most owners of mobile homes simply do not understand the economics underlying their ownership and how this really affects them. Studies point to the fact that capital growth associated with mobile homes inheres in the land they are located on. An educational program must address not only hurricane safety but also the larger issues of mobile home ownership or occupancy.

As Florida's cities expand, mobile home parks that were once on the periphery have been engulfed. Many of these parks have been or are being redeveloped, though typically as apartment buildings and at rents the former occupants cannot afford. Outside of metropolitan areas the pressure to re-develop may be non-existent, as the state has an ample supply of existing and current single-family developments. People living in mobile homes are a growing segment of the population among the lower economic sectors of society. Manufactured homes already represent an important portion of the housing stock in Florida. From the research findings disclosed before it can be seen that upgrading of mobile home parks is very difficult and nearly impossible without special zoning considerations, except when they are dedicated to other uses such as apartment units and others. Apartment living is unacceptable to many people who now live in mobile homes. The result of these barriers is that many of the less privileged members of society live in the older generation of mobile homes, those that are the most vulnerable to hurricane impacts. It is apparent that policy is needed that will facilitate the upgrading of mobile homes and communities in order to reduce the potential for damage from hurricanes.

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A MULTIDISCIPLANRY DESIGN METHODOLOGY FOR SOUTHERN HOUSING

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ABSTRACT

Under the auspices of the US Forest Service and the Coalition for Advanced Housing and US Forest Product Laboratory, the Southern Climatic Housing Research Team -- a multidisciplinary group of wood scientists, architects, landscape architects, mechanical and civil engineers – is designing a research and demonstration house for the Southeastern United States on the campus of Mississippi State University. The objectives for this house are to solve climate-related housing construction problems endemic to hot-humid climates: high heat, humidity, decay fungi, mold, high wind, low velocity ventilation, and various insects, including the devastating infestation of the Formosan termite. An overview of the design strategy and research strategy that respectively underpinned the proposed design of a research and demonstration house and organized the multidisciplinary research agendas amongst the five members of the team is presented. The design strategy involves six social, historical, constructional, landscape, environmental, and formal strategies. The research strategy entailed three significant components, all of which are ambiguous in nature. The first is an ambiguity between design and scientific experimentation; the second is an ambiguity among the five disciplines, and the third is an ambiguity among three objectives. Because this is a work in progress, the conclusion will take the form of descriptions of a selection of particular research projects.

1. INTRODUCTION

According the 2001 American Housing Survey, over one third of all housing units and one half of all housing units constructed in the last four years were in the Southern US. [1] Over ninety percent of all houses constructed in the US use wood and wood products. Conversely, it has been estimated that decayed wood and termite-infested damage cost US homeowners approximately $500 million annually in replacement costs alone. Also, if the construction lumber is not properly treated, then additional 266 million trees must be harvested to meet present demands. [2] The development of design ideas and construction techniques that address durability and energy efficiency concerns particular to the southeastern US would have not only regional ramifications but have national benefits.

Under the auspices of the US Forest Service and the Coalition for Advanced Housing and US Forest Product Laboratory, the Southern Climatic Housing Research Team -- a multidisciplinary group of wood scientists, architects, landscape architects, mechanical and civil engineers – is designing a research and demonstration house for the Southeastern United States on the campus of Mississippi State University. The objectives for this house are to solve climate-related housing construction problems endemic to hot-humid climates: high heat, humidity, decay fungi, mold, high wind, low velocity ventilation, and various insects, including the devastating infestation of the Formosan termite. The goals for the research and demonstration facility are practically and educationally oriented. We intend to provide researchers, architects, and contractors with practical definitions for energy efficiency and durability for wood-constructed residences for hot-humid climates. We also want to educate the public on how to design and construct a moderately priced house that requires only twenty-five percent of the typical amount of consumable energy used today in a residence of comparable size, to insure that all wood remain durable during the life of the house, and to maintain a healthy indoor air quality, yet presents a conventional appearance.

In this paper, I will present an overview of the design and research strategies that respectively underpinned the proposed design of a research and demonstration house and organized the multidisciplinary research agendas amongst the five members of the team. In conjunction with the description of the research strategy, there will be a discussion of several proposed research projects.

Before presenting the design strategy, a brief description of the members is in order. The idea of the house and the coalition of different disciplines is the brainchild of Terry Amburgey, professor in the Department of Forest Products. He is a leading expert in microbiological concerns in wood products, in particular decay and termite infestations. During his thirty years of investigating these concerns in both the laboratory and in residences around the world, he has experienced a myriad of inappropriate construction techniques, to which he wishes to address in this proposed house. Concerning termites, his expertise includes the Formosan termite, which are rampantly infesting the city of New Orleans and which eventually will overrun areas as far north as the 35^{th} parallel in the US. [2] A second member of the group is Pete Melby, Co-Director of the Center for Sustainable Design, a professor of Landscape Architecture, and author of *Regenerative Design Techniques: Practical Applications in Landscape Design,* which present strategies for sustainable design for both architecture and landscapes. Our third member, Louay Chamra, is a mechanical engineer, who is presently researching residential applications for cooling, heating and power systems, which are called MicroCHP. There are two civil engineers, Chris Eamon, who has also trained as an architect, and specializes in severe lateral loading, ones generated during severe storms and tornadoes and Ralph Sinno, who has research uplift problems in residential structures and who is presently working with other architecture faculty on this problem in manufactured housing. The last member is myself, who has over twenty years of architectural practice specializing in housing and energy efficiency.

2. DESIGN STRATEGY

The design strategy, like the research strategy, entails ambiguous relationships among three concerns**:** first, to establish a facility that functions as a house, a research laboratory and a demonstration classroom; second, to produce a building whose overall form is energy efficient for hot-humid climates yet present a conventional aesthetic; and, third, to be capable of transforming spaces and construction so to comply with particular research projects.

As much as the first intent of designing a facility that must function equally as a house and as a research laboratory may appear contradictory, we employed two tactics that endeavored to conjoin the two aesthetics. Regarding the research aspect, the general principle of scientific research to use a control along with the test manifested itself into a split building. The building has two main components; a northern wing and a southern wing that are connected with an entry foyer. In general the northern wing will contain conventional features, such as typical construction, slab on grade, a standard HVAC unit and duct layout, while the southern building will contain the more passive-oriented systems, such as use of thermal mass and controlled direct lighting, along with the MicroCHP unit, a proposed heat interceptor wall, a ceiling plenum air distribution, and treated-pier foundation.

Complimenting the research dialectic of northern conventional and southern innovative, we planned the room layout to respect a conventional public to private distribution. The arrangement, room sizes, and public and private area organization are not dramatically altered from the typical. The “house” is intended for a typical family, two parents and two or three children, which translates for the typical US house as three bedrooms with two and one-half bathes. The distribution respects the conventional public to private areas transition, wherein the more public areas are adjacent to the front door, while the more private farther away. Concerning the demonstration aspect, we intend to educate a wide variety of people, from school-age children, to university students and faculty, to fellow researchers of sustainability and durability of wood products, and the public at large with the goal to inspire people to design their own energy efficient and durable houses. The educational aspect extends beyond the building. The chosen site was intentionally difficult. It is quite common for the typical US house to reside on a flat site, either one naturally defined or man-made. The reasons are strictly economical; a slab-on grade foundation is cheaper than a raised floor, yet the raised floor allows for cross ventilation. Our site slopes over six feet (2m) over the diagonal length of the house, which will require a combination of slab and raised floor. Raising the house above the ground creates stability problems for the foundation because of drainage issues. A particular educational component of the site is to illustrate carbon dioxide sequestering. The typical house in America requires three acres of trees and vegetation to sequester the carbon dioxide given off by the house. We will plant three acres of trees and vegetation to illustrate the required acreage and demarcate the area required for ours.

Regarding the juxtaposition of energy efficiency and conventionality, we defined six social, historical, constructional, landscape, environmental, and formal tactics. Socially, we recognize the design attributes of traditional southern houses as antecedents for this research and demonstration house. It is not our intent to romantically rekindle the aesthetic of the past with contemporary technology. The traditional houses were constructed prior to central heating and cooling; therefore, their geometry, their orientation, their proportions, their construction, their relationship to the ground, responded directly to providing comfort, which we ironically conceive as energy efficient design. The most significant energy savings derives from the strategy of correct buildings proportions and orientation. To abet cross ventilation, residences in hot-humid climates should have a minimum of a 1:2 proportion with the long axis oriented due east and west. The long faces receive the maximum amount of low angle of our winter sun during the four months of heating and, more significant, to reduce the solar heat gain on the east and west elevations during our six months of cooling. In conjunction with proportioning, other passive means, such as extensive overhangs, trellises, screen porches, thermal mass in the floors, high ceilings, which range up to seventeen feet in height (5.3 m) and thermal interception systems in the walls. However, to live in an energy efficient house, people typically believe they must dramatically alter their lifestyle, which the majority of the US population is unwilling to do. As with some suburban houses, the narrow side faces the street, the garage projects forward, and the front door is sometimes recessed. In the proposed house, the garage is situated on the northwest corner, which places it closes to the road and which will block northwest winter winds. The front door is located in the interstitial room that both distinguishes and connects the northern and southern wings.

Besides planning we addressed conventionality through the size of the house. In the US, the average sized house is approximately 1798 square feet (app. 180 sq. m) [1], while according to the Tennessee Valley authority, the primary electrical power source for the southeast region, in the southeastern US the average size is 1,761 square feet (app. 176 sq m). Our proposed house is 1776 square feet (app. 176 sq. m) of conditioned space. The social intent behind this conventional sizing is to illustrate that the size of an energy efficient house need not be either abnormally small, which suggest that fewer square feet translates to less area to heat and cool, nor abnormally large, which suggests additional rooms to accommodate the extra features. And from an economic perspective, the house should appear affordable to the broadest audience. The room sizes are also standard with bedrooms ranging from twelve by twelve feet (3.6 m by 3.6 m) to twelve by sixteen feet (3.6m by 5m). The living and dining rooms are both nominally twelve feet by sixteen feet (3.6m by 5m). However, all living areas, such as living and dining rooms as well as the bedrooms have an adjacent room or space that provides the impression of a larger living environment and allows the inhabitation to vary according to seasons. It is our intent to design a dynamic house. People can expand or contract their living space according to the seasons. Lastly, this issue of conventionality also influenced construction. The longest span of any room is 16 feet (5 m), which can be readily achieved using stock dimensional lumber. All of the house can be built with conventional materials, however not all walls are the same thickness. We will vary thickness according to orientation, which will make the house more efficient, yet not be readily apparent.

3. RESEARCH STRATEGY

The research strategy entailed three significant components, all of which are ambiguous in nature. The first is an ambiguity between design and scientific experimentation; the second is an ambiguity among the five disciplines, and the third is an ambiguity among three objectives.

It has been our intent to investigate architectural concerns, such as climatic, durability, and health issues within an architectural setting. To date US Forest Service demonstration houses are conventional appearing houses with a few monitors and sensors. We, however, intend to investigate a myriad of biological, architectural, climatic, and structural influences on the design of a house for hot-humid climates. The issue, therefore, is: should we produce a laboratory that looks like a house or are we producing a house that contains a myriad of laboratory experiments. In other words, what is the relative value of architectural design to scientific experimentation?

It was decided early on that the house should respect aspects of conventional architecture and incorporate transformative characteristics. The research and demonstration house must appear to be a house (versus a laboratory), but more significantly allow for typical inhabitation, which suggests a typical program, planning, and presume everyday lifestyles. We recognized that allowing people to live in a house, which is also a research laboratory, would result in a gamut of indoor climatic conditions, rather than precisely controlled ones. It may make the collection of data more difficult; however it may also make the data more applicable. As a result, we intend for the facility to be both a livable house and a research laboratory.

The second ambiguity of our research is the interdisciplinary ethos. It is readily apparent that five disciplines are represented in this research project: architecture, landscape architecture, civil and mechanical engineering, and wood science. Each discipline, or rather member, has his/ its own concerns regarding energy efficiency, durability, or indoor air quality. To diagram the relationship amongst the five disciplines by discipline would grossly misrepresent the actual relationships. To begin, each member has a particular expertise brought to the table; but, that expertise has not been considered more relevant than another's body of knowledge. Secondly, to suggest that correspondence between two disciplines is greater than another two disciplines would also misconstrue the ethos. For example, to suggest that the relationship between inhabitation and wood preservation issues has taken precedent over or is considered more pertinent to the overall objective than the relationship between the regenerative landscape design and indoor air quality is simply not the case.

The question, therefore, arises: how do you represent the interdisciplinary ethos of this research group? First, you must eliminate the titles and traditional boundaries of a discipline. Even though I am called, the "architect," and I am responsible for construction documents, I am the liaison amongst the members regarding the research projects and the house. However, and more critical than the naming of responsibilities, we organized our research according to the three primary objectives and relationships between objectives.

The three objectives are: 1) reducing energy consumption by at least 75% through a variety of means; 2) to insure durability of the building by maintaining a moisture content of at or under 20% (MC20) for all untreated wood and wood products; and, 3) to maintain a healthy indoor air quality by maintaining a relative humidity of 45 – 50%. Individually the objectives are easily achievable and would not be considered innovative. Zero energy homes are readily available in the US. Sufficient building products are already on the market to produce tightly protected structures. Mechanical systems can maintain RH of 45-50% at the flip of a digital switch. However, many vapor barriers used to deal our buildings trap moisture in the walls, which causes the moisture content in the lumber to rise above MC 20, which in turn transforms that lumber into the ideal environment for bacterial growth and food for termites. To depend solely on mechanical units, even though their efficiency has dramatically improved in recent years, does not question the paradigm of complete reliance on technology to provide comfort? In particular, and quite ironic, the ducts of forced-air systems are breeding grounds for bacteria because the relative humidity in them needs to be quite high. Also, the sultry RH of the southern climate does not lend itself to using passive cooling needs for much of the year. As a result, our methodology is comprised of research projects that address at least two objectives simultaneously.

4. PROPOSED RESEARCH PROJECTS

In this final section, three proposed research projects will be introduced that particularly address the relationship between energy efficiency and indoor air quality.

4.1 Evaluation of the Traditional Theory that Taller Ceiling Heights Provide Cooler Spaces

Tradition has manifested a belief that taller ceiling heights produce cooler spaces. This cooling occurs because the warmer air molecules rise to the highest elevations, while cooler air molecules settle. Optimum ceiling heights are not known that insure appropriate stratification of air temperatures for inhabitation. Today, construction and cost factors control ceiling heights rather than air temperature. Also, mechanical air conditioning provides inhabitants with uniform temperatures throughout a residence, which results in uninhabited portions of rooms, eg. above head heights, being over-conditioned, and not allowing natural convection currents to regulate temperatures.

Using the federal guidelines, 78^0 F for cooling and 68^0 F for heating as standards, we will determine the appropriate ceiling heights that insure these temperatures for the inhabitation zone, floor level to six feet above finish floor. Various means of conditioning the air will be employed: passive means only, ceiling fans to stratify, and mechanical means to establish the guideline temperatures and determine the percentage increase in energy consumption, eg. compare an eight foot ceiling height with a twelve foot height and determine which required more energy to maintain the requisite temperature. Because the research and demonstration house contains room whose ceiling heights vary from eight feet to seventeen feet, it is possible to incorporate sensors in every room. Also, the dining room will have an operable ceiling that will be raised and lowered so to measure heights between those other rooms.

4.2 Evaluation of Radiant Heat through Roof Systems

Older homes contain ventilated attics that buffer the heat radiated through roofs. However, it is common for people today to inhabit their attics or construct cathedral ceilings. Both of these design situations require the rafters to contain sufficient insulation to buffer the radiant heat and conversely, do not ventilate heated air. My general question is: Does the traditional design feature of a well insulated and properly ventilated attic the most appropriate means for buffering radiant heat through a roof in a hot-humid climate? The proposed research will involve the evaluation of an alternative design proposal that allows the attic spaces to be inhabited. The north building will contain two roof systems. Above the dining room and hallway will be a conventional attic space: flat ceiling with blown insulation, rafters, sheathed and metal roof. The two bedrooms will contain raised ceilings with insulated 2” x 10” rafters, sheathed with reflective coated and treated OSB, 1” x 2” runners and a metal roof. Sensors will be place midway in the insulation and monitored on a weekly basis.

4.3 Ceiling Plenum

Forced-air ductwork system contains an inherent problem; the increased pressure in the duct increases the relative humidity (RH) of the conditioned air. Also, they tend to be noisy and localize the point of conditioned air. A recent alternative of using sealed crawl spaces as plenum eliminates the issues of noise and localization, but not completely insure against reduction in RH, which in turn increases the potential for bacterial problems. In the south building, a suspended ceiling, approximately one foot deep will be incorporated into the living room and master bedroom. This ceiling will consist of a wooden frame and screen inset panels. These panels will be made of Teflon-coated fabrics, initially supplied by the W. L Gore Corporation Architectural Fabrics Division. The porosity of the fabric will be evaluated with the intent of providing a uniform distribution of quiet, low RH conditioned air through out the rooms.

5. CONCLUSION

How should a designer develop a house that respects the land, its local climate, possibly local construction practices, durability issues as they apply to materials and maintenance, all the while acknowledging that the average home buyer can afford only a relatively small lot, a relatively small house, for Mississippi a monthly utility bill of $168 and who wishes to be like his/her neighbors? This question underpinned the design intentions of a proposed research and demonstration house located on the campus of Mississippi State University.

To define the average, the common ground, the typical in American housing is arguably an impossible task. Geographical distinctions, historical features, cultural differences as well as the more abstract concerns, such as convenience or taste, distinguish particular housing. However, we transgressed these aesthetic and cultural factors by incorporating into the design mix a scientific methodology that potentially could inherently transform the southern house.

Throughout this paper the terms sustainability and green have been conspicuously absent. It has been by intent that they were replaced by more measurable terms: energy efficiency, durability, and indoor air quality. Arguably one of the most used, but least understood terms by architects, engineers, or environmentalists is sustainability. It is an idea that when used as a noun, sustainability, it is not a thing but a goal: a circumstance, standard, or ethos to which we aspire, yet understand that it now is more closely akin to Thomas Moore's *Utopia* than any realistic objective. This idealistic state defies establishing significant boundaries for practical purposes. Our methodology, which is based on ambiguous relationships amongst the disciplines investigating the southern house and which will develop practical definitions for energy efficiency, durability, and indoor air quality for the southern house, will derive a precise understanding of sustainability for the southern house.

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The Wildland-Urban Interface and the Design Professions

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ABSTRACT

This paper defines the wildland-urban interface and identifies opportunities for the design professions in the design, planning, and management of development in the wildland-urban interface. The paper explores the wildland-urban interface and the design professions role through understanding fire's history, a case study of a fire-damaged community, policies, codes, and ordinances, and Firewise.

1. THE WILDLAND-URBAN INTERFACE AND THE DESIGN PROFESSIONS

1.1 Wildland-Urban Interface Defined

The wildland-urban interface is defined as "an area where various structures, most notably private homes, and other human developments meet or are intermingled with forest and other vegetative fuel types" (Kline et al., 2004).

2. PURPOSE

This paper's purpose is to explore the emerging role of the design professions in the Wildland-urban interface. The paper addresses basic knowledge about the Wildland-urban interface and identifies opportunities for design professionals in the design, planning, and management of the Wildland-urban interface.

3. METHODOLOGY

This presentation focuses on the role that the design professions can have on development in the Wildland-urban interface. Specifically, the methodology consists of analyzing, comparing, and synthesizing fire's history, case study evaluations of a fire-damaged community, policies, codes, ordinances, organizations, and proposes potential avenues that the design professions can take to positively influence design and development in the Wildland-urban interface. In order for the design professions to better address planning and development issues in the Wildland-urban interface, fire's history must be understood.

3.1 Fire's History

The heightened risk of fire, predominately wildfire, is a serious concern regarding development in rural areas. Fire's history precedes human history, but the human influence on fire's history is significant. Stephen Pyne states that, "humans have so thoroughly restructured fire on Earth that it is difficult to find truly natural fire regimes" (Pyne, 2001, p. 20). Pyne (2001) also points out that "we are truly a species touched by fire" and that "every place humans visited they touched with fire" (p. 24-25). Our early ancestors utilized and manipulated fire to gain control of their environment and as a result impacted our species evolution. Human's use of fire played an integral role in broadening fire-adapted ecosystems.

With this propensity to burn, a fire regime that met our ancestors' needs was established. This anthropogenic fire regime remained in place in much of the world until the Enlightenment (Pyne, 2001). In the U.S., by the mid-19th century, fire's use to manipulate the land began to decrease as conservation ideals gained favor (Sorvig, 2001). This change in philosophy resulted in the altering of many landscape level fire regimes. In many instances, the fire-prone (starved) landscapes we see today, including the Wildland-urban interface, can be attributed to our removal of anthropogenic fire and the subsequent change in the fire regime (Brose et al., 2001). This change in philosophy is significant ecologically, culturally, economically, and in some cases catastrophically. Based on the wildfire events seen in the last few years, especially those occurring in the Wildland-urban interface, the consequences extend beyond biological and include cultural and economic ramifications.

As development patterns continue to blur the edge between the urban, suburban, and rural landscape, the Wildland-urban interface expands. The expansion of the Wildland-urban interface increases the likelihood of a wildfire event. The increased demand of building and inhabitation in these areas is largely spawned from exurban populations seeking a rural *woodsy* escape (Monroe et al., 2003; Kline et al., 2004). The primary amenity or reward is the *natural* landscape, however, the natural landscape burns, and without human *control*, the landscape is prone to burn *uncontrollably*. In these instances, with reward comes risk.

3.2 **Case Study of Fire Damaged Communities in the Wildland-Urban Interface**

In order to understand how the design professions can contribute to minimizing potential wildfire damage in their projects, it is worth taking a close look at a community that has suffered a substantial loss to wildland fire. The 1991 East Bay Hills Fire in the Oakland-Berkeley area of California captured the attention of a national audience, partially due to the sheer magnitude and tremendous damage to the community. This event also created a much broader national concern for wildfire in the urban interface, and became a pivotal example that led to the heightened federal and state efforts that we see taking place today.

The East Bay Hills region is no stranger to periodic wildfire, in fact it is seemingly built for it due to the state's unique climate, terrain, and natural fuels. Significant wildland fires have occurred in the Oakland-Berkeley area throughout the twentieth century, including the Berkeley fire of 1923, the Fish Canyon fire of 1970, and the Wildcat Canyon fire of 1980. Each of these major fires occurred after a period of extreme drought and during a season of the area's unique gusty winds. Fire marshals recognized as early as the 1920's that building homes with wood shingle roofs and siding, and that maintaining vegetation right next to the homes should not be allowed in this high fire risk area, but the community stubbornly refused to enact these ordinances. Thirty-nine homes that had burned in the 1970 fire were rebuilt in exactly the same location, only to be destroyed again by the 1991 fire. The direct cause of the 1991 East Bay hills fire is still undetermined, but we do know that a dry brush fire that seemed to be easily managed suddenly gained strength in the growing winds, and was soon out of the control of firefighters. Within 15 minutes of the intense flare-up the first residence burned, and within the first hour of the firestorm, 790 homes were consumed. The East Bay hills fire of 1991 was the worst wildfire event in California's history and was the costliest urban fire in the nation at that time. Twenty-five people were killed and another one hundred and fifty injured. Two thousand four hundred and forty nine residences were destroyed, along with four hundred and thirty seven apartments and condominiums. The wildfire was estimated to have cost over $1.5 billion in property damage alone.

A report from the US Fire Administration after the fire revealed that a dangerous situation was created from a prolonged drought, the steep terrain, low humidity levels, and the gusty 'Diablo' winds. The report also pointed out, however, that there were other risks that contributed to the extent of the fire. One factor was the inadequate separation between the woodland vegetation and the residential structures. The state of California suggested as early as 1961, that a minimum of a thirty foot fuel break should be around all structures in high fire risk areas, and that hazardous fuels should be reduced within one hundred feet of structures. The report also mentioned that the use of wood shingles for roofs and structural siding was a major cause of property damage and that the narrow winding roads hampered firefighting and evacuation efforts in the cities and subdivisions. The report specifically mentions that damage could have been reduced through the use of fire-resistant landscaping and construction materials and methods. It was evident that the homes that did escape fire damage had large cleared yards from vegetative and other fuels as a common element. Whether design professionals were involved in any of the residential properties or community planning or not, taking wildland fire seriously in the designs could have saved structures or possibly lives.

3.3 **Policies, Codes, & Ordinances**

Over the past decade, a significant increase in the number of ordinances in cities, subdivisions, and counties concerning wildland-urban interface development has occurred. These ordinances directly impact all development, including the scope of work for architects and landscape architects. Each community has differences in codes and regulations according to fire hazard severity, but zoning laws apply to various aspects of land use. In addition to contacting local or regional planning agencies, a comprehensive national database on wildfire hazard mitigation ordinances can be accessed on the National Wildfire Programs Database. These zoning aspects include, but are not limited to: require covenants on structural components such as roofing materials; implement defensible space standards such as vegetative clearance around structures; incorporate infrastructure such as fire apparatus access and water supplies; develop preventative measures such as greenbelts and fuel breaks; discourage development in areas prone to wildland fires; encourage reduction of fuel loads.

3.4 **NFPA 299 (1144)**

The publication NFPA 299, *Standard for Protection of Life and Property from Wildfire,* has been the standard reference for many state and community fire ordinances. The National Fire Protection Association is a nonprofit organization that has established codes and standards for fire safety. This guide provides the criteria for fire safe development in areas that may be threatened by wildfire including: definitions and addressing the creation of defensible space; providing safe means of access and evacuation; provision of road signage; structure location, design and construction; and community planning.

NFPA also provides the basis for analyzing the severity of wildfire hazard for improved properties, and includes a ranked checklist for measuring wildfire risk based upon a point system. This is the Wildfire Hazard Severity Rating Checklist for Homes and Communities that uses the NFPA as a basis. Basically, the higher the points scored for an area, the higher the degree of fire hazard or damage potential. In 2002, this guide was revised and is now known as NFPA 1144. The revision incorporates the latest research and industry data, and reassesses the attributes of wildland/urban interface subdivisions.

3.5 **The International Urban-Wildland Interface Code ™**

On the regulatory side, the International Code Council, Inc. (ICC) produced the International Urban-Wildland Interface Code™ in 2003. The ICC is a nonprofit organization dedicated to developing national model construction codes. This ready to adopt wildland-urban interface code is written for municipalities and counties to administer and enforce development standards for fire prone areas. The document provides for minimum regulations for land use and development in wildland-urban areas, and covers the administration and authority of government; definitions of terms; permitting; special building construction regulations; and general fire-protection requirements.

The ICC International Urban-Wildland Interface Code calls for the review and approval of all plans within a designated wildland-urban interface area by a code official (typically within the fire department), and includes the fire safety of the properties topography, width of roads, landscape and vegetation details, vegetation management plans, locations of structures, and types of construction materials. Obviously this code has strong impacts for design professionals working in fire risk areas. The code provides strong limitations on the choice of building and plant materials, the preservation and management of native vegetation, driveway widths, utility locations, and planting and management plans. Municipalities and their citizens should look closely at the regulations of these model codes before adoption and determine which are in the best interests of their community.

3.6 **State public resource codes**

The only states that currently have statewide wildland/urban fire regulatory codes are California, Colorado, and Oregon. In 1997, Oregon adopted a state law to reduce losses to wildland fire. The Forestland-Urban Interface Fire Protection Act sets out minimum standards for fuel hazard reduction in wildland-urban interface areas. In 1996, Colorado adopted a state law to require counties within the state to adopt a master plan for the physical development of the municipality. This statute gives the authority to the Colorado State Forest Service to determine the areas of wildfire hazards. Within these designated areas, special requirements for wildfire risk mitigation may be subject to approval for certain land uses.

Of all the states, California has enacted the most comprehensive regulatory wildland fire protection standards for lands within State Responsibility Areas. The state regulations address work within the scope of landscape architects services that include emergency access standards for roads, signage and building numbering, and fuel modification standards. Since 1992, all new parcels, construction, land development, and new road construction must have building permits reviewed by the local California Department of Forestry and Fire Protection.

3.7 **Community wildland-urban zoning codes**

States with local zoning and subdivision regulations regarding wildland-urban planning include Florida, Montana, Washington, Utah, Arizona, New Mexico and Idaho. In certain communities, development plans for subdivisions are regulated, subject to review, and given approval by the local fire departments. While the state of Florida does not have a statewide urban-wildland public law, a model ordinance for local communities has been developed through the Florida Department of Community Affairs. The guide, *Wildfire Mitigation in Florida* is a comprehensive document for regional communities on land use planning strategies and best development practices in wildland-urban zones. Similar to Colorado, counties and municipalities are required through a Florida Statute to produce a *Local Government Comprehensive Plan* to guide their future development and growth. Local jurisdictions can adopt local policies, such as wildland-urban regulations with oversight from the FDCA, as part of their comprehensive plan. A major difference between this ordinance model and others, such as the International Urban-Wildland Interface Code™, is that the regulation language is not intended to be incorporated verbatim, but instead offers informed choices from which communities can then decide. This document is a highly educational reference for communities to learn about wildland-urban issues. This document includes background information on Florida fire ecosystems, examples of neighborhood design for reducing wildfire risk, Firewise construction principles, general cost ranges for individual residence modifications, landscaping examples for wildfire mitigation, and maintenance and management.

3.8 **The National Fire Plan and Firewise**

As a result of the devastating fire year of 2000, the National Fire Plan was borne in Congress through a fiscal year 2001 Appropriations Act. The Act mandated that State and Federal agencies address the wildland fire problem through hazardous fuels reduction and habitat restoration. A National ten-year Comprehensive Strategy was drafted with all 50 states as partners in the planning, decision-making and implementation of the plan (DOI, USDA, 2001). As a result of the National Fire Plan, the National Wildfire Coordinating Group was formed from multiple agencies including the USDA Forest Service, the Department of the Interior, the National Association of State Foresters, the U.S. Fire Administration and the National Fire Protection Association.

This interagency group prioritized public education and wildfire awareness with Firewise, a program that offers public workshops, instructional media, and accessible resources for landowners and communities in order to minimize fire risks on private and public lands. The Firewise Communities/USA recognition program allows members of small population areas to assess the fire risks in their communities to create a plan for hazard reduction, and to implement solutions with state and federal assistance (National Wildland/Urban Interface Program, 2004).

