A third year building design (BS) studio is integrated with a building environmental systems (BES) studio, which is referred to as the Integrated Project Studio (IPS). The same 18 students are in both the building design studio and the building environmental systems studio. The instructors for each studio, one an active practitioner who is a managing partner in a local firm and also a full time lecturer in the department and the second a full time academic (professor) collaborate together on developing the content for both courses.

The quarter starts of with a series of intense short workshops that used an interchangeable use of digital and physical media to focus on BES topics such as day lighting, electric lighting, and skin vocabulary to lead students to consider these components as part of their form-making inspiration. In integrating BES components with the design studio, a nine-step methodology has been established to provide students with a compelling and tangible framework for design.
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IPS is one of ten sections of design and BES taught in winter quarter, but it is left up to the individual instructors how and when building environmental systems (BES) topics such as day lighting, electric lighting, thermal behavior, acoustics and water and waste systems can be made part of students’ design investigations, in particular their articulation of building space and skin. The difficulty of synchronizing activities in the building environmental systems studio, BES lecture and design studio were formidable, and it was decided by the instructors to link these two studio activities as closely as possible in order to emphasize to students that ECS issues were fundamental to their design work.

**IPS Course Objectives**

- That students recognize that BES knowledge is not distinct from design knowledge
- That students develop a “rules of thumb” working knowledge of core BES topics such as day lighting, electric lighting, thermal performance of buildings, acoustics and water and waste systems and can synthesize them into their design studio project
- That students recognize that the designer has the responsibility to configure buildings so they are healthy for occupants and are resourceful and efficient
- That students learn to conceptualize buildings not as discrete objects but rather as an assemblage of systems and elements that are connected to and interact with the larger world. Discussions in this class will focus less on the what (what it is, what it looks like) and more on the how (how it works, how it interfaces with the surrounding environment).
- That students are able to competently analyze an aspect of their building design project from the perspective of environmental performance (acoustic quality, shading of a window, appropriate daylight levels, and so on) and use this analysis to inform and inspire subsequent design work.

**IPS Diagram**

NOTE: ECS refers to the Building Environmental Systems (or BES)
IPS List of Topics

<table>
<thead>
<tr>
<th>Week</th>
<th>#Activity Themes</th>
<th>Reading Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>(1) Analog &amp; Digital Tools Warm-Up Ex. &amp; (2) Conceptual Understandings Ex.</td>
<td>Representation</td>
</tr>
<tr>
<td>02</td>
<td>(3) Daylight Precedent Studies</td>
<td>Infrastructure &amp; Water</td>
</tr>
<tr>
<td>03</td>
<td>(4A) Space Moods of Day Light &amp; (4B) Spatiality of Night</td>
<td>Light &amp; Materiality</td>
</tr>
<tr>
<td>04</td>
<td>(5) Acoustics &amp; Volume</td>
<td>Sound &amp; Senses</td>
</tr>
<tr>
<td>05</td>
<td>(6) Volumetric Configurations of Space [MID-Review]</td>
<td>Skin</td>
</tr>
<tr>
<td>06</td>
<td>(7) Skintegration (Thermal Optimization - exterior skin)</td>
<td>Space &amp; Body</td>
</tr>
<tr>
<td>07</td>
<td>(8) Process Integration</td>
<td>Building Typologies</td>
</tr>
<tr>
<td>08</td>
<td>(9) Process Integration</td>
<td>Building Typologies</td>
</tr>
<tr>
<td>09</td>
<td>(9) Project Integration</td>
<td>Building Typologies</td>
</tr>
<tr>
<td>10</td>
<td>(9) Project Integration [FINAL Review]</td>
<td>Building Typologies</td>
</tr>
</tbody>
</table>

Note: Reading and Reading Themes (the majority of the studio text was taken from “Questions of Perception, Phenomenology of Architecture”, by Holl, Pallasmaa, & Perez-Gomes) discussions and sketchbook “aphorisms response” assignments provided a shared thematic framework, with a focus on how experiential, phenomenological aspects of architecture can be enriched and informed by a background understanding in BES.

