SCI-TECH: A Fully Integrative Approach to Building Design, Culture and Technology

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BACKGROUND

In 2002, the Department of Architecture at Iowa State University decided to radically restructure its Master of Architecture program. The majority of our students are enrolled in a five-year B.Arch curriculum, however, we also offer 60 and 100 credit M. Arch. degrees, which together graduate 12-16 students annually. Traditionally, these programs have been theory-intensive due to the interest of graduate faculty in that area. However, over the past several years our faculty expertise has shifted to include a greater proportion of practitioners, which suggested a new program that utilizes a more balanced approach. In recognizing the need to transform the M.Arch. program, we as a faculty did not want to merely assemble a traditional professional degree. Rather, we intentionally sought ways to take advantage of our location to connect to environmental, cultural and social forces both locally and globally. A program committee composed of design, technology and history/theory/culture faculty members was charged with developing a curriculum that met these goals while emphasizing the integration of these curricular aspects into a coherent program.

The result was a three-pronged "new core" curriculum for the first four semesters of our three-year program. Rather than divide coursework into separate lectures, this "new core" takes advantage of our relatively small enrollment to provide integrated class work that is entirely studio and seminar-based. While design studio remains a focal element of each semester, it is joined by equally weighted courses in culture and SCI-TECH. A survey of our architectural students shows that there is a tendency to favor studio coursework heavily over other classes, resulting in a last minute or nuisance approach to completing non-studio assignments. This is due in part to the proportionately larger number of credit hours for studio, but also to a frequent disconnect felt by students between studio work and technology courses. We decided to shift all three components of the curriculum, Studio, Culture and SCI-TECH, to 5 credit hour blocks. Thus we emphasize the equality of the three areas and work as equal partners in the educational process. The result is a fifteen credit-hour term divided equally into three lobes, emphasizing the interaction between the traditional 'corners' of architectural education – design, culture, and technology. To emphasize this integration, all three courses are taught in the studio, where for the first two weeks the students construct an operable seminar space to hold all group discussions, pin-ups and digital presentations. No separate classes are taught during this time and all graduate faculty participate to assist in the critique and assembly of this seminar 'room'. (Figs. 1 & 2)

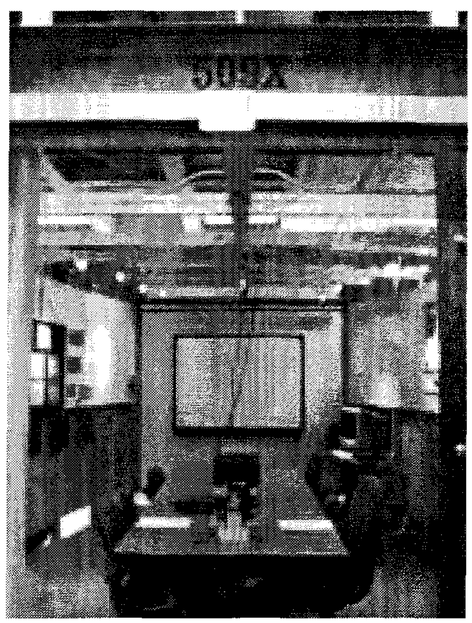

Fig. 1. The SCI-TECH seminar space.

Fig. 2. Seminar space wall detail.

Such a sweeping approach to re-casting the graduate curriculum demanded equally radical work on the three major lobes of the program. We were assigned to develop, in close coordination with the Design and Culture teams, a four-semester course program that would simultaneously meet the NAAB requirements for building science and technology and be a full partner in the redeveloped course sequence. Given the number of students, we had the luxury of developing a science and technology sequence based in a seminar format, which has had a profoundly positive effect on students' learning experience. We also had the challenge of 'mainstreaming' coursework that is often segregated by schedule and location from the crucible of the design studio. The SCI-TECH sequence is thus in part design-based, with a series of design laboratories that put scientific and technical principles into practice. This resolutely architectural context has allowed us to edit the traditional curricular elements, and to propose additional emphasis on aspects that relate directly to the ecological and social goals that have been explicated by the new curricular framework.