4. CONCLUSION

The design professions must accept fire as a natural process that must be understood. Homeowners, architects, landscape architects, and others continue to perpetuate visions of living within idyllic woodland settings when it is actually a fire ecosystem. We have a responsibility to understand and mitigate wildfire concerns when working in the wildland-urban interface. There are many issues propelling development in wildland-urban interface areas, such as: increasing population, changing demographics, economic development, changing land use, and land related policies (USDA, 2004). Likewise, the aftereffects of these issues will significantly alter and influence our economy, environment, and society for better or worse.

In order for the design professions to successfully engage the issues and ramifications of wildland-urban interface development, we must recognize, accept, and address these issues at multiple scales including: regional-land planning scale, state, city, and county planning and policies, community scale, and the site scale. The design professions must contribute in this endeavor through research, practice, public education, and governmental involvement. Fire officials and foresters are in the forefront because they understand fire dynamics and its impact on safety, so must we. This presents an opportunity for professionals working in high risk areas of the wildland-urban interface to establish, understand, and incorporate the necessary planning elements and management strategies to minimize structural damage and potential loss of life.

Developing in the wildland-urban interface must address a broad range of factors that extend beyond a single discipline's expertise. Therefore, in order to successfully integrate development into wildland-urban interface areas, a multi-disciplinary approach is essential. The design professions routinely collaborate with one another, however, the issues posed by the wildland-urban interface requires the design professions to broaden their collaborations to include: ecologists, biologists, federal agencies, state and local governments, foresters, fire departments, insurance companies, developers, stakeholders, and the public.

Wildland-urban interface development poses significant challenges. The design professions can contribute in the building of these areas to ensure the health, safety, welfare, and sustainability of the land and its inhabitants. Whether it is developing alternative strategies for areas of high risk at a regional scale or designing defensible space at the site scale, the design professions must recognize and address the challenges presented in the wildland-urban interface.

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Re-envisioning Neonatal Intensive Care through an Interdisciplinary Pedagogical Studio

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ABSTRACT

At Rensselaer, an interdisciplinary research team and collaborative studio course with architects and biomedical engineers have coalesced to re-envision the Neonatal Intensive Care Unit (NICU) in order to improve health outcomes of infants. Rensselaer's development of cross disciplinary programs such as its NSF funded: Product Design and Innovation (PDI) – linking Architecture, Engineering and Social Sciences; and Design as a Creative Model for Technical Inquiry – national interdisciplinary workshop dissemination, responds to the mounting concern for the future of professional education. Traditional practices have intensified disciplinary insularity through barriers of language, values, prestige, and proprietary interest. As an alternative to normative practice, we look at the potential for complex problem solving through team based interdisciplinary design, specifically in reconceptualizing neonatal intensive care.

1. BACKGROUND

At a seminar on interdisciplinary design at University of North Carolina (UNC) – Greensboro in 2002, Anna Marshal Baker talked about her research on incubator performance challenging its current boxy tray-like enclosure. As she notes: "existing incubators evolved as medical equipment with a singular purpose of providing a controlled, secure environment for preterm infants; yet infant incubators are living spaces that must accommodate and adapt to the ever-changing needs of the infant occupants and their caregivers. A well designed incubator will address adequately concerns related to infant development as well as basic functional issues related to caregiving, access, and physical dis-/comfort of attending family and staff.[14]"

At Rensselaer we began discussing the issue with biomedical and mechanical engineers, anthropologists, artists, and architects, analyzing the current and historical state of the incubator and its environment as a benchmark for start-of-life care and brainstorming the issue of experientially based care. Our project's objective, to utilize interdisciplinary methodology to solve complex problems was exemplified through the design of better products/environments for the NICU. The process intent was addressing the role of an interdisciplinary pedagogy, how teams form and thrive, how a specific research problem can deeply inform learning models, and what social structures are necessary for cross disciplinary initiatives. The product intent was to help neonates grow into healthy babies, ameliorate stress for parents, and enable the work of medical staff. This paper marks the initial stages of our cross-disciplinary investigations and our ultimate goals of using this experiment as a model for interdisciplinary pedagogy, research, design and assessment.

2. THE NICU

The NICU has evolved from being relatively low-tech and low-impact into a highly charged, sensory-overloaded condition. Undersized infants lay intubated in incubators surrounded by bulky equipment. Nurses and doctors observe, monitor and care for the infants, while parents stand by. Light and noise are

[14] Baker, Anna Marshall (2001) "DESIGN OF AN INFANT BED FOR HOSPITALIZED PRETERM INFANTS"

incessant. The environment is at-once life sustaining, yet antagonistic to the normal physiological of the infant and psychological development of both the infant and family. Such negative impacts are documented[15] and normative design works reactively to mitigate them. Unfortunately the design of NICUs does not yet positively focus on issues that benefit neonatal outcomes and promote infant development.

The challenges of NICU design go beyond biological to issues of functionality and logistics, requiring a complex set of interdisciplinary inputs. Aside from the matter of infant development amidst critical care, NICU design poses challenges to staff in that care delivery, and to parents who wish to understand the medical predicament, bond with their infant, and aid in the infant's development. The NICU, an appendage of complex medical facilities, has been at the mercy of half century old institutionalized design practices.

Even with the research that has been done on the developmental effects of the NICU environment, NICU design has been slow to change. The older NICU guidelines were developed by engineers working for large corporations, and were based on adult ICU guidelines[16]. The 80s focused on advanced equipment leading to insufficient attention to the environmental needs of all involved; the 90s switched to developmentally appropriate care, leading to dimly lit NICUs possibly compromising benefits of having the latest technology; now hospitals combine both, making varying commitments to the assembly[17].

More importantly, the trend seems to represent the compromise of research done about NICUs, both from social science and medical perspectives. The NICU is more than a sterile environment designed to keep a neonate alive; everything about it will eventually affect the babies' development. For example, prior to 32 weeks of gestation, neonates require perpetual dim lights. Later, they need a lighting cycle to feed their diurnal rhythm[18]. Few units address this. Even with guidelines rapidly being updated[19], many NICUs follow older codes, as there is a lack of funding, organizational restructuring, and staff training to restructure.

Babies need to be touched; this is no different in a NICU[20]. However, normative NICU environments do not actively support this. Parents must come to terms with the fact that what they anticipated is not the outcome, and must also realize that they still have a child requiring love and attention[21]. Alienation between the parents and the babies unintentionally furthered by interactions with staff (i.e., comments like "It looks rough, there's no way of knowing if your baby will make it") make it less likely for the parents to come to the NICU to touch their babies. This presents a problem in the home environment, too, when the baby is finally discharged. The parents are unable/unwilling to take care of their children, in part because they still see conflicting images of what they assumed their baby was going to be and what their baby looks like in the incubator. So, the children never get the opportunity to enjoy "normalcy", even if it is medically possible[22].

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[15] There is much documentation on this matter. One example : Hancock, E. (Summer 1976). "Crisis Intervention in a Newborn Nursery Intensive Care Unit." Social Work in Healthcare 1(4).
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White, R. (2002). Recommended Standards for Newborn ICU Design. http://www.nd.edu/~kkolberg/DesignStandards.htm These guidelines were created in 1992, based on previously existing guidelines, are updated periodically after major conferences (1993, 1996, 1999 and January 2002)
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[21] Hancock, E. (Summer 1976). "Crisis Intervention in a Newborn Nursery Intensive Care Unit." Social Work in Healthcare 1(4).
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3. THE DESIGN PROBLEM

Neonatal intensive care provides an excellent context to study the effective development of an interdisciplinary team approach to problem-centered research. At Rensselaer's School of Architecture we try to design with the following model: "The designer (most often, without the sponsor) identifies how to "devise courses of action aimed at changing existing situations…," in effect, deciding what concrete actions will produce the preferred situation… Methods are not neutral, and while one's values may bias one to employ certain methods and not others, conversely, the availability of a predetermined set of tools to work with, or the belief that there is only one tool that one needs to work with, leads to specific and differing 'courses of action aimed at changing existing conditions…' As the psychologist Abraham Maslow quipped: 'If the only tool you have is a hammer, you tend to see every problem, as a nail.'"[23] We, as in many schools of architecture, rarely interview the eventual inhabitants, nor do we engage the experts in the field. So we perpetuate the insularity of our design decisions – which ultimately have aesthetic pre-occupations.

For this project, it has been essential to introduce all participants to as many points of view about neonatal care as possible. The current NICU situation resulted from a segmented, rather than a systems, approach to design and begs for the collaboration of architects, engineers, physicians, social scientists, parents, community, and staff, with the goal of rethinking the overall environmental conditions that currently surround the infants, staff, and family. Beyond positioning us to contribute to the discourse, we hope to present a viable model for cross disciplinary work while also challenging normative architectural studies.

4. THE START OF THE PROJECT

Rensselaer School of Architecture convened students in Product Design and Innovation first semester, first year, Design 1 class, a cross-disciplinary course with Architecture, Science and Technology Studies, and Engineering to examine a problem that opens up multiple issues and perspectives of design.

To begin, we held a seminar with all faculty involved, students and most of our consultants, establishing what the various issues of design would be. The Chair of Biomedical Engineering, with expertise in design and cellular cleaving, questioned the differences between static and dynamic situations of NICU conditions including those changes the infant experiences moving from inside to outside the womb, all moments of transition such as the overall psychological developments of a neonatal child, the engagement of the parents in decision making and care giving, positive as well as negative stresses on the child, and the causes of prematurity. Then, architect Ted Krueger presented "Redefining Human" offering alternatives to what constitutes human and how technology extends the definition of what a human is.

Our Lighting Research Center and Workplace Design faculty stressed that buildings are already implicated in health risks of many kinds. Preventive care, where the effects of the indoor environment on occupants is exacerbated, is even more obvious in the condition of the incubator and its extended housing – the NICU.[24]

For first hand experience, students toured the Albany Medical Center NICU, where the clear focus is the infant incubator - as Baker notes – "a piece of medical equipment that has remained relatively unchanged since the 1940s." The incubators have a large range of sophisticated diagnostic and monitoring equipment

[23] Warriner, Ken, Design 1 Syllabus at Rensselaer Polytechnic Institute, 2003 (quoting Herbert Simon)
[24] Wyon, David P., Solicited Review of PhD for Rensselaer Polytechnic Institute School of Architecture, ICIEE, Copenhagen, 2003

and the incubator is the infant's living space for an indeterminate amount of time. Based on observation, research and medical staff interviews, the class concurred with Baker, "that the incubator precludes efficient delivery of care and prevents forms of care-giving that best promote infants' behavioral development.[25]" The resident doctor shared what he saw as the strengths and weakness of the organization, namely issues of access, noise, light, and parental alienation. The head nurse's requests for the NICU concentrated on the quality of the working environment, including more desk space for report writing.

After this visit, Dr. Linda Layne, a cultural anthropologist, shared her own personal story of having a baby (ultimately diagnosed with Cerebral Palsy) in the NICU with the challenges and frustrations that she experienced. Layne spoke of her struggles to answer the question that was frequently asked by those around her, "How's the baby doing?" and challenged American narratives of linear progress which works with technology, but not necessarily with the development of sick neonatal infants[26]. Trying to force an actual situation which is very nonlinear into the assumed linear progression of things gave Layne a feeling of inadequacy, as though there were something wrong with her or with her child. During her experience she came across three different non-linear narrative models: the rollercoaster, the graduation and the course, which fit much better with her experience in the (NICU)[27]. The talk provided a context in which to understand some of the complexities from a parental viewpoint. Neonates can be improving in one area of development, and yet be struggling in others. Frequent backsliding and unforeseen obstacles are par for the course, and if seen as a conceptual programming framework, could improve organizational strategies.

After 2 weeks of research, including looking at normative development of infants and designing alternative models for enhancing current care, they were asked to investigate the incubator as an extension of the infant, of the parent, of the medical staff and of the space of the NICU with the goal of achieving a preferred condition through the means of technology, social interactions, and through a combination of both social interactions and technology. Embedded into these investigations were issues of medical access, parental involvement, sensory conditions and awareness, ease of continuing care, organizational models and the idea of extensions to the body or the space.

The assignment and research posited that the conditions of the NICU: are not optimal; compromise diagnostic and therapeutic capabilities; and frequently result in infant physiological and psychological developmental deficiencies. With the recent advent of the new HIPAA (Health Information Privacy Act) regulations, special attention was focused on exploring the concerns of privacy, security, and ethics, and the implications of each for design solutions and infant, medical staff, and family outcomes. Aside from the matter of infant development amidst critical care, it became evident that NICU design poses great challenges to nurses and doctors in delivery of that care, and to parents who wish to understand the medical predicament, bond with their infant, and aid in the infant's recuperation.

The aim became to design a flexible NICU environment that is simultaneously a family centered clinical care facility for the infant, a research and data based laboratory, and an agile educational facility. Moreover, it had to be able to accommodate the health, research, and learning needs off site and to have an integration of clear models of communication to staff, families, and researchers. The NICU environment itself needs to be self-learning, self-regenerating and have the ability to perform locally and globally, through the use of clear models of communications and seamless connections between the caregivers, infants, the space, and the technology used.

[25] Baker, Anna Marshall (2001) "DESIGN OF AN INFANT BED FOR HOSPITALIZED PRETERM INFANTS"
[26] Layne, Linda L. (1996) "'How's the Baby Doing?' Struggling with Narratives of Progress in a Neonatal Intensive Care Unit" Medical Antropology Quarterly 10(4): 629
[27] Layne, Linda L. (1996) "'How's the Baby Doing?' Struggling with Narratives of Progress in a Neonatal Intensive Care Unit" Medical Antropology Quarterly 10(4): 632-639

Here the NICU of the future is seen as an organization and a strategy for the evolutionary transformation of the resource, both physical and organizational. The need for a multi-disciplinary team becomes imperative to study ways to develop ongoing as opposed to discontinuous renewal of the unit.

5. RESULTS OF THE SUMMER STUDIO

Preliminary research led students to posit designs countering the hurdles presented by the current set-up of the NICU including: rethinking the overall layout of the space; developing hand-held intubation ports to allow for higher parental interaction; creating vital monitors in the form of wristbands worn by parents on and off-site; redistribution of space for extended families and consultation; and incubators modified to the body proportions and movement of infants. Later discussions with post-doctoral students and medical faculty at Harvard's School of Public Policy stimulated investigations into administrative culture, quality control and improvement, relationships, and interdependence of technical and organizational change.

Fig. 1: Light Changer

Fig. 2: Port Connector

Fig. 3: NICU Redesign

These initial proposals proved that an intensive interdisciplinary research-centered investigation of design issues in the NICU could yield innovative products, approaches, and designs. A permanent team of two architects and a mechanical engineer with leadership experience in interdisciplinary projects, a biomedical engineer and entrepreneur, a medical anthropologist, and a pediatric neurologist has been formed - working together to codify the sensory integration and unitary processing of the NICU neonate in the areas of vision, tactile sensation, sound, and olfaction and create a working set of principles blueprint for the design of products (neonatal clothing, headgear, haptic interfaces, filters etc), as well as environments and organizational systems. This interdisciplinary approach will integrate a broad range of coexisting forces in the NICU: biological/medical; behavioral/sociological; technological/ethical; and political/economical.

6. FURTHER INVESTIGATIONS

Following on the success of the first year design course, we started a hybrid Biomedical Capstone design and Architecture design course with a three-pronged approach for research into current social, technical, and environmental conditions. Students collaborate to devise new design solutions while building interdisciplinary teams. These design solutions optimize existing neonatal intensive care technologies and environmental set-ups, while examining whether to re-purpose them from and for other contexts.

The focus of this class shifted from the NICU to neonatal intensive care in the context of technologically underdeveloped countries burdened by overcrowding, uncertain sources of electrical power, limited availability of clean water, non-sterile conditions and lack of technically trained professionals. The class decided to focus its energy on the most acute problem[28] in order to have the greatest impact on the overall health of premature babies. Examining neonatal care, for 32+ week gestation, through the lens of a developing country, encouraged us to reevaluate the singular technologically centered approach of our health care system towards a more family centered one with a goal of increasing the overall level of care.

For these conditions, ventilation of the neonate is one of the main obstacles inhibiting both transportation of and parental interactions with the infant. The students concentrated on integrating a new method of ventilation with a carrying device using kangaroo care. Kangaroo care provides heat by placing the neonate in skin to skin contact with the caregiver's own body, instead of relying on expensive equipment to provide a stable heat source. The carrying device can act as a filter for unwanted light and sound, protect the neonate from temperature swings, adapt to the changing needs of the growing neonate and provide portable ventilation allowing the neonate to be brought home earlier. Other designs include an electricity producing stroller that can also power an integrated ventilation system; a self-sufficient low-cost low tech, family centered comprehensive system of care for neonates and prenatal care with capabilities to provide clean drinking water to reduce the number of premature births by maintaining the health of the mother.

The biomedical engineers have focused on integrated CPAP (Constant Positive Airway Pressure) designs that work in this context. Premature and underdeveloped lungs are in danger of collapse; CPAP augments a neonate's breathing by providing a pressurized source of enriched oxygen that increases the neonate's absorption of oxygen and keeps the alveoli in the lungs from deflating. One of the designs incorporates a humidifier, thermal regulator, and mixing chamber into a single unit, thereby simplifying use. As the air moves into the mixer it is heated and humidified, a heating element in the pipe itself keeps the air mixture at the correct temperature as is dispensed to the neonate. The heating elements of the unit serve the dual purpose of preheating the air to reduce stress on the neonate's lungs, as well as producing steam to sterilize the machine after each use allowing all of the pieces to be reused, which will save on operating costs. In one design, because the unit is connected to the mother's body, a venturi was used as the mixing chamber to reduce the number of moving parts, and decrease the size and weight of the unit[29].

7. INTERDISCIPLINARY ISSUES

The project is very exciting with huge potential, but highlights the difficulties having to do with negotiating differential curricular schedules, discipline values, etc. Geisler notes, "Communication between disciplines is kept to a minimum due to barriers of language, values, prestige, and proprietary interest (as each discipline seeks to protect its information in order to remain indispensable.)"[30] In group meetings it was quickly agreed that prenatal care in developing countries should be the focus. Subsequently there has been conflict as the engineers are being led by their professor to generalize, ignoring site specific cultural and environmental issues. The architects see specific context as key to understanding the design and the criteria upon which the project will ultimately succeed.

Beyond the difficulties that Geisler identifies are the structural barriers to interdisciplinary design. Although this course was 8 months in planning, the difference in operation between the disciplines and the needs of interdisciplinarity were not clear to the chair of the Biomedical Engineering department. She didn't realize that the classes have to meet together to clarify disciplinary responsibility nor that the large differences in expectations between the two disciplines ultimately can cause the demise of the project. The engineers have a very structured course that is designed to move rapidly towards resolution and finished products. The architects have a very open-ended course that meets separately from the engineering course, and is

[28] Neonatal deaths in developing countries account for 99% of all neonatal deaths a year: http://www.commondreams.org/headlines05/0303-05.htm

[29] SLIC Solutions: Jenny B. Chang, Mariah Hughlock, Conchita Mirasol, Vianny Lembert Santana, Jamie Scurrah, Jenn Zuba (March 10, 2005) "Neonatal Ventilator for Developing Countries: Progress Report #2"

[30] Geisler, C. (2002) 'Multidisciplinary: The Renewal of the University and its Curriculum,' *NEH Seminar*, Boulder.

being assessed by different professors. These split administrative entities create barriers to collaboration between the engineers and architects who are responding to very different expectations, both cultural and specific to the course. The students have figured this out, and are meeting independently as a collective group, separate from scheduled times with faculty. There is a definite learning curve to interdisciplinary interactions. As the class proceeds, trust and mutual valuing is growing. We don't believe that the shift from our original conception of redesigning the NICU and its technological and social context to the rethinking an adjustable ventilation device with skin-to-skin care for developing or rural environments could have emerged in a single discipline's answer to the problem.

Despite the many challenges and obstacles it is clear that interdisciplinary design is necessary for real change to occur in the dynamic world we inhabit. The problems that we are facing in the twenty first century are too complicated for a single discipline to have all of the answers. For years we have had specialists working in isolation from each other on problems with very limited scopes. Neonatal intensive care is a perfect example of thinking in terms of systems and interactions on multiple levels with advanced technology that inhibits parent child interactions, and infant development. Having students face some of the obstacles while still in school allows for an opportunity to experiment in an environment where failure has less catastrophic consequences, enabling them to take risks and develop a new way of working.

Fig. 4: Kangaroo Care

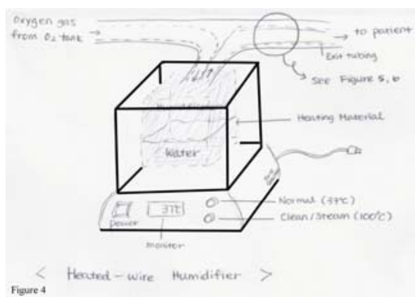

Fig. 5: Ventilation Integration with Kangaroo Care

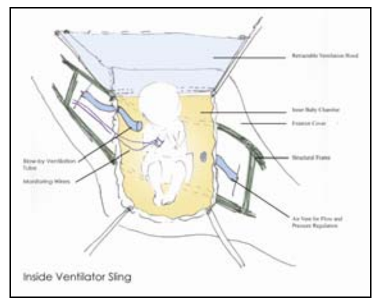

Fig. 6: Mixer Diagram 1

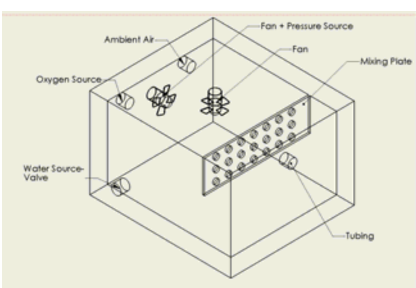

Fig. 7: Mixer Diagram 2

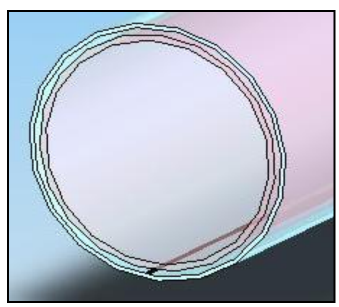

Fig. 8: Venturi Mixer

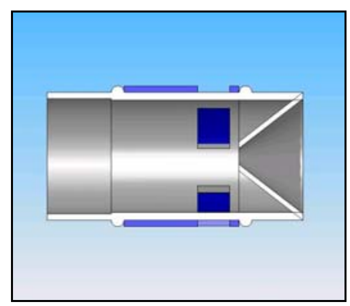

Fig. 9: Integrated Heating Wire

The Use of Interactive Dynamic Simulations for the Purpose of Architectural Representation

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ABSTRACT

Architects have always grappled with graphic representation as a medium to capture the corporeal experience of being in a space. It is difficult to present this nature of a design through the written or verbal language and almost impossible through representation (even digital) techniques. Perhaps it would be impossible for any medium of representation to truly capture the "placeness" of a place. Thus, new representation techniques should only try to get closer to the actual experience than actually hope to replicate it. This paper describes how the use of dynamic simulation and interactive presentation tools present architects with a more accurate and experiential representation of their design; perhaps moving them one step closer to achieving "placeness".

1. INTRODUCTION

The essence of architecture still remains in the ideation of "human" creative endeavors and ephemeral glimpses or visions of owner(s), designer architects and builders. These exploratory dreams and visions exist beyond formulas and rational machine models (Barrow, 2000). In response, most digital media tools used by architects today are only computational equivalents of traditional drafting and presentation tools. For example, AutoCAD simulates the drafting board, 3D Studio replaces the watercolor rendering. McCann even argues that the digital tool itself is inadequate in capturing the true depth of perceived space - *Computer modeling introduces the capability of viewing emerging designs perspectivally, but with its virtually limitless depth it aggravates the tendency for the designer's mind to "go out to wander" no further than the confines of the screen and the illusive depth portrayed there* (McCann, 2004). Although it would be presumptuous to assume that digital media (for that matter, any form of representation) will be able to replicate actual corporeal experiences; this paper argues that the use of dynamic simulations for architectural representation can bring architects one step closer to the experience.

Dynamic simulations help the designer to model digital objects with physical qualities in digital space. So, curtains can be made of a specific fabric and hence respond to wind, furniture can have material qualities – mass and inertia, thus be affected by gravity and force. Couple this physicality of the digital space with interactivity and the architect can present the "experience" of his/her space – because instead of just *moving* through a digital model, the user can *interact* with the simulated space. Through the course of this discussion we will describe what dynamic simulation is, how it is different from traditional animations, analyze various digital tools and experiments to develop dynamic representations, and finally evaluate these tools in comparison to static images or key framed animations.

2. EXPERIENCING PLACE

When we leave a place, we remember not the place itself, but our experience of it. Echoes, smells, sudden changes in temperature when we pass from light to shadow, heat radiating from a sunlit wall, enframed or hidden views, a feeling of mystery, all contribute to our experience of architecture, and they all stem from the depths of our embodiment…lack of embodiment only produces concretized ideas and geometric constructs (McCann, 2004). Johnson however argues that not all experiences are corporeal; in his paper he mentions that we often have "virtual" experiences - *…dreams, imagination, fantasies, day-dreams, and hallucinations are all part of human existence. We remember dreams as vividly as we remember real experiences.* (Johnson, 2002). Johnson further mentions that there may even be physical virtual spaces, stemming from our imaginations and our fantasies; for example, a child's play structure may become a pirate ship; an elaborate theater set may become 18th century England. What they share is a conscious and constructed reference to some other place, taking advantage of the link between memories and experience.

As virtual representation techniques become pervasive in the profession of architecture it is important to understand that digital reality is only "abstraction" of reality. Users do not actually interact with a digital object; instead what they have really learnt is to negotiate digital space to behave in a manner that they want by mastering the use of input devices. Bui et al. describe the point of "negotiated reality", an event where the users decide to agree upon what is real and what is not. In this process, reality becomes simply more and more artificial while the virtuality becomes more and more real (Bui et al., 2005).

The experience of a real space also stems from our activities within and the resulting (predictable or unpredictable) reactions of that space. The sound of the floor creaking when we walk across it, the movement of a curtain when we brush against it, the interrupted flow of water when we extend to touch it; these everyday actions create the necessary complexity and unpredictability in our spaces that is difficult to represent through images and drawings. *Causality* is perhaps the most important criteria for perception of what is real and what is not. To the computer a curtain is no different from a table cloth on a table; it only sees data structures aligned differently. In reality though, the curtain is made of a lighter fabric than the table cloth, the curtain is hinged at one end while the table cloth is constrained only by the shape and size of the table, brushing against the curtain would cause a different set of reactions than brushing against the table cloth. Hence to attain "objecthood", objects must have peculiar intrinsic qualities because of which interaction within the space would induce a set of causal reactions unique to that object.

In the digital world because there are no intrinsic physical constraints, causation is simulated (Kirsh, 2001)

3. DYNAMIC SIMULATIONS

3.1 What is a Dynamic Simulation?

Physical objects obey Newton's three laws. They have mass and hence inertia, so it takes force to move them and force to stop them. They have resistive capacity so any force applied to them encounters an equal and opposite force. None of these attributes are true of digital objects. Digital objects are computationally generated elements that can be displayed in wall projections, on screens, or be used in computer programs. They exercise no resistance; they have no mass, inertia, no intrinsic color, shape, size, or solidity. (Kirsh, 2001). In early digital representations, the work concentrated on computer graphics; it was highly demanding to generate a scene because of processing capability and memory usage. "Modeling" an environment was usually taken to mean describing the appearance of an object: geometry, texture, lighting and so on. Attributing object behaviors was not a consideration made for architectural representation. In general, the person exploring the environment could do nothing unless the person constructing the environment anticipated it (Willis, 2004).

As computers became more powerful and intelligent, it became possible to render large behavioral models. The gaming industry responded first with the creation of algorithms that replicated real world physics through collision detection, fluid simulation, and rigid/soft body dynamics. These gaming engines (like the Unreal Tournament engine) are used today to create interactive games that afford users multiple levels of interactions with the environment they are in: object manipulation (that which can be grabbed, moved, so as to initiate physical processes); and triggers (that which can start a certain process with the environment's objects) (Cavazza et al., 2004).

Dynamic simulations allow the designer to infuse digital objects with specific intrinsic properties and physical constraints within a digital space. Digital objects are no longer intangible data structures created by a computer to enhance a space; they become objects designed to react to physical forces (like gravity, wind, human interaction). By not keying qualities of the object itself, the designer now affords the space an order of unpredictability – abstracting the experience of being in a real space. Mediated interaction with an object or a certain family of objects can initiate other objects to react in often unpredictable manners. Thus, digital representation evolves from a "beautiful picture" to a true abstraction of reality and causality.

3.2 Animation vs. Simulation

Architects have traditionally used animations and walkthroughs to present their designs. *Walk through simulations allow the designer to move perspectivally through a sequence of spaces in an emerging design…movement is part of the experience, causing elements to realign and alter visually in relation to other elements* (McCann, 2004). Traditional animation techniques use a method called "key framing" or "tweening" to animate objects in digital space. "Tweening" comes from the word *in-between*; referring to in-between artists who would take two of the animator's "key" frames and draw the frames in between.

Today the computer replaces the in-between artist through the process of tweening. When a designer wants to animate a ball moving down an incline, he/she first sets the ball on the inclined plane; defines the first "key" frame and the last "key" frame, showing the initial and final position of the ball. The computer then uses its resident animation algorithm to generate the in-between frames and "animate" the ball rolling down the incline (see fig. 1).

The problem with key frame animation is that the computer only does what the animator asks the computer to do. The animation will run predictably and unchanged every time you run it. The animator has to carefully align the ball to the incline and make sure that the computer does not tween the ball *through* the incline at any point in the animation. In short, neither the ball nor the incline holds any native intelligence; and to the computer they are both data structures with no individual character except shape, size and position.

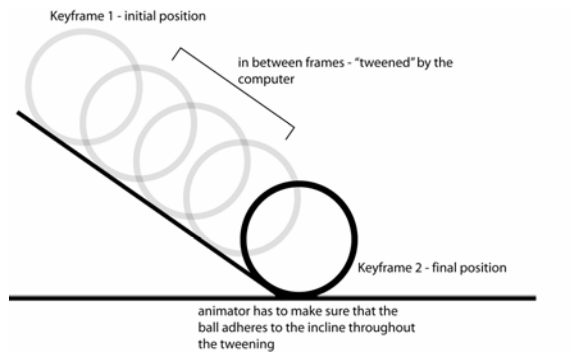

Fig. 1 Key framing the animation

Dynamic simulations on the other hand create objects with individual properties of material and mass. Objects are defined are hard bodies, soft bodies or constraints; each with different properties and reactive qualities. The objects themselves react to forces like gravity and wind and as simulations become more intricate, objects may take on additional properties like friction, air resistance, and bounciness. Dynamic objects can build into themselves inertia and momentum based on the configuration of external forces. Hence, dynamic objects hold within themselves a defined complexity of intelligence and character which is absent in other digital objects.