Students Feedback Regarding IPS

- “I really enjoyed the BES/Design collaboration this quarter. I don’t think I’ve ever had a quarter in which the two were so well integrated. I liked the fact that we got to explore the BES side of design by focusing on the general concepts rather than the number-crunching side.”

- “I think the skin (skintegration exercise) is a great opportunity to create spaces that people will find inviting and to create a different relationship with the exterior.”

- “The … process was very integral in developing a design vocabulary, in terms of form and most importantly skin. It provided a firm inspiration for defining that skin, without that it would have proved a difficult struggle to find a foundation to leap from.” “(The process) has helped me in creating a strong architectural language that has guided me throughout my project. Thus, I was not distracted by the many issues that faced me, but was able to rationalize and keep my idea(s) clear and strong.” “The use of multimedia (analog-digital tools) and the intense pace of this studio created a strong and direct process that inspired my design throughout the quarter. While all the parts remain exercises within themselves, it is when you see how they all relate to one another and speak of a unified process that makes this design approach so significant.”

Instructors Reflections Regarding IPS

The overall quality of the studio projects — when compared holistically to the other nine third year BES/design studios — was mostly visible in the strength of both the interior and exterior architectural vocabulary of students’ projects. There was also an ease of understanding how a student’s project (in looking at the documented design process) related to the concept, BES issues and how project evolved over the duration of the quarter. Both the vocabulary development and the clarity of the process was due to the following: first, the quarter started with the analog-digital warm-up exercise (which established the foundation for design tools framework and architectural vocabulary); second, this same framework was used for the strategy of studying the BES components for their individual project; and finally, continuing to use this framework for the synthesis of the significant BES components into final development of design studio project.

Summary of the nine steps for BES and Design Studio Project integration:

**Exercise 1. Tool Building Warm-Up Exercise** - This warm-up exercise, an exercise accomplished in collaborative teams of 4 students, provided an opportunity for all students in the studio to come up to speed using a range of digital tools in the context of solving a design problem. In addition, the outcomes from this team project became a foundation kit-of-parts vocabulary that each individual student would use for developing their own project vocabulary. Examples of these types of exercise include students developing light machines to understand the dynamics of light, etc.

**Exercise 2. Understandings** - Students are also provided a warm up exercise in the BES studio so students can understand the poetic aspects of building environmental systems are asked to represent these findings with compelling representations and also with ‘poetic’ written descriptions of the sensory stimuli they experienced. A goal of these assignments are to identify formal and material qualities that are ordinarily out of sight and out of mind in the typical building design studio and therefore ask students to recognize that buildings are connected to a web of systems that extend well beyond the building footprint. Examples of these types of exercises include building large scaled physical and digital models of building cladding section details developing sun analysis studies, etc.
Exercise 3. Daylight Precedent - Student groups study significant architecture precedent examples by prominent architects (Aalto, Bruder, Holl, Kahn, Le Corbusier, Piano, Wright, Zumthor) as a way to explore daylight as a form generator. After an initial gathering of information on the precedent, students are asked to develop a hypothesis about the impact of daylight on the experience and functioning of the building. A large-scale physical model and digital modeling studies of the precedent enable an accurate study of interior light conditions. Digital images of the interior of the model are also usually taken at different times of day and year and presented to the class. Students revisited the original day lighting hypothesis based on their more intensive and refined analysis.

Exercise 4A. Space Moods of Light – Impact of daylighting in effecting the architecture is looked at. Students are required to generate “initial concepts” in response to design projects. During an in-class charrette, students developed a concept narrative (“catch phrases”) on a predetermined theme and create a concept ‘light’ sketch using a range of media for and interior space. This space became the form-generating programmatic component of their final design. From these initial studies, and using the daylight precedent study as inspiration, students developed a large scale ‘double wall construction’ day lighting model of the interactive main space.

