WHERE DO WE LEARN CLIMATE SCIENCE? A CURRICULAR CASE STUDY

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ABSTRACT
The updated Landscape Architecture Accreditation standards integrate climate science into the landscape architecture curriculum within Standard 3: Professional Curriculum. This addition aligns the professional curriculum with practice, as the American Society of Landscape Architects Climate Action Plan calls for achieving zero embodied and operational emissions, and increased carbon sequestration design by 2040. Current students will be mid-career by 2040, and the success of the ASLA Action Plan will, in part, be based on their understanding of climate science, and by extension climate responsive design.

This paper examines undergraduate student perceptions of preparedness for undertaking climate responsive design in the context of a design studio at California Polytechnic State University, San Luis Obispo. A survey to examine student self-assessment of climate science knowledge was administered following the design studio, and the survey results were analyzed using word frequency and qualitative theme analysis. Survey results were mixed and indicate the need for further attention to how and where climate science is learned in the curriculum, including beyond courses in the major.

Keywords
Climate Responsive Design, Curriculum, Landscape Architecture, Undergraduate

1 INTRODUCTION

Climate science is now an integral part of the landscape architecture curriculum. The updated Landscape Architecture Accreditation Board (LAAB) standards name climate science within Standard 3: Professional Curriculum (LAAB, 2021). The American Society of Landscape Architects (ASLA) Climate Action Plan calls for achieving zero embodied and operational emissions, and increased carbon sequestration by 2040 (American Society of Landscape Architects, 2021). Current BLA students will be mid-career by 2040, and the success of the ASLA Action Plan will, in part, be based on their understandings of climate responsive design. These developments prompt the focus of this paper – where is climate knowledge and skills learned in the BLA curriculum, and what forms does this learning take? Earlier studies of climate responsive design in landscape architecture have used literature reviews and faculty assessment of student work, while this paper uses a student survey to examine climate related learning.

1.1 Background

Although the design and construction industry is responsible for a significant portion of C02 emissions, gaps in knowledge and skills among both professionals and students have been identified. (Boarin et al., 2020; Hahn, 2022). These findings suggest that there is a need for climate responsive design education to fill the gap in the profession. Climate change in the landscape architecture curriculum generally focuses on the methods and outcomes of individual design studios, with a smaller percentage of articles examining the topic across the curriculum. (O'dwyer et al., 2023) In this section findings from both types of studies are reviewed and summarized.

The primacy of the design studio as a focus for climate change studies is reflected in Moncella and Keane's call for a reconsideration of design education "specifically through the pedagogical framework of the design studio and its delivery." (Moncella & Keane, 2023) They propose that design be understood as "cycles of learning with feedback loops internal to each phase." (Moncella & Keane, 2023) The idea of feedback loops in the design process is echoed in other studies of design studios. "Develop and test climate responsive design proposals" (Lenzholzer & Brown, 2013) and "design and evaluation of climate adaptive design proposals" (Cerra, 2016) are design methods examined in these papers, and suggest a needed emphasis on metrics and proofs in climate focused studios.

The papers by Cerra and by Lenzholzer & Brown, define a common method for earlier stages of the design studio as well, including:

- Reading and understanding climate change projections and impacts (either through government reports or scholarly literature); and
- Conducting site analysis at a systems or regional scale in addition to the site scale.

In addition, Cerra emphasizes the need for precedent studies to identify relevant climate adaption options, while Lenzholzer & Brown emphasize the need for "real world" design problems. Taken together, these two papers outline an emerging method for climate responsive design instruction in landscape architecture studio courses.