In order to simulate the same ball moving down an incline, the animator defines the ball and the incline as two separate hard bodies with collisions between them. The animator then defines object properties like mass, friction, air resistance; and finally the force of gravity acting downwards (in digital space, there is no up or down, no top or bottom; you can define forces to act in any manner that you choose). On simulating the scene, the computer's native simulation algorithm makes the ball react to gravity and looks for collision with the incline. Since gravity acts downwards and the ball has a certain mass, the ball will start rolling down, colliding with the incline as it does so (as in real life). Depending on the friction and air resistance, the ball also picks up or loses momentum as it rolls down (see fig. 2).

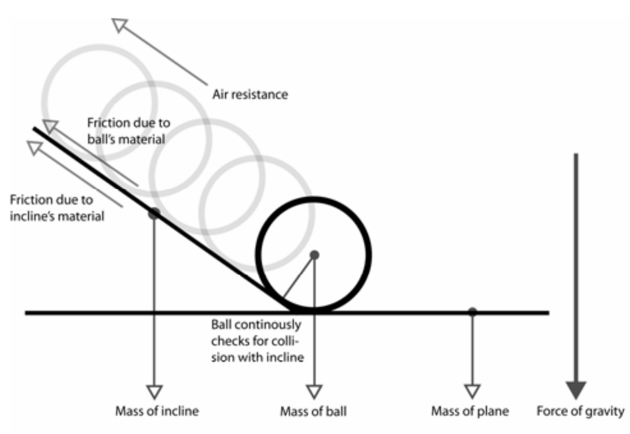

Fig. 2 Simulation using dynamic objects

Once the native character of the objects and those of the forces have been defined, the computer will essentially simulate the scene without the supervision of the animator and the simulation will almost always give different results depending on the alignment of forces in the space.

4. RESEARCH METHODOLOGY

The Design Research & Informatics Laboratory (DRIL) is a multi-platform platform for carrying out interdisciplinary research projects; the exploratory nature of the DRIL enables faculty and students to carry out multiple levels of design research, including research into the use of digital media at various levels of architectural design and education. Recent research is being conducted primarily with post-professional graduate students enrolled in the Masters of Science in Architecture program at Mississippi State University's College of Architecture. Graduate students have a foundational 'design process' education, enabling them to more easily learn how to integrate various levels of digital media into their traditional hard copy design processes. For this project, the students were introduced to different tools for dynamic simulations and encouraged to use interactive simulation methods to represent their designs. The use of these techniques and tools employed by the students were analyzed as a part of the continuous evaluation of digital media in the graduate design studio. Surprisingly, even though we have students from many different disciplines; we have found that only students with a background in architecture or engineering prefer to use dynamic simulations for representation. Other students seem to understand the potential of the technology but are often hindered by their lack of knowledge in physics and structures.

The students work mainly with two softwares: Discreet's 3D Studio Max and Alias's Maya Complete. Although Maya has a more flexible dynamics engine, the students find 3D Studio Max's interface more learnable. The HAVOC engine on 3D Studio Max also supports interactive presentations and is easier to use in an architectural environment because of support from Autodesk's AutoCAD and Revit. Both softwares are capable of rendering movies in extremely high photo-realistic outputs; but we find that 3D studio Max with its Radiosity/Brazil/Mental Ray engine has more output options than Maya with its Mental Ray engine.

5. USING SIMULATIONS FOR ARCHITECTURAL REPRESENTATION

With the help of our students, we analyzed different methods of using dynamic simulations to represent architectural space and/or phenomena associated with space. The challenge was to take a technology that has been used for quite a while in other industries and adapt it for architecture and design. For this paper, we shall briefly elaborate on two of the methods students used: the first one is a "baking" method for animation; and the second one is an "in-software" method that creates interactive presentations

"Baking" animations:

The set up of this scene is similar to other dynamic simulation setups; each object is given peculiar physical qualities and forces are set up in the scene as per the requirement. The simulation is run and if the designer is satisfied, that simulation is "baked". During the process of baking, the computer creates key frames and frames for the scene like a traditional "tween" animation but this time using information from the simulation. The designer may choose to change the set up of the space multiple times until everything works best within the described constraints. The final animation can be rendered at whatever quality the designer requires. This method is most effective because the output is in the form of a movie (Windows Media or QuickTime) and software independent, thus universally viewable on most computers.

“Interactive” simulations:

Although there are a few extra conditions to consider (real-time mediation, object manipulation and triggers) when setting up the scene, the basic premise still remains the same – each object has its own properties and reacts to forces in the scene. The difference in this method is that the output is left open for user interaction. The user not only moves through a space but also interacts with systems and objects in that space. Each object, based on its native property reacts differently to different mediated inputs. Although current representations are very controlled, we are in the process of developing complex dynamic simulations for interactive architectural presentations. One drawback of this method is that the output is software dependant and hence cannot be viewed universally. Since the power of this method is in the interactivity, we are currently working with software manufacturers to look at the possibility of making the interactive window software independent.

Although both methods are equally plausible techniques for representing architectural space, we feel that only interactive simulations, because of its experiential nature, can truly represent “placeness” of a design.

In the end, it is important to understand that true power of simulations will eventually be harnessed when a professional architect can use it to visualize as well as communicate the subtle nuances of his/her design. Our graduate students continuously push the boundaries of simulation on their desktops and notebooks, with the sincere hope that one day their work will find its way into the design studios of architectural practice.

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QUANTIFYING ARCHITECTURE: MEASUREMENT AS A BASIS FOR INQUIRY

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ABSTRACT
This is a description of a research methodology used to give works of architecture a central role in architectural scholarship and research. The methodology results in a database of works of architecture so that quantification can occur and direct comparisons can be made. The methodology is meant as a means to supplement scholarly research that has already occurred.

OVERVIEW
New Mexico contains some of the oldest settlements in America, noted along with the vast landscape for their purity and beauty. Continuous inhabitation of the landscape is discernable from the variety and continuity of settlement remains and includes sites that are ruins as well as those that have been continuously occupied. During the process of on-site work – planning, design, construction, and consultation – on a number of ancient inhabited sites, the sensitivity and complexity of the environment made clear the need for understanding the whole environmental system. The built environment of New Mexico has been extensively documented, with written as well as graphic source material. The vastness of information makes a comprehensive understanding of the whole an arduous task.

This paper describes a systematic method of inquiry that uses quantitative information about architectural works as the basis for engaging historical material. The method uses graphic analysis and precise measurement of a group of architectural works with historical, material, and geographic commonalities. This addresses the architecture of a particular place and time. The analysis is complementary to other scholarly research about architecture. It provides a way of reading historical texts – in some cases illustrating what has been written, and in some cases making corollary comparisons. The analysis offers three kinds of conclusions: confirmation of what has already been discovered, illustration of new information, confirmation that also provides updated information or new avenues for exploration. In all, the analysis provides a means of exploring the architectural edifice as a central figure in the discussion about it. Graphic analysis, in other words, puts the edifice central to the discussion where writing about it might favor other subject matter, for example history.

The focus is on 17th century mission churches in New Mexico. The confines of New Mexico were in the 17th century delimited not so much by political borders, but rather by natural features, a central river, vast dry plains, definitive mountain borders, and pre-existing settlements. Spanish conquest overlaid a pre-existing human and cultural landscape, settlement was therefore within an already-built context. The Franciscans, the missionary settlers and builders were continuous through the 17th and 18th century, and therefore some rules of building have been defined as well. The results of their efforts were the pueblo mission complexes throughout the state. On the surface there appears to be a large variety of architectural solutions (ex., figs. 1 – 3), in part because of the extensive landscape and insertion of a uniform building typology (the mission) into differing site conditions. But working with the mission churches, the impression is left of extensive similarities rather than differences characterizing the group. The problem, then, was to address the work for similar architectural attributes rather than for pictorial differences as a means of understanding the built context. The study, now in its early stages, has as its central focus a database of the architecture. Two components and conclusions that can be drawn from these will be discussed here – a timeline and a comparison of church plans (Figures 1 – 4). Because of the methods used, the conclusions discussed here include those that confirm, but extend scholarship.

Figure 1- 3 – N.S. de Guadalupe, Zuni; San Esteban del Rey, Acoma; San José de la Laguna, Laguna

HABS Photos: 1 - PERSPECTIVE VIEW OF EAST (FRONT) AND NORTH SIDE HABS, NM,16-ZUNIP,2-2; 2 - Historic American Buildings Survey James M. Slack, Photographer, April 4, 1934 FRONT ELEVATION (EAST) HABS, NM,31-ACOMP,2-5; 3 - Historic American Buildings Survey James M. Slack, Photographer, February 27, 1934 VIEW FROM SOUTHEAST HABS, NM,31-LAGUP,1-1

Scholarship on New Mexico mission churches includes primary sources that are complementary. Here, a primary source, George Kubler's *The Religious Architecture of New Mexico* is used as a point of departure. Kubler's work is seminal in classifying the mission architecture of this region. Written in 1940, it covers earthen churches from the Spanish conquest through to the time of the book's writing, and includes both Native American mission churches and Spanish New Mexican village churches. For a comprehensive understanding of the mission churches, there are a few important companion texts. Most important here are the Adams and Chavez *The Missions of New Mexico 1776* and John Kessell's *The Missions of New Mexico Since 1776*. Also, for many of the mission settlements there are Historic American Building Survey (HABS) drawings, with surveys at the pueblos beginning in 1934 and continuing through the 20th century, and for the sites that are in a ruined state, there are archaeological surveys, including a large number done by the 19th century anthropologist Adolf Bandelier and base information from various archival sources. Base information is important here because even in the recent history of the missions, there have been alterations or new archeological discoveries. To date, the database focuses on the Kubler text, and updated information from these other sources is added in a methodical manner.

GRAPHIC ANALYSIS

Kubler's text provides thorough classification and analysis. He gives interpretation and draws insight about individual works as well as tendencies in the group. The thoroughness of the research allows for a broad view of the subject matter as well as accessibility to information. He provides, for example, some measured drawings, some site information, information about dates, and primary attributes that pertain to the architectural group as a whole. The establishment of the database began with an attempt to illustrate and make clear Kubler's data. The premise here is that reorganization of this information in graphic form would provide accessibility to the concepts, ideas and conclusion that would be useful while working with the mission settlements. The missions could be understood as separate architectural entities, and conclusions would be informed by the whole group.

George Kubler's "Chronological Table of the Churches"[31] raises numerous questions. The table, in alphabetical order by place, provides supplementary reading of the text. But comprehension of the relationships between the works of architecture through the information given is not possible. The chronological table included a number of types of information including name, date, site, repairs, tree-ring dating, builders, donors. Only name, date, and location information are consistently addressed. This suggested organization first according to time of building.

A HISTORY OF SETTLEMENT: TIMELINE, 17TH AND 18TH CENTURY

[31] Kubler, George, *The Religious Architecture of New Mexico.* Albuquerque: University of New Mexico Press, 1990, pp. 117-127.

The timeline (fig. 6) covers just under 200 years, with equidistant horizontal intervals marking every year across the top of the image.[32] Churches are arranged in sequence according to the dates given by Kubler in his chronological table. A separate line is given for each church, therefore the vertical axis is an indication of quantity (69 churches identified by Kubler built from 1598 through the end of the 18th century). Kubler's dates are either precise (if the historical documents allow), or listed such as before 16xx, after 17xx, or ca. 18xx. He sometimes uses other time designations, for example 'early eighteenth century' or 'eighteenth century'- the first of these two is put at the start of the century, the next would be place at the middle. The timeline uses these dates assuming that the purpose – to give a framework to understand missions and settlement – has a large enough sample for any errors in the data.[33] The status of each church, if not standing, is as recorded by Kubler (d for destroyed, r for ruin).

The timeline lists the churches in chronological order. This indicates the frequency of building. Clusters indicate more than one church in a period of time and gaps indicate the lack of building. The timeline has written notes indicating major events that affect settlement and construction. A sample of these is illustrated here. These help to give historical context for the timeline. Indicated here, for example, on the left are the early days of building by the Spanish in New Mexico, indicated by the establishment of the first settlement in 1598 at San Juan Pueblo and the founding of Santa Fe in 1610. Both include the building of a church, as was the custom for Spanish *entrada* settlement. The Pueblo Revolt of 1680[34] is illustrated by the vertical column at approximately the halfway point of the timeline. It is one of the most important markers in history affecting Spanish settlement in the pueblo lands. This is immediately apparent, with a gap of thirty years where no church building was initiated after 1662 until 1692. A gap in the initiation of church building (and settlement that accompanies it) is seen in the eighteen years prior to the Pueblo Revolt. Also indicated on the timeline during this period is the abandonment of two pueblo settlements from 1669-1678. Abandonment of the settlements of Chilili, Tajique, and Abo, all in the Salinas group of pueblos in the mountains and dry plains southeast of Albuquerque, are generally thought to have been caused by drought. These events do not directly affect the specific events of the Pueblo Revolt that occurred later in time and to the northwest of the Salinas group. They are settlement-related activities and to a degree suggest a trend against new settlement. The events and many like them are indicators of hardship that were in part responsible for fueling discontent amongst Native Americans at the time in the more extended dry regions (from Chihuahua north) at that period in time.

Another gap of twelve years is indicated by the timeline after the pueblo revolt of 1680. In 1692 this gap is interrupted. The re-entry by the Spanish into Santa Fe is marked with the building of a church. Over the next few years, establishment of new or reestablishment of pre-revolt pueblo sites by the Spanish missionaries is indicated through church building – San Ildefonso, Picuris, Patowka, San Felipe, Santo Domingo, Santa Cruz, Walatowa are all close sites to Santa Fe, indicating reacceptance of and/or redomination by the Spanish in a tight geographic area. In 1706, Kubler indicates that the building of eight churches was initiated. These coincide with the establishment of a provincial governor in New Mexico and the founding of Albuquerque. Up until this time, church building is primarily in relation to pueblo missions.[35] After this time, the timeline shows a steady effort at building churches and a mix of sites, some in Native American and some in newly-established Spanish settlements.

Conclusions can be drawn about the importance of settlement-making in the 17th and 18th century in post-Spanish conquest New Mexico. The making of settlements is directly related to the historical events and to some degree in this context they initiate and physically represent the historical events. The timeline therefore places the architectural edifice as a important factor in the historical continuum.

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[32] Kubler's chronological table includes earthen churches from 1598, through to the 1930s. The initial focus of this endeavor was early mission churches – the 16th-18th centuries. This give enough of a temporal context to examine the early missions up to 1680 (the pueblo revolt).

[33] Kubler's data is from 1944. The data will be updated as further information is discerned.

[34] The pueblo revolt is marked specifically in time, however, unrest in the dry regions of the southwest (including what is not Northern Mexico) occurred for some time before and after 1680 and had a great affect on the whole region.

[35] Exceptions include churches in Santa Fe and Albuquerque, and Juarez, Mexico. Juarez is included by Kubler because of its inclusion at the time as an entry to the northern Spanish settlements (El Paso del Norte).

ARCHITECTURAL TYPE: PRE-PUEBLO REVOLT CHURCHES

Pre-pueblo revolt churches in New Mexico (before 1680) comprise a group of settlements belonging to early colonization of the Spanish in New Mexico. It represents along with other areas of the Americas the establishment of Spanish domination at a further distance from the initial settlements in and around Mexico City. The Spanish, in moving northwards out of the populated areas of central Mexico bypassed the extensive dry region of what is currently northern Mexico and instead concentrated on establishing settlements in the pueblo areas. Although some of the sites have changed physically, authenticity can be discerned because of the extensive recording and research done over time and from eye-witness accounts of events in or around the buildings and settlements. In the body of the *Religious Architecture* text, Kubler separates the pre-revolt missions from the later missions. Speculation about the architecture is made from understanding the group and the attributes of these churches. Many of his conclusions about the architectural attributes of the churches are presented with guarded speculation. After working in and with the architecture of a number of these sites, many of Kubler's speculations seem plausible. Some of his conclusion about siting, methods of building and decision-making appear to be discernable.

Graphic analysis focuses on the understanding of the pre-revolt group of mission churches as works of architecture central to settlement. The timeline for this group, taking into consideration variable dates given by Kubler, indicates a steady and consistent building program over a period of less than seventy years. Building of churches represents the establishment of missions. When mapped over time, the methodical practice of building is supported by a logical geography of settlement – mission church building began in the northern Rio Grande river valley, and gradually flourished, first in a pattern starting from the river valley as a center outward. This pattern of settlement, when mapped, can be seen through the use of the timeline. It of course makes logical sense for the Franciscan missionaries to build a network of concentric missions, but the confirmation of this in graphic terms gives a better context in which to understand the architecture. The timeline (fig. 7) differentiates between mission churches with still-extant original material[36] and those that have been destroyed. Eleven of the thirty-two early churches belong to this group.[37] Nine of the early churches are Native American mission churches – the exceptions are San Miguel in Santa Fe and N.S. de Guadalupe in Juarez, Mexico, both municipal churches.

When the plans of the churches are organized adjacent to one another, some patterns emerge. For example, there appears to be a consistent use of sizes. The churches at Pecos,[38] Giusewa, and Isleta have similar lengths, as do the pair at Soccoro and Quarai. The three largest churches are at Acoma, Abo, and Humanas. The measurements for these churches are not precisely the same, and the level of perfection in building and materials used vary. However, examining the churches based on the measurement system of the time they were built confirms the appearance of consistency. The measurements can be broken down in size to discern the use of the *vara* stick and the *cordel*,[39] the unit of measure used in building the missions. Variations in the exact measure of the stick and the rope, as well as variations in terrain and variations in building precision would logically lead to variations in the overall measure of buildings. Consistency in measurement, from building to building, therefore, should be seen as something approximate. Preliminary work shows some consistency in proportion (plan/section and use of wall thickness) between the churches as well.[40] A focus on measurement of the churches gives a fresh look at the group, confirming some of Kubler's speculation but shedding new light on a method of inquiry and comparison about the architecture. A look at the grouping overall raises questions about how they were built and the principles of construction and measurement used.

[36] In this case, still-extant churches include those whose original material has been established.

[37] There are three more churches to add to this group – the churches at San Cristobal, Hawikuh, Halona, and Juarez (information from Bandelier and/or contemporary sources is available).

[38] Pecos was re-built after the Pueblo Revolt, and the church plan in the Kubler book is reflective of this (for the sake of consistency, this is the information used at this time). John Kessel in *The Missions of New Mexico Since 1776* notes that the discovery of a larger foundation in 1965 was representative of the first church. The plan used here is in the process of being updated.

[39] The *vara* is measured by a stick that is approximately 33" in length. The cordel equals 50 varas. At Acoma and Laguna, the measurements have been checked to find that the mission complexes adhere to these measurements and proportioning systems that are organized using these measurements (*Acoma Mission Studies,* Playdon and Wingert, 2000).

[40] Measurements and analysis of measurements at during the preservation of the mission (1999 – 2000) have indicated a fairly precise degree of accuracy in the measurement of the foundations, according to proportioning systems (*Acoma Mission Studies,* Playdon and Wingert, 2000).

At this preliminary date, the sampling appears to be giving some indication of this as a consistently applied method of building.

One more example illustrates the 'uses' of the database. Orientation of the churches has been cited as having unique qualities in the mission churches of New Mexico. To quote Kubler in his first chapter, *Emplacement*:

> "Orientation: The traditional direction for churches, with the sanctuary at the eastern end, occurs in New Mexico, only at Pecos, at San Miguel, and the *parroquia* at Santa Fe, at Tomé, and a few other sites…..In New Mexico, the façade usually looks east and the sanctuary faces west as at San Felipe, Santa Ana, or Zia. This arrangement may be considered standard, and it constitutes a reversal of traditional European practice. It is an exception when the churches are properly oriented, as in the examples just cited, and in fact, buildings are more likely to face south than west as at Abó, Quarai, Giusewa, the old church at Taos pueblo, and the smaller buildings at La Bajada or Las Colonias. Thus the facades look east, or south in some cases, rather than west, and this situation offers a problem to which the answer, again is elusive."[41]

Kubler provides further speculation about orientation, suggesting that there are immediate cultural needs and/or site factors that might be at work in the siting of the churches.[42] In the passage above, Kubler has classified these churches by orientation, but has included churches from a number of time period groups. A look at only the existing Pre-Revolt churches shows some consistencies. There is one important correction to the plans.

Because of the information available at the time the book was written, Kubler's version of the Pecos church (drawn here) is actually a second version, rebuilt and sized down after the Pueblo Revolt. The original version of the church is flipped 180 degrees, with the entry and apse reversed. Bandelier's surveys of pueblo ruins indicate the orientation of two other pre-revolt churches. Hawikuh (1630) faces northeast, and San Cristobal (1626) faces east.[43] In addition, the still-extant church at Juarez faces east. We can discern that nine of the group tend towards the entry from the east and three tend towards the entry from the south (fig. 5). The exception in this group is San Miguel, Santa Fe. Kubler's quote ends by naming this an 'elusive problem.' But looking at the relationships graphically along with on-site observation suggests possible explanations. One possibility is that the placement of the missions relates to the pueblo proper. This could imply the coordination of buildings with important site features, including sites in the larger landscape. Some of the early mission sites have the mission adjacent to the pueblo, and this relationship might be an important factor in orientation. Consistencies in the relationship might indicate a building system on the part of the Franciscans. Kubler also suggests that the orientation of churches is related to the need for optical effects for the architecture. New Mexico is generally noted to be the place where the clerestory window of the church was developed as a means of lighting the sanctuary. Kubler suggests that the time of mass (morning) and the use of the clerestory might be related.[44] Another explanation for the location of the entrance might have to do with the relationship of openings in the church to celestial bodies and landscape features. Orientation of openings, as determined by the inhabitants, might discern the location of parts of the church.[45] It is also possible that multiple factors are at work here, but importantly, the comparison of these churches according to their orientations highlights their similarities more than their differences. The issue of orientation is an important one, and the graphic analysis not only confirms speculation already made, but suggests a clear grouping of examples to examine in order to find specific tendencies of building.

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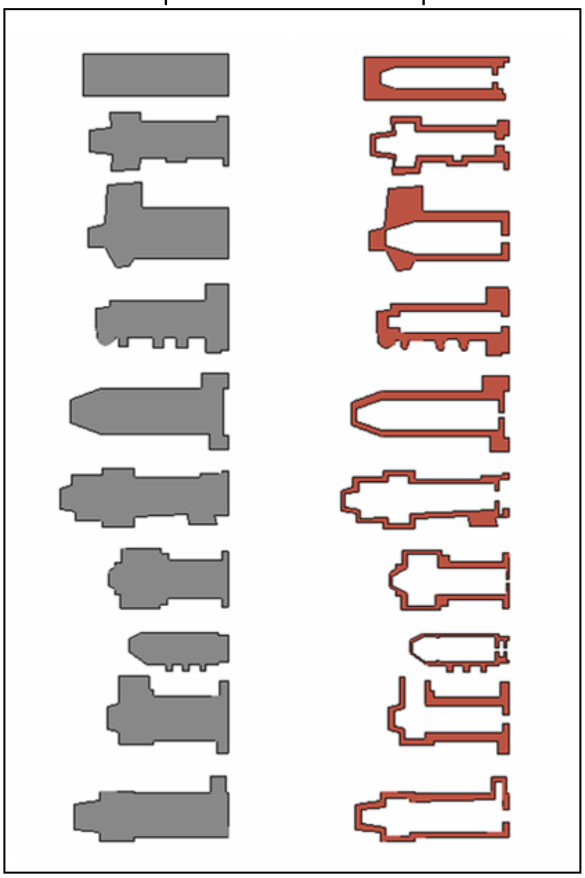
[41] Kubler, George, *The Religious Architecture of New Mexico.* Albuquerque: University of New Mexico Press, 1990, p. 23.
[42] Ibid, p. 23.
[43] See ibid, pp. figs. 50 and 51.
[44] ibid, p. 23.
[45] In the spring of 2001, a conversation with an elder at the Pueblo of Laguna indicated that the light coming in through the windows of the church were used to mark time and indicate the start of planting season. At Acoma, the celestial bodies outside the window above the entry are observed to mark the start the Christmas during the midnight mass celebration. It is unclear if these observation activities are adapted to the building or if the building is adapted to the needs for observation.

CONCLUSION

The analysis builds on scholarly research thoroughly and precisely carried out. Re-visiting and updating the important issues of Kubler's book is in itself a worthwhile endeavor. Grouping of 'like' entities and using graphic depictions, on the one hand confirms and supports information already at hand. By looking at the missions as groups governed by time, some new areas of exploration are opened. For example, comparisons of measurement and proportion allow for an architecturally based (rather than historical or geographic) understanding of the buildings. This has led to further exploration of the use of building systems and typology. Statements like the following, "The pueblo churches of New Mexico are particularly significant because only in that area of all the Southwest did the Spanish missionaries encounter an indigenous building tradition"[46] predominate in the discussion of this architectural group. The New Mexican mission churches are usually noted for their rusticity and beauty in comparison to other groups – earlier churches in Mexico, later Franciscan churches in California, or the Jesuit churches of Arizona and Sonora. A study that relies of a graphic analysis rather than a pictorial one makes it possible to see the attributes of the architecture in different terms.



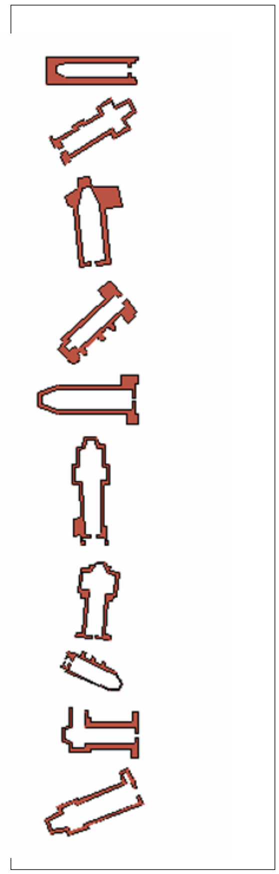


Figure 4: Pre-Pueblo Revolt churches in New Mexico, size comparisons.
Figure 5: Pre-Pueblo Revolt Mission churches, Orientation comparison
Plans - North is up for each church

From top: N.S. de la Asuncion, Zia (bef. 1614); N.S. de los Angeles, Pecos (ruin, 1625, rebuilt 1692); San Jose, Giusewa (ruin, ca. 1626); San Augustin, Isleta (bef. 1629); San Esteban, Acoma (1629-1644); San Gregorio, Abo (ruin, ca. 1630); La Concepcion, Quarai (ruin, bef. 1633); San Miguel, Santa Fe (after 1640); San Miguel, Socorro (mid 17th c.); San Buenaventura, Humanas (ruin, 1659)

[46] Mullen, Robert. *Architecture and its Sculpture in Viceregal Mexico.* Austin: University of Texas Press, 1997, p. 215.

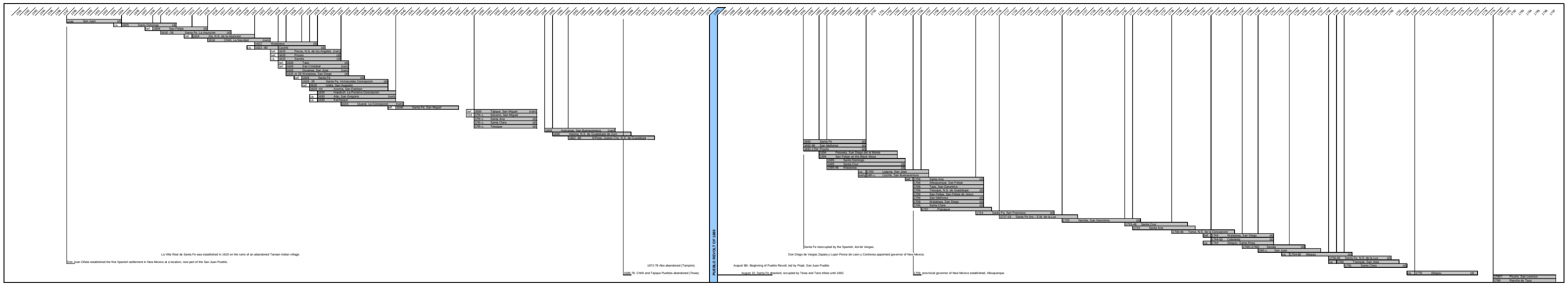


Figure 6 - Timeline, New Mexico Churches, 1598 – 1780

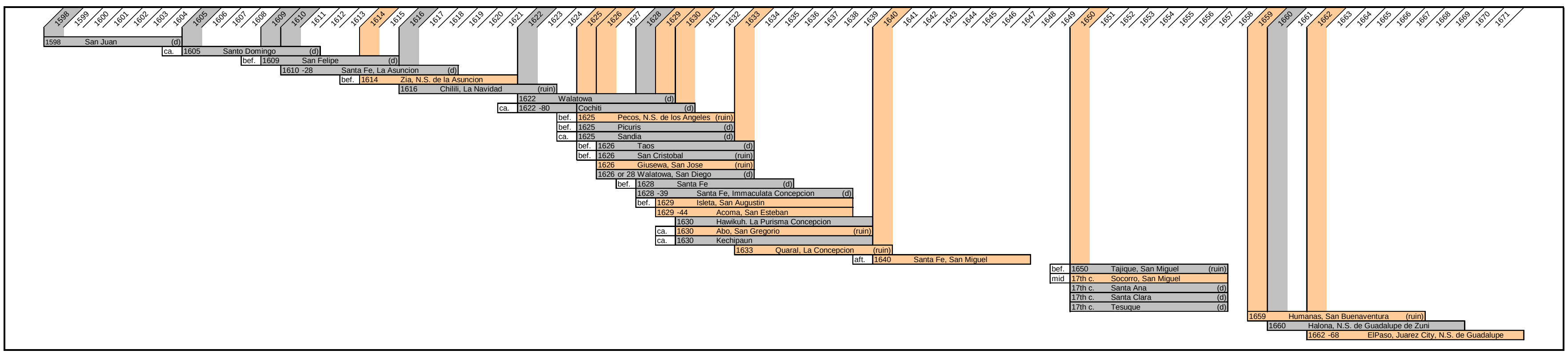


Figure 7 - Pre-Pueblo Revolt New Mexican Churches, 1598 – 1668

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A PRINCIPLED APPROACH TO ARCHITECTURE 101

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ABSTRACT

When asked to teach Introduction to Architecture at the Savannah College of Art and Design (SCAD), I pondered what would unite and inspire a young, diverse student population with minimal exposure to design and mixed levels of analytical skills coming from Nigeria, Colombia, Venezuela, Jamaica and Japan and throughout the United States.

