

A Technical Design Challenge: A Medium for Integrating Technical Knowledge and Design Skills

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This paper discusses the effectiveness of engaging students with a “design challenge” to bridge the two common sectors of lecture-based courses and design studios in architecture curriculum. This study is set out to describe the planning and implementation of a typical design challenge and critically review its capacity in conveying as-needed technical knowledge to students through both analytical and experimental approaches. Furthermore, the paper provides empirical evidence through an explanation of a 90-day experience with a team of undergraduate students who participated in a university-wide CleanTech Challenge. Finally, the recent experience of implementing a design challenge is synthesized into three sets of considerations, including the instructor’s role, the students’ engagement, and space-supplies requirements, and some substantial considerations are suggested for better conducting a hybrid learning environment.

1. INTRODUCTION

A growing body of literature in architectural design pedagogy indicates that the information carryover from a lecture-based course into studio utilization is significantly less than the information carryover from as-needed studio talks or discussion sessions¹. Hence, several attempts have been made to offer technical knowledge through some hands-on activities or group projects in lecture-based courses². Such activities develop a conceptual schema and allow the acquired knowledge to reside in the student’s mind for the long term. This paper proposes the effectiveness of engaging students with a “design challenge” to bridge the two common sectors of lecture-based courses and design studios in architecture curriculum. Design challenges may be planned and implemented as a part of a lecture-based class or be offered as an independent opportunity within the curriculum.

In the first section of this paper, the specific features of a typical design challenge are described, including both its analytical and experimental approaches in conveying as-needed technical knowledge to students. The design challenge’s specificity is explained by comparing it with design studio projects and research projects in lecture-based courses.

The second part of the paper describes a 90-day experience with a team of undergraduate students who participated in a university-wide CleanTech Challenge³. This part includes an explanation of how the students tied their technical knowledge on waste transformation in the building industry. Furthermore, the students’ artifacts made out of plastic wastes, along with the key themes that they learned and employed throughout this challenge, are presented. In the final section, the recent experience of implementing a design challenge is synthesized into three sets of considerations, including the instructor’s role, the students’ engagement, and the space-supplies requirements. Such a discussion elucidates the contribution of similar design challenges to architecture education. Moreover, some substantial considerations are suggested for better conducting a hybrid learning environment.

2. CHARACTERISTICS OF COMPELLING DESIGN CHALLENGES

Unlike conventional design studio projects and group projects in lecture-based courses, where a pre-defined problem is to be solved, a design challenge is open to include participant’s thoughts in the problem identification⁴. Planning a design challenge usually begins with drawing the prospective participant’s attention to socio-environmental concerns, such as homelessness, the refugee crisis, pandemic health risks, and global warming. Then, participants have the chance to narrow down a broad topic and propose a specific problem for further investigation and solution. Additionally, the outcome of a design challenge is expected to be assessed by either actual stakeholders or the corresponding market. However, in conventional design projects in both lecture-based classes and studio settings, a jury or team of instructors is expected to review the design or research project’s outcomes regarding the curriculum-based topics and share their thoughts with the students. Although both types of design exercises enhance students’ creativity and critical thinking skills, a design challenge is expected to have greater emphasis on student initiatives and leadership in identifying the problem and the problem-solving process. Accordingly, students may require study cross-disciplinary topics to accomplish the design challenge. Moreover, the instructor has a minimum instructional role throughout the challenge and collaborates with the team as a facilitator or project manager.

	Scope	Process	Outcome	Assessment
A research-based design project in lecture-based classes	• Understanding course-related topics • Expanding student's knowledge	1. Studying the pre-defined problem 2. Proposing a solution to the problem 3. Evaluation	• Reports • Papers • Posters • Presentations	• Instructor's assessment
A conventional design studio project	• Fostering design creativity • Application of inter-disciplinary studies	1. Studying the pre-defined problem and relevant precedents 2. Designing a solution 3. Evaluation	• Architectural drawings • Mass models • Scaled models	• Peer-review • In-house jury usually only from the field of architecture
A design challenge	• Fostering design creativity • Cross-disciplinary theoretical and experimental studies	The seven described steps, in particular: Problem identification and post-processing	• A real-size prototype • Supplemental documents such as user's manual	• User's assessment • Experimental tests

Table 1. The features of a typical design challenge, a conventional design studio project, and a conventional research-based design project in lecture-based courses.

A typical design challenge is based on an iterative process that includes the following steps:

1. Initiation of the challenge: According to the course-related goals as well as a real-world problem, participants frame a design challenge and articulate a design problem. The students' primary goals begin to shape at this early step.

2. Problem structuring: Prior to offering any solution to the articulated problem, the students must study the precedents and understand the problem's context. In this step, they are expected to learn about the constraints that may arise from the problem space, economic limitations, human resources, user's expectations, and political and social matters. Furthermore, students may need to incorporate cross-disciplinary studies on topics far from their major to understand and solve the problem better.

3. Ideation: Through a divergent thinking approach, such as a collaborative brainstorming session, the team may propose a series of possible solutions.

