Teaching Industry Disruption: Studying LBC Projects to Develop Carbon Positive Knowledge, Behaviors, & Advocacy

CARYN BRAUSE
University of Massachusetts Amherst

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The urgency of addressing climate change challenges architectural educators to employ methods for cultivating stewardship and advocacy in emerging designers by integrating a broad array of performance domains into the curriculum. This study contributes to the literature on teaching with case-based pedagogical methods by analyzing deliverables from an applied professional practice course studying Living Buildings, which are designed to meet the most stringent certifications and rating systems developed by the Architecture, Engineering, Construction, and Owner (AECO) community.

Voices from the Field is a seminar and field-based course that employs cases pursuing high performance standards to demonstrate the interrelationship of technical, organizational, behavioral, and operational domains in the process of taking buildings from concept to realization. The study analyzes four sets of course deliverables produced by students who studied two Living Building Challenge (LBC) projects. The deliverables, called Field Reports, comprise student accounts of the project issues that arise from their review of project documentation, their construction site visits, and their interviews of project team members. Using a grounded approach, the Field Reports were coded for evidence that students increased their understanding of the strategies, attitudes, and behaviors necessary to achieve advanced building performance targets. Importantly, the analysis also demonstrated that students gained greater understanding of the advocacy necessary to apply their sustainable ideals to real world contexts. The research considers how to empower emerging practitioners to disrupt established design, construction, and regulatory systems in order to build a more sustainable and equitable society.

INTRODUCTION

There is increasing urgency to address the accelerating impacts of human-created climate change by shifting design and construction practices to those that restore and regenerate the earth's systems. Researchers, practitioners, and educators are searching for methods to radically reduce atmospheric carbon dioxide associated with buildings and their operations through carbon positive strategies. In architectural education, these curricular concerns extend beyond technical spheres to include organizational, behavioral, and operational processes. Moreover, they require teaching an integrative approach to balancing competing project objectives, akin to professional practice. While the studio remains the primary curricular vehicle for simulating the complexity of a practice environment, there are domains that are difficult to integrate into this setting and that are essential to achieving building performance targets. Among these are the interrelated domains of professional roles, project delivery methods, collaborative practices, regulatory and supply chain issues, and labor.

This paper discusses a pedagogical research project that employs an experiential approach to integrate these topics into the curriculum through a case-based applied professional practice course. The cases selected for study are building projects pursuing high performance standards. The cases are selected to provide a variety of construction systems and phases, as well as project structures and delivery methods. This paper focuses on qualitative data analysis of student deliverables for a subset of cases studied that are participating in the Living Building Challenge. The paper thus considers what students learn from studying projects designed to meet the most stringent framework developed by the Architecture, Engineering, Construction, and Owner (AECO) community.

CASE BASED PEDAGOGY

Case-based instructional methods are used in varied academic contexts as they provide students with the opportunity to learn from holistic situation-specific narratives and integrate multiple information streams in an authentic context.[1] How the case method is employed relates to each discipline's body of knowledge.[2] For example, law and medicine feature a highly defined knowledge base so cases are used in a factual and deductive manner; the goal is for students to find the correct answer. In disciplines that are characterized by a knowledge base that is more open to interpretation, such as business, multiple answers are reasonable and the goal is to train students to be managers who can respond to dynamic situations and human factors. In science curricula, case method has been credited with improving students' critical thinking, their ability to make better connections across multiple content areas, to have a better grasp of the practical applications of core

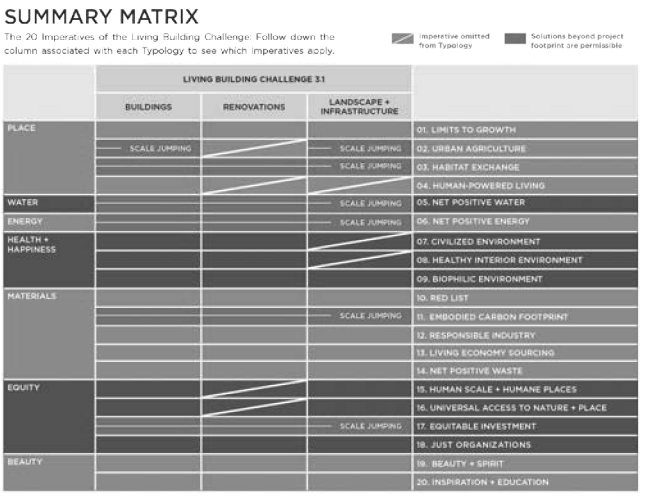

Figure 1.Living Building Challenge Summary Matrix of Imperatives.