After researching how Intro courses are taught around the country, I came to the conclusion that the purpose of this course is to enable students to engage in architectural discourse verbally and graphically and to have a coherent set of principles by which to approach the design process.

Instead of turning towards chronology as an organizing element for the course, I asked them one question on the first day and again, ten weeks later, on the last day of class –

What is your favorite building? Why?

I asked them to bring an image of their favorite building on class two and to be prepared to describe it to someone who is unable to see the building. This enabled us to begin to address the vocabulary of architecture. This also enabled us to address the next question –

What is architecture?

Beyond the incorporation of vocabulary, the underlying intention of this course is to enable students to harness what passion and interests have brought them to architecture school. By helping students identify their connection with architecture early (their favorite building), we enable them to feed from that experience in the upcoming years of education and practice.

This general discussion of favorite buildings and whether they are "Architecture" continued through the term. The context for the discussion was a list of "principles" which I presented to the students:

1. **Formal Ordering and Shelter**
2. **The Natural Environment**
3. **The Built Environment**
4. **Structure and Technology**
5. **History**

In conjunction with readings, field trips and class discussions, students were given assignments from a range of media relating to the five principles. Dialogue about their favorite buildings and Architecture increased through the quarter and by the end of the quarter they produced informed diagrammatic analyses of a building.

The goal was not to define Architecture, but to use the question as a foundation for an architectural education.

INTRODUCTION

> "*The principal goal of education is to create men [and women] who are capable of doing new things, not simply repeating what other generations have done – men [and women] who are creative, inventive and discoverers. The second goal of education is to form minds which can be critical, which can verify, and not accept everything themselves, partly by their own spontaneous activity and partly through materials we set up for them; who learn early to tell what is verifiable and what is simply the first idea to come to them."* (Piaget from Feigenberg, p.270)

It is a basic tenet of architecture that every structure requires a sound foundation. The foundation of architectural education is not the design studio, as it has often been described. The foundation of architectural education is the Introduction to Architecture course taught at most architecture schools across the country and around the world. This first introduction to our complex and multi-dimensional field (often the first course a student of architecture will take within the major) will be the basis on which all courses to follow will be evaluated and processed by the student. It is the equivalent of basic language and math skills in relation to higher education.

While there are prolific writings on the differing approaches to architectural studio, inclusion of theory in architectural education and inclusion of sustainability in architectural education, I have been unable to locate any specific research into how introductory courses in architecture are approached and the success of differing approaches. The 2005 Beginner's Mind conference for the Beginning Design Student in San Antonio, Texas presented sixty-six papers of which none of the abstracts directly addressed introductory courses in architecture.

With this paper I hope to begin a dialogue regarding teaching models for introductory courses in architecture and to demonstrate the model that I have developed.

THE NEED FOR A DIDACTIC APPROACH

> *"All effective teaching, of course, proves itself by stating what it wants, what changes in behaviour it seeks to effect among the students, and therefore what aims it sets out to achieve."* (Johannes, p.3486)

There is a manifesto entitled Model for Architectural Design Education (MADE) by Ralph Johannes that approaches the decline in the quality of design education as a result of teaching by teachers who were never taught to teach. "They will seldom or never consciously use a consistent teaching method, or even conduct their courses in accordance with didactic principles, of which most of them are in any case unaware." (Johannes, p.3471)

I agree that architectural education requires a clear structure and organization. However, the MADE document is, once again, addressed at the design studio rather than the introduction to the architectural education.

My own approach to teaching can be summarized with Feigenberg's statement "[i]deally architectural education should not focus on students' retention of facts and formulas, but rather on the enhancement of their ability to think critically and to learn how to learn." (p.266)

MY APPROACH

My interest in this course began when asked to teach Introduction to Architecture at the Savannah College of Art and Design (SCAD) in Fall 2004. Multiple sections of the course are taught simultaneously, at least one section taught each of the four quarters. Recent student evaluations had not been high and the department was interested in revamping the course to provide a more successful introduction to architecture than previous courses had provided. As long as I met the NAAB criteria, I had the freedom to design the course as I deemed appropriate.

The department provided me with previous syllabi for this course over the recent years. One professor had approached the course as a 20th century architectural history course. Another professor approached the course as an introduction to architectural theory and a third professor had been so frustrated at the seeming disinterest of his students that he asked them to write a paper describing what they thought the course should be teaching them. These papers were the first indication I had of the challenge required to engage these teenage students in the complexities of architecture.

In considering how best to create this course, I chose to approach it as I would any design problem. Who is the client? What are the precedents? What is the schedule? What is the budget? What is the intent?

Client

The client in this condition is predominantly freshman students who intend to major in architecture at SCAD. They are a young, diverse student population with minimal exposure to design, mixed levels of analytical skills, coming from all over the world (16% of students in the architecture program at SCAD are international). What they have in common is their age, energy level, and some inherent interest in architecture that brought them to this class.

In previous courses I have found that freshman students in architecture are at risk of becoming overwhelmed and disenchanted with the complexities of architecture. I wanted to keep them engaged by tapping into the passion and interest of these students, allowing them to discover the basic skills in architecture that would enable them to flourish in architectural studio.

My approach to teaching has always been to engage the students fully and offer positive feedback, while retaining very high expectations. I have learned that with younger students, lecturing is not nearly as effective as discussing. Given the small class size at SCAD (maximum of 20 students in lecture courses), I recognized the potential for dialogue as well as opportunities for student presentations.

Schedule and Budget

My schedule in the SCAD quarter system is ten weeks. But, my budget is the youthful energy of these students. Having worked with young students in the past, I knew that, if inspired, the potential energy is incredible. To keep their attention, I incorporate a continually changing array of media for my own presentations as well as for their assignments.

Precedents

I compiled numerous syllabi from Intro courses at other institutions. I also sent out a questionnaire to practicing architects and architectural educators asking about their memories of their introduction to architecture course. By evaluating this data and discussing the success of these courses with the teachers and students who had taken them, I organized these findings into three basic methodologies – introduction to history and theory, introduction to design fundamentals and introduction to architecture principles.

Which methodology is taught at a given school is dependent on a number of factors: Is the class exclusively for architecture majors or is it open to other majors? When in the architecture curriculum is the course taken? What is the size of the class? What is the overall philosophy of the department and what NAAB criteria need to be addressed to complete the curriculum criteria? But at SCAD, my approach was to design the course based on principles.

Intent

I realized that the success of an introductory course in architecture could be evaluated by a student's ability to respond coherently to the question "What is Architecture?" To answer this question coherently, one must have a solid grasp on the basic issues in architecture. I also saw that there needed to be a structure around which to build this vocabulary.

I created the following list of five principles as a set of areas by which to evaluate whether a building is "Architecture".

1. Formal Ordering and Shelter
2. The Natural Environment
3. The Built Environment
4. Structure and Technology
5. History

PROCESS

Beyond the introduction of verbal and graphic means of communication in architecture, the underlying intention of this course is to enable students to harness what passion and interests have brought them to architecture school. By helping students identify their connection with architecture early, we enable them to feed from that experience in the upcoming years of education and practice. If we can engage students in discussions of "meaning" and "value" initially, then the memorization inherent in the learning process will have a context.

Instead of turning towards chronology as an organizing element for the course, I ask the students one question on the first day and again, ten weeks later, on the last day of class –

What is your favorite building? Why?

After teaching four sections of this class over two quarters, I have found that student responses are quite consistent. About half of the students bring in a Frank Lloyd Wright building, often Fallingwater. Approximately a quarter bring in an image of their own home and the remaining ones bring in a building that seems to represent something "fancy" to them. There is usually at least one building from Las Vegas, at least one skyscraper hotel (the Burj Al Arab Hotel in Abu Dhabi is popular) and the occasional sports stadium.

I then show the students some of my favorite buildings and I discuss them using architectural vocabulary. Recently I showed Rem Koolhaas and OMA's Seattle Public Library. By asking if it feels like a library, we can immediately engage in a dialogue about typology. We also discuss how well it fits in the city (context), how the structure is a part of the interior expression (structure and technology) and what it means to design a public library in the 21st century (history). I also showed Zaha Hadid's Vitra fire station. The fact that this building never functioned as a fire station engages the question of architectural function as well as sculptural expression and artistry.

The final piece of "architecture" I show is Goldmyer Hot Springs in Washington state. This is a natural hot springs which was discovered in the early 1900's and is a hiker's destination in the foothills of the Cascade mountains, east of Seattle. A cave was dynamited out of a hillside, now offering a 110 degree hot spring tub. All the students recognize its beauty but the question of whether it is architecture brings up questions of function, shelter, manmade intervention and other key aspects inherent in a working definition of Architecture. In the beginning most students do not differentiate between “building” and “Architecture”. By the end of the term, the students may differ on the answer, but they are able to discuss the difference.

The students are asked to bring an image of their favorite building on class two and to be prepared to describe it to someone who is unable to see the building. On class two, they pin-up their images and without pointing at or naming the building, they have to describe it. This enables us to begin to address the vocabulary of architecture. This general discussion of favorite buildings and whether they are “Architecture” continues throughout the term.

Throughout the quarter, I attempt to make distinctions between architecture and building, between personal, sentimental response and architecturally significant work and between architecture that one “likes” versus “good” architecture. All of these issues are discussed within the context of the five principles. Early on, the students begin to understand that I am not looking for answers to these questions. I am seeking meaningful, educated dialogue from them.

PRINCIPLES

Formal Ordering And Shelter

Supplemented by readings from Ching and others, I lecture on the elements of architecture and the possibilities and ramifications of their combinations as exemplified in buildings across time and location. We continually revisit the students’ favorite buildings and discuss them as a combination of formal elements and ordering systems.

I also present an overview of basic architectural drawing that culminates with an assignment to draw plans and sections of their own room. A basic understanding of orthographic drawings is necessary for a meaningful discussion of formal ordering, as well as for the eventual diagramming that the students do at the end of the quarter.

The Natural Environment

The natural environment and issues of regionalism are introduced to the students in film and readings. I introduce the students to bioclimatic regions, vernacular and regional responses and contemporary approaches to environmental issues such as LEED. We look at examples throughout history and throughout vernacular Savannah buildings.

The Built Environment

On the following class, we meet in a square in historic Savannah and do a walking tour in which we identify elements of architecture, urban contextual derivations and responses as well as regional architectural innovations that evolved from natural environmental requirements. Issues include the shape and location of historic Savannah windows, courtyards, building materials, commercial streets compared to industrial and residential streets and more.

I begin to ask the students to explain why Savannah architecture evolved as it did. This is presented in tandem with the presentation of their first major assignment – a Savannah Scavenger Hunt. They are given questions about ten historic Savannah structures. They then have to research these and present photos and descriptions on clearly organized boards. I introduce them to the incorporation of verbal and graphic presentations at this point. All projects to follow are partially graded on verbal and graphic presentation.

Structure And Technology

Beginning with the trabeated system of construction, we discuss the evolution of structural innovation and how it affected architecture. Students are introduced to basic structural issues of tension and compression and we once again return to their favorite buildings to discuss structural innovation and expression. We also refer to the local 19^{th} and 20^{th} century Savannah buildings that exemplify multiple periods of structural and material understanding.

History

In the second half of the quarter we do a quick sweep through the history of architecture in which we are merely discussing what we need to know in relation to the other four principles to discuss contemporary architecture from an informed perspective. The point of this is not to teach the breadth of architectural history, but to help the students understand that as designers, they are part of a lineage. Architecture today can not be designed without a comprehension of what got us here.

All five principles come into play in their final two assignments. They begin with a precedent study comparison of two noted architects – one who practiced pre-1960 and one contemporary architect. Each student does a 15-minute Powerpoint presentation in which they must present an in-depth comparative analysis of at least three buildings of each architect, including plans, sections, elevations and images. The second part of the project is a physical presentation board on which they must present a diagrammatic analysis of one of the buildings they have studied with at least three original diagrams.

OUTCOME

I began this paper with a Piaget quote which includes the following –

> "*The second goal of education is to form minds which can be critical, which can verify, and not accept everything themselves...who learn early to tell what is verifiable and what is simply the first idea to come to them."*

I am challenging the students to think critically and to question their first response.

On the last day of class students are asked again to bring in an image of their favorite building. A few students bring in the same building they started with while most do not. We discuss these buildings yet again and the students usually find that they are able to discuss these buildings with much more facility.

Of twenty students in one section of my Intro class this winter, all but two students changed their favorite building from the first class to the last class. Six students originally presented their own home as their favorite, though none did on the last day. This was in no way my intention, and I actually expressed my belief that our childhood home is, for many, the most important architectural influence we have. But, I do ask the students to question if their response to a building is sentimental and personal or if it is based on the principles that we had learned. It was not my intention that their favorite building need be Architecture, only that they begin to understand why a building is their favorite.

I then ask them if their favorite building is Architecture.

In a recent class, a student from the Ivory Coast changed her favorite building from Casa Mila on the first day to Yamoussoukro Basilica on the last day. This is a 1980's re-creation of Saint

Peter’s Cathedral built in the Ivory Coast. It has tremendous political and social meanings for the culture. When asked if this was Architecture, she and other students responded that if the original Saint Peter’s is Architecture, how could this not be Architecture? Others disagreed and this led to lively dialogue on originality and duplication.

Another student had switched from the Delano Hotel in Miami to Rem Koolhaas’ Villa Dell’Ava in Paris. The exterior walls of this house respond to neighbors’ requirements that they do not want to see the building. So if the neighbors hate the building, can it be Architecture?

As we debate on whether specific buildings are “Architecture”, I clarify that, in my opinion, there is no universal answer to this question. I remind them that they will eventually be in studio where they will spend countless hours every term attempting to create Architecture. Before designing Architecture, they must define for themselves what architecture is. The purpose of the principles was to provide the students the basic understanding and vocabulary to form their own definition of Architecture.

If the students can carry on a meaningful dialogue on the definition of Architecture, then the course was successful. Actually defining architecture is not important. The dialogue is the test of the overall integration of all that we have studied through the quarter.

The real test of the success of this class will come in the upcoming years when I have these students in studio. In the interim, I follow their progress through other teachers who are teaching them. So far, they seem to be leaving Architecture 101 with a principled approach to architecture.

EXAMPLES

Marie-Alice

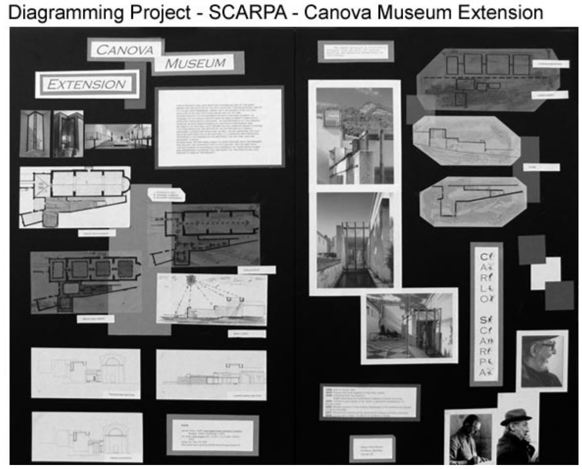
Favorite Building original

GAUDI - Casa Mila

Favorite Building final

YAMOUSSOUKRO Basilica

Diagramming Project - SCARPA - Canova Museum Extension

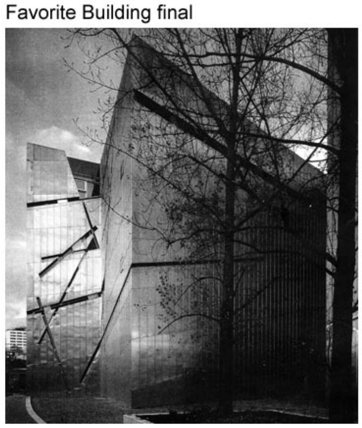


Pamela

Favorite Building original

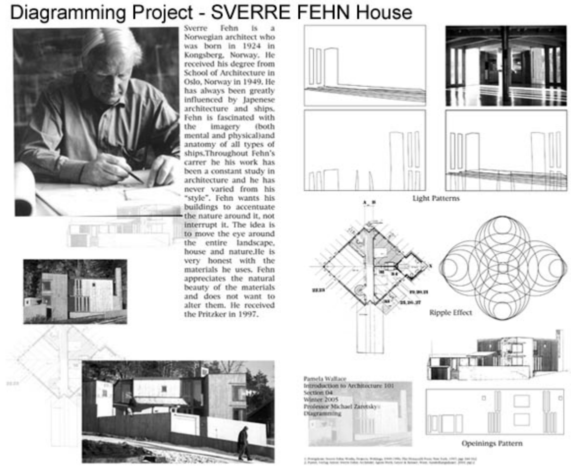
GEHRY- EMP Seattle

Favorite Building final



LIBESKIND - Holocaust Museum

Diagramming Project - SVERRE FEHN House

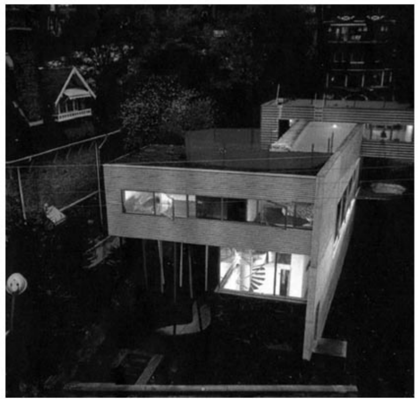


Anna

Favorite Building original

DELANO HOTEL - Miami

Favorite Building final



REM KOOLHAAS - Villa Dell'Ava

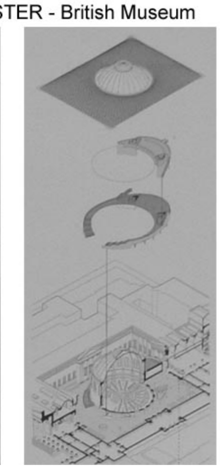
Diagramming Project - KOOLHAAS - Villa Dell'Ava

Tanner

Favorite Building original and final

BURJ AL ARAB HOTEL - Abu Dhabi

Diagramming Project - NORMAN FOSTER - British Museum



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Sharing Tacit Design Knowledge in a Distributed Design Environment

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ABSTRACT

This paper reports a case study that was conducted to observe the exchange of tacit design knowledge in a distributed design environment. Prototype software was developed and tested in a undergraduate design studio in which design students sought advice from experts in remote locations. It provides tools for showing images, such as drawings, renderings, and for engaging in a written dialogue (chat session). Data were collected and analyzed using both qualitative and quantitative methods to enhance the validity of findings--through content analysis, log files, simple statistics, and questionnaires.

1. INTRODUCTION

Throughout the life-cycle of a design project, architects rely heavily on their tacit design knowledge to support design decisions. Tacit knowledge is highly personal, unstructured and implicit (Polanyi 1966). As such, it encompasses expertise, intuitive understanding, and professional insight formed as a result of experience. Due to its implicit nature, tacit design knowledge is typically shared only among colleagues who work in the same office through face-to-face interactions. With emerging CMC (Computer-Mediated Communication) technologies, designers face new opportunities for capturing and reusing tacit design knowledge. However, there is no accepted CMC strategy for sharing tacit design knowledge in the AEC industry.

This research investigates the impact of tacit design knowledge on design performance in a distributed design environment supported by CMC software. The software was developed and tested in three design studios in which design students sought advice from experts in remote locations. It provides tools for showing images, such as drawings, renderings, and for engaging in a written dialogue (chat session). The written and graphic artifacts of the conversation are stored in a Web-accessible database.

The chat sessions included the identification, clarification and explanation of real problems. Dialogue records provide evidence of a significant influence upon the students' approach to conceptual design. Content analysis of the comments from the experts provides qualitative evidence for the software's effectiveness. The participants shared past experience, professional recommendations and intuitive expectations. In follow-up surveys, most participants reported that their experience with the software was very enjoyable and the software is well-designed to support sharing of design knowledge.
This research also suggests that tacit design knowledge may be confidently captured and shared through careful strategic implementation in a distributed design environment. Demographic and attitudinal surveys of the participants suggest that enabling factors for sharing tacit design knowledge include knowledge sharing attitude, just-in-time expertise matching, and timing of the communication.

2. METHODS

Instrumental case study approach has been selected as the most suitable method of inquiry. A design problem was given to a group of participants, architectural design students, and they were requested to produce a design solution to meet the requirements of the design problem. Data were collected and analyzed using both qualitative and quantitative methods to enhance the validity of findings--through content analysis, log files, simple statistics, and questionnaires. Quantitative data such as questionnaire results, log files and counts of frequencies of software use supplement qualitative observational data to triangulate evidence, producing more valid conclusions.

3. SETTINGS

The case study was conducted in an undergraduate level design studio at Texas A&M University, College Station, TX, during 2004. The design studio undertook a design project for the historic downtown of the City of Bryan. The course objective was to generate architectural proposals in responding to the historical architectural context.

The studio instructor encouraged the students to use the software as a substitute of a weekly design critique. Because this design studio was conducted in a summer semester, the class met every weekday. Consequently, Friday is often very tired and stressful for the students. The instructor wanted the students to be more excited about the opportunity to talk with design professionals, such as architects, city staffs, and engineers. The instructor asked students to discuss with the design critics about their own design projects. The design critics and students never had a face-to-face meeting.

A plot in the historic downtown was assigned to the students to be developed as a small commercial shop with the residential functionality. The new building should be kept within the range of 4500 sq. ft. The shop could be designed according to a unique theme, such as a coffee shop, a pub, a bookstore, a casual wear shop, or a sport articles shop. The students were asked to explore the possibilities of linking residential and working activities, but at the same time they want to be able to keep certain residential autonomy. The design of the residential area should incorporate features characterizing the profession of the owners. The residential area is composed of two two-bedroom units for rent. At the time of the experiment, the theme had been already decided and the students were in the conceptual design phase.

4. PARTICIPANTS

The participants for this case study were twelve undergraduate students completing the third year of a four-year Environmental Design program from Texas A&M University. Of these initial participants, seven students participated in real-time chat sessions while other five students just logged in at the chat sessions. The students who participated in the chat sessions completed the post-test questionnaire. None of the participants do have previous work experience as a designer or engineer in the industry. The participants' average age was 20 years. They have similar backgrounds but they have different attitude about knowledge acquisition and CMC technology. The researcher did not participate in the chat sessions except to answer technical questions and to help use the software.

The twelve students were divided into three groups. Since the project is located in historic downtown of the City of Bryan, the instructor was very careful to select guest critics with a great deal of previous experience in this area. One local architect and one city staff person were selected as design critics. Due to the difficulties of finding local design critics, one architect from Venezuela was selected as a design critic. He has in-depth knowledge on the design theories and space manipulation.

5. PROCEDURES

Before the chat session, the students upload a PDF version of their conceptual drawings and model pictures to display them in the chat session. They also asked to fill out a pre-experiment questionnaire. The design critics were asked to look at the design artifacts before the chat session. After conducting a one-hour training session, a 4 hour chat session was conducted in a strictly controlled computer lab environment. The students logged into the system at the same time and spent the same amount of time in the system. The chat session was conducted in a computer lab equipped with Pentium IV computers with high-speed Internet connection. A digital projector was used to demonstrate the software. Then, they communicated in a chat room to discuss the design projects. At the end of the semester, the students submitted and displayed final posters at a gallery area in the College of Architecture. Those posters have been recorded to observe the difference after the chat session. The author sent an email that asked to fill out the post-experiment questionnaire.

6. FINDINGS

6.1 Qualitative analysis

<u>Student 1</u>
This case illustrates reuse of tacit knowledge during the chat session. Student 1 is a 21 years old female student majoring in Environmental Design program. She conducted a 10 minutes online chat with a local architect who is one of founding Principal in a local architectural design firm. The critic's primary expertise is architectural design and visualization technologies. Since he has conducted numerous projects in the City of Bryan, he was able to give valuable suggestions about the site condition and the city regulation.

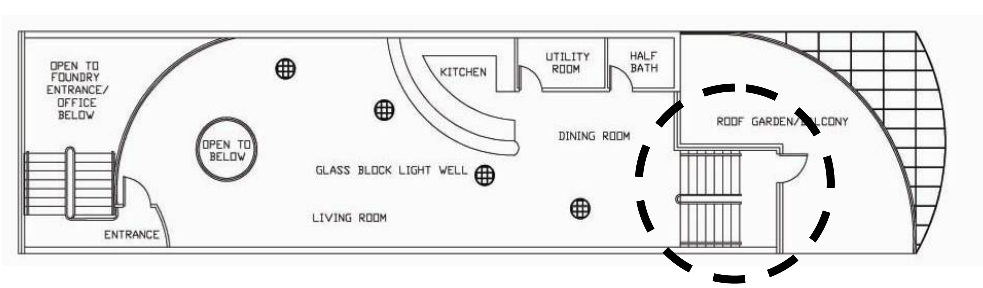
Within her project a small international coffee shop sits next to and beneath a bronze foundry and residential loft. The coffee shop specializes in gourmet coffee from around the world and also offers a selection of pastries and desserts. The presentation of the coffees is kept in the tradition of the country and culture from which it came. The intention is that this unique atmosphere allows for the customer to experience a distinct cultural flavor yet feel as though they are part of a larger cultural diffusion.

When they started their conversation, the design critic asked student 1 whether she read his comments to another student as follows:

Critic 1:	*"Did you read my comments to Barrett about the access issues?"*
Student 1:	*"Yes, I had originally had a lift for wheelchairs at the entrance on the empty space to the right."*

As indicated in the excerpt above, the design critic wanted to give her the same comments about the wheelchair accessibility at public spaces. All students who have the same problem were able to fix their design artifacts according to the critic's comments. She also revised her drawings at the end of the semester as shown in Fig. 1.

Before



After

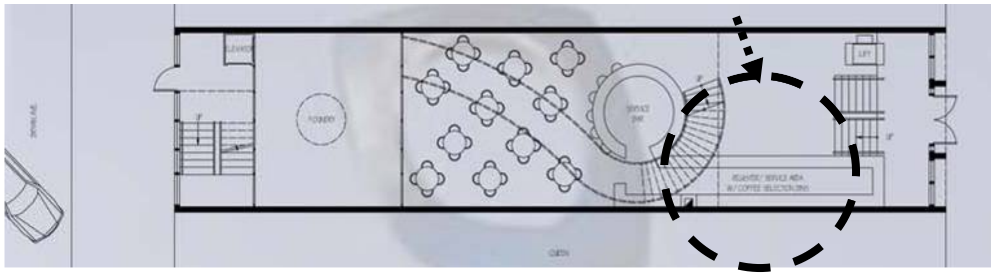


Figure 1 Student Example 1

Student 2

Student 2 is a 22 year-old female student majoring Environmental Design program. Her design critic is an architect working in Venezuela who received a Master of Architecture at University of California, Berkeley. He is very familiar with design theories concepts. Because he never visited the city of Bryan before, he could not give the comments about the local context of the project. The majority of the comments from him are about the design concepts, form, and theories.

Her project is a French bakery attached to a loft home where the family that lives there and operated family-owned business. She wanted to create the same atmosphere for the guests as well. Since the family resides on the top of the bakery, she wanted create an interaction between the two spaces. The wood fire oven is the central feature which is used by both the bakery and the family. The curved form of the elements has been emphasized to create a soft and comfortable environment. The facade also reflects the curves that are happening inside the space. The left side is glass wall so that people can see the oven from outside and invite guests. Her conceptual model was made of paper and green-color form to emphasize the main idea of this project which is a wooden bakery oven (See Fig. 3).

They spent approximately fifteen minutes on reviewing her design concepts. The critic was able to rapidly conceive a problem for her project and quickly made comments to achieve more comprehensive design solution. At first, her idea was really impressive and the design critic was very impressed. However, when he looked at her drawings (See Fig. 2), he made a following comment:

Critic 2:	*"when I see you model I see a strong idea, but when I see your drawings that strong idea almost vanishes."*
Student 2:	*"Well, the oven is definitely the main feature of my building."*
Critic 2:	*"The fireplace and the oven, both can be recognized from the inside as special elements and it serves as function and entertainment value."*
Critic 2:	*"CELEBRATE the elements!"*

Student 2 produced a revised section which reflected the suggestions from the critics, as show in Fig. 4.

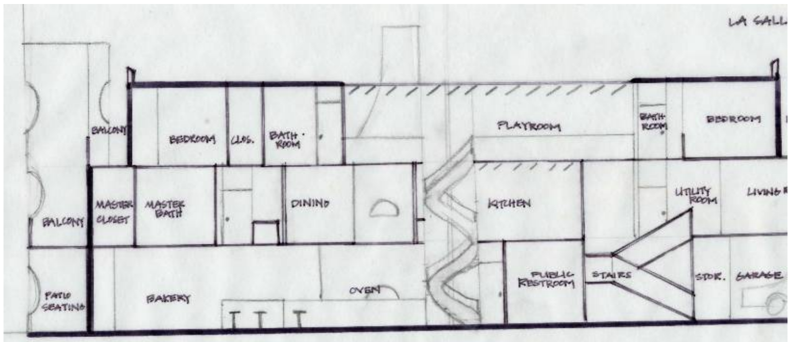


Figure 2 Section (before the chat session)

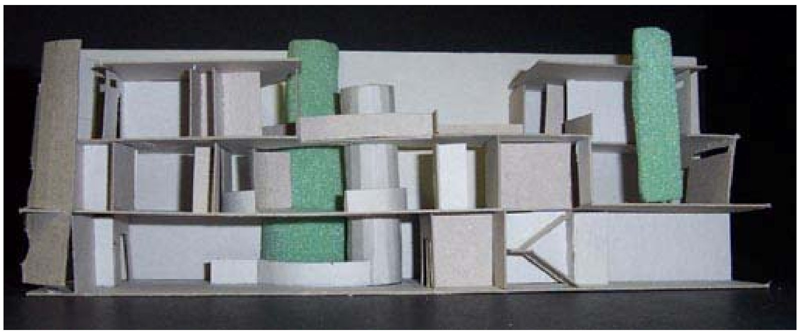


Figure 3 Model picture (before the chat session)

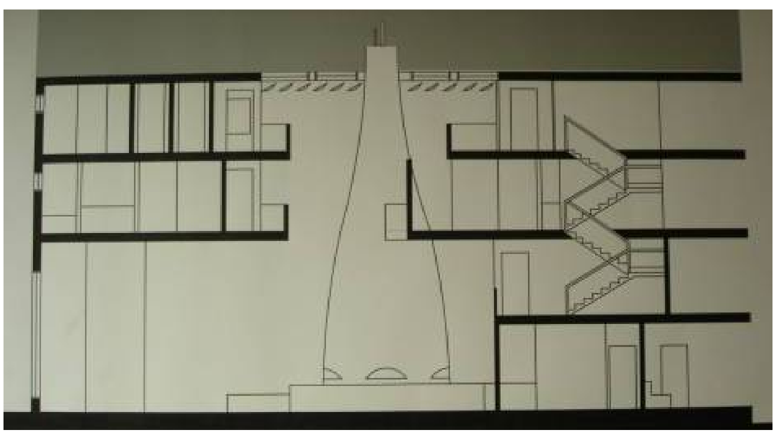


Figure 4 Revised section (after the chat session)

6.1 Quantitative Analysis

The students varied in their perceptions of the integration of CMC technologies in design studios. The questions about CMC technology perceptions were asked twice in both questionnaires. Figure 5 shows the difference in the perception of CMC technology before and after the experiment. The perception of phone, groupware, virtual directory, and email stay the same. However, their perception about chat/instant messaging and video conferencing was greatly improved as shown in Figure 5. The results suggest further that students recognize chat/instant messaging as an opportunity to share tacit design knowledge and interact with others, not as a communication medium in which they only strive for facilitating faster communication.

