The UW Integrated AEC Studio: Pedagogy, course structure, and insights from 2009 - 2016

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High performance buildings require collaboration.
How can AEC students be engaged across studio/non-studio disciplines with different credit hours and curriculum requirements?
UW Integrated AEC Studios

- Begun Winter Quarter 2009
- Teams of 3-10:
  - Architecture, CM, Civil, Structural, Landscape Arch.,
  - Real Estate, Sustainability, Facilitation
- Experiments with different projects, studio spaces, course schedules
- since 2014: 6 cr Arch studio + 3 cr seminars structure
- 10 week quarters
UW Integrated AEC Studios

- Arch Seniors—5th of 6 required arch studios
- Required for Arch/CM dual majors 4th year
- Four seminars—AEC content
- CM Seniors/5th year dual — right before their capstone
- Others take 3 cr. Seminars
  - Usually fulfills elective credits
Course Design: Studios and Seminars

- Traditional arch studio
  - 1 faculty member
- 4 seminars
  - 2 faculty members
  - Teach seminars alternate days
- Seminar students have not had prior studio experience
  - Issues: research, proposition, multi-variate problem solving
  - Pin-up discussions ("out"), research for future ("in")
  - Architecture student "process mentors" for studio habits

6 cr. 3 cr.
Course Design: Studios and Seminars

- Meet MWF, studio/seminars overlap, Friday team day
- Architecture student “lead” attends seminars
Course Design: “Cycles”

- Content “Cycle”—A) introduction [and review], B) design and integrate, team workshop, C) develop/prepare for review

- Reviews include industry experts and outside faculty
- Review responses are team reflections on information learned at reviews
- Facilitation includes team planning, peer assessment
Course Design: “Cycles”

- Content Cycle 0: Intro & analysis, Cycle 1: structural system, Cycle 2: façade/envelope, Cycle 3: “deep dive” system development
Course Design: “Cycles”

- “set-based design”—developed from “set-based concurrent engineering”
  Sets of possible solutions considered concurrently, narrow possibilities, converge on final interim solution. New questions posed. (Toyota; Smith, 1997).

- Parallel to LEAN process, fast-track design/construct, IPD
2016 Studio—Timber Frame Office Building

Stone 34 project:
Just-built developer office building in Freemont

Performance meeting Seattle
Deep Green Pilot program

Studio challenge: reconsider design with timber frame structure

Metrics: cost, square footage, sustainability, constructability

Integrated AEC team design process
2016 Studio—Timber Frame Office Building

Work environment:
Studio space +
Two adjacent seminar rooms

Work ethic:
Team buy-in on project goals
Team-driven work periods

Studio instruction:
Full design team crits usual for M & W
Review project progress and discuss options
Fluid full-team work time most F sessions
All instructors stopping in as able to assist
2016 Studio—Cycle 0: Analysis

Week 1 of 10:
Each discipline analyzed documents and gathered information on the Stone 34 project.

In a Friday workshop, students pinned up work and shared findings across disciplines.

Teams looked for connections between issues identified.
Weeks 2, 3, and 4 of 10: Teams started with 2-3 massing schemes for preliminary framing analysis.

Review at end of cycle 1 was meant to help students use the structural issues to select the best scheme.

Decision not uniformly logical.
2016 Studio—Cycle 2: Façade and Envelope

Weeks 4, 5, and 6 of 10:
Design exploration was assisted by information gathering for materials and assemblies

Sustainability factors & strategies were evaluated
Final design options were analyzed for energy, daylighting, and cost.
Weeks 8 & 9: Partnerships within teams to explore in-depth some aspect or feature in the conceptual design

Each “deep dive” feature should ideally be understood from multiple perspectives
2016 Studio—Cycle 3: System Development

**Structural - Deep Dive Connections**
- Girders to Column
- Beam to Girders
- Beam to Wall
- Steel Beam to Wood Columns
- Column to Column
- Splayed Column to Splayed Column

**Post Tensioned Wood Beams**
- **Design**
  - Two post tendons on the bottom
  - Anchor base composite force
  - Composite member
  - Beam absorbs the moment of flexure due to applied loads
- **Advantages**
  - Reduced floor height
  - Improved structural performance, especially seismic
  - Lower cost than traditional beams
  - Faster assembly, less job site labor
- **Disadvantages**
  - Equipment due to limited use in the US
  - Increased construction time
  - Contraction due to storage
- **Structural Members with PT:**
  - PLY-Wood 24" Wide
  - Post-Tensioned Girders 5" x 5" x 45'
  - Secondary Beams 4.47" x 4.47"
  - Trunkway Beams 4.47" x 4.47"