Exercise 4B. Spatiality of Night: Designing with the Effects of Electric Light - an electric expression to mimic daylight scheme. Typically students will also develop the electric light version that mimics the daylight version. - Students are asked to create “DYNAMIC ATMOSPHERE” with electric lighting working with the same model they generated for the daylight exercise. The original lighting concept was re-evaluated and refined based on discoveries made with the model. In-class discussions center on light distribution, the interrelationship of light and the surfaces on which it falls, and the role of electric lighting relative to day lighting to assist students with the integration of lighting into design projects. Students were encouraged to ‘mimic’ day lighting after dark through the deployment of electric lighting.

Exercise 5. Acoustics & Volumes — Students developed physical models for understanding acoustic performance in their interactive main space. They first calculated the reverberation time (RT) for the space, which required them to make preliminary decisions about building materials and finishes. In most cases the RT’s were high and unsuitable for speech and similar functions. Students reevaluated decisions about materials in an effort to lower the RT. In most cases this led to an enrichment of the palette; perforated panels and fabrics for example were introduced in many projects in configurations that supported the established architectural vocabulary.

Exercise 6. Volumetric Configurations of Space — expressing the project’s concept in the spatial configuration Transforming all of the separate components of the project (e.g., skin, interactive main space, volumetric configurations of space, etc) into an integrated architectural expression allowed students to build on and further integrate lessons learned in earlier exercises.

Exercise 7. Skinintegration — expressing the project’s concept in the skin

Addressing thermal optimization principles required that each of the students develop four skin model details. Each detail has to embody the concept of the project and at the same time explicitly express the response to each of the four orientations.

Exercise 8 – Process Integration During the seventh week of the quarter, students completed the last of the specific BES studio assignments and spent the remainder of the studio (3 weeks) integrating BES topics in their final design project. Instructors required that students meaningfully integrate day lighting and thermal optimization (“skintegration”). They were also asked to select an additional optional BES topic to explore out of electrical lighting, acoustics and water and waste. Students’ overall performance in the ECS studio was measured in part by their ability to skillfully and beautifully synthesize BES issues with other design concerns in their projects.

Exercise 9 – Design Project Synthesis and Integration of BES lessons learned

Students have 3 ½ weeks to refine building design projects.
<table>
<thead>
<tr>
<th>NAAB Criteria</th>
<th>Skills</th>
<th>Comment</th>
<th>Evidence</th>
<th>Weak (−)</th>
<th>Competent (+)</th>
<th>Strong (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (A) Speaking and Writing Skills</td>
<td>Writing in architecture</td>
<td>May be internal and external to project</td>
<td>Extended captions, concept statements, written narratives, reflective essays, and technical reports</td>
<td>Never writes to professional audience. Descriptive, feelings-oriented (420?) Significant errors. Little or no writing in project.</td>
<td>Sometimes writes to professional audience. Describes about project – its specific qualities such as structure, orientation etc. Minor errors. Writing aids drawing in form of titles, labels, notations, and captions.</td>
<td>Consistently writes to professional audience. Clear theme; hypothesis, development, and synthesis (420?) Error-free Titles, labels, notations, extended captions, concept statements, and reflective essays work together with drawings to make convincing argument.</td>
</tr>
<tr>
<td>2. (A) Use of Precedents</td>
<td>Architectural research and use of precedents</td>
<td>Ability to gather, assess, record, and apply relevant information (NAAB). Precedent studies as critical component.</td>
<td>Comparative diagrams, drawings and models that explore connections to project. Cut-and-paste precedent studies; little or no analysis; little or no application to project. Precedent studies re-drawn to consistent scale; graphic and textual analysis; conclusions drawn but not well applied.</td>
<td>Precedent studies re-drawn to consistent scale; graphic and textual analysis; conclusions drawn and well applied to project.</td>
<td>Precedent studies re-drawn to consistent scale; graphic and textual analysis; conclusions drawn and well applied to project.</td>
<td></td>
</tr>
<tr>
<td>7. (A) Collaborative Skills</td>
<td>Collaboration</td>
<td>Within and between disciplines; evidence that students learn from each other.</td>
<td>Teamwork in research and design showing individual and collective effort, description of process/product, self-evaluation of team members. Teamwork acknowledged but not substantiated in project. Teamwork acknowledged and evident in research. Unclear relationship between individual and collective effort.</td>
<td>Teamwork acknowledged and evident in research and design. Clear relationship between individual and collective effort.</td>
<td>Teamwork acknowledged and evident in research and design. Clear relationship between individual and collective effort.</td>
<td></td>
</tr>
<tr>
<td>16. (A) Program Preparation</td>
<td>Programming</td>
<td>Ability to connect program to project</td>
<td>Goals, definitions, mission/vision statement, diagrams, models, narratives, and precepts. Minimal program with no clear application to project. Program developed and applied to project.</td>
<td>Well-developed analytical program applied with clarity and imagination to project.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. (A) Site Conditions 19. (A) Environmental Systems 21. (A) Building Envelope Systems</td>
<td>Responsiveness to site conditions</td>
<td>Principles that govern design of buildings and groups of buildings, as well as site itself.</td>
<td>Diagrams that document and investigate; site plans, sections, and models. Little or no site description. Little or no useful conclusions pertaining to design of building. Site description and graphic analysis. Conclusions drawn and applied to design of building or group of buildings.</td>
<td>Substantial site description and analysis. Conclusions drawn and applied to design of group of buildings and site itself.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Context for Building Design Studio and Building Environmental Systems Studio in Third Year