BROAD INTEGRATED COURSEWORK

Traditional course structures in building construction, technology and structures are usually oriented vertically, with narrow focus and extending in sequence over three or more years in a typical curriculum. In our case, the desire to reserve our M.Arch program's final semesters for a global studio and a thesis option suggested that we work with a new model, one that was broader and shorter. While the revised sequence is comparable with our previous coursework in terms of overall credit load – 20 hours replacing 21 – it has an intentionally richer structure. Realigning classes into five credit hour blocks has required mixing coursework in structures, environment, materials and human factors into each term, rather than segregating them by topic. Each semester explores subjects in these four major themes, but with a narrative sequence rather than the traditional linear arrangement. To describe this approach, we use the analogy of a spiral ramp, which moves upward through each of the four themes gradually, allowing knowledge from one (structures, for example) to interact with others (materials, e.g.). By continually moving between themes, we gradually build a knowledge base that is both internally integrated – understanding the links between ecology, materials, and structural systems – and externally integrated, allowing knowledge to be applied immediately and synthetically to coordinated studio projects. Each semester has one or two major blocks of learning work: for example, in the first semester we try to emphasize basic environmental response and elementary statics. However, the coursework also takes 'breaks' in these major themes, allowing more specific topics to punctuate the larger scale projects.

This structure results from our own concerns about traditional technology sequences that emphasize laborious technical criteria over basic literacy and intuitive understanding. The authors were struck, upon taking the ARE exam, at how limited the licensing requirements for technical knowledge in some areas – structural engineering in particular – actually are. At the same time, our own experience in national and international practice emphasized both the division of labor in building design and the need, usually unmet, for architects to appreciate the broad brushstrokes of various engineering disciplines. In what we see as a classic case of losing the forest for the trees, our previous technology sequence tended toward specialization, depth, and complexity. We charged ourselves with creating a new sequence that would emphasize integration, breadth and clarity. We have a fundamental belief that design, technology and culture are inseparable and should be presented as an integrated process in the practice of architecture.

To do this, our sequence attempts to connect regularly with our program's design and culture sequences. This occurs both analytically – with all three-course areas (design, culture, and technology) using case studies of a common group of buildings to discuss architectural issues, and synthetically – with the sequence responding to likely topics and questions in the parallel studio classes. Thus, the first semester deals with site orientation, elementary structural design, basic building materials, and simple cladding, all of which students explore in their primary studio course. Likewise, each topic is covered not only technically, but also historically and culturally. Structural design, for instance, is introduced through a brief history of the discipline, one that emphasizes the historic connections between statics and architecture in Greek, Roman, Gothic, and Victorian examples. Basic climatology is introduced by examining buildings throughout history from a variety of cultures, discussing how elements of climatic response have been incorporated into statements of social and cultural values.

ECOLOGICAL RESPONSIBILITY

Rather than the traditional structure of three or four dedicated vertical curricular lines – usually structures, construction, and environment – our four-semester set of five-credit blocks interweaves our major themes of structures, environment, materials and human factors. Suffused throughout these are issues of ecological stewardship and environmental responsibility, which are a focus of our entire curriculum. This stems in large part from our location, a rich though severely threatened natural setting, where debates between agriculture, land speculation and the environment make up part of daily life in the state. Iowa is verdant, having some of the best soil and most productive agriculture in the world. It is also among the most heavily modified natural landscapes in the country. No part of our environment has been untouched by development or agriculture; you can drive the entire length of the state and see no landscape that existed 100 years ago. (Fig. 3) A keen awareness of our tenuous condition has given us the attitude that issues of 'sustainability' and 'green design' should not be labeled or marginalized in any way. These are absolute necessities, and simply the way we present the material. 'Sustainable' and 'green' are seamlessly presented as part of the norm, while pointing out the very real resistance present in practice and construction. In order to be agents for change, our students need to be well educated in the means to accomplish ecologically sensitive work and see it as part of normal practice.