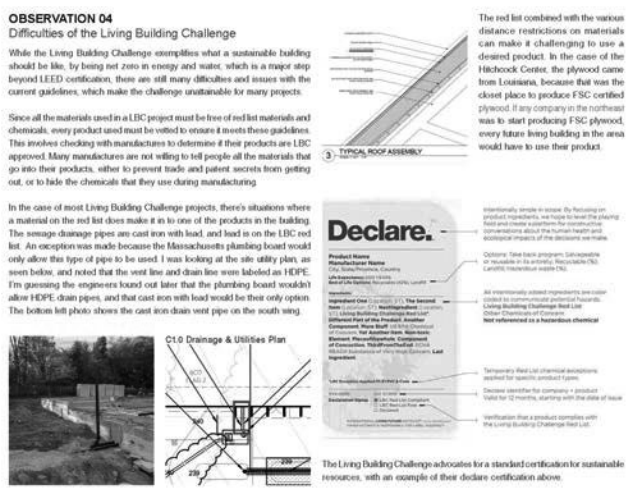

Figure 2. Field Report. Dylan Brown.

concepts, and to be better able to view an issue from multiple perspectives.[3] In fields such as architecture, where multiple solutions are possible, using case method can demonstrate how agents address real-world dilemmas and illustrate how professionals move from theory to application.[4]

LIVING BUILDING CHALLENGE

The architecture, engineering, construction and owner (AECO) community has, over the last few decades, developed green building rating systems to assist building owners and operators in assessing the environmental impacts of their projects and in making more environmentally responsible decisions. The Living Building Challenge (LBC) is considered among the most wide-reaching. Considered a philosophy, an advocacy tool, and a certification program, the Challenge's goal is to employ buildings to shift system behaviors in order to build "an ecologically-minded, restorative world for all people."[5] The LBC is distinguished from other green building certification programs because compliance is based on actual performance data. Projects must be operational for at least twelve consecutive months prior to the audit that verifies compliance with the LBC Imperatives and awards certification.[6] This differs from rating systems such as LEED (Leadership in Energy and Environmental Design), which allows projects to be certified based on modeled, or anticipated, performance.

The Living Building Challenges employs a flower metaphor for the framework, organizing the seven performance categories into "Petals" because the ideal built environment should function as cleanly and efficiently as a flower—converting renewable energy from the sun, contributing to the surrounding ecosystem, and providing beauty and inspiration. The goal are truly regenerative buildings that "give more than they take, creating a positive impact on the human and natural systems that interact with them."[7] Petals comprise the rating system's requirements for Place, Water, Energy, Health & Happiness, Materials, Equity, and Beauty. Each Petal is further subdivided into Imperatives (such as net positive energy and water), for a total of twenty Imperatives that are applied to building projects of every scale and location. (Figure 1) To achieve Living Building status, the project must address all seven Petals; when Imperatives cannot be met due to current market or regulatory conditions, project teams must engage in advocacy to advance the building industry.

VOICES FROM THE FIELD

Voices from the Field is a hybrid seminar and field based course that analyzes case studies of projects in construction. The course, piloted in 2014, was originally developed in response to the 2012 NCARB Practice Analysis Education Report which identified eight areas requiring additional reinforcement in academic curricula including constructability, technology, site design, sustainability, collaboration, communication, professional conduct, and project management. Each semester, five projects are reviewed that are pursuing high performance standards; these are selected to expose students to a range of project teams, structures, and project delivery methods, as well as construction phases and systems. First, students review project documentation to understand conventions for communicating design and detail decisions for construction. Through this construction document review, students are already focused on which elements of the project will be most important to observe at the construction site. Then, they attend site visits with project agents such as architects, construction managers, owner's project managers, and engineers to gain direct experience of the construction process and to become familiar with the roles of project agents during construction. (Figures 3 and 4)

The course's initial objective was to bridge education and practice by increasing students' understanding of the relationship between concept design and technical execution while bolstering understanding of the eight areas identified by the Practice Analysis. Early evaluation of this method investigated whether

Figure 3. Voices from the Field Hitchcock Center Site Visit.

