Integration and Synthesis: Teaching the Parts in Anticipation of the Whole

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Abstract

In 2020, the new NAAB conditions for accreditation marked a deliberate and important change. Systems, technologies, and assemblies are now assessed not only through synthesis and integration with design objectives, code, policy, and other systems, technologies, and assemblies but also by evaluating performance objectives through measurable environmental impacts and building performance analysis.

These new conditions present the opportunity to reframe teaching within a context of decision-making based on empirical analysis through energy modeling, daylighting analysis, building information modeling, and Life Cycle Assessment. However, students must first understand the sense of synthesis and integration. By being able to conceive of building technology in this way and its relationship to empirical analysis then, students can consider how their buildings reveal inefficient societal behaviors, but also how their design decisions can underscore and venerate myriad cultural practices – both new and old – while advocating for spaces of comfort and delight.

This paper presents two faculty members' different methods for teaching an advanced building systems course at University of Louisiana at Lafayette in our graduate program. In each case, the faculty member sought to balance analysis empirically and graphically represented through spatial coordination of systems related to design decisions. Projects included focusing upon full consideration of mechanical, electrical, and plumbing in connection to the development of interior spaces, consideration of envelope design acknowledging different environmental conditions due to orientation, focus upon core and plenum, selection of building envelope based upon environmental behavior, and finally analysis of design decisions using digital evaluation tools.

By breaking down assignments into easier-to-understand pieces, students could use their design skills to consider what they had never had a chance to consider in their studios. By changing focus, students could identify a myriad of new variables and how those variables could be synthesized and integrated to consider their projects holistically. By comparing notes, the authors additionally gained insights into the deployment of conditions across building technology coursework and how individual assignments can stand as a foundation for full synthesis and integration.

Synthesis and Integration

"While the NAAB stipulates the conditions and accreditation criteria that must be met, it specifies neither the education format nor the type of work that may serve as evidence of having met these criteria. The NAAB encourages programs to develop unique learning and teaching strategies and innovative methods and materials to satisfy these criteria, provided the program has a formal evaluation process for assessing student achievement and documenting the results." (NAAB, 2025).

Noah Resnick, Associate Dean of the School of Architecture & Community Development, led Detroit Mercy to one of the first successful NAAB accreditation visits under the 2020 conditions. He maintains that a key success of that visit was organizing the curriculum so that a single building design served as evidence for all SC.5 criteria. Similarly, a single design of a building served as evidence for all of SC.6. A single design can be used to meet criteria in both SC.5 and SC.6, but that is up to the individual school. He maintains that if the specific criteria of SC.5 (or SC.6) are spread across a studio and a building technology or building systems course, it is important that what is assessed is the same group of students and the same design project. The NAAB conditions are silent on whether the project must be the same for all criteria within SC.5 or SC.6, but Resnick asserts that this is the expectation of the accrediting body and team. Curricula that propose completing SC.5 or SC.6 in courses that follow the studio are disadvantaged because it is difficult to maintain the same roster of students. In such a condition, faculty would need to demonstrate pedagogically how the iterative nature of synthesis and integration is achieved for a project where the design is settled mainly at the beginning of the semester.

To effectively combine the specific conditions of SC.5 and SC.6, most programs have established individual criteria in earlier coursework. For example, to demonstrate the integration of structural systems in SC.6, most curricula require students to take coursework in structures previously. However, the conditions that relate to the building technology sequence, PC.3 Ecological Knowledge and Responsibility, PC.5 Research and Innovation, SC.1 Health, Safety and Welfare in the Built Environment, and SC.4 Technical Knowledge, do not contain any criteria that specifically outline the need for coursework on structures. NAAB leaves it to the schools to decide where structures are taught and for the school's narrative to discuss how structures are aligned to meet the conditions. Because structures have long been considered a requirement for accreditation, schools typically have a place in their curriculum to deliver this information. Similarly, evidence of synthesis and integration relies upon introducing the principles of the design of assemblies and systems in a prerequisite class. If these materials are introduced in a co-curricular course, the question arises: Can students learn the principles of, for example, active heating and cooling and simultaneously adeptly apply those principles in an iterative way to influence the integrated studio design project? Again, the construction of most curricula provides space for a prerequisite course on systems prior to the coursework meeting SC.5 and SC.6. When it comes to the final criteria of each SC.5 and SC.6, demonstrating the "measurable environmental impacts of their design decisions" and "the measurable outcomes of building performance," the authors are concerned that these learning outcomes, often considered advanced learning objectives, happen very late in the curriculum and may not provide sufficient space to be incorporated into the iterative design process. "Measurable outcomes of building performance" is widely considered the result of Building Energy Modeling. What is less clear is whether "measurable environmental impacts of design decisions" refers to Life Cycle Assessment. If so, this would align with COTE's goal of having buildings reach zero carbon, both for operational carbon (assessed through building energy modeling and the operational and maintenance portion of Life Cycle Assessment) and embodied carbon (assessed through the building material portion of Life Cycle Assessment). (American Institute of Architects, 2025)