4. Early evaluation: The team needs to filter the primary solutions through a convergent process. They should have defined their goals explicitly early in the first two steps. They may iterate the third and fourth steps to select a single or a few solutions that fit. If any contradictory objectives exist, the team should make a trade-off or innovatively resolve the contradiction⁵. Then, they can move on to the next step of solution development. They may need to revise their selection based on their future studies and test results.

5. Prototyping: Not all the design challenges require a physical prototype. Sometimes, the expectable outcome includes the planning or drawing of the proposal. However, in most of the challenges, making a tangible artifact provides participants with an opportunity to directly observe the performance of the outcome and receive wider and clearer feedback from the stakeholders.

6. Performative evaluation: The artifacts should be tested by clear and pre-defined criteria and requirements. For instance, the prototype of a portable carbon capture system can be evaluated through an actual experiment and measure the amount of captured carbon. Another example is the assessment of practicality of a newly developed building through the construction process and building operation. Shifting the assessment system from external authorities' judgment to user feedback and test results helps students improve their self-assessment and critical thinking skills.

7. Post-processing: Participants should document the entire process of the design challenge, including the identification of the problem and relevant constraints, outcomes of brainstorming sessions, applied theories, design decisions, detailed illustrations, and specifications, as well as the results of tests and experiments. Then, they can post-process their prototype and make the required adjustments.

The abovementioned characteristics of a design challenge help students employ technological knowledge and scientific concepts in a new context⁶. Table 1 highlights the different features of a typical design challenge with conventional design

studio projects and a conventional research-based design project in lecture-based courses.

3. THE EXPERIENCE OF IMPLEMENTATION OF A CLEANTECH DESIGN CHALLENGE

The PSU CleanTech Challenge is an annual design opportunity initially planned to inspire innovators and creative student teams to address today's most pressing environmental problems. In winter 2020, fifteen third-year undergraduate students in the Architecture program, taking tectonic courses, participated in this challenge. They were expected to study the life cycle of different materials, learn about cradle-to-grave versus cradle-to-cradle cycles, and investigate waste transformation methods. The process through which the student tied their socio-environmental concerns with their theoretical studies on waste transformation is described in the following.

Steps 1 and 2: Initiation of the Challenge and Problem Structuring

Early at the beginning of the design challenge, some of the plastic waste facts raised significant concerns. For instance, some estimates indicate that 40 billion plastic utensils are wasted per year in the U.S alone. Further exploration has shown that plastic items do not go into regular recycling containers in many states and end up in landfills and our waterways just after a single-use. The small size of these items doesn't allow them to be sorted from other recyclable materials. Additionally, turning such items into new materials is not an economic decision. Reusing the materials for purposes that let them be in close contact with users' bodies is abandoned because of sanitization considerations. Such information raised concerns for the student participants who were the consumers of such plastic items in food courts and fast-food restaurants. They had learned that the three "R" waste management strategies are Reduce, Re-use, and Recycle. However, they were exposed to a situation where reusing and recycling were rejected in some ways. Thus, they explored further possibilities for counteracting such an environmental hazard. Ultimately, reducing plastic waste emissions through fostering relevant conversations with people became their first design goal. Second, the idea of upcycling these plastic wastes was brought up⁷, suggesting the conversion of the wastes into new products and repurposing them in an improved condition.

The next step was investigating the relevant context and constraints. A rough estimation indicated that in a typical food court discards 28,000 plastic utensils daily. This amount of plastic waste produced by just one food court results in the emission of more than half a kilo pound of carbon dioxide and wastes 3,000 kW/hr of energy per day. The amounts of discarded plastic items, carbon emission, and waste of energy per year reach to catastrophic levels. Students determined to design a building assembly out of plastic waste within a brainstorming session and gives these plastics a new life cycle.

Meanwhile, students were prompted to clarify the scope of the expected outcome by being asked the following questions?

1. What will be the specific advantages and limitations of their artifact in comparison with the existing products made out of upcycled or recycled plastic material?
2. Considering three aspects of their design outcome, including its performance, life cycle footprint, and poetic expression, what are their artifacts' suitable application?

Steps 3 and 4: Ideation and Early Evaluation

Each student made a module of a tectonic element to form a larger surface or volume. The generated models ranged from prototypes with regular and replicable geometry to other sets with infinite and flexible geometry that could easily shape curved and irregular surfaces (see figure 1).

After a discussion session, suitable alternatives that merited further design consideration were selected based on the following criteria:

1. Diversity of utilized utensils regarding their size, shape, color, and texture
2. Required time for fabrication of the assembly
3. Ease of making the joints (e.g., wrapping, pinning, and welding)
4. Flexibility in maintenance and replacement of some elements during the life span of the assembly
5. Stability of the panels (a minimum requirement of being self-standing was considered)
6. Compatibility with different spatial settings such as different framing layouts or position of backup wall or structure
7. Clarity and simplicity of geometry of the assembly

Students emphasized their product's socio-educational effects with several back-and-forth conversations regarding model-making and investigation of different aspects of the plastic waste problem. They reached a consensus on addressing the plastic waste issue by displaying the collected wastes in a poetic or monolithic way and encouraging their audience to be a part of the solution. Finally, the possibility of user's collaboration on the assembling process became the last but not the least objective that necessitates a low-tech design approach.