the situated learning that occurs through engagement with practitioners on the construction site yields a deeper integration of concepts typically covered in comprehensive but compartmentalized coursework.[8] Further iterations evaluated this pedagogical method for its contribution to student understanding of the relationship between project structures and design outcomes.[9]

RESEARCH QUESTIONS

The author is fortunate to teach in an area in which several Living Buildings have been constructed and certified. From the inception of Voices in the Field, the course has included at least one, and sometimes two, Living Buildings as cases. After employing the Living Buildings as cases in five iterations of the course, a select set of pedagogical research questions emerged: What do students learn from studying cases that meet the most stringent certifications and rating systems developed by the AECO community when exposed to them experientially on site, through project documentation, and in meetings with project agents? And, are there any differences between what students learned when studying these cases in construction as compared to when they are complete and certified?

METHODOLOGY

This research project considers course deliverables produced by three sections of students who studied two LBC projects by reviewing project documentation, conducting construction visits, and interviewing team members. Employing qualitative data analysis,[10] student deliverables were coded for evidence of the strategies, attitudes, and behaviors students learn from studying projects designed to meet the most stringent certifications and rating systems developed by the AECO community.

The data analyzed for this project comprise student deliverables, called "Field Reports," following site visits to the LBC projects. The Field Reports, completed after each site visit, comprise photographs of the building and site juxtaposed with annotated excerpts from construction documents, written descriptions of the transformations that occur from drawing to construction, and information gleaned from interviews with project agents. (Figure 2) The reports thus illuminate aspects of the design and construction process that are not readily apparent from the documentation alone. Each Field Report is composed of eight to ten "Observations" of holistic issues associated with the case.

The data for this paper includes four sets of Field Reports (31 in total). There is one set for each of the two projects based on visits during construction, and one set based on visits when they were complete. The study design thus follows a comparative case study approach in which each "case," or set of data, comprises a "case of cases." Comparative case studies emphasize comparison within and across contexts through

Figure 4. Voices from the Field R. W. Kern Center Site Visit.

examination of the similarities, differences and patterns across two or more cases that share a common focus or goal.[11] In this study, comparisons are made across the two projects studied, and across the differing construction phases (in construction vs. complete).

DATA ANALYSIS

The data were analyzed by importing Field Reports into MAXQDA[12] to conduct thematic analysis. The unit of analysis was a chunk based on an "idea unit;" chunks were coded based on the start and end of a single idea.[13] Thus, each Observation in a Field Report might be coded for multiple themes. Preliminary deductive codes included the eight areas identified areas in the Practice Analysis, the seven LBC Petals, and codes for project agents.

One of the most common methods for identifying themes in early stages of analysis is identifying repetitions within and across narratives.[14] While open coding the first set of Field Reports, repetitions were identified and a grounded approach was employed to identify new themes.[15] Visual tools including MaxMaps and the Code Matrix Browser were used at regular intervals to visualize emerging thematic connections and develop hypotheses.[16] Using this iterative coding process, the author identified and developed a set of themes related to the impact of Experiential Learning with LBC projects. Looking for similarities and difference within and across the data is also productive for identifying themes.[17] For this comparative case study project, coding focused whether student experience and documentation of particularities of the two projects, and their phases of construction, resulted in similar or different understandings. An initial codebook was generated and a Visual Map was constructed to establish relationships among the major themes. As each set of Field Reports was coded, a series of hypotheses were developed and then tested, modified, and expanded while coding the subsequent sets of Field Report.

FINDINGS

The data revealed several major themes concerning how employing case-based teaching methods using some of the world's most advanced buildings increased student understanding concerning the application of sustainable ideals in practice. A range of themes emerged concerning the uniqueness of learning from Living Buildings. Codes illuminated the strengths of case-based experiential learning, such as students' increased understanding of the integrated nature of design, and the challenges of applying theory to practice in real world settings, including the need for advocacy and system change.

Nearly all students commented on the specificity of realizing the Living Buildings they were studying, and many compared the effort of realizing these buildings to more typical buildings, even other high performance buildings with which they

Figure 5. Field Report. Josh Guertin.