Landscape architecture is widely characterized as a generalist field that combines knowledge across many disciplines. A 2018 study that sought to determine the "core knowledge domains" of landscape architecture concluded that "Only two knowledge domains appeared in every source and division and thus were deemed core: design and natural." The authors go on to enumerate the biological and physical sciences from which landscape architecture draws its knowledge about the natural domain, including ecology, geography and microclimate, and to conclude that there is no area of knowledge unique to landscape architecture. (Langley et al., 2018) This cross disciplinary perspective is echoed by Shun, who describes an ecological approach in landscape architecture as requiring the curriculum to have a "broader integration of interdisciplinary knowledge, such as combining ecology, urban planning, and socio-economics with landscape architecture." (Shun, 2024)

Perceived knowledge gaps in climate change education in landscape architecture (identified through student and faculty surveys at North American educational institutions) include "governmental policies and regulations, impacts of sea level rise, causes of climate change, irrigation and environmental behaviors/beliefs." (Volk et al., 2022) While not a knowledge gap per se, a study based on a curriculum survey found that while climate related content is taught as knowledge or skills embedded in core courses (such as materials) they are not explicitly described as connected to climate. (Eriksson, 2022)

It is instructive to note that within the literature reviewed for this paper, authors use varying terms including climate adaptive design, climate positive design, climate action, climate change, climate-wise design, climate responsive design, and climate crisis. This paper uses the term climate responsive design, following the documents that informed the design studio (City/County Association of Governments of San Mateo County, 2021).

2 METHODS

Undergraduate students enrolled in a third-year design studio were surveyed at the end of the ten-week term. The students were under the instruction of a single faculty member. The studio theme focused on climate-responsive design. All students in the course (n=17) completed the survey. The survey contained three open-ended questions that sought to collect student perceptions of their own readiness to undertake climate-responsive design, including perceptions of prior learning about climate-responsive design. The survey was distributed on paper and students responded during the last class meeting.
In order to provide greater context for the survey results, a brief description of the studio follows. The studio brief was modeled on a Request for Proposals (RFP) for Schoolyard Greening issued in the San Francisco Bay Area. The objective of the RFP was to create “resilient schoolyard landscapes for the mitigation of climate change”. (City/County Association of Governments of San Mateo County, 2021) Choosing the RFP to inform the studio design was in intentional decision to ground design in applicability to practice.

Climate change specific activities at the start of studio included a faculty lecture on the processes of climate change and potential impacts to urban landscapes, and student-led activities that focused on systems thinking. For example, students diagrammed a system within the urban environment such as precipitation (Figure 1) or waste. The diagramming activity sought to enable students to see connections between human and natural systems within the urban environment.

Students were then introduced to local resources relevant to the project site, including CalRecycle Recycled Content Construction Products Catalog, as well as tools for calculating shade coverage for urban heat island (using LEED and the i-Tree app) and for calculating project emissions and carbon sequestration potential (using the Climate Positive App). Worksheet activities provided a structured method for students to explore each resource prior to beginning site analysis and design. For example, students were given a CAD file for an unrelated site, asked to do area take-offs for vegetation and paving, and use those figures to calculate years to carbon positive using the Climate Positive App. Similar graded practice activities were assigned for all the resources.

Site analysis was structured through a lens of climate and included heat, wind, noise, and air pollution, and was carried out at the level of the site, as well as the district (Figure 2). Students became familiar with the current issues surrounding the site (which include air pollution from an elevated freeway immediately to the west of the site, noise pollution, and lack of tree cover), studied the shading patterns that would be in effect once the development was fully built out, and considered how heat stress would increase from the current day figures.

The design project for the studio was an urban elementary school in a post-industrial neighborhood of San Francisco that is currently being developed into a mixed-used residential and research district. Students used the development master plan to inform their proposals, as well as the architecture proposal for a multi-story school building. Initial proposals made by students were assessed for potential shading, stormwater retention and carbon sequestration, and then re-designed to maximize climate responsiveness (Figure 3). Students quantified areas of hardscape and planting material in their initial proposal and used these to analyze their project in the Climate Positive App. They also used i-Tree to estimate shade coverage of hardscape areas at ten years from installation (following LEED guidelines). Using the information gathered from both analyses, students focused on refining their initial proposal to maximize shading, and to reduce ‘years to climate positive. In the example shown in Figure 4 students reduced the years to climate positive to 10 years from 30 years by increasing tree coverage and reducing hardscape.