**FALL**

**THIRD YEAR BUILDING DESIGN 1**
Development and exploration of architectural theories, building systems, and design processes involved in creating appropriate architecture on a sensitive site; implications of the site as building form generator.

**BUILDING TECHNOLOGY SYSTEMS 1 (Studio)**
Integration of basic building components (envelope, structure, circulation, site), plus codes

**STRUCTURES 1**
Small scaled structures in steel & concrete

**NAAB LEARNING OBJECTIVES**
- Research Skills
- Collaborative Skill
- Use of Precedent
- Site Conditions
- Environmental Systems
- Life-Safety Systems
- Bldg Envelope Systems
- Building Service Systems
- Bldg Systems Integration
- Bldg Materials & Assemblies
- Technical Documentation
- Comprehensive Design

**WINTER**

**THIRD YEAR BUILDING DESIGN 2**
Creating appropriate sustainable architecture with an emphasis on ecological and environmental concerns.

**BUILDING TECHNOLOGY SYSTEMS 2 (Studio)**
Building Environmental Systems
Integration of passive principles in building design (light, acoustics, & thermal)

**STRUCTURES 2**
Large scaled structures in steel & concrete

**NAAB LEARNING OBJECTIVES**
- Research Skills
- Collaborative Skill
- Use of Precedent
- Site Conditions
- Environmental Systems
- Life-Safety Systems
- Bldg Envelope Systems
- Building Service Systems
- Bldg Systems Integration
- Bldg Materials & Assemblies
- Technical Documentation
- Comprehensive Design

**SPRING**

**THIRD YEAR BUILDING DESIGN 3**
Creating appropriate architecture with an emphasis on socio-cultural and space planning/life safety concerns.

**BUILDING TECHNOLOGY SYSTEMS 3 (Studio)**
Focus on mechanical, construction types (steel, masonry, concrete)

**HISTORY**
Architecture & urbanism in form the modern world – 18th century to present

**NAAB LEARNING OBJECTIVES**
- Research Skills
- Collaborative Skill
- Use of Precedent
- Site Conditions
- Environmental Systems
- Life-Safety Systems
- Bldg Envelope Systems
- Building Service Systems
- Bldg Systems Integration
- Bldg Materials & Assemblies
- Technical Documentation
- Comprehensive Design

**WINTER**

**BE Lecture Topics**
(Lecture topics selectively integrated)
- Weeks 1, 2 & 3 Architectural Lighting: Electric & Daylighting
- Weeks 4, 5 & 6 HVAC Systems
- Weeks 7 & 8 Acoustics
- Weeks 9 & 10 Water and Waste Systems