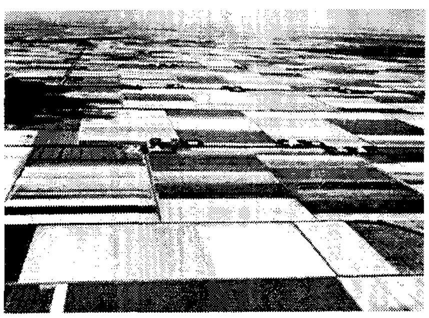

Fig. 3. Iowa landscape.

THE FIRST SEMESTER SCI-TECH SEQUENCE

Following the intensive two-week seminar space design build project, our sequence begins with a three-week focus on the human relationship with climate. This sets the tone for the entire four-semester sequence, privileging intentionally the modification or tempering of the environment as architecture's fundamental act. During this period, students are simultaneously working on an introductory studio project for a spa and bath complex on a local site, which deals immediately with human comfort, air temperature, humidity and solar geometry. Dedicated labs include experiments with environmental modifications and elementary solar orientation. During these hands-on labs students must construct assemblies such as a swamp cooler and a solar path tracking structure. Towards the end of this three-week period, we transition into discussing structural design. This five-week seminar begins with our dropping a brick on the seminar table, and then following, step by step, the loads and forces that action induces and the way in which the table resists these. Inspired by non-technical approaches to mathematics, including David Berlinski's *A Tour of the Calculus* and Per Gulberg's *Mathematics From the Birth of Numbers*, our approach to structures is one of intuitive understanding. We use basic trigonometry and algebra, but given the background of our typical graduate students – usually art instead of engineering – we focus on graphic approaches to understanding the ways in which loads are transferred and resisted. This approach is also mindful of the way architects collect and use information in practice. Laboratories during this period include the construction of a simple force table, to give a tangible understanding of free body diagrams, a beam testing class using bathroom scales and 2 x 4s, and a truss olympiad during which students must span an increasing distance using only soda straws, drafting tape, and paper clips. (Fig. 4) By the end of the five-week period students have a graphic and algebraic approach to calculating reactions and internal shear and moment within beams. A weeklong segment on wood occurs in the middle of the structural sequence; so that by the time we are discussing trusses we have at least one material with which we can design simple members. The first semester concludes with weeklong seminars on masonry and glass, and with integrated principles of building envelopes, focusing on small-scale structures using the specific materials studied – wood, masonry and glass.

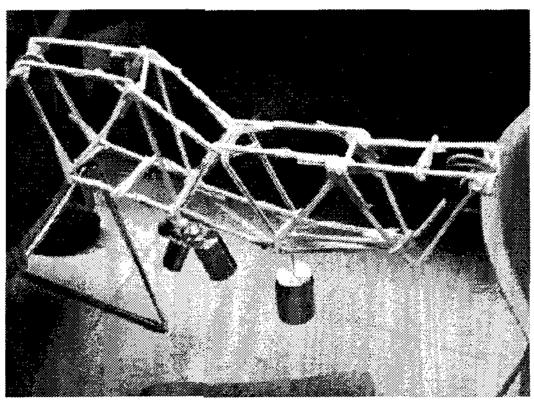

Fig. 4. Truss Olympiad.

THE SUBSEQUENT SCI-TECH SEQUENCES

The second semester is devoted to issues that occur in mid-rise buildings, again paralleling the experimentation and work that occurs in the design studio. Steel, basic concrete, and reinforced concrete are introduced as fundamental building materials in the first weeks, followed by another five-week structural sequence that includes sessions on frames, slabs, foundations and structural systems. At this point, students have the knowledge they need to select structural systems and to size structural elements using basic procedures, charts and simple math. This knowledge is anticipated and integrated into design studio problems in the second semester. Later in the term, we take three weeks to discuss human factors, in particular life safety, accessibility and simple circulation. These subjects, again, are based on good practice and concepts, not a rote memorization of the building code. As such, we currently observe basic principles we've covered being integrated into studio projects as a matter of course, not as assigned criteria. The final two weeks of the second semester are devoted to environmental techniques, including passive and active ventilation and passive solar response.