Case Study: Assignments Preparing Students for Synthesis and Integration of SC.5 and SC.6

Typological method (Sp24)

In this two-week exercise, students consider the integration of systems within the typology of a high-rise building. The outcome of this project is three-fold. The project provides students with the opportunity to discuss how the proportions and shape of the building have a direct influence on the location of structural elements, the bay size and continuity of structure, and the decrease in size of members with a gain in elevation inside the building. Secondly, the limits of the floor-to-floor height along with the dimensions of the core provide consistency of spatial configuration – size, shape, section – limiting diversity to interior spaces and perimeter spaces. Students must manage systems with the confined space of the core and in the plenum, requiring deliberate decisions regarding integrating mechanical, electrical, and plumbing systems in small areas in coordination with the layout of equipment and fixtures within the reflected ceiling plan. Finally, this typology allows an added lesson on coordination between regulatory requirements of egress within the core, sizing of structural members in terms of load, and dimensioning of chases, ducts, and stacks associated with mechanical, electrical, and plumbing. Complexity is in the coordination of systems rather than in spatial or formal consideration (Fig.1). This project is rooted in the principle of coordination of physical, performance, and visual or aesthetic coordination, as described in Leonard Bachman's Integrated Buildings: The Systems Basis for Architecture, which served as one of the references for this course (Bachman, 2003).

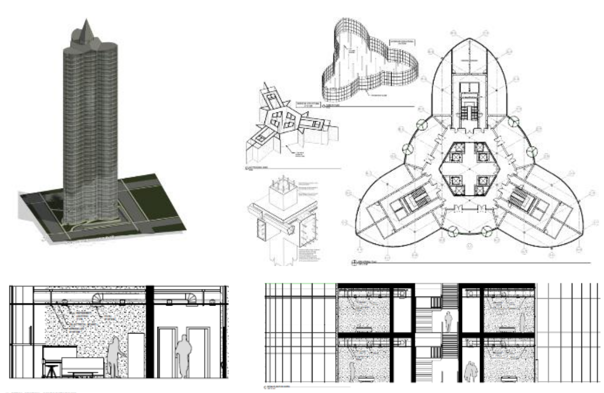

Fig. 1. High-rise building exercise; building systems integration

Precedent Method (Sp24)

This short exercise allows students to study a building of a similar typology to their project, using the solutions of a precedent to inform their own design decisions. This project solves a coordination issue that often exists when a systems class seeks to use a studio project as the basis for its study: studio coursework often spends a third to half of the course focused on preparing the foundation of the design idea, meaning that projects are not complete enough to use as the basis for implementing learning objectives within the co-curricular building technology or systems course. This also offers a solution to a second complexity: within the studio Students were given free rein to develop their design research by choosing their program, meaning that no two projects studied had the same typology (Fig.2).

This assignment explicitly asks students to consider daylighting, passive heating and ventilation, and structure for their studio project. Students determine the typology of their studio project and select a precedent (or precedents) of the same typology that they believe provides strategies for daylighting, passive heating, and ventilation or structure they wish to emulate. To demonstrate analysis of these variables, the students do not create a set of drawings. Instead, they search for how designers have represented this operational or structural condition in an entirely different project, a project that could be a different typology altogether. This requires students to think laterally – to search for and select an image that represents through a diagram how the sun might enter and heat a space in the same way the students understand that it works for the precedent that they selected while also anticipating that same behavior in the building that they are simultaneously designing for the studio. Not only does this emphasize and isolate the specific operational characteristics that the students want to employ, but it also provides the students with examples of how designers graphically represent something invisible, like the flow of air, the reflectance of light, or the loading of the structure. Not only are they considering the behavior of the precedent, but they also survey, select, and emulate the best technique for conveying that behavior. If a faculty member is open to allowing students to employ AI or the critical use of search engines, a facet of the assignment can also consider how to teach students to craft their search criteria.