**Design Studio Support Course**

**CIDS — page 5**
STUDENT WORK

[A Collage of Selected Samples of Work]
SAMPLING OF INTEGRATED PROJECT STUDIO STUDENT WORK
[Shows connections between building environmental systems studies and developed building design project]
Student Work from January 2005 to March 2008

Sanctuary Space for a Pipe Organ
Airport Terminal
The Center for the Study of Light
A Tsunami Memorial Building
Steel Museum (Independent Study)

Immersive View
Physical Model Detail
Roof Skin
Cladding System Detail
Light Machine Study
Cladding System Detail
1/s Scale Physical Model Detail
Precedent Study
Immersive View
Skin System Detail

IPS — page 2
SANCTUARY SPACE FOR A PIPE ORGAN

Project Concept

The building became a backdrop to the canal and layers of the skin provided a series of lighting affects.
<table>
<thead>
<tr>
<th>Sanctuary Space for a Pipe Organ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Concept</td>
</tr>
<tr>
<td>Started my building design as a light machine that will reflect his thoughts of how light, shadow, and color would play within my project center space. My idea was to observe and capture the light images that were reflected by the fan. My light machine was built by finding the left over parts from the existing machine.</td>
</tr>
</tbody>
</table>
Airport Terminal

| Project Concept — | The airport integrates plane and building to create an interactive space (continuation of the initial “light machine” study). Rather than connecting to the building externally, the planes are brought into the building underneath the grand space. The airport celebrates the plane by adapting through it through the configuration of spaces, and the constant transformation that takes place throughout the day as the building’s kinetic steel components extend to meet the plane. |
| Early Light Motion Studies — | The early light box studies of light and movement inspired my precept of the activation of space and how an environment can best showcase a particular use. This translated into the airport project, driving the design process and influencing the configuration of spaces/program, as well as influencing the vocabulary. Throughout the design process, I used both digital and analog media. This proved very beneficial as each helped me to develop certain areas of my project. It was easier to digitally explore multiple variations and take multiple immersive views to get a better feel for the special qualities. Building analog models at various scales helped me to see the project in different ways and work out real connections. |
| Reflections — | Going through this specific design process this quarter was very beneficial. The earlier light machine studies provided a good foundation for the process and the airport project. The use of both digital and analog tools helped me to really understand my project better and develop stronger skills in both areas. I really enjoyed each stage of the process, especially after realizing the importance of and opportunity in each step. This quarter I learned how to most efficiently and effectively approach a design project, as well as how important it is to stay focused in order to really move forward. I am anxious to apply this process to future projects. |
Transience Light Machine (a.k.a “Bowel Movements”) —
The elusive temporal nature of shadows and light are captured through the morphing images projected from the inner structure of the light box. When illuminated, the exterior shows mysterious glimpses of the organism inside.
Building Design Studies

Stills of Digital Animation for the Study of light

Analog Vocabulary Models for the Study of light

More Digital Vocabulary Study Iterations

Digital Vocabulary Study Refinements from Initial Transience Project
Digital Model View of Entire Airport Terminal

More Digital Vocabulary Study Iterations

Physical Model Detail Views of Airport Terminal

Digital Vocabulary Study Refinements from Initial Transience Project

Digital Model Exploded Axonometric of Airport Terminal
<table>
<thead>
<tr>
<th>Center for the Study of Light</th>
<th>PROJECT CONCEPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple Rhythms of Time, is about capturing the many rhythms of the site on the Cal Poly campus using the layered and complex movement of the Light Space Modulator. Utilizing the kinetic power of Moholy-Nagy’s Light Space Modulator—a mechanically driven rotating kaleidoscope projecting ever-changing patterns of light, shadow, and color— the Center for the Study of Light [TCSL] carves itself into the land, uncovering the multiple rhythms of the site.</td>
<td></td>
</tr>
</tbody>
</table>
Class Study of Light – groups developed Light Space Modulators (LSM) to explore the kinetic aspects of light and movement.