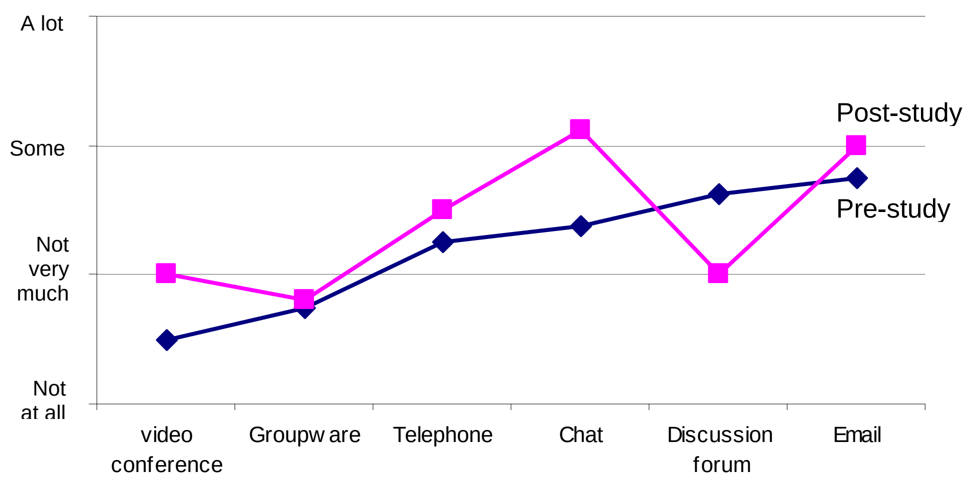


Fig. 5 Student perceptions on CMC

7. THEORETICAL MODEL DEVELOPMENT

A theoretical model for design knowledge sharing process has been developed by formulating the research results (See Fig. 6). Design knowledge sharing is initiated by applying 'generalized tacit design knowledge' to a specific design problem. When the students talked with their design critiques to acquire tacit design knowledge, the design critic's generalized tacit design knowledge may become 'specific tacit design knowledge' with the consideration of a specific design problem.

The students then convert specific tacit design knowledge into explicit formats, such as sketches, models, and drawings. Although those explicit expressions are often inadequate to fully articulate tacit design knowledge, it is a typical process of reflective practice in the design profession (Schon 1983). And then, the students produce a design solution and update 'generalized explicit design knowledge'. Finally, what they experience are converted and accumulated as 'generalized tacit design knowledge' in the form of shared mental model or technical know-how (Nonaka and Tacheuchi 1995).

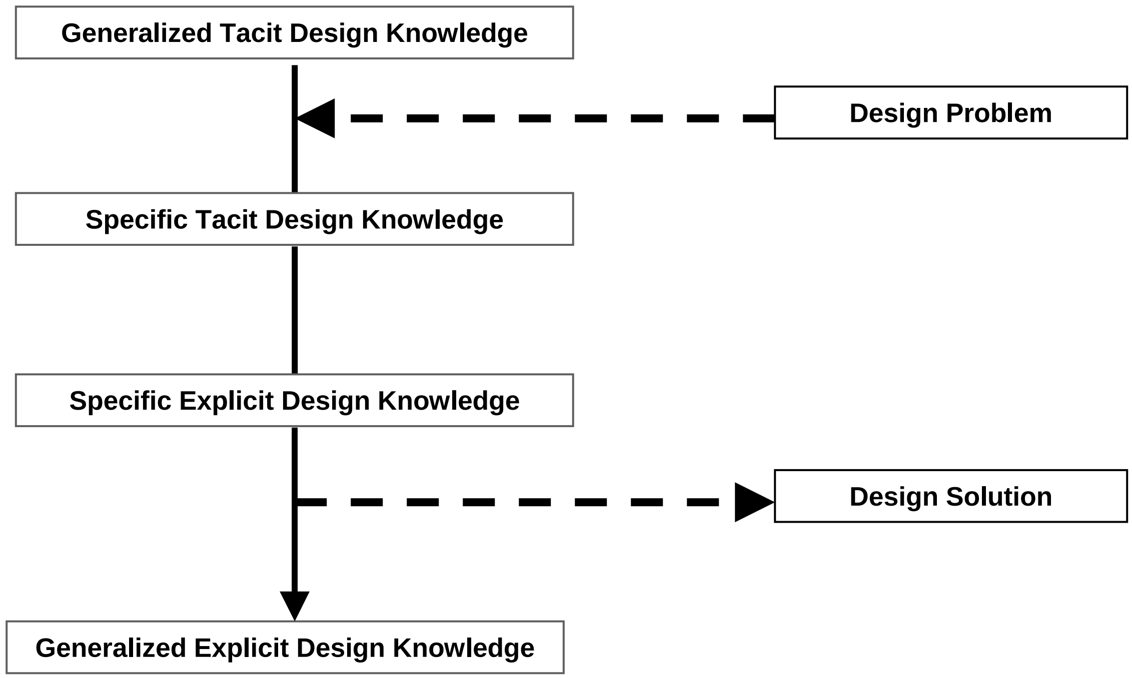


Fig. 6 Theoretical Model Development

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Energy Efficient Elementary School Design: Effect of daylighting on energy consumption and space illuminance in an existing elementary school

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ABSTRACT

This study investigated the effects of daylighting on building energy consumption and space illuminance for an existing elementary school in College Station, Texas, and is generic to similar school designs in hot and humid climates. Skylight and clerestory top-lighting options were analyzed to formulate balanced daylighting designs that provided for energy savings and increased interior daylight levels. Case study school spaces were analyzed using walk-throughs and daylight factor measurements to understand the potential for daylighting. Physical scale models of the study spaces with and without daylighting alternatives were built for daylight factor and daylight penetration analysis. Computer simulation models were created for the base case and all proposed daylighting designs for building energy performance evaluation using the DOE-2 building energy simulation program. One design each from the skylight and clerestory cases, and an overall design based upon specific performance criteria are proposed for the existing school building.

1. INTRODUCTION

The rising world population has a detrimental effect on the limited and constantly decreasing natural energy resources. Renewable energy sources have been neglected sources, with renewable power generation accounting for a very small percent of world primary energy production. Most energy produced today in the United States comes from fossil fuels. According to the U.S. Department of Energy, K-12 schools spend more than $6 billion a year on energy costs and at least a quarter of that could be saved through smarter energy management. The typical school district spends $400,000 each year on utility bills while those in huge metropolitan areas may spend $20 million or more. Daylight is a free, readily available renewable energy resource. A review of past literature on this topic indicates that daylighting can reduce building energy consumption and can lead to a significant increase in students' test scores and promote better health and physical development. This study is part of an M.S. Architecture thesis project undertaken at Texas A&M University that evaluates the effects of daylighting in an existing elementary school building.

2. THE CASE STUDY BUILDING

The school under consideration is one of five elementary schools under the College Station Independent School District (CSISD) administration, and has a total built-up area of 69,000 square feet.

The building is single storied and the front faces northeast. The building spaces considered for daylighting analysis consisted of 2 classrooms each on the north, south, and west side, and the central library space. The total area of the school under analysis was 10485 sq. ft. This area is approximately 15% of the total school building's built-up area.

3. METHODOLOGY

Three methods were used in this study. These consisted of: case study building analysis for actual interior daylight measurements, use of a physical scale model to study proposed top-daylit options, and use of the DOE 2.1e computer program for daylighting and building energy analysis.

3.1 Design information

Permission to conduct research in the CSISD was obtained from the Research Review Committee of the CSISD administration. The design information required to study the case study school spaces using physical models and computer simulation models was gathered. The as-built architectural drawings were obtained from the Architect for the school, and were used in construction of the physical model and also supplied required details for the computer simulation model input. The as-built mechanical drawings, measured hourly electricity use, and measured monthly natural gas use data was obtained from the Energy Systems Lab (ESL) at Texas A&M University. These were used to define the mechanical details in the computer simulation model. Figure 1 shows the plan of the school building.

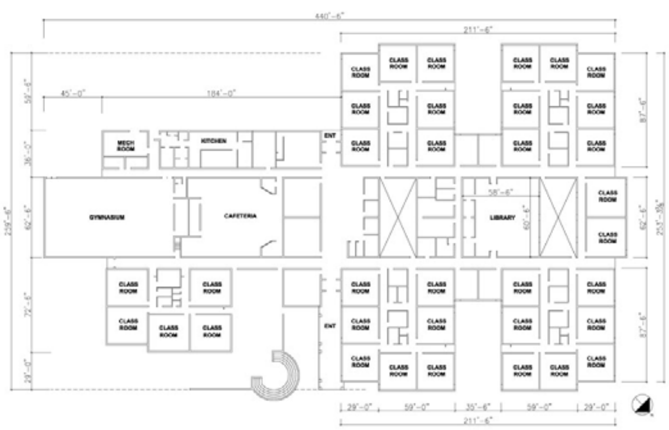

Fig. 1 Plan of the case study school showing classroom and library spaces.

3.2. Proposed daylighting options

Skylights and clerestories were proposed as the two daylighting options for this school building. The details of the proposed designs for a typical classroom are presented in Figure 2. A similar design was applied to the library space, except 4 skylights and 2 clerestories were used to serve the larger built-up area of the library. Skylight areas considered for analysis ranged from 1% to 10% of glazing to total roof surface area, and clerestories ranged from 2 ft to 6 ft of glazing height. All clerestories except the 2 classrooms on the south faced north.

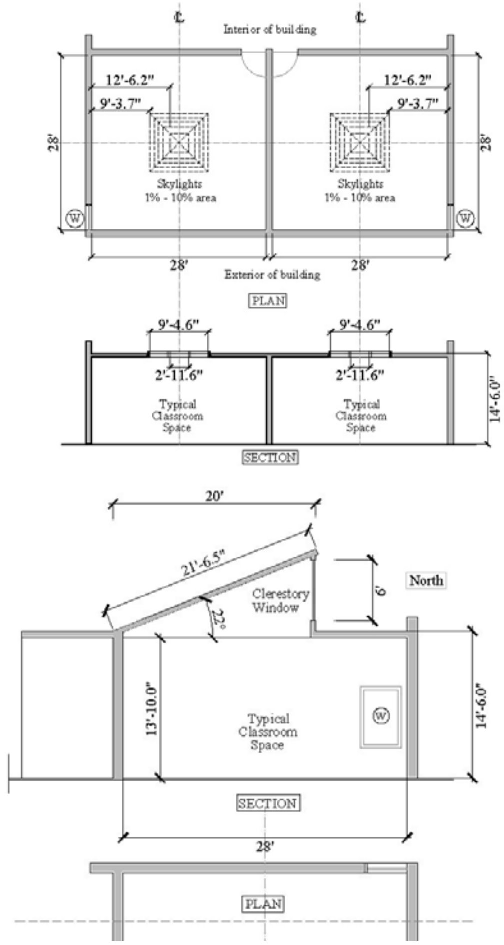

Fig. 2 Plan and section of typical classroom showing proposed skylight and clerestory cases. The dotted lines in the skylight cases indicate the varying sizes of skylights.

A physical scale model of the analysis spaces was built to a scale of 1 inch = 1 foot. Interior model reflectances were matched with their respective actual surface reflectances from the case study site. Flexible model materials were selected in order to experiment with different daylight openings. The window openings were treated with 1/8" glass to correspond with the glass openings in the actual space. Similar treatment was used for all the top-lighting solutions that were experimented with in the model. The model roof was not fixed, and could be substituted for different combinations of skylights and clerestories. Adequate openings, other than the windows, were provided in the walls to insert the cables for the light meters, and also for taking interior photographs using a digital camera. Figure 3 shows the base case model without a roof, a modified 2 feet glazing height clerestory case, and a modified 7% skylight case.

Fig. 3 Physical model photographs: base case with no roof, 2 ft glazing clerestory, and 7% glazing skylight cases.

The DOE-2.1e computer simulation model was built using available architectural and mechanical data. Figure 4 shows a DrawBDL representation of the base case model, a 2 ft glazing height clerestory and a 3% skylight case as modeled in DOE-2. Daylighting commands were added to the DOE-2 daylit base case input file in order to perform daylighting calculations. Skylight and clerestories were added to the analysis spaces, and their effect on daylight illuminance and building energy consumption was analyzed.

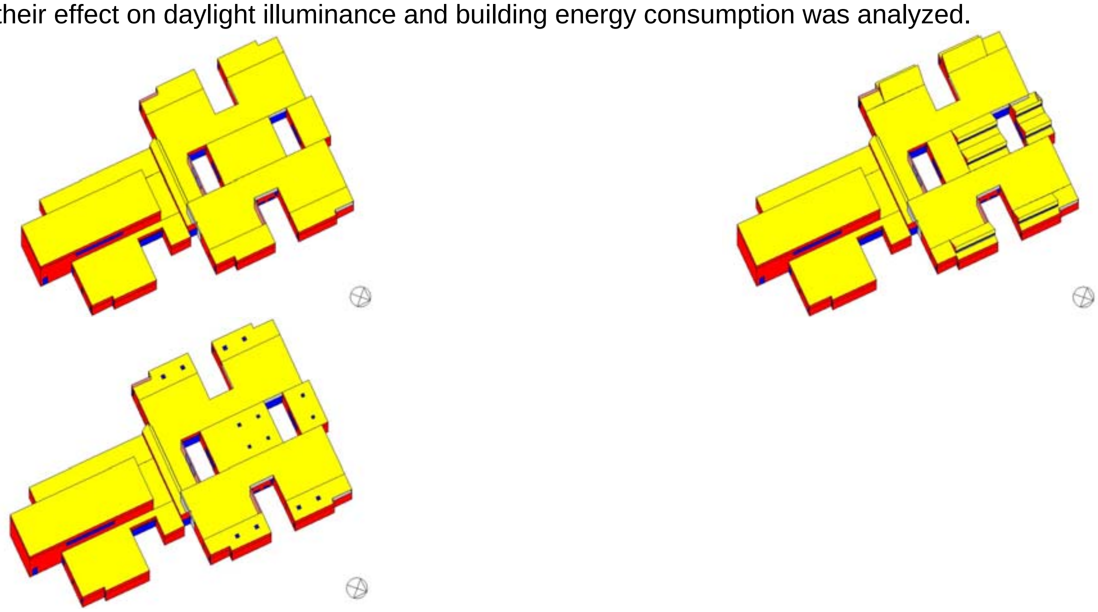

Fig. 4 DOE-2 models showing base case, 2 ft glazing clerestory, and 3% glazing skylight cases.

4. ANALYSIS AND RESULTS

4.1 Daylighting analysis

Calibrated DOE-2 and physical scale models were used for daylighting analysis. The DOE-2 model was calibrated to the measured hourly electricity use and monthly natural gas use. The physical model was calibrated using actual space illuminance and luminance values. Daylight factors measured in the analysis spaces, measured in the physical model and calculated by DOE-2 were compared. Daylight factors from the physical model and DOE-2 were found to be lower than the actual site values. This discrepancy was attributed to various factors, the main being the presence of ceiling-hung television sets near the windows in classrooms. Other factors could be the actual window transmittances, internal light reflections due to furniture and blackboards inside the classrooms, and the presence of trees outside the spaces.

The second part of the daylight factor analysis involved a comparison between the DOE-2 values and the physical model values for the proposed skylight and clerestory designs. Minimum and maximum skylight and clerestory cases (1% and 10% for skylights and 2 ft and 6 ft for clerestories) were considered for comparison. The daylight factors obtained from the physical model were found to be more than the factors from DOE-2 in both the skylight cases. The difference was approximately 2 times in the 1% case and approximately 4 times in the 10% case. In the minimum (2 ft) clerestory case, DOE-2 values were consistently higher for all the spaces, whereas they showed an irregular trend for the maximum (6 ft) case. DOE-2 calculated daylight factors were found to be inaccurate and hence daylight factors from the physical model were considered for further analysis.

A FUNCTION input was added to the DOE-2 input file in order to replace the daylight factors calculated by DOE-2 with user-defined daylight factors (in this case, physical model daylight factors). The functional input used for this study is similar to the one developed by M. Steven Baker from the Oregon Department of Energy. For actual input details, please refer to the publication in the *Proceedings of the Solar Energy Society Conference, Denver, Colorado, 1989*. A comparison of the DOE-2 output before and after the use of the FUNCTION command showed a distinct difference in energy use and space illuminance values in all the spaces (reduction in energy use and increase in illuminance).

4.2 Space daylighting summary

The space daylighting reports from the DOE-2 output were analyzed to understand the effect on lighting energy reduction and space illuminance values in all the analysis spaces through the use of daylighting.

Comparisons were made between all the proposed cases with reference to a daylit DOE-2 base case.

Average lighting energy reductions of 48% and 57% were observed for the skylight and clerestory cases respectively. The lighting energy reductions as compared to the daylit DOE-2 base case were 26% and 33% for the skylight and clerestory cases respectively.

Average space illuminance values of 76 footcandles and 80 footcandles were observed for the skylight and clerestory cases respectively. The increase in the average space illuminance (all spaces included) was 44 and 47 footcandles for the skylight and clerestory cases respectively as compared to the daylit base case.

4.3 Building energy analysis

A comparison of energy consumption between the daylit and non-daylit DOE-2 base cases showed a decrease in lighting energy throughout the year for the daylit case, whereas the cooling energy also decreased, especially in the hot season between the months of April to October. The base case daylit model indicated a decrease in whole building electrical energy throughout the year, but the heating energy showed negligible increase or decrease for any of the months. The base case daylit model performed better than the non-daylit base case model.

4.3.1 Lighting energy analysis

To better understand the effect on lighting energy use, the different daylighting cases (skylights and clerestories) were analyzed for March 21, June 21, September 21, and December 21 (vernal equinox, summer solstice, autumnal equinox, and winter solstice). The lighting electricity energy consumption was seen to be consistently lower than the base case in all the cases for all the four typical days, with a maximum of 16.5% reduction for the 10% skylight case, and a minimum of 11.5% for the 1% skylight case. The most savings were observed on the day of March 21. The clerestories showed a similar trend, with a maximum of 16% reduction for the 6 ft case, and a minimum of 14.9% for the 2 ft case. The most savings were observed to be on the day of September 21, followed by March 21.

4.3.2 Cooling and heating energy analysis

Hourly cooling and heating analyses were performed on September 21 and December 21 respectively, being the hottest and coldest days of the year. Though the cooling energy showed a clear decrease in the daylit base case, there was a consistent increase in the cooling energy between the daylit base case and the different skylight and clerestory cases. This effect was attributed to heat transfer through the glazing materials of the skylights and clerestories. The absence of additional glazing during the base cases comparison might have led to the decrease in the cooling electricity energy consumption. The cooling electricity use increased with increasing skylight to roof ratio and higher clerestory glazing size. No noticeable trend (increase or decrease) was observed in any of the cases during hourly heating energy analysis. The heating energy remained almost constant for all cases studied.

4.4 Energy Savings and energy cost savings due to proposed designs

The 1% and 3% skylight cases and the 2 ft clerestory case were the 3 cases that provided some cooling energy savings whereas all other cases showed a loss. Lighting energy savings were the highest at 14.70% for the 6 ft clerestory glazing, followed closely by the 10% skylight case at 14.52%. These two cases performed the worst though in terms of cooling energy saving. Clerestory cases performed better than skylight cases in terms of heating energy (natural gas use) savings, with all clerestory cases showing positive, though minimal savings. Total electricity use was best in the 3% skylight case and the 2 ft

Skylights	Energy Savings (%)	Energy cost savings($)	Clerestories	Energy Savings (%)	Energy cost savings($)
1% Skylight Area	2.65	2311.51	2 ft glazing	3.17	2742.97
3% Skylight Area	2.95	2569.53	3 ft glazing	2.99	2577.23
5% Skylight Area	2.65	2295.38	4 ft glazing	2.77	2374.13
7% Skylight Area	2.39	2063.72	5 ft glazing	2.53	2157.23
10% Skylight Area	1.76	1536.98	6 ft glazing	2.29	1934.93

Fig. 5 Energy savings and energy cost savings from the proposed daylighting options

clerestory case, the 2 ft glazing case performing slightly better than the skylight case. The 3% skylight case was the best among the skylight cases, while the 2 ft glazing performed best in the clerestory category. In all, the proposed cases perform better than the base case in terms of total energy savings.

Total average annual energy savings of 2.6% and total average annual cost savings of $2500 were achieved through the application of any of the proposed designs.

An important factor to be considered is the area of the spaces under analysis. The sum of the built-up areas of all analysis spaces was just 15% of the total built-up area of the school. The proposed daylighting options have been limited to this 15% area, and the estimated energy and cost savings reflect the effect of the modifications made to this 15% area on the entire school building. Under the circumstances that the entire school building is daylit through the use of skylights or clerestories, the projected savings would be much higher than the present calculated value.

6. CONCLUSIONS

Daylighting has a direct effect on building energy consumption and interior daylight illuminance levels. Use of daylighting reduces the total building energy consumption and has a high potential for lighting electricity savings. Assuming that about 80% of the total built-up area of the school can be daylit, if the savings for the 15% analysis area can be used for the whole school, simple extrapolated savings would be:

Total average annual energy savings of 14%, corresponding to around $13000 in annual cost savings; and

Total average annual lighting electricity savings of 66%, corresponding to around $7500 annual cost savings.

7. ACKNOWLEGDEMENTS

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Dialectical Ecologies at Hulsey Yards

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ABSTRACT

Rural wooded lots, green pastures, desert landscapes, open plains, and mountain cliffs. These spaces appear to be the ideal setting for ecological design, according to recent publishing. At these “out-there” sites, solar orientation is registered. Surface treatments are hung. Fins are cantilevered. Water is recycled. Roof grass is planted. Geothermal technologies are buried. Low voc paints are brushed. Higher efficacy machines are specified. While the value of these ecological strategies and use of new green products is clear, not even one hundred million new solar houses could environmentally redeem the unforgiving amount of low-density greenfield development built during the last twenty-five years. This paper argues that decoupling the eco-tec project from the urban one is futile, and that the bottom line of sustainability is not the individual low-entropy building but urbanism.

1. INTRODUCTION

1.1 Eco-Social Dynamic

In a review of a dozen books published between 1996-2002 on sustainable architecture, historian Richard Ingersoll reaches the conclusion that in order to “dismantle the burden of determinism” associated with the ecological design movement, the emergence of a “dialectical ecologist” seems more valuable to the ecology movement today than all its good intentions or innovations. (1) Ingersoll drives the point home that decoupling the innovative eco-tec project from the urban one is futile. He writes, “any theory of design and ecology must acknowledge that the bottom line of sustainability is not the individual [efficiently-designed] building but urbanism.” For Ingersoll and others, without urbanism, all of the right eco-tec building in the world will not add up to much.

And yet buildings worldwide, more than any other urban infrastructure, are responsible for about 40% of CO_2 emissions, the US being the largest culprit by far. Despite a US governmental pledge at the 1992 Earth Summit in Rio to reduce emissions of green house gases, air pollution is increasing - over 60,000 Americans die each year from air pollution alone. In 2000, carbon dioxide emissions were 14% higher than they were in 1990. (2) By the year 2020, world population will have grown from six to eight billion. In effect, a reduction in energy consumption in buildings is a design imperative, especially from the world’s largest consumer.

It is in this tensional space between the urban project and the ecology one that prompted a “dialectical research method” for a graduate design studio located at Hulsey Yards in Atlanta, Georgia. Following environmental philosopher Allen Carlson’s call for “an appreciation of paradoxes and dialectical relationships,” a multi-phase eco-urban research agenda was developed where complexity and conflict could be nurtured. (3) Strategizing a critical approach to ecological design, the studio process set out to incorporate conflict and dissimilarity ~ conflating what James Corner calls “modernist dualities into fantastic worlds of mutuality, paradox and difference." (4) Rather than object architectures - too often associated with contemporary green building despite all the right intentions - this studio sought out "environmental architectures," architectures associated with a new understanding of building as a *field of forces*, both natural and cultural. A 35-acre post-industrial, inner-city site became a space of reciprocity between collaborative and individual work for twelve graduate students in their final year of study. Students were encouraged to think in unconventional ways about making environmentally responsible buildings that contribute to vital, local place-making. The results of the research fed a range of issues including lifestyle, landscape, structures and materials. It also raised doubts and shed new light regarding many well-worn definitions of ecological architecture.

2. DIALECTICAL RESEARCH METHOD

2.1 Environmental Science and Ecocriticism

Environmental science, in one form or another, has formed the central part of ecological discourse. This is particularly evident in architecture. When addressing the subject of ecology, most architecture programs prescribe two required environmental [control] systems courses in their curriculum. The second law of thermodynamics serves as a starting place. Energy is plotted. Solar angles are graphed. Gravitational forces are registered. Thermal flows are demarcated. Comfort is mapped. These environmental science principles are fundamental to shaping new alternative energy systems, as well as, eventually, the plan and sections of our new buildings. The science behind the environment continues to prosper, generating new technologies, new construction systems and new green products. Evidence of such is well documented and marketed. Since the 1960's, environmental science has been a primary force behind the work of many of leaders in the ecological design community [Soleri, Fisk, McDonough, Addington, Dunster, Yeang].

Set in dialectical relation to this exercise - following the dialogic framework of the studio - students were simultaneously introduced to ecocriticism, or green criticism - one of the most recent interdisciplinary fields to have emerged in literary and cultural studies. David Teague loosely defines ecocriticism as the study of the mutual constructing relationship between culture and the environment. (5) For Ursula Heise, it is defined as the role that the natural environment plays in the imagination of a cultural community. It examines how the concept of "nature" is defined, what values are assigned to it or denied it and why, and the way in which the relationship between humans and nature is envisioned. More specifically, it investigates how nature is used literally or metaphorically in certain literary or aesthetic genres and tropes. This analysis in turn allows ecocriticism to assess how certain historically conditioned concepts of nature and the natural, and particularly literary and artistic constructions of it have come to shape current perceptions of the environment. (6)

Andrew Ross' essay "The Social Claim on Ecology" introduced the students to ecocritical thinking. Ross does not deny the physics of the environment or the reality of environmental degradation. However, he is exceedingly skeptical of the role and weight that environmental science has to diminish global warming and alike. If scientific methodology is, after all, essentially relative, he argues, how does on ascertain claims of real scientific improvement. For Ross, environmental degradation is, in the end, not a scientific problem but a cultural or urban one. Before anything like sustainable development can be made effectual, according to Ross, economic, social, and cultural inequalities must be addressed. (7)

It is in this tensional space between environmental science and ecocriticism that students were asked to situate them selves and their work. In terms of environmental science, the studio was divided into three teams of four students. Each group was charged to investigate one the four elements - air, water, sun, and earth - extending the lessons they learned in their required environmental systems courses. They collected technical data, sorted it, and organized it into five categories: properties, principles, problems or issues, applications and design considerations. Each team also presented two case study projects that were driven in large part by the forces inherent to the element they studied – one at the urban scale and the other at the building scale. They were called upon to reveal both the conceptual ideas and specific strategies of the projects as they pertain to one of the elements. At the same time, students were introduced to a series of green topics drawn from a collection essays in “The Nature of Cities: Ecocriticism and Urban Environment.” Topics included urban wilderness, American pastoralism, urban nature, nature in suburbia, the urban park, working landscapes, urban ecofeminism, environmental justice, urban fauna, and simulacra of nature. As a group, these topics provided the parameters for an ecological component often missing from cultural analyses of the city and an urban or socio-cultural perspective often lacking in environmental approaches to contemporary culture.

2.2 Eco-Tectonics in an Ecology of Sprawl

In her book “Building Suburbia,” urban theorist Dolores Hayden acknowledges “the contributions of architects who create green architecture. Citizens can see substantial demonstrations of better ways to plan and build.” But, she adds, “New designs alone cannot redeem a throwaway culture organized around the continual consumption of un-developed land.” As Bill Dunster writes, we are a culture currently consuming enough resources to need three planets to survive. (8) Even a program for one hundred million new solar houses could not make the United States sustainable. Hayden’s argument is if the United States is to become a more sustainable and more equitable place, existing under-developed territories have to be saved rather than abandoned on the way to making new projects." (9) For Hayden, Dunster and others, there is little point to build energy efficient buildings if transport and food miles are not first addressed. The rate of suburban expansion must be slowed, and in turn, the rate of urban infill must be expanded.

Hayden’s point resonates in Atlanta. During the last twenty-five years, Atlanta has produced more than its share of unchecked suburban growth. While economically popular, this wasteful, placeless form of development has led to unforgiving amounts of low-density greenfield development, homogenous subdivisions, unparalleled long-distance travel routes, and reportedly some of the worst air and water pollution in any US city. The environmental impact is dramatic and unsustainable. Thermal glass, solar panels and green roofs are simply not up to the task of competing with this scale of earthly transformation.

So one might ask, why has ecology primarily produced mechanical or prescriptive methods in individual buildings in light of the possibilities for a vibrant exchange between ecology and urbanity? Why is there ambiguity over ecology’s content and relationship with urbanism? Why hasn’t the transformative phenomena of ecology had a greater effect on the production of urbanism? Why has ecological design been drawn more from objectionist and instrumental models of ecology, while design creativity has all too frequently been reduced to dimensions of environmental problem-solving? This lack of inventiveness is both surprising and difficult for many architects. This is especially true for those who entered the field believing that ecology and artistic creativity might together help develop new and alternative forms of architecture and urbanism.

2.3 Green Transit and Urban Redevelopment

Arguably, much the same way as an infrastructure of highways led to suburban expansion and urban depopulation in the last twenty-five years, an expansion of mass transit infrastructure will lead to both the revitalization of neglected urban land and the protection of our natural ecology and resources. This urban repositioning led the studio to piggy-back the Belt Line Atlanta Project.