Traditional pedagogy often approached building systems—such as structural, environmental, and envelope systems—in isolation. However, a shift toward integrated systems thinking has gained traction in the last twenty years, emphasizing the interplay among these systems and their collective impact on building performance, sustainability, and user experience (Bachman, 2003). This approach aligns with the broader pedagogical frameworks of constructivist learning. Constructivist learning, a foundational theory in architectural education, supports the notion that students learn best when they construct knowledge themselves, often by exploring real-world challenges. This principle is evident in integrative design studios, where students grapple with system interdependencies while working on holistic projects (Kolb, 1984).

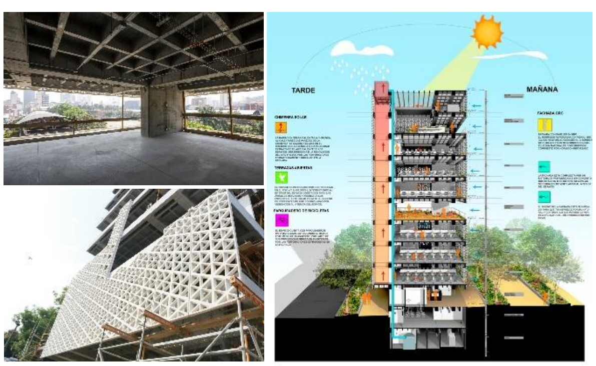

Fig. 2. Study Case, Colombia's EDU Headquarters (Archdaily.com)

Envelope (Fa19, Fa20, Sp22, Sp23)

During the selection of envelope precedent, it is easy to assume the students understand the assembly and connection of parts and then can apply that knowledge to their designs. This assignment sought to ensure that students had attained that understanding. Students selected an example of an "ideal" envelope condition from the book Modern Construction Envelopes by Andrew Watts (Watts, 2019), with each student selecting a different example. This textbook provides orthographic, perspectival / isometric / axonometric, and digital representations of a bay condition. From these forensics, students re-constructed the model in Rhino or Revit. In the rebuilding process, students had to look much harder at the existing drawings. They had to answer questions about missing information hidden from the documentation and make decisions about connections between elements, which were often obscured by the layering of materials and elements. By constructing the examples, students reasoned their way through the projects, understanding the placement of layers like glass within the assembly, how frames encapsulated those layers, and how the entire system connected to the structure. The students' reaction to discovering errors within the book's original models was most surprising. At first, they reacted with surprise, questioning themselves. With the instructor's encouragement, they reasoned through the errors, gaining a measure of confidence in their own reasoning capability. The final assignment piece asked students to represent their models two-dimensionally – through orthographic and isometric drawings. With their newfound understanding of how these drawing types can obscure information, the students were careful to identify the specificity of the drawing view.

Analysis of Earlier Project (Fa20, Sp22)

This assignment addresses students' difficulty in understanding the holistic integration of MEP systems. Students place elements such as plumbing and light fixtures, switches, diffusers, and outlets within their orthographic drawings based on design principles and calculations focused on restroom and kitchen layout efficacy, lighting levels, or thermal comfort. This assignment asks students to think about how these elements connect to one another and other services as they enter or exit the building, using a previous project as a basis for this analysis.

Based upon the tradition of the plumbing diagram, students use an axonometric base drawing of their project and overlay linework that shows their ideas about how wiring or conduit, ductwork, hot and cold supply, and plumbing stacks connect these elements. To simplify, these systems are represented through single lines rather than their actual size and are differentiated through indexed color. The resultant drawing is similar to a Revit Clash Detection drawing, but instead of revealing inherent problems, this drawing focuses on opportunities for integration. Students are encouraged to identify chases and to simplify vertical runs of systems like plumbing stacks. Finally, when students express interest in adding elements like solar panels or cisterns, this drawing method allows students to identify how these elements connect to the MEP system holistically (Fig.3).

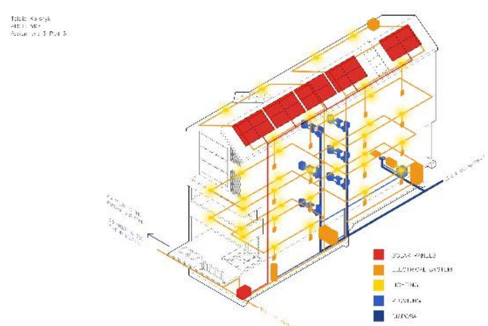

Fig. 3. Illustration of the MEP systems.