Although not intentional, many of the teaching strategies echo the methods of design, analyze, and reiterate, of multi-scalar site analysis, text-based learning, and use of real-world projects described in earlier studies by Cerra (2006) and Lenzholzer & Brown (2013).

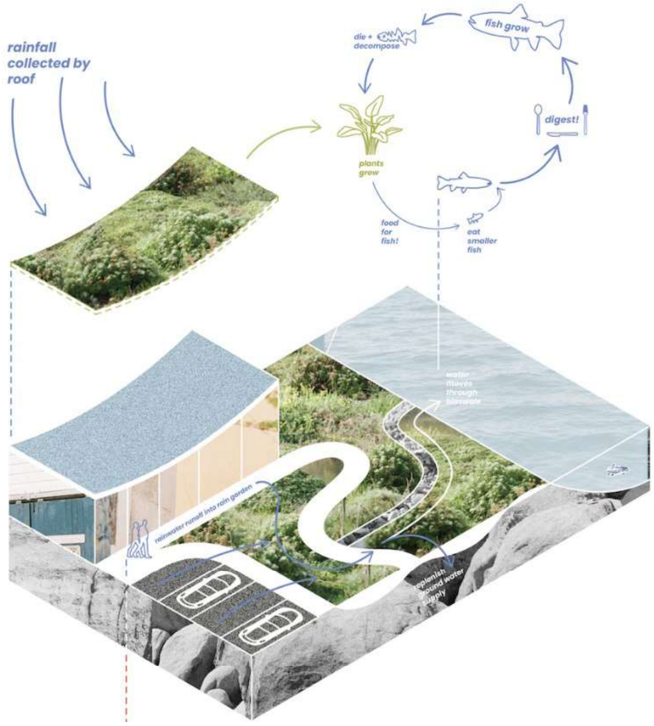

Figure 1. Systems thinking was introduced through diagramming exercises (2023). Reproduced with student permission.

Figure 2. Site analysis examined sun and shade patterns, tree coverage, noise and air pollution, and heat for the site and district (2023). Reproduced with student permission.