Begun as a Planning Thesis at Georgia Tech in 2000, The Belt Line Atlanta Project is a green transit and urban redevelopment project that is now the focus of a $1 million study by the

Georgia Department of Transportation. (10) The proposal consists of a 22-mile light rail loop with 45 stations that would weave through the city on existing railroad rights-of-way. It would also intersect with five existing MARTA [Metropolitan Atlanta Rapid Transit Authority] stations. The Belt Line would consist of an hour and a half journey through over 4,000 acres of neglected urban sites. With over half of that land suitable for residential and mixed-use development, approximately 100,000 residents could be accommodated in new mixed-use, brownfield, transit-oriented districts.

Hulsey Yards has been designated as the location of one of the 45 stations. It has historically been associated with Atlanta's rail system since the mid 19^{th} c. In 1979, MARTA opened several new transit stations, including both the Inman Park/Reynoldstown station and the King Memorial station, located at the east and west ends of the site respectively. The King Memorial station is the highest station in the Atlanta system, the tracks being 51 feet above ground. Since 1985, Hulsey Yards has been owned and operated by CSX, a major U.S. freight carrier.

Hulsey Yards is also located at the nexus of four historic neighborhoods. Each has a unique history of its own. Inman Park is Atlanta's first garden suburb. Located northeast of Hulsey Yards, it was conceived and developed by Joel Hurt, an Atlanta entrepreneur in the 1880s. It included large lots, curving streets, lakes and open park areas throughout the neighborhood. In 1973, Inman Park was officially listed on the National Register of Historic Places. Reynoldstown, located southeast of Hulsey Yards, was founded after the Civil War, when freed slaves came to settle and find work rebuilding the railroads. The community's residents became carpenters, mechanics, maids and teachers. In 1952, the Reynoldstown Civic Improvement League (RCIL) was organized during a time when the city was segregated and voting rights were denied to its predominantly African-American residents. The RCIL is still very active, with missions that include preserving the character of the neighborhood, improving quality of life for residents, encouraging diversity and participation in community. Cabbagetown is Atlanta's oldest industrial settlement, located southwest of Hulsey Yards. Founded in 1885, the community supported labor at the Fulton Bag & Cotton Mill. Many of the laborers were recruited from the North Georgia Appalachians. The workers brought their rich heritage with them, including religion, crafts, folklore, music, and their land ethic. Artists, musicians, and students discovered Cabbagetown's eccentric character and affordable homes, and were among the first new residents. Today, Cabbagetown has an eclectic population of young families, artists, musicians, students, and professionals. Many of the shotgun cottages have quaint gardens and large porches. The Old Fourth Ward neighborhood is located northwest of Hulsey Yards, near the Sweet Auburn district, where Martin Luther King, Jr. was born and raised, and where he preached. Recently, residents and the City government have taken steps recently to restore the neighborhood. An example fitting to this project, Dynamic Metals Lofts opened in 2004 on the site of an abandoned scrap metal yard. The site was an environmental challenge. Demolition revealed the residue of the site's history in remaining petroleum hydrocarbons, chlorinated solvents and heavy metals. The project represented the first voluntary clean up under the Georgia Brownfields Clean Up Act and received the US EPA Regional Brownfield Award in March, 2004. (11)

Students were charged to unearth the urban histories of these neighborhoods, sorting through their findings and organizing it into four categories: history, culture, demographics, and ecology.

2.4 Mapping Relationships and the Subdivision of Blocks, Lots, and Rooms

A mapping method was used to solicit relationships between the two prior phases. Students were asked to brainstorm a list of connective measures, sort their conclusions into categories that made sense to them, and rate each item regarding how important they were to the place at hand. A questionnaire was given to the studio-wide group who developed a list of physical variables plausibly related to innovative outcomes. They rated the importance of those items, developed hypotheses and each selected one that became the basis of their individual design studio project.

Various subdivision strategies of Hulsey Yards - into streets and blocks - were developed. Each strategy weighed the role and relevance of the urban and ecological forces of the site. Differences in weight shaped alternative organizational strategies of the site. Each group of students was asked to propose a subdivision scheme [street and block configurations] on a 30-acre site adjacent between MLK Jr and Inman Park/Reynoldstown MARTA Stations. At Hulsey Yards, it was not immediately clear where the actual Beltine right-of-way would be located at Hulsey Yards. The subdivision schemes incorporated different positions of the Beltline. After a couple of weeks, studio members reached consensus around a combination of two of the four schemes, but eventually incorporated attributes of all four schemes. Each of the twelve students selected an individual block to design within the overall subdivision scheme. Blocks ranged in size from 100'x400' [smallest] to 200'x700' [largest].

Following, each student subdivided their block into lots. A set of rules were established. Each block had to be divided into privately-owned lots. Minimum area of the block was to be dedicated to common space. The maximum lot size was thirty feet by one hundred and twenty feet. The maximum lot coverage was seventy-five percent. The minimum car/unit ratio was one car for studios and one bedroom’s and one and a half for anything larger. These car/unit ratios are less than code. Finally, and perhaps most oddly, there could be no elevators at Hulsey Yards.

Given these rules, each student was asked to calculate a) the highest possible density on their block; and b) the maximum number of lots on their block. Searching for the maximum was in fact an arduous task, as it required, unbeknownst to the students, a firm knowledge of housing. They had to quickly move from looking at the problem from the outside. The classic "inside-outside" lesson became central in this exercise ~ that is, an understanding that the organizational structure of the house, with its conventional dimensions of bedrooms and bathrooms and hallways and doors and door-swings, eventually has everything to do with the organization of the building on the lot, the lot on the block and the block layout at Hulsey Yards.

3. THREE STUDENT PROJECT EXAMPLES

3.1 Light House

This vertical, metallic, tower-like project recalls the cultural history that industry and the arts have played at and around Hulsey Yards. The scheme was designed fo smaller families, artists and artisans and students. Given the narrow dimension of the block and slope of the site, the “double-front” condition was one of the unique aspects of this scheme. The primary site strategy was modernist in approach, elevating buildings off the ground. Bearing lightly on the earth, 80% of site remained pervious surface, applying a combination of surface textures including grass, gravel, grasscrete, and water retention areas. Parking surface areas were sloped and located partially below grade. This provided environmental protection for the cars and screened them from the housing above. The water that naturally flows into these partially sunken parking areas is led to a horizontal retention trough for grey water use. Staggered arrangement of the dwellings on the block generated complex views. Various degrees of natural ventilation could be accessed through multiple sliding perforated metal screens with double-glazing behind. Screens could be opened for views to the neighborhood or for direct sunlight and fresh air. The metallic surfaces afford low maintenance and recall the industrial nature of the site. No exterior paint or other similar finish on-site treatments were necessary. The double-skin roof system incorporated photovoltaic panels and solar hot-water heating.

3.2 Co(ol) Habitation

Two primary agendas directed the design of Co(ol) Habitation, the project with one of the highest densities in the studio. The first is cooling. The second is cooperative housing. The courtyard as a type was used to address both ecological and urban agendas. Referring to selected research on cooling associated with courtyard design [Reynolds] and on courtyard housing more generally [Sherwood], ecological and social agendas were conflated in plan and in section. The courtyard provided opportunities for adjacent units to meet if so desired. Integral screening mechanisms using recycled honeycomb plastic panels allowed for privacy when needed. Taking advantage of the mild slope from south to north, a parking deck was sunk five feet below the high point of the site, with integrated rainwater cisterns. The first floor was raised five feet above grade and surfaced with reused railroad ties. Applying stack effect principles, cool air from the parking deck was drawn up through the section of the building.

3.3 P.O. Box

This project explored the idea of a "porous open box." The porous open strategy was a response to a formal investigation of cross-ventilation and daylighting, and operates at both urban and building scales. At the urban scale, porosity drives the urban order of the block. Serving primarily larger families, this occurs by separating the townhouse-like buildings from one another enabling air circulation between the buildings. Akin to the shotgun house type, the 1x10x5 ratio of the outdoor space between buildings increased air pressure and thus air movement through the block. The level at grade was also perforated. This allowed for openings into the parking structure below, for daylighting and air exhaust and greywater storage. Programmatically, the spaces between the buildings serve as gardens with native landscaping. Some included open riser staircases to provide access to units above. At the scale of the building, the "ventilated plan" and "ventilated section" optimized air flow in both the x and y axes or horizontal and vertical spaces. Interior openings varied in dimension. Some were as small as one foot by two feet and as large ten feet by ten feet. The openings occurred not only between floors within the same unit but also between floors of different units. In these cases, the openings became air shafts, either to the garden space or garage level below. The porous strategy also included pixelated skins for solar protection. At the ground level, facing the Belt Line, music and religious shops, as well as a corner market, were interspersed with open porches the size of living rooms, enabling interaction across public/private boundaries.

4. CONCLUSION

Final density across Hulsey Yards was 30 units/acre. The lowest unit/acre on a single block was 20 and the highest 40. Density variation from block to block was perceived positively. Total added residential population on site was approximately 1,400 persons. In the end, maximum densities were trumped by seeking higher quality living conditions, defined in large part by creatively employing passive ecological strategies. Overlaying urban agendas with ecological ones were demanding. Surprisingly the program type most familiar to students, namely housing, became the most difficult to grasp. This may be a by-product of where most students grow up these days, the very problematic that this studio aimed to address.

If the United States is to become a more sustainable and more equitable place, existing under-developed urban territories have to be saved rather than abandoned on the way to making new projects. There is little point to build energy efficient buildings if transport and food miles are not first addressed. The bottom line of sustainability is not the individual low-entropy building but urbanism.

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The Analytical and Alternatives Generation Phases in Urban Design Practice in US Cities. The Case Study of Pittsburgh Development Plan 2001

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ABSTRACT

According to some experts, urban design plans adopted in US cities are often developed without being underpinned by relevant analytical content, or are not based on in-depth analysis for the specific problem of the study area. There may be need to examine current urban design plans to provide local authorities with new processes that would improve urban design and implementation. This paper examines the analysis and alternatives generation methods used in a selected case of urban design practice in Pittsburgh and compares them against various theoretical conceptions. It attempts to establish gaps in its methodology and to explore the extent with which the analytical content underpinned the design solutions. It has been found that the plan's content has emphasized the role of research and analysis in its methodological framework and had a significant impact on the development plan yet with various degrees of success. The paper identifies the methodology and techniques adopted in both phases, and highlights the gaps in each phase as well as gaps between both phases. The paper found that the analysis phase and the analytical content have had significant impact on the general and the specific levels of the development plan yet with different degrees of success. In sum, the policies were generally good at expressing the analytical content and consultative bases of policies.

1. PRELIMINARIES OF THE DEVELOPMENT PLAN: THE HISTORICAL AND URBAN CONTEXT

Recent urban development of Pittsburgh features three main distinct stages throughout which it has been regarded a model of public /private development. In the first stage during the 1940's and1950's, it was the site of the first American urban development project. It is believed, according to Garvin (2002), that Pittsburgh would not rank sixth in the nation as a major corporate headquarters center if it had not virtually rebuilt its downtown through this project and other related projects such as Point State Park and the gateway center office complex at the confluence of the Three Rivers,[47] one of the city's nationally recognized icons (Garvin 2002, p.3). At the second stage during the building boom of the early 1980's, a number of large corporate towers and mixed-use projects were built in the commercial core of the Golden Triangle which is defined by the Three Rivers. At the turn of the 21st century which marked the rise of a third stage of Pittsburgh's development, the regional economy completed its transition from manufacturing to a more varied and diversified base primarily driven by technologies and knowledge-based enterprises (Stern 1998, p.25).

[47] - Monongahela, Ohio, and Allegheny Rivers.

In spite of the major economic and social changes throughout these stages, Pittsburgh's Downtown maintained its competitive advantages and efficiencies over suburban locations such as the high concentration of the region's office space[48], the strong architectural character and sense of history and place, and its location at the center of the region's radial transportation system. Therefore, Pittsburgh's Downtown maintained its role as a regional center of business and employment, which includes its role as a transportation hub, a symbol of national and international recognition and identity, and a main stage for business, ports, and cultural achievement (Downtown Development Plan, 1998, p.3). However, certain stress points evolved gradually in its urban fabric and lead the city to experience certain weaknesses relative to its fast-growing surrounding suburbs. The Downtown has remained largely a 8:00 AM - 5:00 PM business center with a vulnerable retail district, an underachieving entertainment sector, a meager residential population, worsening traffic congestion and parking shortage, and limited riverfront access and amenities despite its prime setting (Stern 1998, p.25; Downtown Development Plan, 1998, p.3).

In light of these realities, it was essential to develop a comprehensive development strategy to address the afore-mentioned stress points and to manage the major economic changes in its Downtown that occurred since the last development plan in 1961. Hence, *Pittsburgh's Downtown Development Plan (PDDP)* is meant not only to address the downtown's weaknesses but also to integrate the ongoing and proposed development projects. The plan's explicit and foremost goals were transforming Pittsburgh Downtown into an 18- to 24-hour city, and integrating ongoing public and private development and planning proposals, including transportation and public infrastructure, into a "comprehensive 10-year vision"(Stern 1998, p.25; PDDP, 1998, p.3). The mission of the development plan was "creating a vision" for Pittsburgh's downtown within which the plan aimed at creating a downtown of a great social and economical diversity that could serve the maximum number of citizens.

2. SCOPE AND APPROACHES OF THE DEVELOPMENT PLAN

2.1 Scope of the Development Plan

Although the Golden Triangle, the area bounded by the Three Rivers and the Crosstown Expressway, has traditionally defined the Downtown (Figure1), the plan extended the scope of the study area to include other surrounding areas such as the north and south shores as integral parts of the anticipated downtown development (Figure 2). This conceptual shift from the downtown's traditional limits meant that the plan has re-imagined downtown as encompassing the entire "Three Rivers Basin" with the rivers flowing through the heart of the city rather than dividing it. In a broader scope, the plan also considered the downtown's regional context within metropolitan Pittsburgh to strengthen the downtown's role as the core of the city and to help maintain its regional role in all aspects of urban life. Accordingly, PDDP considered downtown development at three concentric levels: the traditional downtown, the development plan study area which includes the traditional Downtown as well as its surrounding areas and shores, and the regional context of Pittsburgh's downtown.

2.2 Approaches of the Development Plan

2.2.1 The Collaborative and Multidisciplinary Approach

The initial step in the plan's development process focused on designing an action plan to guide and advance each stage of the process. It involves defining a team structure which consisted of four key participants: the oversight committees, the community task forces, the planning group, and the core team that would generate and serve as a container of

[48] Two thirds of the regional office space is located in Pittsburgh Downtown.

information (PDDP 1998, p.7). Each team was assigned certain tasks which helped create a multi-disciplinary collaborative professional environment. The Oversight Committees formed a partnership to bring the diverse technical, financial, and managerial expertise to the development process. Community Task Forces that correspond to the six focus areas of the development plan convened a diverse group of business leaders, administrators, design professionals, residents, clergy, and other concerned citizens (PDDP 1998, p.7). The planning team invited public participation and conducted detailed research and analysis to inform the development plan and underpin its design policies with analytical content.

2.2.3 Design and Development Approaches

The plan states that:
………..*there is no right way to organize an effort as complex and all-encompassing as Pittsburgh Development Plan. Its attempt was to be inclusive at every turn and to create a process that covers as much ground as possible and allows ideas to surface* (PDDP1998, p.7).

The plan's methodology adopted two main approaches that affected the plan's structure and the type of its design guidance. The first approach, which affected its structure, was breaking the plan into a series of interlocking parts in the form of six focus areas that could contribute vitality and strength to the whole. In another breakdown, the development objectives and projects were broken into two phases. In phase one (1-4 years), most projects were proposed inside the traditional boundaries of Pittsburgh Downtown and were integrated with transit and pedestrian improvements[49]. In phase two (5-10 years), the emphasis in development projects shifts into the areas surrounding the traditional downtown.[50] The second approach which affected design guidance was combining two types of design guidance. The first, highly prescriptive guidance, contains fixed requirements for mix/density, sets out a road layout, and provides an indicative site layout. The second, enabling guidance, places most emphasis on design and the relationship between buildings, vehicles, and the landscape, with minimal restriction on layout and access position (Turner 1994, p.297). This approach facilitated flexible change of design control and level of details in both, focus areas and districts. For each focus area, an agreement was first reached on broad principles that subsequently laid the foundation for a general development strategy of the plan. Therefore, the design guidance involved emphasis on design elements at various hierarchical levels ranging from the intermediate scale of landscape and urban design considerations to the detailed issues of architecture and urban management.

The adoption of both approaches may be viewed as a response to two various attributes of PDDP. The first is the variety of the plan's goals from the broader level of development plan such as integrating the work of task forces and focus areas to the more specific level of urban design focus areas such as studying the physical implications of development proposals. The second is the multiple levels of details in designing the different districts of PDDP which was essential to address the diverse types of developments proposed within the study area at both design phases.

3. METHODOLOGY OF THE ANALYSIS PHASE

[49] Of eleven projects proposed in this phase, six were proposed inside traditional Downtown, four were outside it, and one project was a connecting bridge across one of the rivers.
[50] Of ten projects proposed in this phase, one of them only was located inside the traditional downtown, and the others were distributed throughout the surrounding areas.

Urban design process operates within a wide range of scales, which necessitates different levels and techniques of analysis. This section explains the levels and techniques of the analysis phase in PDDP, and compares them with their counterparts in theory.

3.1 Levels of Analysis

Analysis in urban design practice takes place at three various levels: the level of town in its landscape setting, the level of the built-up area which is subdivided into various urban areas that share specific homogeneous form characteristics, and the level of urban space in each of these urban areas (Gosling 1993, p.216; Skauge 1995, p.427). Carmona et al (2003) defines the analysis levels with different hierarchical order: district/region-wide, area-wide, and site-specific-wide. However, PDDP methodology did not structure and organize the analysis process according to scale criterion but under three various headings of tasks that were conducted progressively as the plan's content develops from general to specific issues.

The first analytical task was collecting and analyzing existing information about the downtown area in relation with its urban context to identify the areas' strengths and weaknesses. This task lead to defining the plan's outline, scope, goals, and most importantly, the major aspects comprising the downtown plan: economic and social life, physical attributes, and transportation systems. The second analytical task departed from the premise that the downtown's form and function are affected by two major factors: the current committed or under construction development projects, and the anticipated market forces which recommended conducting extensive research to identify the future market demands for various development types in the downtown area. Hence, this task involved field survey, data gathering, and analysis of three major focus areas of the development plan: market analysis, design issues, and transportation (Figure 3). The second analytical task has lead to the definition of the plan's specific goals and objectives, and the development of focus areas and task force key principles and development initiatives in order to accomplish the plan's objectives.[51] The third analytical task subjected each focus area and key principle to an analysis-synthesis procedure as a tool to create scenarios of downtown development. This stage of the work involved design charrettes to analyze the development scenarios in order to select and developing a draft development strategy.

3.2 Analysis Techniques

Each analytical scale and context requires relevant analytical technique and assessment approach to develop alternative concepts based on an understanding of the area's positive and negative characteristics and distinctive patterns (Carmona et al 2003, pp.240-244). The methodology of PDDP involved three main analytical techniques: the SWOT, the cities tour, and computer-assisted analysis.

The SWOT[52] technique was conducted within the first analytical task to collect and structure data. The information collection and analysis were structured by listing and categorizing aspects and qualities of the project area under three main categories: strengths, weaknesses, and opportunities. The threats category was not considered in that approach. SWOT technique used the matrix form implicitly as a tool for dissecting the project area's properties and potential which were examined under three main broad headings: the physical attributes of the built environment and its infrastructure (particularly transportation), the natural environment and open space, and the economic conditions. The outcome of that analysis did not follow the same structure. Instead, it was represented as a list of statements that indicates the potential of each project area for achieving the desired goals and

[51] Those focus areas are: retail and attractions, business climate, housing, institutions, transportations, and urban design.
[52] SWOT technique refers to the following indicators: Strengths, Weaknesses, Opportunities, and Threats.

objectives. The list did neither outline the policies or steps necessary to achieve the desired goals and objectives nor did it question the underlying premises.

The analysis phases involved a tour of other downtown cities to compare Pittsburgh situation to that of other metropolitan areas[53] that were selected because of having successful experience in one or more of the areas that were considered as major aspects of Pittsburgh downtown plan. The findings of the tour were one of the major sources of information upon which the plan's recommendations were based.

The analysis phases also involved using a 3D computer model to support planning teams at different stages of the plan's development. Images of ongoing and proposed development proposals imposed on Pittsburgh's downtown computer model were extensively presented in the final report. It was used to build a set of analytical capabilities whose layering structure was arrayed into three groups: environmental-geographic, movement fabric, and architectural components. All development proposals were placed in this model at their real sites and elevations to examine how the parts could fit together and retain spatial coordination (Gosling & Gosling 2003, p.251). However, it was not effectively used for these analytical techniques or in any other core tasks such as research, analysis, synthesis, or implementation. The computer model had to fully represent the topographic structure associated with extending the downtown realm beyond the limits of Golden Triangle. It may be used also as the interface of the task forces and planning committees with public at large to analyze development scenarios in design charrettes. The computer model may have been used a means for visual analysis and objective analysis of the three-dimensional fabric of the city derived from Kevin Lynch's -or other's- vocabulary of urban form. The outcome of that analysis also could have been extended into a more subjective analysis upon which areas of tranquility, repose, confusion, permeability, and imageability may be defined either by task forces, groups or from sample surveys selected from groups of users, residents, and visitors.

3.3 Gaps in the Analysis Phase and the analytical Content

Literature suggests that analytical methods should be easy to comprehend and should embrace all aspects of the urban environment (Punter and Carmona 1994, p. 208). In PDDP, other analytical methods and techniques for which computer models are either useful or essential could have qualitative improved the analytical content. The following is a list of methods and techniques that may have been useful to address major aspects and focus areas of PDDP such as pedestrian movement, spatial structure, transportation, and three-dimensional modeling of development proposals:

- Spatial structure analysis, which includes space syntax to analyze the pedestrian network and to configure the public realm. Both of which are major elements of the urban design policy and its desired objectives.
- Network analysis for modeling transportation and vehicular links.
- Computer analysis to assess the visual and physical impact of the development proposals, and to assess how these proposals integrate with other aspects of the development plan (Roberts & Greed 2001, p.52).
- Tissue studies which involves comparing the scale and layout of different urban fabrics.

Analyzing the context of new development and utilizing it to develop design principles is critical if sound design policies are to develop (Punter and Carmona 1994, p.208). Content analysis indicated that the analytical content of PDDP lacks the coverage of three essential components: detailed functional analysis, land subdivision and building coverage analysis, and visual analysis. The first component, detailed functional analysis should include analyzing the constituent elements of the study area and their interrelationships over time, in

[53] These cities were: Indianapolis, IN, Denver, CO, Seattle, WA, Oakland and San Francisco, CA.

both original and contemporary urban fabric to understand how different land-uses, activities, and spatial relationships have evolved. Although this technique has been used in analyzing only a single major aspect of the plan, i.e. the market forces which involved housing market, retail market, office market, business climate analysis, and entertainment market, a comprehensive analysis of city functions was required to address the functional relationships between market and other uses such as education and hotels. For the second component, land subdivision and building coverage literature suggests that consideration of land and its subdivision makes the link between the building scale and the city scale, and helps better understand the major qualities of the urban environment such as human scale, permeability, variety, pedestrian comfort, and visual qualities (Sandalack 1998, p.36). However, analysis included examining block organization, but did not consider the scale of the lot[54]. Ideally, land subdivision patterns should be mapped and critically analyzed in the study area. This component is specifically importance to Pittsburgh because its plan involves developing large office, entertainment, and parking structures as well as hotels. These developments translates to massive structures which may eventually lead to block consolidation and lot amalgamation that requires assessing how they respond to and be integrated with the existing urban patterns, overall spatial structure, skylines, and street vitality.

The third component, visual analysis, is critical because the integration of Pittsburgh Downtown into its metropolitan context is the plan's overall goal. Therefore, a clearer understanding of the character of that context was critical and requires a qualitative assessment of its visual aspect such as elements of the urban form, the volumetric characteristics of the urban fabric, and most importantly, the physical and visual relation of the Three Rivers Basin with its urban context. A clearer understanding may help designers critically evaluate the spatial changes that may take place due to development proposals (Sandalack 1998, p. 36). Although the 3D computer model was used to represent the visual impact of the development proposals on their urban context, it was not used effectively to create 3D views that may explicate the above-mentioned analytical tasks or bridge the gaps in the analytical content.

Finally, a typical SWOT analysis should comprise socio-economic conditions as a main heading (Moughton 1999, pp.70-71). However, content analysis was confined to economic conditions only and did not indicate any reference to the significance of social aspects.

4. CONCEPTS GENERATION

4.1 The Methodological Approach of Alternatives Generation Phase

The gradual movement of the plan's content from the general to the specific was guided by the methodological approach of the six task forces that addressed the three major aspects of the downtown plan. At each focus area, the task forces conducted a five-step systematic process to establish their broad design principles and implementation tools. This process involved five steps: challenge, research, approach, opportunities, and guidelines. Each task force determined the desired goals that guided the subsequent phases of survey, research and analysis of the existing, on-going, and proposed projects. The design principles of each focus area were subject to discussions and revisions in Task Force Workshops to create developed design principles and concepts. Subsequently, the developed principles and concepts were synthesized in development scenarios that have been reviewed and analyzed in design charrettes.

[54] Lots are the basic cells of the urban fabric, and their significance stems form their role in linking built form to the land and open spaces.

Upon setting the methodology of PDDP against various design paradigms, it may be argued that its framework has followed the *analysis-synthesis model*. Theoretically, this model is a didactic approach that defines design as a process in which standard rules are applied, general and more specific data are analyzed, and new ideas are developed and tested (Figure 4). It utilizes the design process as a vehicle for incorporating information collected in various ways while expressing design proficiency. The first step in this model, research, involves the acquisition and assessment of knowledge to produce general rules, while the following step, design, is a process that breaks the design problem into discrete elements. The next step, analytical activity, involves analyzing research information and applying it to the discrete elements that are synthesized into a coherent whole in the following step, synthesis. Subsequently, the final stage involves evaluating the results after implementation to improve future projects (Figure 5).

In PDDP, analysis phase and its content have had dual effect. The first, they have determined the approach, goals, and premises on which the methodological framework was developed, and the second is the level of the plan's major aspects and their corresponding areas. Yet, PDDP's methodology deviated from the conceptual framework underlying the analysis-synthesis model, because it dealt with the discrete elements as parts without consideration to or assessment of their complex relationships and interaction within the urban environment as a whole. That deviation affected the design process in its analysis as well as alternatives generation phases. In analysis, it deprived the process from thorough and comprehensive understanding of the issues inherent in urban design problems. In alternatives generation, the impact might have been significant because at that phase, the planning teams seek an integrated solution which synthesizes their understanding of the design problem with other sources of information such as research data and findings, SWOT analysis, distinctive characteristics of the study area, public input, and project's program. The final recommendations of the development plan, as such, were derived from several sources, but ironically none of them refer to the analytical content[55] (PDDP-Executive summary-p.2).

4.2 Gaps in the Alternatives Generation Phase

Literature suggests that there are two types of activities involved in generating alternative solutions. The first, search, involves identifying existing prototypes to be taken of the shelf as the occasion requires, and the second, design, depends on innovation and creative response (Bayne 1995, p.307). The methodology of PDDP, in spite of few gaps found, emphasized the role of search as well as research, survey, and public input, but the role of design was meant to be vague and too implicit to be interpreted through content analysis. The PDDP did not explain explicitly how essential intellectual tasks and decisions, such as the development, assessment, and selection of scenarios have affected alternative generation and selection. For instance, the transition from, and the input of, research and analysis phases into scenarios has not been explicated or even documented. The numbers, development procedure, constituent factors, and variables affecting scenarios have not been revealed or made explicit. The criteria with which scenarios in the design charettes have been assessed and selected were not discussed. Although the plan argue that the public input has had significant impact on the plan methodology, particularly in analyzing development scenarios, they did not indicate the extent to which that input has influenced the development process and how did it vary-if any-from recommendations made by planning teams.

In another related gap, the role of subjective interpretation of the planning teams was not explicated. Literature suggests that the definition of the problem and the approach of concept

55 the stakeholder group reports, the economic impact study, the cities tour report, main street principles and programs, urban retail properties response to the collaborative, modified "market place" plan,, construction cost analysis, information provided by the Urban Redevelopment Authority, national Institute for Justice, and Pittsburgh History and Landmarks Foundation

generation depend in large on these interpretations which are influenced by the analysis process (Bayne 1995, p.309). The content analysis was unable to interpret how the planning teams found the best fit between the study area problems and the study approach. This gap highlights the importance of comprehensive documentation of the design process which should include the intellectual tasks, discussions, annotations on plans and documents, and criteria adopted in generating, assessing, evaluating, and selecting the design solutions.

4.3 Role of Analysis in Alternatives Generation

According to Milburn and Brown (2002), data and research are collected, analyzed, and then integrated with the design process in three forms:

1. Criteria against which design concepts are tested and modified.
2. Experiences and information, which aid in creating general principles used to assess specific design situations and to evaluate alternatives.
3. An intellectual framework for design which is assessed according to criteria established by rigorous research and behavioral studies (Millburn, L. and Brown, R., 2002, p.49)

Although PDDP has integrated information and research in all the above-mentioned forms and at various levels of its development process, these forms had various degrees of influence on that process. The content analysis was unable to clearly recognize or identify the impact of the first form because the process of developing, assessing, evaluating, and selecting design alternatives were not explicated. The impact of the second form was particularly significant in developing key design principles of task forces. Each task force has utilized survey, analysis, and research to identify their objectives, a statement of a mixture of economic, aesthetic, functional, and behavioral ends. Subsequently, each task force identified its approach, which includes principles explaining the link between their desired design objectives and a pattern or layout of the urban environment. Finally the task forces utilized design guidelines, the operational measures which specify how to meet the design objectives. Similarly, the six task forces and their design principles that addressed the focus areas should deliver a full range of design alternatives or development scenarios, the number and content of which were derived from the overall goals, objectives, and the methodology of the design process. Therefore, survey, analysis, and research have had significant impact in setting the design objectives as well as design principles and guidelines used to achieve them which, all together theoretically determine the quality of the urban design product (Uniaty, 2000, p.4). The third form has affected the plan’s methodology. It helped identify PDDP major aspects which highlight the areas in which consultancies should conduct analysis[56], and then identify the six focus areas by the collaborating groups.