A Building Slice (Fa19, Fa20, Sp22, Sp23)

To coordinate with the architectural studio, students select a building section through a conditioned portion of their project. This is a four to ten-foot-wide modeled cross-section through the entire building, depicting structure, enclosure, and systems. This includes exterior building materials, shading devices, and building assembly at walls and roofs, including glazing, structural systems, lighting, and conditioning systems. Students choose their sections to best show passive ventilation, solar collection, or rain collection systems like cisterns. The outcome of this assignment is a two-dimensional axonometric of the building section, emphasizing coordination between systems and consideration of envelope and passive system design in relation to building orientation. Annotation of materials, connection, envelope, assembly, and systems allows students to present their decision-making holistically. The addition of climatic conditions, such as the depiction of breezes or sun angles, aids in coordinating the synthesis of environmental conditions with consideration of the integration of assemblies and a corresponding increase in building performance. This assignment is typically completed at the resolution of 1/4” to 3/8” scale and can be initiated when the students are still at a very schematic scale, as small as 1/16” = 1’-0”. Surprisingly, the large jump in scale, only at this one location in the building, is easily achievable, and upon completion, students find they have made a surprising number of decisions that can be applied throughout the rest of the building (Fig.4).

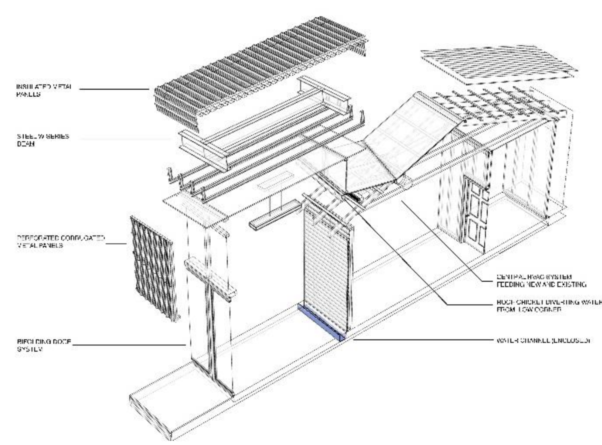

Fig. 4. A two-dimensional axonometric drawing shows building systems.

Case Study: Preparing Students for Incorporation of Empirical Analysis within SC.5 and SC.6

Cove.Tool (Sp24)

Cove Tool provides students with the ability to change conditions in real time, testing a variety of configurations. Because of its interactivity, the authors feel it is important to start with a very simple two-story general office building project as the relationship between variables is easily observed. This simplicity allows students to explore relationships, rather than focusing upon the specifics of form and spatial configuration. This approach aligns with the broader pedagogical frameworks of experiential learning, which stress that students build knowledge through active engagement and iterative problem-solving. Experiential learning encourages direct application of theoretical concepts through hands-on activities, site visits, and software-based simulations — methods that provide a deep understanding of architecture's technical and performative aspects. Once the students master the control of the variables, they approach the integration of analysis of more complex buildings into the design process with confidence and discipline.

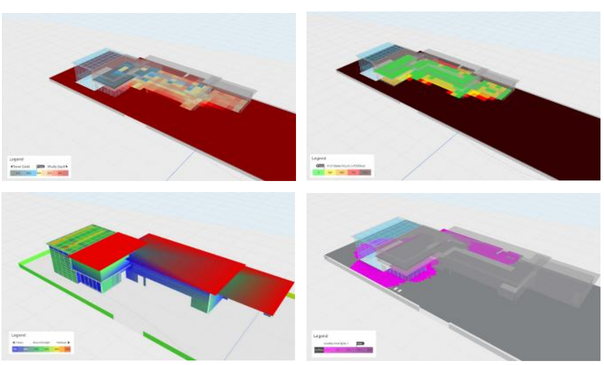

Fig. 5. Building performance simulation using COVE.TOOL (Daylight analysis, solar radiation, and quality views).

Ladybug Tools (Fa19, Fa20, Sp22)

To introduce the study of solar radiation levels on building form and façade surfaces, students use Lady Bug for analysis. With their studio project located in a tropical/subtropical climate, students select four precedents in a similar climate, with at least one being located below the equator. In particular, students are encouraged to select precedents with punched openings, carved spaces or balconies, overhanging roofs, or other building configurations that modify the climatic conditions. After building massing models in Rhino, students analyze solar radiation levels across three time periods for each precedent using a script in Ladybug. Students are asked to evaluate the configuration of the building for effective shading for the climate in the summer, while providing opportunities for increased radiation and promotion of comfortable microclimate in the winter. Students are then asked to improve the massing to promote shading in the summer or increased capture of solar radiation in the winter. Finally, for the buildings below the equator, students relocate the buildings to the Northern Hemisphere in a similar climate and again analyze the buildings. By changing location, students can better ascertain the effectiveness of the orientation of the massing of the building.