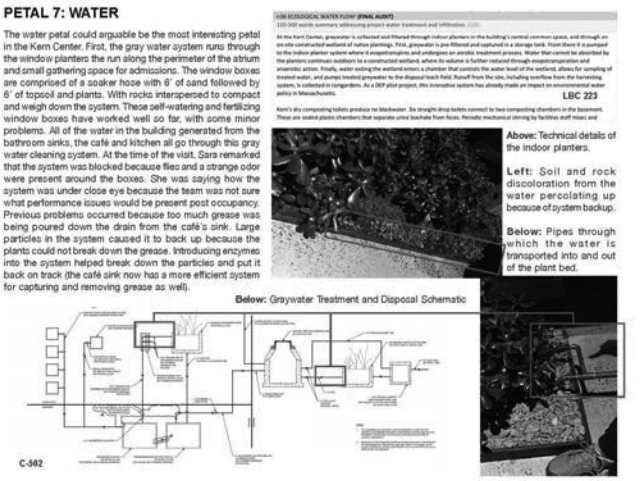

Figure 6. Field Report. Kaeli Howard.

were familiar. In their Field Reports, students remarked on the difficulty of achieving all of the petals. One student captured this sentiment in their Field Report writing, "At the site visit, it became quite apparent how much more planning and research is necessary to follow the stringent guidelines of the LBC, a challenge seeking to change not just design, but the construction market as a whole." Many students were impressed by the ambitions of the LBC to change the industry and paid particular attention to aspects of the projects that were experimental or pilot studies.

UNDERSTANDING THE INTEGRATED NATURE OF DESIGN

Many excerpts from the Field Reports concern students' developing understanding of the integrated nature of design decisions when realizing advanced buildings, and Living Building in particular. For example, the underlying biophilic emphasis of the LBC was apparent to students in design decisions ranging from place-based strategies to material selection. One student wrote, "The environment is the foundation of the Living Building program and the buildings should reflect that. As we walked through the Hitchcock Center, you could see that they added large windows in every room, along with a door to the outside." While students understood the connection between biophilia and the Health and Happiness Petal, many students remarked on the ways that designing for connection to nature was interrelated with decisions regarding structural and mechanical systems as these affected ceiling height and thus available daylighting and connection to the outdoors. One student documented the development of a particular construction detail: "An under-slung center beam system is used where the perpendicular beams rest on top. Different from the traditional layering method of rafters, this steel connected joint design and engineering produce the highest interior space as possible. This allows the curtain walls to rise up higher and bring in more light." This student connected the technical and material decisions necessary to enrich human experience and meet performance targets. (Figure 5)

As delivering a Living Building requires intense scrutiny of building metrics, students also noticed the integrated nature of design decisions when related to programming decisions that would impact building performance. For example, in the Kern Center, the decision was made to include a small café in order to assure that the building would be well used by building occupants. One student wrote, "This fact increases the demand on building systems, particularly energy and water usage. They [the architect] compared this conception with that of the Bechtel Center, which functions as a dry field laboratory, for which they question its sustainability due to the lack of daily use." The student notes how the project team wrestled with a definition of sustainability that relies on lower occupation to meet performance goals. Several students remarked on this choice to increase occupation, even though the decision changed the building's energy and water budget. In their Field Reports, they recognized that each decision triggered other design, performance, occupant behavior, and maintenance issues, which then needed to be resolved.

APPLYING THEORY TO PRACTICE

Several codes captured increased student understanding of the challenges of applying theory to practice in real world settings. Student understanding of the requirements necessary to meet the Water and Materials Petals, in particular, illustrated how using case-based methods demonstrates how project agents address real-world dilemmas to students. Analysis of student Observations provided evidence that they recognized the actions engaged in by the design and construction teams to shift industry and regulatory system behaviors to address these dilemmas.

A majority of students remarked on the extensive vetting process used to determine whether a product contained materials on the "red list," a list of materials banned due to the presence of toxins harmful to human health. One student outlined the process in their Field Report, "The project team hired a consultant for this job. The consultant contacts manufacturers for a list of the materials in specific products. If the list is clear of all red-listed items, the material will be submitted for approval by the LBC committee, and once approved, can be ordered for construction." They, and others, discussed a road block on one of the projects: "The typical material used to encase electrical wires, for instance, is banned. HDPE (High-Density Polyethylene) pipe, however, is approved. This piping is typically used to carry natural gas. The Hitchcock Center had a special order made to be used for electric. The special order was necessary because the company only produced HDPE pipe with a red stripe connoting gas, and they changed this to a yellow stripe denoting electric for the Hitchcock order." Students pointed out that the process of material vetting created associated project delays and increased project costs. They learned that, to act on their values, they would need to advocate to address supply chain limitations and lack of transparency, which make it difficult to assess environmental and health concerns.