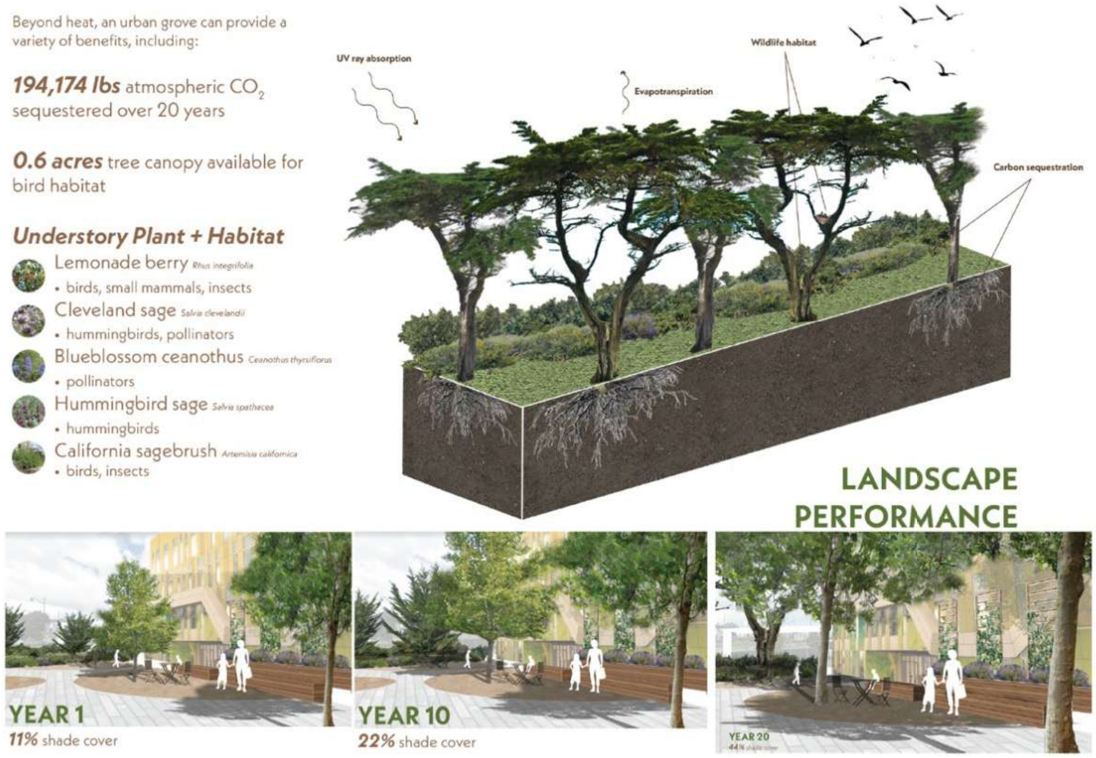

Figure 3. Student analysis of climate responsive design outcomes for shading, carbon sequestration, and habitat creation (2023). Reproduced with student permission.

Figure 4. Students analyzed the midterm proposals (on left) and re-designed to maximize climate responsiveness in carbon sequestration and shading (on right) by reducing paved areas and increasing shading (2023). Reproduced with student permission.

3 RESULTS

The survey results were analyzed using word frequency and qualitative theme analysis, and the findings are presented below by question.

The first question asked Do you feel your education prior to this studio adequately prepared you for climate responsive design? If so, how?

A small majority (53%) agreed that their education prior to the studio had adequately prepared them for climate responsive design. Students reported coming into the studio with a general, basic or conceptual knowledge of climate change processes, and that they had been aware of the "climate crisis." They also reported being aware of climate adaptive and sustainable design strategies but were not always confident that they knew how to implement them. Likewise, some students shared that they knew about climate change from "environmental" classes, but not how to relate the concepts to design. One student also referenced learning about climate change in high school more so than at university.

Q2. What skills or concepts did you apply during this project that you learned earlier in the BLA program, if any? What courses did you learn them in?

Students named stormwater management (n=9) and plant materials (n=5) most often as skills and concepts applied in the project. Sustainability, heat island effect and math were other skills mentioned by students in their responses. Students reported that they learned these skills and concepts in Site Engineering (n=3), Plant Science (n=3), Landscape Ecology (n=2), LA 101 (n=1) and Design Theory (n=1). While the question sought to understand prior knowledge from landscape architecture courses, the answers revealed that a course in another field, plant science, was regarded as highly impactful. (Figure 5)

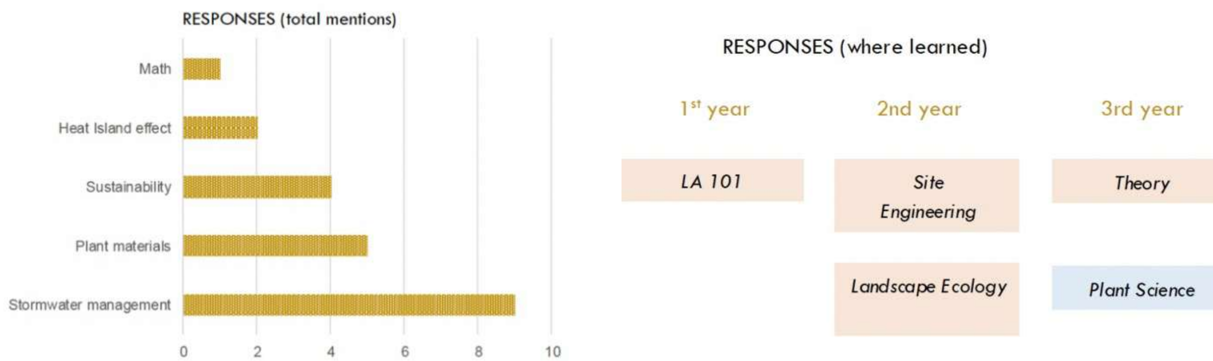

Figure 5. Student perceptions of skills and knowledge learning earlier in the program that were used during the project (left) and the courses where they learned the skills and knowledge (right). Orang shading on the right indicates courses within the landscape architecture department, and blue shading indicates courses outside of the department. Diagram by the authors.