Autodesk Insight 360 (Sp23)

This group project asks students to run a gamut of analyses, where each iteration alters a single variable. The result is a matrix of results that allows students to quickly understand which variables have the greatest effect on energy use intensity. Using a single standardized building, students vary location, orientation, perimeter to volume ratio, roof orientation, and percentage of window to wall. Organizing the results, presenting both the building configuration and the associated data analysis in pie charts, allowed students to quickly ascertain the scale to which energy use intensity, heating and cooling requirements, and overall utility cost changed. Students were asked to identify trends, with associated reasoning. They were also asked to identify perceived anomalies, and to evaluate whether those anomalies were the results of inherent inaccurate assumptions, issues with the modeling software, or errors generated through mistakes initiated by erroneous student data entry. The graphic organization of the data resulted in students easily identifying trends and anomalies.

Tally (Sp23)

Just a few students initiated work with Tally, the life cycle analysis software. The hope was to initiate a comparative study between a single standardized building, where wall assembly is varied, and develop a matrix of results like what was achieved in the Insight Assignment described above. Unfortunately, the faculty and students simply ran out of time before completing the study.

Exploring Other Pedagogical Methods

Half a generation ago there was a shift in teaching structures to develop pedagogy that resonated with design students and allowed them to deeply understand structural principles so that they could productively communicate with engineers. This change in pedagogy also provided the language with which architecture graduates could effectively explain structural decisions to clients, de-emphasizing and contextualizing technical decisions to those who are not native to the discipline. In this same line of thinking, assignments such as those described earlier in this paper seek to establish how teaching the evaluation of performance objectives to architecture students is different from teaching within the disciplines of architecture engineering and mechanical engineering. At the same time, these methods also provide a catalog of tools and methods that graduating students can bring to firms as they transition into the profession, develop a way of communicating systems integration, energy modeling, and life cycle assessment to clients in an accessible way.

This paper represents only a few pedagogical methods for preparing students assignments that focus upon synthesis and integration. The authors recognize there are myriad solutions. The authors are currently working to design and implement a survey to capture current teaching methods, identifying where there are perceived gaps in resources and then cataloging digital tools that faculty consider best for introducing architecture students to digital empirical analysis in conjunction with methods for introducing integration of building technology, and why faculty perceive them as particularly well suited. Such a survey will provide an understanding of the landscape in which we are working, with data and interviews from faculty teaching integrated design and energy modeling coursework across a broad range of institutions. While the current NAAB conditions promote expression and a range of personalized solutions to meeting the requirements, we believe there is an opportunity for building technology educators to share how they are meeting these conditions, to evaluate pitfalls that are impeding success, and to begin a conversation on the substantial opportunities for change to the architecture discipline as faculty incorporate digital empirical modeling and the resulting data into the design process. The ability to deliver thoughtful pedagogical models that meet the learning outcomes required by NAAB relies upon this broader curricular conversation and coordination across building technology faculty.

Conclusion

Historically, design projects have often addressed essential building systems (e.g., structure, envelope, mechanical, electrical, and plumbing) in relative isolation. However, the new NAAB standards underscore the importance of decision-making driven by empirical analysis, performance objectives, and regulatory considerations (Aksamija, 2013; Bachman, 2003). In parallel, demands for greater accountability and resilience in the building industry have spurred the adoption of energy modeling, life cycle assessment, and sustainable material selection in both practice and pedagogy (Allen & Iano, 2017; Anderson, 2014).

By requiring students to synthesize user requirements, accessibility, site conditions, and environmental control and structural systems within a single framework, SC.5 and SC.6 seek to ensure that graduates can deliver efficient, context-sensitive, and innovative solutions. As such, the revision to the NAAB conditions marks a pivotal shift in teaching architectural design—one that insists students grapple with complex, data-driven concepts early in their academic trajectory. Grounded in measurable outcomes, such as energy performance and occupant comfort, these standards offer educators an opportunity to refine course objectives, assignments, and assessment strategies to better prepare students for contemporary practice.

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