Students similarly noted the extensive actions taken by the project team take to work with, or around, governmental regulations. In many jurisdictions, the strategies necessary to achieve the net-positive water imperative conflict with building codes and health department regulations, and require a fine-tuned approach to occupant behavior.[18] Many students wrote about the project team's efforts to pilot new systems. For example, one student wrote about the Hitchcock Center applying for an exception in order to pass the Water Petal: "Their water system is permitted but not yet approved as an 'experimental pilot product' through the Quabbin reservoir." Similarly, students wrote about a pilot system to manage building grey water by pumping the grey water through a sand filter and into a constructed wetland: "This pilot design is a very intriguing one, because if it works well, then we can expand and add this system to more buildings, and put grey water to good use." Students demonstrated that they understood each project to be a piece of a larger effort, rather than a stand-alone endeavor.

Nearly all students wrote about the difficulties of achieving the Water Petal. When students visited the completed and occupied projects, their Field Reports were filled with detailed descriptions of the systems and procedures necessary to manage rain water, grey water, and dark grey water. (Figure 6) Importantly, their accounts are filled with the many post-occupancy efforts to test and adjust the system, and to come up with new solutions to emergent problems. For example, students wrote about the challenges that arose from operating the café: "they came up with an interesting and creative method to help prevent bulky coffee particles from going down stream. They are using pantyhose as their first line of defense. The pantyhose allows the greywater to travel through into the tank but stops the coffee particles from entering the tank…Once the pantyhose becomes full, they will take it out and replace it with another pair of pantyhose." Coffee did not present the only challenge. Another student wrote, "Other instances that came up affecting the grey water system was the consistent turnover of related staff. The cafe staff would change yearly and had to be trained every time as they discovered that dairy products and certain cleaning products affected the system." The student accounts highlighted the practical realities of designing for human occupants, operators, and caretakers of advanced buildings, which is not always a focus for design team members.

DISCUSSION

There are few studies on the effects of teaching cases that are pursuing or have achieved Living Building Challenge certification as the number of buildings that have achieved full living certification is still quite small.[19] However, prior research has demonstrated that employing cases to teach building performance enabled students "to make more meaningful and intuitive connections between theory and design, between initial intent and final outcome."[20] This study contributes to the literature on teaching with case-based pedagogical methods by integrating varied professional practice domains, including technical, organizational, behavioral, and operational processes, and by employing cases that are pursuing Living Building status.

The findings demonstrate that teaching experientially with LBC projects increased student understanding of the integrated nature of design decisions and the challenges of applying sustainable ideals in real-world contexts. While there were findings that were consistent across all four sets of student deliverables, some findings were particular to the stage of construction that students experienced. Naturally, students who visited projects in construction were more focused on issues of constructability and this focus connected more directly to issues of materiality and to meeting the criteria for the Materials Petal. Moreover, when students experienced the buildings in construction, some of the challenges experienced by the project team became more salient. In particular, the need for advocacy towards industry to source materials that were free from "red list" toxins was experienced more intensely because of construction delays and cost increases.

Students were powerfully aware of the uniqueness of LBC projects both in construction phases and when the buildings were certified. But once the buildings were complete, students could feel the quality of the spaces and could connect the stories of design decision making to their experience of those spaces. This came through clearly in discussions of adopting a limited material palette to reduce material vetting and to

source materials locally. It also emerged in discussions of the Health and Happiness Petal, particularly in student experience of building occupant access to daylight and connection to nature. Finally, once the buildings were complete, students were attuned to the continued active participation of occupants and caretakers in the post-occupancy period, such as managing ventilation, monitoring water quality, and continuing to work with regulators on pilot systems.

CONCLUSION

Addressing our climate challenges now, and in the coming years, requires that emerging practitioners gain an integrated understanding of diverse practice domains and optimism with which to pursue their professional futures. This project considers evidence that by situating learning in projects designed to meet the most stringent certifications and rating systems developed by the AECO community, students learn strategies, attitudes, and behaviors that will equip them to apply their sustainable ideals to real-world dilemmas. Additionally, the research suggests that studying Living Building cases, in particular, empowers emerging practitioners to advocate for shifts in established industry and regulatory systems in order to build a more just and sustainable society.

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