Q3. If you could start over now with the same project, what would you do differently to better address climate resilience?

The main themes of the student responses focused on increasing plant density (described as "more plants" or "less paving/more plants") and on prioritizing a focus on systems during design. Other themes described focusing on materials other than plants, on connecting the projects more directly to climate change (or a "bigger why"), and on addressing urban heat island. Students also mentioned they would use diagrams rather than design drawings to describe impacts on climate change, and that they would focus on the Climate Positive App calculations sooner. Following are a selection of the responses.

"I would focus more on how what I designed connects to a bigger picture of climate."

"I would offset water runoff and carbon emissions from more than just our site. I'd want to connect it to more of the city."

"I focused on planting and education. If I started over, I would relate (these) back to heat island."

4 DISCUSSION

The survey revealed that almost half of students had not felt prepared for the rigor of climate-responsive design by their prior coursework in the major. Students had experienced general introductions to climate change topics, including heat island effect, but lacked understandings of how these related to landscape architecture in tangible ways. Site engineering and plant science courses were identified as the main courses in which students had learned about climate-responsive design prior to the studio. The survey also revealed that students understood the value of iteration and testing in climate-responsive design by the end of the studio.

These findings suggest that to best support climate responsive design a curricular approach is required. In the case of the program being discussed in this paper, climate-responsive design is included in design studios based on instructor interest. This approach does not allow all students to be exposed to the topic, nor does it intentionally prepare students in support courses to address the topic which is reflected in student perceptions of readiness. The constraint of the individual studio approach is also noted in O'Dwyer et al, who similarly note the potential for inequity and inconsistency in the model. (O'Dwyer et al., 2023)

The student survey supports a curricular approach, with consideration of support and general education courses. The survey revealed that courses outside of the landscape architecture department, in plant sciences, were of equal to site engineering, and more impactful than other landscape architecture courses, for learning relevant to climate responsive design. This finding is consistent with Langley et al's characterization of the discipline, as well as O'Dwyer et al's questioning of the primacy of studio as a delivery model for climate change curriculum. (O'Dwyer et al., 2022; Langley et al., 2018)

Initial student design proposals did not integrate climate-responsive design thinking although it was a required part of the program brief. The structure of the studio required that students analyze their proposals in terms of climate outcomes in the second half of the term, which advanced the projects significantly in regard to climate responsive design. This suggests that undergraduate students need time to organize program and spatial sequence before being able to address climate response. These findings support earlier discussions in the literature review of the need for feedback loops in climate focused studios (Moncella & Keane, 2023; Cerra, 2016; Lenzholzer & Brown, 2013)

Methods and findings of earlier studies of climate-responsive design studios discussed in the literature review included literature reviews and faculty assessment of student work. This paper supports earlier studies with data collected directly from students in a climate-responsive design studio.

The study is based on a single small cohort, which limits the findings. Additional research is needed to understand the connections between student skills and knowledge and curricular approaches to climate science and climate responsive design across landscape architecture programs. In addition, the survey administered here would have been improved by including a pre-knowledge survey of key concepts, such as emissions scopes and sequestration, to provide a baseline understanding of student knowledge that could contextualize both their learning in the studio, and their perceptions about their own understandings of climate change.

5 CONCLUSION

The curriculum of climate related content is still being defined for landscape architecture. It certainly includes climate adaptation and mitigation measures, many of which are currently taught as skills. The ASLA Climate Action Plan expands the knowledge base for a climate responsive practitioner to include emissions scopes, ecosystem services and carbon drawdown strategies and calculations. While the design studio is currently perceived by educators to be the main site of learning for climate responsive design, there needs to be attention paid to the entire curriculum, including support courses and general education courses to more equitably support learning outcomes in this area. A curriculum-based approach would recognize the generalist approach of the field and ensure that students had training in the knowledge and skills needed to successfully address climate responsive design.

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