Plans for semesters three and four include significant (three to five week) seminars on illumination, building services, and construction process, sequencing and budgeting. Advanced topics in materials and structures include coursework on high rises and long spans, component design, and aluminum, plastics and composites. Our human factors thread concludes with active circulation, and we will take advantage of an international-class theater on campus to discuss, demonstrate and experiment with building acoustics.

FORENSICS

Recognizing that the pace of the design studio mandates a tailing off of other coursework toward the end of the term, each semester concludes with a one-week case study of building failures and forensics, each manifesting problems from the topics covered in the previous semester. During the first semester we discuss structural failures such as the Kansas City Hyatt Regency collapse, the Mianus River Bridge failure, and a wide variety of masonry, wood and human comfort failures, of which there seem to be no shortage. Later semesters will examine other notable failures whose root causes are more complex, including the Tacoma Narrows Bridge, the Boston John Hancock Building, the Standard Oil Building in Chicago and various seismic failures. In the final semester of the sequence, we plan for a one-week session on the World Trade Center, asking the rhetorical question of whether their collapse can be considered a building 'failure'. We plan to focus on both the well-documented structural issues, and to use recently published evidence to describe the failures of the fire suppression and escape systems. This, again, allows us to weave issues of culture, design and technology as an inseparable, integrated whole.

THE COMMON SEMINAR

This experiment in the new graduate program has, in fact, begun. We launched the program in the fall of 2003 after spending significant effort preparing the initial sequences and coursework. This preparation was made substantially more difficult not only by the reshuffling of subject matter, but by a sincere desire to integrate coursework across the design / culture / technology spectrum. A mechanism we have successfully used to ensure overall discussion has been a common weekly seminar session. Design and SCI-TECH 'donate' one-half hour per week to a single three-hour section of common discussion facilitated by the culture professor, and attended by all students and graduate faculty. The subjects for the seminar are integrated in nature and are presented each week by different members of the group, both students and faculty. Part of the seminar also includes detailed building case studies researched and presented by the students. The current group of cases is on the topic of the studio project, baths and pools. This case study research includes information on design, culture and technology and stresses the connections between the areas. It is difficult, when looking at a completed project case study, to avoid discovering that all decisions are made synthetically, and that a seamless story must unfold from the integrated nature of that decision making process. The case studies also begin to feed into what we loosely refer to as our 'canon' of significant work: a set of roughly 100+ projects that we collectively use between Design, Culture and SCI-TECH.

WEEKLY CLASS SEQUENCE

The weekly sequence of the dedicated SCI-TECH seminars have also been arranged to draw connections between different areas of the subject matter. The classes are broken into three ninety-minute sessions per week, with each segment having a particular focus. Typically the first seminar covers the technical and theoretical aspects of the subject matter, the second segment shows examples of projects using the subject matter, and the third seminar is a hands-on laboratory. These classes also work with accessible background readings and problem sets to supplement the discussion.

An example of this sequence can be seen in the *solar geometry* course outline. The topic covers basic terminology and concepts such as sun angle, azimuth, and the solstices. This leads to a discussion about the shifting position of the sun during the year dependant on latitude, and the use of sun path diagrams to calculate solar position. Regional historical building types are studied for their natural relationship to the environment, and the basic strategies for daylighting are covered. In the previous environmental technology sequence this would complete the study of solar geometry, however, in the new sequence this is the outline for the first session. The second session uses specific project examples from the 'canon' to demonstrate various successful and unsuccessful responses to solar orientation and control. This sets up a number of useful pedagogic techniques. To cover the breadth of the information in the first class requires a rapid overview of topics, while the second class allows for repetition of each area in relationship to a built project. Every important concept or skill is covered multiple times and in different formats to strengthen each student's comprehension of the topic. The practical examples are both contemporary and historical, which also allows for discussions between design and cultural issues related to the technical areas being covered. The final class in the solar geometry sequence is a group lab conducted in the studio space, based on calculating the sun's position on a number of days and times. A reference point is marked which will cast shadows throughout the space based on time and date, and the positions are marked using the appropriate sun path diagram. These markings are left in the studio and the points are viewed and evaluated during the course of the year. The final lesson is then reinforced with an ongoing example of the principles of solar geometry.