Theoretically, as important as the analytical content is the process of translating it into design concepts, strategies and alternatives. Conceptual urban design plans provide a means to convert urban analysis into positive design proposals at a city scale (Gosling 1993, p.221). Other supporting illustrations such as concept diagrams; building envelope guidelines; indicative sketches; axonometric drawings; and models illustrations could enhance the role of conceptual urban design plans in guiding the transition from analysis into concept generation. The role of those illustrations may be even emphasized by plans such as location plans, plans of site and surrounding area, historic plans, and figure-ground diagrams. In PDDP, conceptual urban design plans have not been used as a means to deliver alternative solutions. The other illustrations were used discretely, particularly in layering the proposed development projects and movement networks on their urban settings. They did not represent a coherent intellectual phase within the methodological framework, and, as such, did not influence the process of synthesizing the analysis into design alternatives and solutions, and, in consequence, were not effective in generating the development scenarios.

[56] These areas are: market forces, design issues, and transportation.

Therefore, in PDDP, the impact of survey, analysis, and research on the procedural aspects of the design process was significant, but a similar impact on the substantive aspects was not recognized. As the plan content moved from general to specific, that impact was also recognized in the six focus areas and their respective task forces, but diminished substantially in the alternatives generation phase. Most importantly, an effective impact was neither recognized at the scenario development phase nor at the following phases. The variety in the magnitude of impact may be due to the different urban design modes of PDDP that translate to different degrees of abstraction and intervention in the urban environment. These interventions ranged between prescriptive urban design guidelines to a more detailed and enabling design guidelines.

5. CONCLUSIONS

Several major conclusions could be drawn concerning the gaps at each phase and between both phases in PDDP. Although the plan content emphasized the role of research as well as analysis in its methodological framework, the extent to which the analysis phase and the analytical content underpinned design policies is difficult to assess because these policies feature various degrees of reference to that analysis. Few policies revealed their analytical methodologies or the extent of their surveys and studies. The content analysis identified four types of reference to the analysis: explicit, implicit, integral, and no evidence of analysis. Explicit analysis is evident in the plan and provides a clear analytical basis for policy making. The plan's topics which involved this type of analysis such as land-use and transportation, urban design, open space, and economic factors responded directly to local conditions, often tailoring policies specifically to individual localities and often including details of the analysis within the plan. Implicit analysis is interpreted in some topics such as user perception and behavior. Analysis that is integral to the plan, such as in the areas of sustainability and natural factors sets future directions for development, yet it tends to be largely descriptive and did not translate to clear design principles. Some topics such as historical areas and plans' history show no evidence whatsoever of analysis of the locality. In sum, the policies were generally good at expressing the analytical content and consultative bases of policies.

Further, the content analysis found that the analysis phase and the analytical content have had significant impact on the general as well as the specific levels of the development plan yet with different degrees of success. At the general level, it helped establish the conceptual framework on which the methodology was based, and it has succeeded to recognize the distinctive characteristics of the project area at the contextual urban level. That success was paralleled by another success yet less rigorous in addressing what is unique and distinctive at the local urban level. Some policies, such as transportation policy, were underpinned by a thorough, all encompassing, and in-depth comprehensive analytical task, as opposed to others, such as public realm guidelines. Ironically, the plan content considered the public realm "the focus of concern for the urban design guidelines" whereas the analytical content lacks thorough study of its spatial structure. This phenomenon recurred in the sustainability policy where analysis, performance criteria, and design guidelines have not addressed that issue comprehensively.

Another gap existed in the analysis and alternatives generation phases when an explicit analytical content did not underpin any respective policy. Consultants analyzed Pittsburgh's downtown physical assets and found that the architecturally significant stock of historic buildings and structures represent important physical assets of its downtown and make important contribution to the visual character and texture of the city. However, the list of focus areas and their task forces lack any independent historic preservation policy or conservation study. Instead, vague prescriptive and subjective guidelines such as, sympathetic infill, promote contextual design, and sensitive renovation have been embedded within the urban design policy. An independent historic preservation and conservation study was essential to assign significant visual, aesthetic, functional, and cultural roles for historical buildings as a whole as well as building group particularly those which are considered nationally recognized landmarks.

Collectively, the plan was successful in seeking an optimum balance between being general and specific. However, focusing on retail, business and marketing was a slight deviation from that balance, and represented a flaw aggravated by the lack of a parallel focus on socio-cultural context.

The awareness of design as a process had underpinned the whole methodological approach, and was recognized particularly in the development proposals of some districts. These proposals were diagrammatic and abstract, which implies that they follow the approach of "urban design as a second order" to create a sound environment for subsequent detailed architectural design decisions. However, the notion of design as a process should have encompassed the entire range of contextual and development-specific considerations and weight them against one another. Obviously, that entire range was not fully considered in the analysis phase of PDDP.

Although the computer model offers capabilities that help conduct additional analytical tasks that are otherwise inapplicable with conventional tools, it has been used as a presentation media to represent the development proposals in their context rather than to support planners in core design tasks through the analysis and alternative generation phases. These additional analytical tasks could have improved the analytical content and helped tailor the design policies to the study area's environment.

Finally, the analysis and proposed policies were very weak in their theoretical underpinning. Analytical techniques were not based on any coherent framework neither at the second level i.e. major aspects of the downtown plan, nor at the third more specific level. The analytical content could have improved the quality of the urban design process and product should that content relied on values, principles, vocabulary, and methods of a theoretical framework.

6. FIGURES

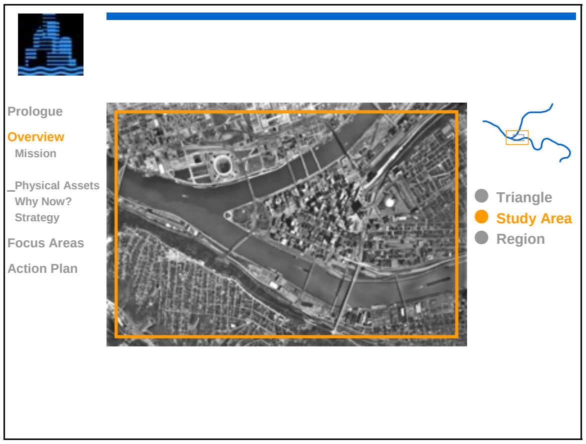

Figure 2: The traditional scope of downtown Pittsburgh

Figure 3: The project area encompassing downtown Pittsburgh with its urban context

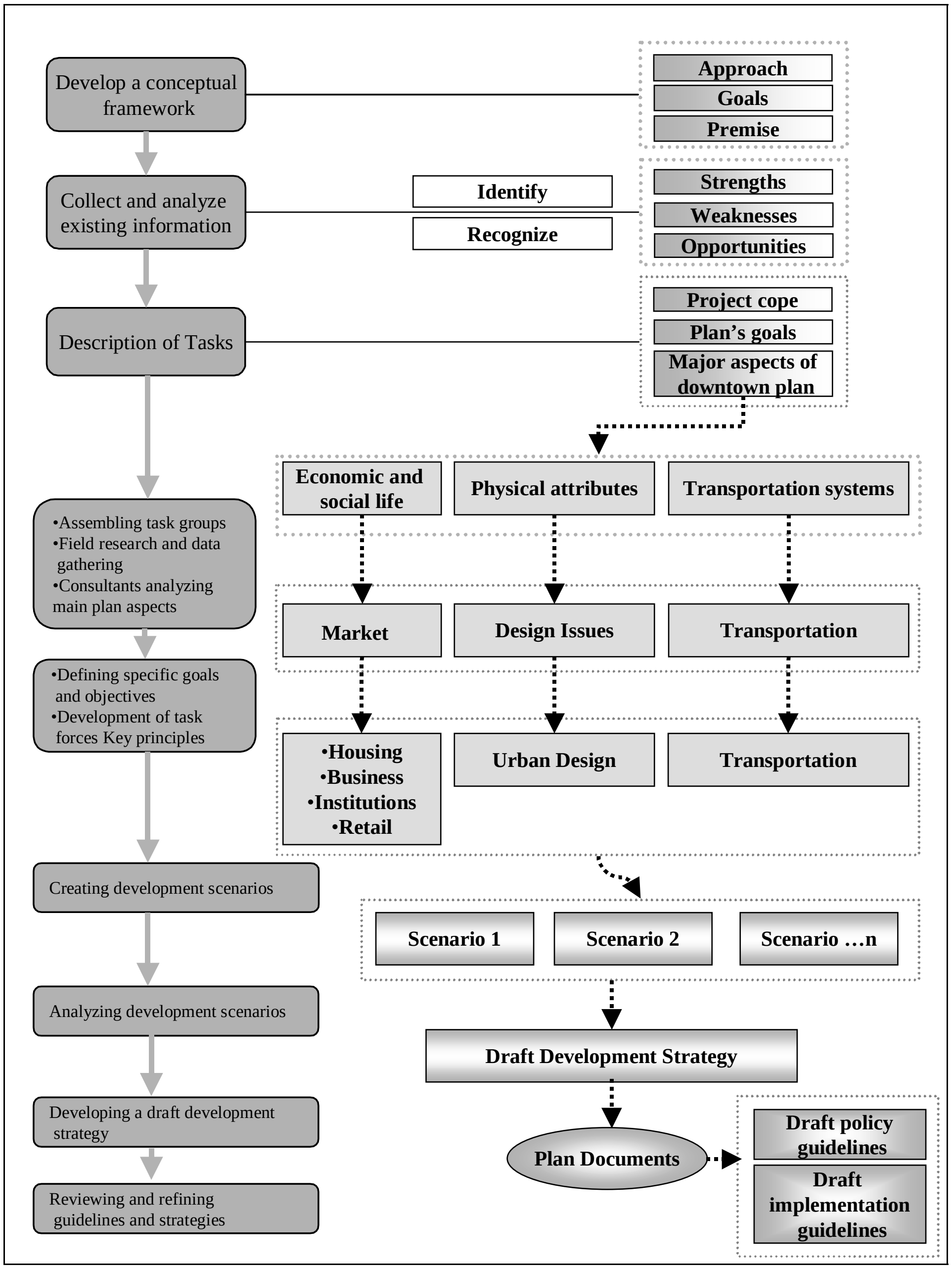

Figure 4: Schematic diagram conceptualizing the main intellectual tasks and products in the development process of Pittsburgh downtown plan.

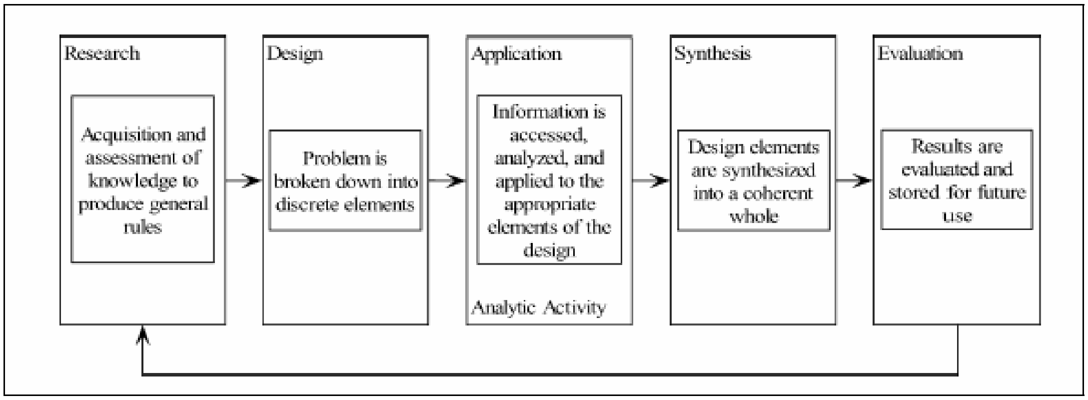

Figure 5: Relationship between research and design as identified by the analysis–synthesis model (Milburn, L. and Brown, R. 2002 p.51)

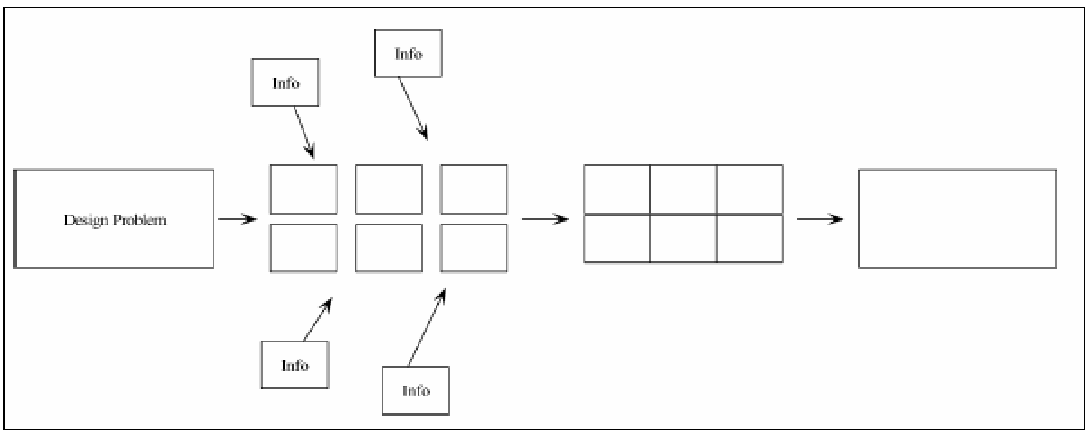

Figure 6: Schematic diagram of the analysis–synthesis model (Milburn, L. and Brown, R. 2002 p.52).

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ARCC Research Conference 2005 Best Paper Award:

Materials Matter: The Cases of Thomas Herzog and Ove Arup

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ABSTRACT

An interest in the expanding field of building materials has resurfaced in architectural practice. And the frequency with which new materials are invented, produced and deployed has prompted a re-evaluation of the role played by building skins in the development of innovative architectural projects. The work of Thomas Herzog and Ove Arup will be reviewed in this regard and their collaborations with the building industry, research institutes and affiliated non-profits will be also be highlighted. For each has participated in the search for innovative materials and contributed to the construction of ecologically determined buildings.

1. INTRODUCTION

Architecture, as a modern phenomenon, is a theoretical and historical trope most visibly manifest in the technological innovations which have, over the past two centuries, drastically reconfigured building processes and their techniques. In this regard, central has been the role played by new materials in altering the very nature of architectural practice. The history of modern architecture can, in part, be written as the invention and unprecedented use of novel materials in the service of alternative building types, forms and procedures.

We need only recall the watershed development of an entirely new language at the turn of the twentieth century which registered significant transformations in the production and consumption of building materials. The metaphor of the 'machine aesthetic' with its instrumentality and technological determinism underpinned a theoretical shift in the nature of construction and the triad of materials then charged with making manifest this transformation was that of glass, iron and reinforced concrete.

In 1928, Siegfried Giedion identified the iconic role which iron was to play in his book *Building in France, Building in Iron, Building in Ferro Concrete*; "Industry completes the transition from handicraft to machine production. The introduction of iron into architecture signifies the change from craftsmanship to industrial building production. "[57] And with the introduction of iron in the making of concrete an entirely new material was developed precipitating the rise of the even more radical ideology espoused by Futurists Antonio Sant' Elia and Filippo Marinetti, who stated; "…the calculation of the strength of materials, the use of reinforced concrete, rule out 'architecture' in the … traditional sense…the *Futurist* house must be like an enormous machine…"[58] "… the new architecture is the architecture … of reinforced concrete, iron, glass … and all those replacements for wood, stone and brick that make for the attainment in maximum elasticity and lightness. "[59]

[57] Sigfried Giedion, *Building in France, Building in Iron, Building in Ferro Concrete* (Getty Center for the History of Art and the Humanities, 1995), p. 88.
[58] Ulrich Conrads, Antonio Sant'Elia/Filippo Tommaso Marinetti, " Futurist architecture" in *Programs and manifestoes on 20th century architecture* (Cambridge, Mass.:The MIT Press, 1970), pp. 34-38.
[59] Reyner Banham, "Sant'Elia and Futurist Architecture," *Theory and Design in the First Machine Age* (Cambridge, Mass.: The MIT Press, 1967), p. 129.

Notwithstanding the never realized social, political and aesthetic revolution these new materials hoped to engender, unveiled in the unbridled optimism which Giedion and the Futurists had for their deployment, was the rhetorical dimension of architectural technologies. Indeed, by the 20th century, one contributed to the articulation of an architectural paradigm merely in the choice of a building's materials and in the modes of construction they occasioned.

It is the aim of this paper to advance that, a full century later, a form of material determinism has once again motivated a considerable radicalization of the architectural project. The altering of our contemporary landscapes, street-scapes and buildings is in large part the result of sweeping transformations in the nature of materials. And examining the manner in which these changes have redefined the age old relationship between architectural design and the building industry is of direct interest.

The structure and composition of recently developed building materials are vastly other than those customarily identified with modernism. The configuration and organizing parameters of metal meshes, fiber optics and polymers of all kinds, are in excess of existing modes of material thinking and in so being are incommensurate with the structure of either Gottfried Semper's 19th century four fold material cosmography or Kenneth Frampton's development of the 'Tectonic' a hundred years later.[60] Carpentry, stereotomy, earthworks and the art of weaving were undoubtedly productive building archetypes within which to organize the world of matter at the origins of the industrial revolution. However, in the context of developments in nanotechnology, electro-technology and digital technologies, this particular structuring of matter no longer suffices. Moreover, notwithstanding the enlightened and rigorous theory postulated by Frampton in his seminal book *Studies in Tectonic Culture*, his interpretation of the building arts as conceptualized through the architecture of modern masters Louis Kahn, Mies van der Rohe, Carlo Scarpa and Jorge Utzon only reconfirms conventional building processes predicated on a craft tradition.[61]

But a decade following Frampton's publication, material inventions have fundamentally transformed building products and modes of architectural practice. Their expanded uses now condition a more complex terrain within which architecture is constructed and construed. And disciplines outside of architecture - such as medicine, aeronautics, and engineering - have contributed to this development in two ways. On the one hand, entirely new materials have been created in laboratory settings which investigate the workings of matter at a level beyond nature's reproductive agenda. On the other, as in the example of translucent concrete and structural glass, atomic properties have been manipulated radically transforming the corporeal nature of existing materials.

Recently, the most compelling technology transfers have taken place in the area of sustainable design. The appeal for ecologically sound objects, buildings and landscapes has precipitated the greatest number of innovative material solutions. And two design practices which have been highly exemplary in this regard are the German architectural firm of Thomas Herzog + Partner and the international engineering firm of Ove Arup. Their world wide professional and academic success can be measured in dozens of ground-breaking projects in their respective areas of building technology. And while both have invested substantially in the development of energy conscious projects, they have done so by concentrating on the design and construction of building enclosures. For decades, Thomas Herzog and Ove Arup have been at the vanguard of advances in architectural skins and facades and it is to these particular inventions that this paper is addressed.

2. THOMAS HERZOG

Thomas Herzog's designs and inventions are now legendary. In the span of thirty years no architect has more carefully re-imagined the relationship between a building's structure, its mechanical environment, and the circulatory systems to which it owes its state of balance. Indeed, no other designer has more

[60] Gottfried Semper, *The four elements of architecture and other writings* (Cambridge; New York: Cambridge University Press, c1989).
[61] Kenneth Frampton, *Studies in Tectonic Culture, The Poetics of Construction in Nineteenth and Twentieth Century Architecture*, (Cambridge, Mass.: The MIT Press, 1995).

convincingly deployed the tools of '*ingenium*' to resolve some of the most pressing issues confronting the building industry today.

As educator, building technologist, architect, and activist, Herzog has promoted the unconventional use of emerging materials along with their alternative modes of construction. Desirous to substitute unskilled building crafts with highly engineered prefabricated systems, his architectural projects have encouraged the use of components constructed in highly controlled environments. And concerned with responding to the increased demands placed upon the performance of materials, assemblies, and operating systems, Herzog has dedicated a substantial portion of his career to actively conducting research in various areas of building technology. To this end, the architectural component most highly favored by his investigations is that of the building's surface; the skin and physical interface which most acutely registers atmospheric and thermal conditions. Time and again, Herzog has returned to this material threshold separating a building's interior from its exterior in the hope of advancing not only its operational functions but equally in attending to its representational role.

"The highly complex subject of the building "skin", its adaptability and manipulation, using the appropriate techniques, is something I regard as mainly the prerogative of the architect. Inevitably, the question of an adequate design form is also involved. Architects who tackle this subject, however, will need to understand something about construction, technology, materials and physics – at least so much that they can confidently discuss these matters with specialists."[62]

So stating, it should be of no surprise that Herzog's success is directly related to his embrace of a collaborative methodology wherein highly productive networks are developed amongst engineers, the building industry, academia and research institutes. Even in the early years of his career, Herzog initiated highly productive ventures with manufacturers and suppliers of building facades. In 1973, he worked extensively with *Petrocarbona* a manufacturer of external load bearing wall panels made of rigid and flexible foam. He helped the company develop prototypes and marketable products and, along with his then partner Vladimir Nikolic, invented a highly customizable panel system which incorporated both the structure and skin of the facade in one tectonic member.[63] But a few years later, in cooperation with Helmut Muller, Herzog extended his interests to metal skins and collaborated with the *Fischer Unit Construction Facade System*. He conceived of an early 'double-skin system' which was lightweight yet capable of passively stimulating the flow of air in its two layered section; a building principle Herzog has returned to on numerous occasions throughout his career. [64]

His fascination with building skins of all kinds has prompted further investigations with materials such wood and glass, clay, air and Aerogel. Following a decade of experience building housing projects conceived to maximize solar heat gain, in 1984 Herzog co-authored a book with Julius Natterer on the construction of wood and glass skins.[65] Most recently, turning his attention to the benefits of clay tiles, Herzog has devised the "*Modinger* facade system" in collaboration with Max Gerharer. Incorporating a variety of clay sections suspended from an aluminum structure, the system maximizes the material's innate thermal capacity and integrates heat gain into a ventilated wall system, furthermore advancing the operational potential of architectural skins. Projects which have incorporated the *Modinger* system include a public housing development in Linz, a spa in Kassel and a high rise tower in the city of Hanover. Herzog's interests have also involved the study of architecture's lightest material, air. As early as the completion of his doctoral thesis in 1972 at the University of Rome, Herzog admired the material possibilities of pneumatic structures. Publishing his book (*Pneumatische Konstruktionen, Bauten aus Membranen und Luft*) *Pneumatic Construction* in 1976, he demonstrated vast knowledge of both the science and art of deployable structures.[66] And albeit, in a manner far different from the large scale balloon structures dotting the science fiction landscape of his publication, decades later in 1997 he employed the material characteristics natural to air to the benefit of his corporate client, Siemens. In the decision to refurbish a 1930's steel and brick industrial storage shed into a contemporary office

[62] *Thomas Herzog, Architecture + Technology* (Munchen, London, New York: Prestel, 2001), p. 37.
[63] Ibid., "Career and Background Interview with Thomas Herzog," p. 27, and "*Petrocarbona* External Wall System," p.155.
[64] Ibid., "Fischer Unit Construction Company ," p. 157.
[65] Thomas Herzog & Julius Natterer, *Habiller de verre et de bois/ Gebaudehullen aus Glas und Holz* (Lausanne, 1984).
[66] Thomas Herzog, *Pneumatische Konstruktionen, Bauten aus Membranen und Luft*, (Stuttgart: Verlag Gerd Hatje, 1976).

space for the company's design department, Herzog actualized the potential of plastic skins in a manner ingenious and complex.[67] By collaborating with José-Luis Moro and the Bavarian membrane manufacturer *Koch Hightex*,[68] Herzog inserted a two layer translucent membrane within the existing building section, carefully controlling the quantity and temperature of insulating air caught between the plastic film and the existing exterior wall. In so doing, the team had not only rendered thermally viable a 60 year old building whose obsolescence would have otherwise greatly contributed to the problem of landfill, but in having subverted the relationship between interior and exterior skins, constructed a highly ethereal environment whose poetic dimension transcended its technologically determined details.

Another material of early interest to Herzog, and whose further integration into the building arts promises substantial architectural innovation, is that of 'Aerogel.'[69] In collaboration with the *Fraunhofer Institute for Solar Energy Systems* (ISE), Herzog designed and built an exterior facade system for a private residence using this space age product employed extensively in the aeronautics industry. Its highly porous structure exists at the scale of nanometers and made up of 99% air insulates at a rate 40 times that of fiberglass. Herzog adapted the material's thermal capacities in the design of a 16 mm silicate infill sandwiched between two layers of glass and in so doing achieved thermal comfort without a correspondent loss in transmitted light.

In the end, regardless to which architectural material Herzog directs his attention, an essential component of his design method involves radicalizing accepted building paradigms. In this regard, his collaborations with research institutes, both private and public, have been vital. Laboratory facilities and technical expertise offered by agencies such as the *Fraunhofer Institute for Solar Energy Systems* (ISE), the *Center for Applied Energy Research* (ZAE) and the *Bartenbach Lighting Laboratory* have been productive venues for the testing of his inventions. And without their assistance many a sketch and idea would have remained just that. In one example, Herzog successfully designed the "Daylight Grid System" in collaboration with Christian Bartenbach and the Fraunhofer Institute.[70] As a result of his access to computer simulations measuring the thermal and energy transmission of various sky light prototypes, a number of laminated glass and aluminum sections were selected for world wide production; not before, however, having featured the grid-shaped device designed to reflect and diffuse large quantities of light in the structure of his curved glass roof spanning the Linz Exhibition Hall.

His academic work at the Universities of Kassel and Munich has also contributed to an expanded repertoire of material inventions. In collaboration with doctoral students, Herzog has continued to challenge the frontiers of facade design and in one case in particular, the research work of Waldemar Jaensch (1977-1980) resulted in the development of an ingenious kinetic sunscreen directly responsive to light and energy.[71] In the ability to modulate the device's solid to void ratio, a method was developed to attain desired thermal levels and energy conservation. And in excess of its sun shading benefits, the patterns and configurations which resulted from the kinetic modulations offered an extraordinarily poetic language of surface articulations.[72]

Herzog's commitment to the design of sustainable buildings is three decades old and as we have seen encompasses all aspects of his career. The development of new materials and their accompanying construction processes situate the conservation of energy at the center of his practice, making ecologically sensitive decisions the rule and not the exception. And a project which acknowledged this

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[67] See Layla Dawson, "Eco Membrane" in *Architectural Review*, Vol. 204 (August, 1998), pp. 24 –25, Rossella Mombelli, "Un intervento leggero –Siemens Design Department" in *Arca* n. 123 (February 1998), pp. 74-77, and *Thomas Herzog, Architecture + Technology* (Munchen, London, New York: Prestel, 2001), pp. 102-103.
[68] Herzog had collaborated with the manufacturer Koch years earlier when working with membrane structures at the University of Kassel. See *Thomas Herzog, Architecture + Technology*, p. 29.
[69] See Layla Dawson, "Light Spirited" in *Architectural Review*, Vol. 197, n. 1175 (January 1995), pp. 20-21, Witte, Chen, Faircloth, Hodge, Kim and Lee, "98% nothing: Transparency by degrees" in *Journal of Architectural Education*, Vol. 56, n. 4 (May 2003), pp. 27-29, and *Thomas Herzog, Architecture + Technology* , pp. 170-171.
[70] *Thomas Herzog, Architecture + Technology*, pp. 80-87 and 168-169.
[71] Ibid, "Changeable Surfaces – Processes for Assessing Kinetic Manipulators in the Skins of Buildings as a means of Regulating the Indoor Climate," pp. 180-181.
[72] *Thomas Herzog, Architecture + Technology*, pp. 180-181.

goal at an architectonic scale is the Administration Building for the Hanover World Fair completed in 1999.[73] All aspects of this high-rise building are exemplary and for the purposes of this paper it will suffice to highlight but one. The building's facade was conceived as a double skin system incorporating the latest technological innovations in matters of air transfer with the goal of securing large scale energy savings. Running the perimeter of each floor is a ventilated air chamber, roughly four feet wide which separates the interior surface of the building from its exterior. In this section are orchestrated all temperature adjustments necessary in maintaining the inside of the building at a constant air temperature. Shading devices are installed on both surfaces and the ability to re-circulate the heat generated within the cavity increases thermal comfort and decreases the need for additional sources of energy. All building details and mechanical systems were devised to further support the facade's operations.

Detailing further the myriad of ways Thomas Herzog has developed an exemplary career in his innovative approaches to the use of materials and to the rehabilitation of art of building would be an arduous task, however fruitful. Suffice it to conclude that he has offered the architectural profession the example of a most virtuous building activity, and one that we would do well to study in the hope of devising more sustainable approaches to our own buildings.

3. OVE ARUP

At a scale far different is the work of the Engineering Consortium Ove Arup whose world wide recognition situates this practice at the forefront of building innovations. Scant are the international building sites, irrespective of project type or size, which have not been in some measure affected by its expertise in matters of structural design, environmental systems or sustainability. Founded as a construction company by Sir Arup (1895-1988) in post World War II London, it has grown into a global firm of design and engineering consultants with thousands of employees and commissions on all five continents.

Of particular interest to this paper is the continued attention Arup has conferred upon the design of building facades, upon the innovative use of materials, and upon their unconditional commitment to developing ecologically sound environments. To begin with, noteworthy is the presence of 'The Building Facade Engineering Department', a division exclusively dedicated to advancements in architectural skins. Whether concerned with structural glass, traditional masonry or ventilated double-skin facades, the group's expertise has been of consequence in the development of numerous projects in the city of London including Cesar Pelli's Bank Street Buildings, Sir Norman Foster's City Hall,[74] and Kohn Pederson Fox's AIG European Headquarters. Indeed, the very presence within the company's structure of design services entirely dedicated to architectural enclosures signals, more generally, the increasing complexity of contemporary skins, particularly when conceived in conjunction with a building's heating, lighting and ventilation systems.

Secondly, Arup's commitment to the study of materials is equally remarkable. The 'Material consulting' division facilitates the selection of building materials, offers an assessment of their measure of sustainability, and evaluates their performance in a number of different contexts.[75] To their efforts must be connected the ground-breaking project designed by Future Systems for Selfbridges Department Sore in Birmingham, England. Material investigations made possible the construction and attachment of 15, 000 spun anodized aluminum discs which were structurally tested against the weight of adventurous humans who might one day desire to climb its surface.[76]

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[73] See Layla Dawson, "Systems Analysis – Trade Fair Administration Building, Hanover Germany" in *Architectural Review*, Vol. 209, n. 1247 (January 2001), pp. 46-50, and *Thomas Herzog, Architecture + Technology*, pp. 122-129.