**Thermal Performance of Green Roof**
- Two story model to be tested
- Heat retaining, >90% retention

**Hydrological Performance of Green Roof**
- Model peak flow in EPA-SWMM
  - Green roof applied:
    - Divided into 12 units for drainage
    - 4% peak flow reduction
  - Gravel pavement applied:
    - 11% peak flow reduction
    - Potential cover, the size of outlet pipe

**Open Air Stair Rain Finer & Heated Handrail System**

**Staircase Construction Sequence**

**Integrated AEC Studio**

**College of Built Environments**
2016 Studio—Team A

ASCEND 3400 Stone Way N

Team A

Team Members

ARCHITECTS
SHANNEN
MELANIE
GEORGE
RILEY

LOGISTICS
SIDDHARTH
CHRISTINA
NHI

STRUCTURAL
ENGINEERS
JEAN-LUC
MIRA

COST
ESTIMATORS
antoine
TING

SUSTAINABILITY
ADVISORS
PEYTON
XIQUING

Integrated AEC Studio

COLLEGE OF BUILT ENVIRONMENTS
TYPICAL MULTI-STORY ORGANIZATION

In a typical multi-story office, tenants operate in isolation. Even when occupants work for the same organization, their interaction is minimal.

CONNECTED ORGANIZATION

The pie chart illustrates the costs of various components within the building. The 'Big Stair' design is one of the most significant costs, totaling $1,791,180. The cost breakdown includes:

- Glazing: $24,516
- Metal Paneling: $16,632
- Masonry: $3,150

These components, along with others, contribute to the total exterior envelope cost of $3,120,908.

Integrated AEC Studio

COLLEGE OF BUILT ENVIRONMENTS
Energy & Performance Analysis

Comparing with scenario 1, scenario 2 consumes less energy for cooling and heating as the total conditioned space is reduced.

Comparing with scenario 2, some of the core office zones are turned to be perimeter zones after the stair becomes an open air space in the scenario 3. So in the scenario 3 the building consumes less energy for cooling, but more energy for heating. When comparing the total energy consumption, scenario 2 consumes the lowest.

When the staircase is open, the maximum temperatures during summer are reduced by 7.0% in the West, by 7.6% in the South, and by 7.2% in the East compared to the scenario 2. This reduction is probably attributed to the effectiveness of natural ventilation as those three areas are turned into perimeter zones. Natural Ventilation helps a lot in moving away the cooling loads from the office space. While, during winter, the minimum temperatures are not decreased too much. And this can be explained with the high internal heat gain in the office space offsets part of the heating load.

Considering both the energy consumption and the comfort condition, scenario 3 is the best design scenario.
Framing, Columns, and Connections

Structural Connections Cost Analysis

<table>
<thead>
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<th>Description</th>
<th>Quantity</th>
<th>Cost</th>
<th>Total</th>
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<td>60</td>
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<td>One Level Cost</td>
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<td><strong>Total Cost</strong></td>
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PT Beam Structure

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<th>Quantity</th>
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Post Tension Beam Cost Analysis

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<th>Length</th>
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<tr>
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<td>30</td>
<td>$35.78</td>
<td>$99,826.20</td>
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<tr>
<td>8.75&quot; x 31&quot; x 30'</td>
<td>310</td>
<td>15</td>
<td>$35.78</td>
<td>$11,207.00</td>
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<tr>
<td>12.25&quot; x 24&quot;</td>
<td>189</td>
<td>30</td>
<td>$45.00</td>
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<tr>
<td>PT Beams</td>
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<td></td>
<td>$8.84</td>
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<tr>
<td>(2) 2.5&quot; x 12&quot;</td>
<td>224</td>
<td>30</td>
<td>$29.82</td>
<td>$100,195.20</td>
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<tr>
<td>PT Cable</td>
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<td>Columns</td>
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<td>$188,970.00</td>
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<td>CLT Skab</td>
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<td><strong>Total Building Cost</strong></td>
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<td>$3,196,146.95</td>
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Insights: Cooperation vs Collaboration

Team B Cooperative 4D Model

Team A Collaborative 4D Model
Insights: Spaces Reinforce Norms

- Teams differed significantly
- Collaboration norms established early
- Co-ownership in design
- Strong relationship between space usage and interaction

“It is not only a matter of appropriate hardware and software, but also one of appropriate digital studio layout to facilitate collaborative team work.”
- Bob Holland
Examples: Communicating Analysis