Each topic uses a similar set of techniques to simultaneously cover broad subject areas and push for multiple ways to understand and apply what was learned. Individual case studies from the 'canon' are also used to explore subjects, such as structural explorations of the Crystal Palace. In this case students are asked to research the project and perform a number of exercises in transforming the original iron structural system. The structural components are evaluated and sized in both steel and carbon fiber, which produces immediately evident differences that quickly demonstrate the varying properties of the materials. This type of exercise also strengthens the ability of students to evaluate the environment around them continually and critically, which is fundamental to the practice of architecture.

SUMMARY: ARCHITECTURE'S 'TWO CULTURES' CONSIDERED HOLISTICALLY

While this pedagogical experiment is only just underway, the initial response from students and our first experiences of teaching this structure suggests a pattern of success that we hope to repeat as we move through the sequence. In particular, the dedicated focus on one topic per week allows us to quickly define our goals for each subject, backtrack a bit to ensure an understanding of basic ideas, and then move efficiently through principles, case studies and laboratories. The weekly shift in focus forces us to bring topics to a meaningful conclusion, and it allows students time to work on areas of particular difficulty. We have already found, for instance, that the interlude of one week covering wood has permitted some students extra time to master the initial statics work, which did prove challenging for some with a non-technical background. In a traditional structures sequence, this might have proven problematic, as the constant flow of new material works against the inevitable needs of some students for extra practice and study.

In a broader sense, we have seen the beginnings of a profound weaving together of Design and Culture with the SCI-TECH coursework. Students bring their design work to class, seeking advice on environmental, material and structural aspects of their work. Likewise, we have seen in these very early stages awareness in studio of the environmental and structural topics covered in the first semester of SCI-TECH. We anticipate that this integrating work will continue through the sequence, offering students the chance to recognize the inevitable reliance of design on technology, and vice versa. This is not to say that the course has been entirely smooth-logistical issues with the amount of new visual material required and the broad range of math literacy among our incoming students have both presented challenges. However there is a real sense that the basic premise of the sequence is giving our new students a deeper appreciation for the potential integration of objective, technical work into their conceptual designs. We are in particular looking forward to the linking of further cultural and theoretical coursework with this sequence, as it promises exploration of a largely ignored territory-the critical assessment and analysis of technology's place in architecture and in a broader cultural context.

Week	Fall Year 1 Arch 540	Spring Year 1 ARCH 541	Summer Year 1 ARCH 542	Fall Year 2 ARCH 543
1	Introduction	Introduction	Introduction	Introduction
2	Human Factors	Materials–Steel	Site Planning	Building Envelope III
3	Human Comfort	Materials–Concrete	Site and Building Ecology	Construction Sequence
4	Basic Climate	Reinforced Concrete	Materials–Aluminum	Cost Control
5	Solar Geometry	Frames	Building Envelope II	Services–HVAC
6	Forces and Loads	Slabs	Illumination–Principles	Services–Plumbing
7	Stresses	Foundations	Illumination–Application	Services–Electric
8	Materials–Wood	Structural Systems	Life Safety Systems	Acoustics
9	Truss Design	Long Span--Frames & Arches	Interior Construction	Materials-Plastics
10	Shear and Bending	Life Safety--Code Compliance	Component Design & Fabrication	Materials--Composites
11	Beams and Columns	Accessibility	Exterior Construction	Vertical Transportation
12	Materials–Glass	Stairs and Ramps	Membrane Structures	
13	Materials–Masonry	Ventilation–Passive	High Rise Structures	
14	Building Envelope I	Ventilation–Active	Technical Documentation	
15	Case Studies	Building Failures	Case Studies	Building Failures

SCI-TECH Master Schedule