[74] Sara Hart, "Technology and ingenuity contribute to energy-efficient performance," in *Architectural Record*, Vol. 191 (February 2003), p. 116, Malcolm Turpin, "Great Hall" in *Civil Engineering* (August 2003), pp. 36 -45.

[75] As claimed on the Arup webpage; http://www.arup.com/skill.cfm?pageid=486 .

[76] As described on the Arup webpage; http://www.arup.com/facadeengineering/project.cfm?pageid=1784 See Catherine Seron-Pierre, "Future Systems Grand Magasin en Centre Ville Birmingham" in *AMC*, n.137 (October 200), p. 54-58.

And finally, in what concerns Arup's greater commitment to issues of sustainability, the firm's charter identifies amongst its priorities a commitment to sound environmental practices. As inventors of the 'Vertical-Axis Wind Turbine Extractor (VAWTEX)' used to maximize wind power at the Harare International School in Zimbabwe,[77] as consultants with the non profit group based in the Netherlands - Global Reporting Initiative, and as inventors of their trademarked sustainability tool, SPeAR®: Product overview, Arup's division of 'Sustainability Services' has repeatedly demonstrated vanguard approaches to the design of ecologically determined environments.

By way of these examples, therefore, it is apparent that within the very structure of Arup as a professional organization is recognition of the firm's commitment to the design of enhanced facades, emerging materials and the promotion of a sustainable consciousness. These are the targets around which Arup continues to expand and intensify its terrains of investigation and in the review of two recent projects this paper seeks to demonstrate how so.

To being with, throughout the years, Arup designers have maintained a close association with the world of art, often collaborating with spatial and material visionaries.[78] This was in fact the case when in the year 2002 structural engineer Cecil Balmond[79] worked alongside artist Anish Kapoor charged with installing a larger than life sculptural figure in the Turbine Hall of the Tate Modern. Kapoor enlisted the help of Arup to engineer all aspects of the project he entitled, *Marysas*. Even the most cursory of looks at the final installation reveals the artist's inspiration; the mythological Greek figure who in losing a musical challenge with the god Apollo was destined to being skinned alive. To this end, Kapoor devised the construction of an enormous steel structure sonorous in profile and 140 meters (roughly 450 feet) in length. Covered in 3500m^2 of an alarming red PVC–coated polyester membrane, also supplied by the contractor 'Hightex', the carefully constructed figure achieved its mathematical precision by way of wax models, Real Time software and a computer program used for non linear form derivations called, 'Fabwin'.[80] And setting aside the spectacular quality of this architectonic installation, many lessons were learnt throughout the project's various stages of design, construction and material selection; all of which will undoubtedly contribute to the expanding dimension of Arup's knowledge base. It is often precisely in collaborations with members outside of a strictly defined building economy that many of the most innovative results are intuited. And it is to Arup's credit that projects such as these will soon bear fruit within the traditional building arts. Indeed, their experiments with innovative membranes have already facilitated significant transformations in the nature of architectural surfaces and they have helped us better understand the symbiotic relationship which exists between the design of a building's skin and the design of its heating, lighting and ventilation systems.

One material which has most recently contributed to this dialogue and pioneered a particular approach in sustainable design is the recyclable film known as ETFE, Ethyltetrafluoroethylene; a highly transparent foil, trade named Teflon, with a weight of one percent that of glass and whose structure and insulation value is achieved by the addition of forced air.[81] Lighter and more thermally resistant than glass, it is a material perfectly suited to greenhouse enclosures.[82] And this is precisely how it was used by Arup in collaboration with architect Nicholas Grimshaw in the construction of a botanical garden in Cornwall England for a non-profit group called 'The Eden Project'. In the construction of eight quasi-geodesic domes termed 'biomes,' the use of Teflon 'pillows' organized in a series of structural hexagonal frames gave rise to a veritable landscape of pneumatic structures. Their physical measures

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[77] As reported on the Arup webpage; http://www.arup.com/environment/feature.cfm?pageid=1658 .

[78] Arup collaborated with James Carpenter in the design of a glass skin, see James S. Russell, "Bring Form to Light" in *Architectural Record*, Vol. 178 (November 1990), pp. 108-111. They also collaborated with Jenny Holzer at the Berlin Reichstag, see "Engineering the Reichstag sign" in *The Arup Journal*, (1999), p. 21.

[79] Cecil Balmond is a deputy chairman of Arup and has most recently collaborated with Oscar Neimeyer in the construction of the Serpentine Gallery, a temporary building installed in Hyde Park, London, Summer 2003.

[80] Cecil Balmond et al. " Marsyas at Tate Modern" in *The Arup Journal* (January 2003), pp. 40- 45.

[81] As claimed on the Arup webpage, http://www.arup.com/europe/project.cfm?pageid=187. See also Isabel Allen, "A taste of Eden," *in The Architect's Journal*, (February 22, 2001), pp.30 -37.

[82] "Pillow Talk" in The *Architect's Journal* (April 15, 1999), p. 42.

defy reality, with some cushions measuring 30 feet in diameter and others six feet in depth. The great genius of Arup's involvement was to have integrated the design of this air filled plastic surface within the building's system of energy recovery and distribution; the challenge of which was enormous given that beneath the domes rainforests and moonscapes were simulated.

And if 'The Eden Project' had not been challenging enough, using the same system in the design of an aquatic environment will certainly test this material to its very limits. In collaboration with the Australian architectural firm PTW, Arup has been commissioned by the People's Republic of China to engineer the construction of its 2008 Olympic Pool. Using the same material and structural logic, the project identified as the 'Water Cube' will use ETFE - Teflon air inflated cushions for both the inner and outer skins of the building.

The practices of which I have presented but mere samplings of their work occupy at present the forefront of innovations in building technology as they continue to offer architects profoundly different possibilities for the conceptualization of space and for the manipulation of matter. In many ways this is a time no different than that first recognized by Giedion and Marinetti who saw in the use of iron and reinforced concrete a potential far different than ever imagined. We would do well, however, to remember that the social and political transformations which they dreamed to be the natural outcome of material innovation never materialized. Therefore, in the practices of Herzog + Partners and in that of Ove Arup, we are all the more fortunate to have as models a deeply humanitarian belief that building technology and new materials are distinctly suited to the creation of sustainable environments of all kinds.

Architecture – Little "D" and Big "D" Design

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ABSTRACT

This purpose of this paper is to assess the current state of technology impact in architecture and gain insight into possible emerging practice and educational opportunities.

The intent of the literature review was to gain a sense of the evolution of the architect, both as designer and process manager through history. Initial reviewed sources focused on the architect in history (Smith, Harvey, Kostof, Gothwaite and Burns). Thereafter, additional readings included architects in the modern era (i.e. 20th century – Gropius and LeCorbusier). Further investigation looked at technology infusion in the related fields of the marine, aerospace, and automotive industries. A spin out of this research lead to further reading in the areas of management theory and principles of organizational strategy with a focus on process and change management for the purposes of leveraging technology. The literature review revealed limited technology and management research relative to technology in architecture and construction; however, a plethora of sources were found relative to technology impact and management strategies in related manufacturing fields.

Additional primary source data was compiled via two (2) architectural project case studies that are technology centric. Other underpinning primary evidence was provided via interviews and conversations with relevant organization and institutions representatives pertinent to the profession of architecture.

The research findings indicate the profession of architecture is slowly mutating through process and product change of significant impact on a scale arguably similar to that of the Renaissance. During the Renaissance the master builder and the guild workshop system were denigrated; this ultimately resulted in the process of architecture splitting (fission) into the two primary fields of design and construction. In the contemporary context, the research indicates the act of architecture is increasingly considered as a holistic issue of design-construct-operate. The research findings indicate that technology evolution and congruent management organizational models are increasingly integrating (fussing) collaborative design-construct-operate specialists in the process of making architecture. This evolutionary trend requires a management "hub" firm; will this void be filled by architects, engineers, builders or managers? How BIG will architects define 'design' in the future?

1. THE ARCHITECT'S ROLE

1.1 The Master Builder Revisited

I claim the *Master Builder* is re-emerging as a dynamically networked specialized team of design and construction specialists. Bi-lateral knowledge exchange, enhanced with emerging information technology strategies, is occurring between owners, architects, builders, engineers, and a plethora of design consultants as well as machines. This emerging 21st century *Master Builder* is not a literal individual, as seen in the historical craftsman guild of antiquity; but rather, the emerging 21st century *Master Builder* is a group of knowledgeable design-construct-maintain specialists who are networked via the global internet and an information management "hub" firm.

1.2 Little "d" and Big "D" Design

The emerging professional practice environment may require reevaluation of the role of the architect as a "design-specialist" or project-leader "integrative-generalist. Technology continues to disrupt architecture, resulting in increased design-build specialists, project delivery compressed time frames, as well as higher client demands and user expectations for performance and quality. Hence, I have coined the phrase "little d" for the former concept of design as an 'aesthetic' exclusive driven process and "big D" for the latter concept of design as a 'holistic' inclusive driven process.

2. THE RESEARCH FINDINGS

2.1 Overview

I offer as evidence substantiating findings from the research of the architect in history as well as contemporary findings extrapolated from research of contemporary manufacturing industries. Additional research findings include data analysis of nationally recognized organizations and governmental agencies. and supplemental observations and interviews of specific key individuals in design-build-manufacture industries. Additional research, specific to architecture, were two (2) architectural project Case Studies in which Frank O'Ghery and Associates (FOGA) were the design architects.

3. BACKGROUND

3.1 Project Delivery Evolution

Over the last two decades, numerous alternative project delivery models and competitive players have emerged in the architectural industry. Additionally, new forms of architectural practice and service areas are expanding (Baker, 2000). Often architectural firm's partner with the owner's external Construction Management firm, under various project delivery models, where the architect's role and project control is diminished (Barrow, 2000).

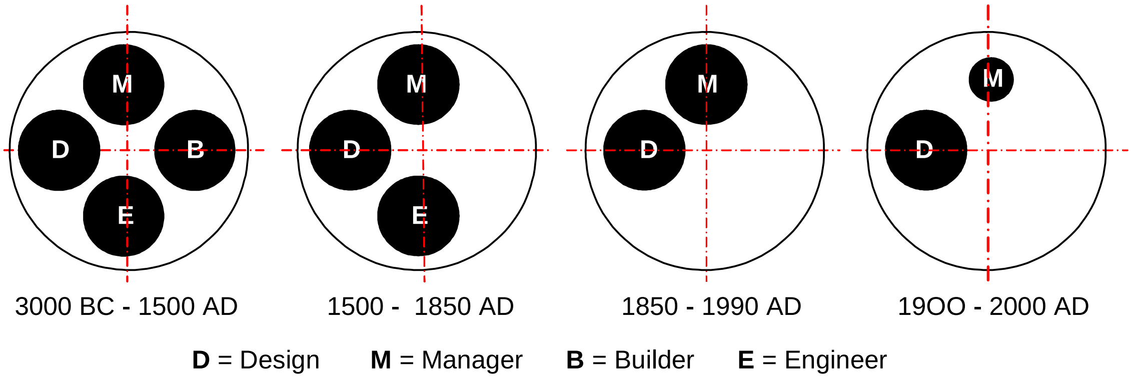

Fig. 1 Evolution of the Architect in History (Barrow, 2000)

4. THE ARCHITECT IN HISTORY

4.1 Early Antiquity

Ancient Egyptians were highly organized and engaged in meticulous *planning and design* (Smith, 1996). Imhotep, the immortalized Egyptian architect, is credited with inventing the means of cutting and placing large stones, which enabled the new architectural expression in the pyramid form. The title of architect was equated with *Master Builder* and "overseer of works"(Kostof, 1977). The research indicates the Egyptian architect was typically designer and builder; we find this similar project delivery principle of integrative design-build as well in Greek and Roman culture (Harvey, 1971, Kostof, 1977).

4.2 Emergence of the Renaissance Designer- Artist Architect

During the Renaissance Alberti argued "architecture had nothing to do with construction (Kostof, 1977)." Alberti, an upper class humanist architect, sought to separate the architect's identity from the lower class craftsman master-builder. Consequently, the master-builder function was slowly decomposed into 1) theoretical-artist architect, 2) practicing architect, and 3) mason-builder. As a final result, the implicit knowledge of the estranged craftsman was cut-off from the initial design process. Thus, due to the shifting roles of the architect, we find an increase in the design architects originality and creativity; however, the role of the architect diminished as process integrator. This was the birthplace of the modern architect.

4.3 The Modern Architect

Walter Gropius foresaw specialization as an inherent consequence of evolving technology. Gropius's theory focused on two fundamental principles, *unification of diverse skills and collaboration of diverse individuals*. Gropius essential theme was *unity of purpose*, thus, promoting design for the needs of society.

Thus, for Gropius, the role of the architect was to be a **"coordinator"** who would "unify the many social, technical, economic and artistic problems," and in this way the modern architect was reconnected to the integrative role of the past master builder architect, in the words of Gropius,

> The historical mission of the architect has always been to achieve the complete coordination of all efforts in building up man's physical surroundings" (Kostoff-p.76);

> and "in all great creative periods, architecture, in its highest embodiment has been the dominating mother of all the arts, has been a social art" (Kostoff, 1978).

Diminution of the role of the individual designer is an inherent consequence of collaboration, Gropius felt that it was *subjective individualism* that lay at the root of the problems of modern design education, for "only the collaboration of many can succeed in finding solutions which transcend the individual aspect"; thus, immortal works of art would be the product of the *group*, not of the individual."

5. ARCHITECTURE AND DESIGN

5.1 Architecture

Modern dictionaries define architecture as "the art and science of designing and erecting [constructing] buildings." Therefore, mainstream society includes construction as an integral component of architecture.

5.2 Design

Modern dictionaries define design as "the act of making a plan." For the sake of our discussion and argument, the question is, how **BIG** is the plan?

5.3 Construction Design

Pollalis and Banos (1988), in their assessment of technology impact and process management in architecture, argued design decisions occur in all phases of the act of ideation and making. Accordingly, Pollalis and Banos coined the terms "Conceptual Design," "Design Development," and **"Construction Design."** Further, Pollalis and Banos argued design and construction cannot, and are not separate acts or processes.

6.0 MACRO FINDINGS

6.1 The General Services Administration

Many felt collaborative design-build project delivery models would remain in the private sector and not transfer to the public sector; however, governmental agencies are increasingly pursuing design-build-operate project delivery models. Numerous publications, to include the AIARCHITECT, have documented this migration of attitude and goals of the largest real estate owner in the US, the Federal government's General Services Administration (GSA). The GSA is now researching and implementing pilot projects regarding collaborative design-build with the intent of finding a project delivery method which improves design quality while establishing cost, scheduling, performance and long-term operational expenses. Thus, even in the public sector, architecture is experiencing shifts in fundamental process.

6.2 Construction Cost and the American Institute of Architects

In 1997, the AIA conceded to decades of public and legal pressure to assume responsibility for the owner's budget. Consequently, we now find many firms abandon the role of "fiduciary agent" for the client to lower risk.

6.3 The Design-Build Institute of America

Further evidence for the claim is offered; data obtained from the Design Build Institute of America (DBIA) indicates that in 1985, traditional design-bid-build project delivery accounted for 87% of all non-residential construction, in 2000 design-bid-build project delivery accounted for 54% of the market, with other collaborative-integrative project delivery methods being responsible for 46% of the market. The research indicates a slow shift continues in project delivery methodology from traditional design-bid-build linear process to collaborative design-build project delivery models (see Figure 2).

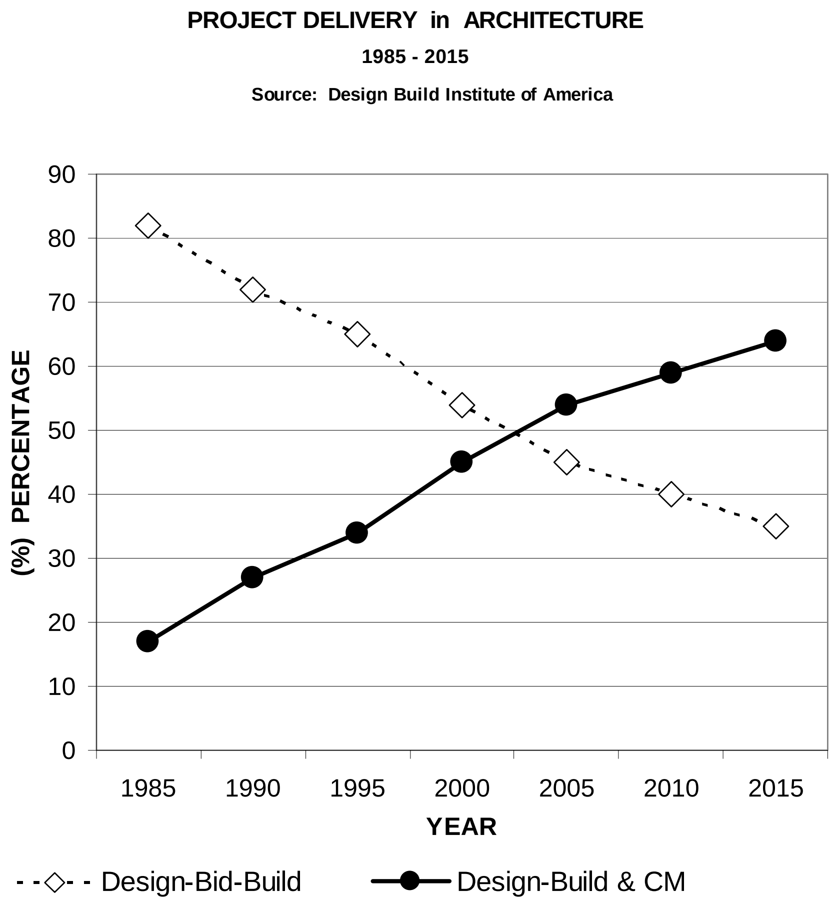

Fig. 2 Shift in Project Delivery Methodology (DBIA / Barrow, 2000)

The Design-Build Institute of America (DBIA) was founded in 1993; the following is a summation of DBIA goals:

1) The integration of services, in the process of architecture, via the promotion of a "single-contract" entity.

2) The promotion of innovative design and management techniques using empowering "information-age management techniques" to control the process of architecture.

3) "Remaking the image" of America's construction industry.

Additionally, the research indicates some progressive general contracting firms have migrated into pure management[83], verses construction, and have been early adopters of technology. Further, they view technology as a competitive differentiator as consultants to the owner; and they now envision themselves as *professionals*.

6.4 Manufacturing Industries and Technology

Experts in the related automotive and aerospace industries, that are much more mature relative to technology implementation than architecture, argue that *mission and organizational issues* are much more important in the implementation of technology strategy than *technical* issues (i.e. hardware & software) (Tushman, Nori, Monger, 1988). Furthermore, experts in the management field maintain that in the current context of decomposed large organizations into smaller micro firms that allow fast-track Just-In-Time (JIT) processes, the need for a "Hub" management firm is absolutely essential to maintain equilibrium of the system.

7.0 FOGA CASE STUDYS

The case studies are comprised of two Frank O'Gehry Associates (FOGA) projects; the Disney Concert Hall (circa 1988) and the Bilbao Guggenheim Museum (circa 1992). A summation of comparative findings follows.

7.1 The Disney Concert Music Hall

In the case of the Disney project, the County of Los Angeles administered the project through the Walt Disney Concert Hall Committee (WDCHC) which was comprised of appointed members. The WDCHC utilized multiple layers of Project Managers and General Contractors teamed with FOGA, the design architect, and Dworsky Associates, the Executive Architect. Ultimately, no one took responsibility for Cost and Schedule and the project went out of control resulting in extensive delays and disappointment to the Disney family. Mrs. Disney, the primary benefactor who donated fifty million dollars in 1988, passed away without seeing or hearing her dream. Additionally, multiple lawsuits ensued among the professional team and bad publicity abounded for most of the duration of the project. The project was ultimately completed in 2003; however, simply stated, the pursuit of aesthetics drove the project. There was no management Hub firm or Executive Architect who took responsibility for the comprehensive needs of the client relative to Cost and Schedule.

The writer interviewed the Executive Architect, Dan Dworsky, his final summation of the Disney project was that following his Disney experience, "he preferred to act as both designer and Executive Architect and he would not recommend a 'limited' responsibility role to other architects where they had no authority relative to budget and schedule control.

7.2 The Bilbao Guggenheim Museum

In contrast to the Disney Concert Hall, the Bilbao Guggenheim Museum was completed on time and budget. A very tight streamlined organizational management model was formed by the owner as the Basque government hired Juan Vidarte, an MIT Sloan School of Management Ph.D. graduate, *who had never built a building*, as the Director of the Consorcio Guggenheim Museum (CMG). The CMG administered the project and managed the entire design-build (architecture) process. IDOM, a local architect/engineering firm, with extensive industrial project experience, was hired as the Executive Architect. IDOM accepted contractual responsibility for the project cost and schedule as well as interfacing between FOGA - the design architect, and seven (7) prime contractors. Most notably, **NO** General

[83] Examples - John Tocci , Tocci Builders (interview) and William Berry of W. A. Berry & Sons, Harvard Design School course visiting lecturers.

Contractor was involved. IDOM negotiated directly with the persons who would build the building. FOGA provided 80% working drawings and IDOM completed the final details using input via collaboration with the seven (7) prime contractors.

The writer interviewed the CMG Director, Juan Vidarte; he indicated he told Frank Gehry he wanted his “best building, as long as it met IDOM’s [the Executive Architect] cost and schedule requirements.”

7.3 Disney and Bilbao – A Comparative Study

Comparatively, the Disney Concert Hall cost 110% per Square Foot (SF) more than the Bilbao Guggenheim Museum and took 150% longer to complete, even though Bilbao was 10% larger and utilized a more expensive titanium skin. The primary difference between these two projects was the owner’s organizational and management model and the role played by the Executive Architects relative to process management.

In the case of the Disney Concert Hall the Executive Architect, Dworsky Associates, was hired with no authority and were to just “draw the plans for FOGA.” In the case of the Bilbao Guggenheim Museum the Executive Architect, IDOM, was hired by the owner (CMG) with complete responsibility, and associated authority, for Budget and Schedule control; thus, IDOM acted professionally as the owner’s fiduciary agent. Additionally, In the Bilbao project, the CMG, directed by a non-architect and non-builder PhD Manager, Juan Vidarte, acted as the key player in managing ALL aspects of the project process.

8 SUMMARY OF FINDINGS

The research indicates that through most of history, the architect has been responsible for the design and construction process. Only in modern times do we find the decomposition of the master builder into specialized roles. In the modern era, Gropius foresaw the evolution of specializations driven by technology, and he felt the architect should be a generalist who collaborated and managed a diverse team of experts as a means of accomplishing architecture.

The research indicates owners increasingly want quality design, on time and budget with long term operating efficiency. The balancing of the complex "system" of the *process* of architecture requires extraordinary management skills. The research indicates there are no clear paradigms at this time; moreover, the research indicates that during the recent period of owners increased management demands, many architectural firms have chosen to defer “risks” to other emerging “professional” entities (i.e. project managers and contractors).

In this seemingly dilemmatic posture for the architect, where we see change and chaos, is there opportunity for reinvention of the profession and practice of architecture? It maybe that it is now time for the “architect” to once again be split into another “specialist.” Many terms are emerging that hint at the future, some experts see the emergence of a Building Information Management (BIM) “hub” firm which may act as a central management firm that will manage the entire process of design-build-operate (big “D” design – comprehensive). Yet others claim this is not the appropriate role of the architect and we should remain focused on “design” (i.e. little “d” – aesthetic driven). It maybe that our educational model needs to address specializations and offer “advanced” focus areas; in this manner, the truly gifted “designer” would be all the more empowered to be a “creative artist” and pursue intuitive “beauty.” Other students, of a contrasting gift, could be educated to fill the need for “rationalization” of architecture and fill the need for central process “hub” management. Based on the research, we should expect various types of design and practice models to emerge at an increasing rate, and one can not say what is right or wrong for the individual architect or firm. Rather, the talent and aptitude of the individual architect should drive the career choice of the architect. The large question remains with the jurisdictional organizations as to the breadth of choices available in the professional architects educational, licensing and practice alternatives. Additionally, we may anticipate new educational and practice models to emerge in the mist of chaos and change in architecture.

The Bilbao Guggenheim Museum project provides a "real world" prototype. FOGA acted as the conceptual "design" firm, IDOM acted as the Executive Architect "DESIGN" firm under the auspices of the owner's non-builder MIT Ph.D. Director/Manager Juan Vidarte. This project posse as many questions as it does answers; can the profession of architecture learn from and leverage this organizational model in the future?

The emerging 21st century *Master Builder* is not a literal individual, as seen in the historical craftsman guild of antiquity; but rather, the emerging 21st century *Master Builder* is a group of knowledgeable design-construct-operate specialist who are networked via the global internet and an information management "hub" firm. Who will fill the role of the "BIG D" **design** management "hub" firm?

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ARCC Panel Discussion:

Compiled from notes by David Perkes

Fatih Rifki:

Former attitudes toward research in architecture schools were that, for various reasons, architecture schools are special and do things differently from other departments on campus. Those days are over. Architecture schools can no longer set themselves apart but must learn to contribute to the larger academic community.

Jim West:

Jim Barker at Clemson University has an attitude that we can all learn from. He says "Instead of saying were different – meaning the department of architecture in the context of the rest of the university – say that we are a profession of collaborators." Departments of architecture can turn the tables around to present the positive aspects of architecture.

David Perkes:

The professional collaborative skills of architecture can be brought outside the school as an alternative research practice through efforts such as Community Design Centers.

Frances Bronet:

At Rensselaer in spite of the effort to get a Community Outreach Partnership Center (COPC) grant we were not able to convince the university president that such work qualifies as research.

Therefore, what can be done to demonstrate that collaboration as a professional skill has value in the context of university research?

Michael Zaretsky:

Is the university administration bias against such outreach efforts as research based on the notion that technical research brings more money into the university?

Mark Clayton:

The College of Architecture at Texas A&M has a history of having a vital part in the university's research agenda. We have taken the approach to be strategic in planning our own research agenda with two key questions in mind: "What are the important problems on the horizon? And how can we define our activities as being relevant to those problems?

For example the problems on the horizon include things like, global warming, public health, city form and its impact on the environment, entertainment, terrorism, etc. All of these problems have a physical planning dimension and will be upon us in a matter of time. The question that we need to ask ourselves is, will architecture be involved or will such issues be taken by engineers and social scientists?

Fatih Rifki:

The fact is we already missed the boat with issues that are now current such as solar energy, housing, and sustainability.

Frances Bronet:

An example of how far we have missed the boat is illustrated by the fact that architects are not part of the decision making team for public housing issues.

Jim West:

How can we make architecture more relevant?

Susan Mulley:

We need to encourage more students to get PhD degrees.

Brooke Harrington:

I agree, however, the PhD's need to be relevant. Over the years I have gotten several personal grants for my areas of interest. But the university research office doesn't go after grants under a million dollars. Instead of providing support to architecture faculty to pursue research interest too often the university puts up barriers.

Frances Bronet:

One weakness that architecture faculty have is a sort of independence. When it comes to the way we work we have never really learned to collaborate. If you look at other disciplines such as engineering they always have research partners.

Another problem is the absence of graduate students. In most architecture programs students don't have the time or the interest to do research.

Susan Mulley:

We need to teach research methods to our students.

Jim West:

What are non-technical problems that are relevant to architecture? For example, studies show that the operating cost for a business is 65% personnel and only 8% building related costs. However, good work space design can be connected to the productivity of personnel as part of that 65%. We have many examples that people want to work in better environments.

Frances Bronet:

In a similar way we need to address the perception that technology and design are separate and competing concerns.

Brooke Harrington:

This bias will persist as long as the split between design and construction technology is maintained in our definition of architecture as a decorated shed.

Larry Barrows:

That's what I have been trying to say with my complaint about the bias to distinguish between big D and little d in architectural design.

Brooke Harrington:

How is it that the leading European architects, such as Rogers, have learned to integrate design and technology?

I have found a resistance from young faculty and from students to change their interest toward technical issues.

Susan Mulley:

Another barrier to research is the administrative bias of nine month faculty positions. There should be summer stipend money available for young faculty to do research.

Anijo Mathew:

Contrary to some people's beliefs design is not an expertise.

Fatih Rifki:

I feel that it is a problem that it is a rare studio that gets students to collaborate. We tend to emphasize individual creativity.

Frances Bronet:

At Rensselaer we have tried having engineers and architects work together on assignments.

Michael Zaretsky:

Oregon doesn't have grades which seems to lead to more natural sharing of ideas.

Fatih Rifki:

It is not grading but the dominant value system that continues to favor individual work.

Frances Bronet:

What could ARCC do to build a research infrastructure? What could be done beyond organizing the annual conference?

Fatih Rifki:

We recall the Initiative for Architectural Research which was an effort within ACSA.

Mark Clayton:

Currently the NRC (National Research Council) does not include architecture on their list of research disciplines. The listing has become politicized and has been shaped by administrative parameters such as the number of graduate students. Perhaps the ARCC could play a role in changing the NRC policy. After all, the NRC determines how NSF, NEA and other federal funds are allocated.

Fatih Rifki:

ACSA has not really taken on the issue of PhD degrees in architecture in relation to university research.

Frances Bronet:

There may be an opportunity to change that orientation with the current ACSA president.

Fatih Rifki:

It seems that ARCC could be the organization that addresses graduate degrees in architecture. ARCC could declare themselves as the organization to initiate such an agenda.

Frances Bronet:

Can ARCC lobby? Despite what most people think the NSF reviewers are not engineers. How can we get information out? Architecture faculty typically doesn't go to the various organizational meetings.

Anijo Mathew:

What is the effect of the belief that a master's degree is considered a terminal degree in architecture?

Larry Barrows:

I am an opponent of the idea of a “studio genius.” I am interested in post-professional degrees. I feel we should keep studios as they are and use post-professional degree programs to work with a smaller group.

Brooke Harrington:

NAAB has research as one of its criteria, but doesn’t require a course on research. Temple University has incorporated research skills in their curriculum without a research method course.

Defining the role of post-professional degrees will be tied up as long as the master's vs. bachelor degree battle is still going on.

Mark Clayton:

Many architecture programs look at faculty qualifications with the notion that a license and a PhD are somehow equivalent. In actuality such is not the case. While a research one university requires a PhD, if a person wants to work in a practice based school a MArch degree is sufficient.

Jim West:

Is a PhD faculty good for design?

Mark Clayton:

The two qualifications are not exclusive.

Frances Bronet:

PhD’s get pigeon holed, and in some cases are seen as a threat as being somehow “over qualified” and are typically not seen as designers. We should be able to be more inclusive and not define faculty as simply one or the other.