Final Review Cost Analysis

Figure 1. Total Cost Breakdown with Total Budget Bar Chart

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<thead>
<tr>
<th>Description</th>
<th>Bill</th>
<th>Actual</th>
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<tr>
<td>Bedroom</td>
<td>550</td>
<td>595</td>
</tr>
<tr>
<td>Living</td>
<td>300</td>
<td>290</td>
</tr>
<tr>
<td>Kitchen</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>Bathrooms</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>Mechanical - HVAC</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Electrical</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Plumbing</td>
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<td>150</td>
</tr>
<tr>
<td>Sheet Metal</td>
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<td>50</td>
</tr>
<tr>
<td>Kitchen</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Total</td>
<td>1725</td>
<td>1800</td>
</tr>
</tbody>
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Total Budget Cost Breakdown

- Total Units: 135
- Total Modular: 214
- Residential Area: 64,972
- Commercial Area: 81,000
- Amenity Area: 127,5
- Total Assignable: 64,705
- Usable Area: 107,891
- Assignable Usable: 67%
- Modular Budget: $5,722,596
- Substructure Budget: $1,542,818
- Total Budget: $14,292,424
- Total Annual Rent: $2,416,982
- Year to Return: #

Figure 2. Final Low Rise Data Table

1-Bedroom Cost Breakdown

- Total SF: 789
- Total Cost: $15,750
- Total Budget: $12,500
- Percentage: 100%

Figure 3. 1-Bedroom Cost Breakdown Table with Pie Chart

Figure 4. Total Cost Comparison Table with Line Graph

Narrative: Final Review Cost Analysis has taken all of the research done thus far and modified costs to match all assumptions, and re-designs. Assumptions include 10% reduction for all factory/moldable offsite work (Figure 5), reduction of Walkable Skylight, corrections to structural costs to match agreed upon materials, corrections to exterior enclosure to match agreed upon materials (Figure 3), and corrections to Transportation to account for shape of modules and transportation of two modules for 1-Bedroom, Penthouse, and two Amenity Areas (Figure 2). The changes mentioned above not only made our estimates more accurate, but reduced our costs significantly from $23.7 million to a total of $19.7 million with inclusion of Overhead (Figure 1).

Figure 2 also depicts that our total Assignable and Usable Areas have decreased due to more accurate design take-offs. Even though these areas have been lost we have gained costs in Landscaping costs (Figure 1) which include Green Roof, Bio-swales, Trees, and Interior Aquarium. We have been able to not only reduce our costs, but also create a more functional and efficient community space which exhibits a sense of welcome inside and out.

We have also gone back and took a look at our past cost estimation and came to find out that we have been on quite the adventure. As Figure 4 shows, we have abandoned the High Rise - SR 125 option and continued on with the Low Rise - SR 85. The biggest change in cost occurred between Cycle 2 and Cycle 3 when our modular structural system, exterior enclosure system, and transportation took on high 3/F and micromanual costs.

Through this Cycle we have learned that there is always room for data, design, and assumptions to change and improve. At this stage in our studio project development we have achieved a reasonable cost for modular Low Rise construction, at $151 SF of total cost, with an amazing low return rate of 8 years (Figure 2). The data presented here represents our best and final numbers for the project at hand, as well as our understanding of the entire project itself. This project has given us an interesting perspective of all components and key players that are involved in the Design-Build process. The amount we have learned as a team is exponential, and will be extremely useful in all of the different fields that we will be pursuing individually.
Examples: Communicating Details
Examples: Communicating Constructability

STEP FIVE: MODULES LEVEL ONE

Integrated AEC Studio
Presenting to Industry and Instructors
The UW Integrated AEC Studio: Pedagogy, course structure, and insights from 2009 - 2016

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Complexity → Interdisciplinary Learning

More than one discipline

Methodology

Language

(Schaffer et al. 2008; Orr, 2006)

Interdisciplinary studio (lab) design courses

(McCuen & Fithian 2010; Dossick & Pena 2010; Holland et al. 2010; Dib & Koch 2010; Gardzelewski et al. 2010; Salazar et al. 2010)
Interdisciplinary Work

“design as a social process”
(Bucciarelli 1994)

develop shared mental models collaboratively
(Orr 2006)

A move away from cooperative approaches
- division of work into independent parts
(Smith et al. 2005)

Collaborative interdisciplinary learning
- unstructured processes
- negotiate goals,
- define problems,
- develop procedures, and
- produce socially constructed knowledge
(Goldsmith & Johnson 1990, Dorsey et al. 1999)