<table>
<thead>
<tr>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
<th>Study 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Kinetic Energy Physical Model" /></td>
<td><img src="image" alt="Kinetic Energy Exploded Digital Model" /></td>
<td><img src="image" alt="Kinetic Energy Digital Folded Out Shadow Projection Model" /></td>
<td><img src="image" alt="Kinetic Energy Digital Folded Out Shadow Projection Model" /></td>
</tr>
<tr>
<td><img src="image" alt="Wholly Mo Holly Digital Model" /></td>
<td><img src="image" alt="Wholly Mo Holly Physical Model Detail" /></td>
<td><img src="image" alt="Wholly Mo Holly Physical Model Connection Detail in Motion" /></td>
<td><img src="image" alt="Wholly Mo Holly Physical Model Photograph of Device in Motion" /></td>
</tr>
<tr>
<td><img src="image" alt="Play of Light = Play of Movement Digital Model" /></td>
<td><img src="image" alt="Play of Light = Play of Movement Digital Model Perspective View" /></td>
<td><img src="image" alt="Play of Light = Play of Movement Digital Model View in Motion" /></td>
<td><img src="image" alt="Play of Light = Play of Movement Digital Model Detail View" /></td>
</tr>
<tr>
<td><img src="image" alt="Mysterious Machine Physical Model" /></td>
<td><img src="image" alt="Mysterious Machine Physical Model" /></td>
<td><img src="image" alt="Mysterious Machine Physical Model Detail" /></td>
<td><img src="image" alt="Mysterious Machine Physical Model Detail" /></td>
</tr>
</tbody>
</table>
Student developed study #1 into architecture project.

<table>
<thead>
<tr>
<th>Analog Model Interpretation of Light Space Modular (LSM)</th>
<th>Digital Model Interpretation of LSM</th>
<th>09 Exploded Digital Model Interpretation of LSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploded Digital Model of Entire Building</td>
<td>Exploded Digital Model of Entire Building with Site</td>
<td></td>
</tr>
<tr>
<td>Digital Longitudinal Section of Entire Building on Site</td>
<td>22 Digital Cross-Section of Entire Building on Site</td>
<td></td>
</tr>
<tr>
<td>Digital Wall Section, by Sergio Ramirez</td>
<td>Digital Wall Section Detail Close Up, by Sergio Ramirez</td>
<td></td>
</tr>
</tbody>
</table>

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Project Concept

A Project memorial was designed in response to the tsunami that devastated Southeast Asia on December 16th 2004. In the aftermath of the tsunami many thousands of people’s lives were fractured and broken. In Banda Aceh, Indonesia there was a river of moving debris from the destruction caused by the tsunami. Within the debris were hundreds of victims the tsunami had claimed.

Large Scale Built Physical Model Details Analysis

A Reflection on Building this Detail @ Half Scale

Throughout the process of discovering the environmental factors of this administration building, we came to the conclusion that the shading devices hugely affect the interior condition of a large envelope building. Large envelope buildings are characteristic of being extremely affected by the heat mechanical devices as well as heat that the human body gives off. Since these two already give the structure enough heating, they wanted to make sure that the exterior climate doesn’t contribute to the heat gain. The intent of the architect is quite clear. Their main concerns were to allow natural day lighting in without letting in the heating qualities of the light, as well as limiting the amount of temperature exchange between interior and exterior. The solution of using the movable louvers was very efficient due to the mobility of the shading devices. The mobility allows for the building to be adaptable, changing to fit the need of every season. The characteristic of the interior of the building is consistent day lighting throughout. This was mainly contributed by the reflective panels located on the top portion of the window treatment. This device controls the light by bouncing the rays off the panel and distributing the light evenly throughout the space. The interior space really benefits from the distribution of light because statistically humans work more efficiently with the more natural light they are in contact with. The architect was successful in their attempt to create an efficient and well lit structure.
Large Scaled Physical Cladding Models were Built and Studied
Cladding Detail (above) and Immersive Space Detail (Below)

Skin Study Progressions
Project Concept

The main concept of this project was to utilize steel mill machines to derive the gestural museum’s form. Because the site is currently completely undeveloped and the future context is unknown, a form of independent character is intended to emerge from the inward. The south facade is generated by tracing the steel mill machines.