Steps 5 and 6: Prototyping and Performative Evaluation

It took some iterations to refine the geometry of the suitable prototypes and establish an instructional procedure for creating the geometry. A graphic assembly instruction was prepared

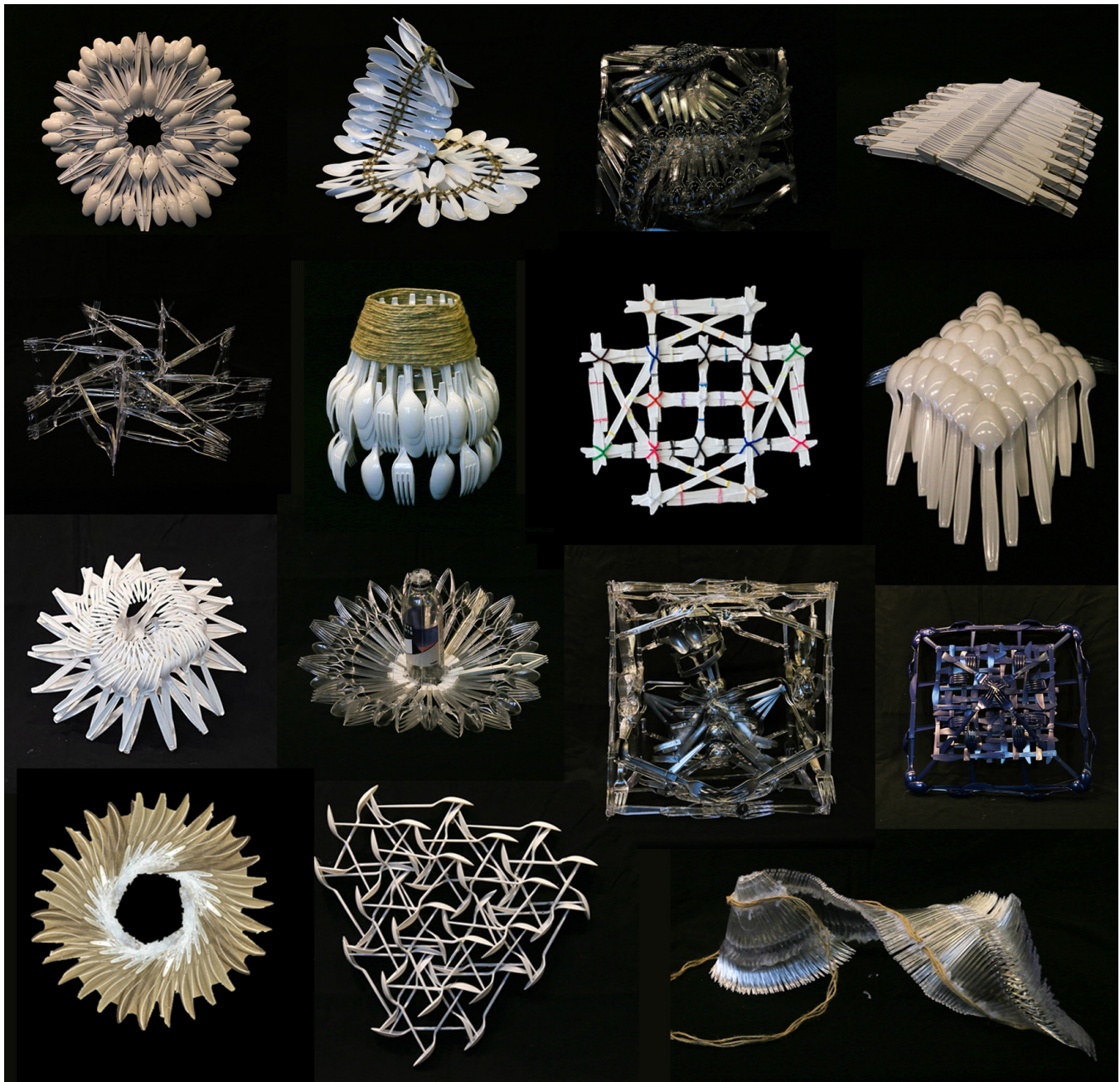


Figure 1. Assembly modules of plastic utensils fabricated by a group of students at the School of Architecture, Portland State University, Winter 2020. Image credit: Anahita Khodadadi.

to encourage the users to be a part of the manufacturing team (see figure 2). In preparation of this user's manual, efforts have been made to demonstrate the assembling process in a way that non-expert users can understand and become engaged.

4. DISCUSSIONS AND CONCLUSION

In conclusion, incorporation of a design challenge with a technical course in an architecture program, helps students acquire and apply the technical knowledge on an as-needed basis. The design challenge needs to be planned thoroughly to

feature both socio-environmental concerns and the relevant technical issues.

Fostering and sustaining student motivation are the major concerns in the implementation of a design challenge. Failure to identify the problem or determine the design goals may trigger disappointment and hinder students from making a continuous effort and reiterating some steps to get the suitable outcome. Usually, engaging students with the current socio-environmental crisis in their own community will strengthen their passion for positive change. Such an approach

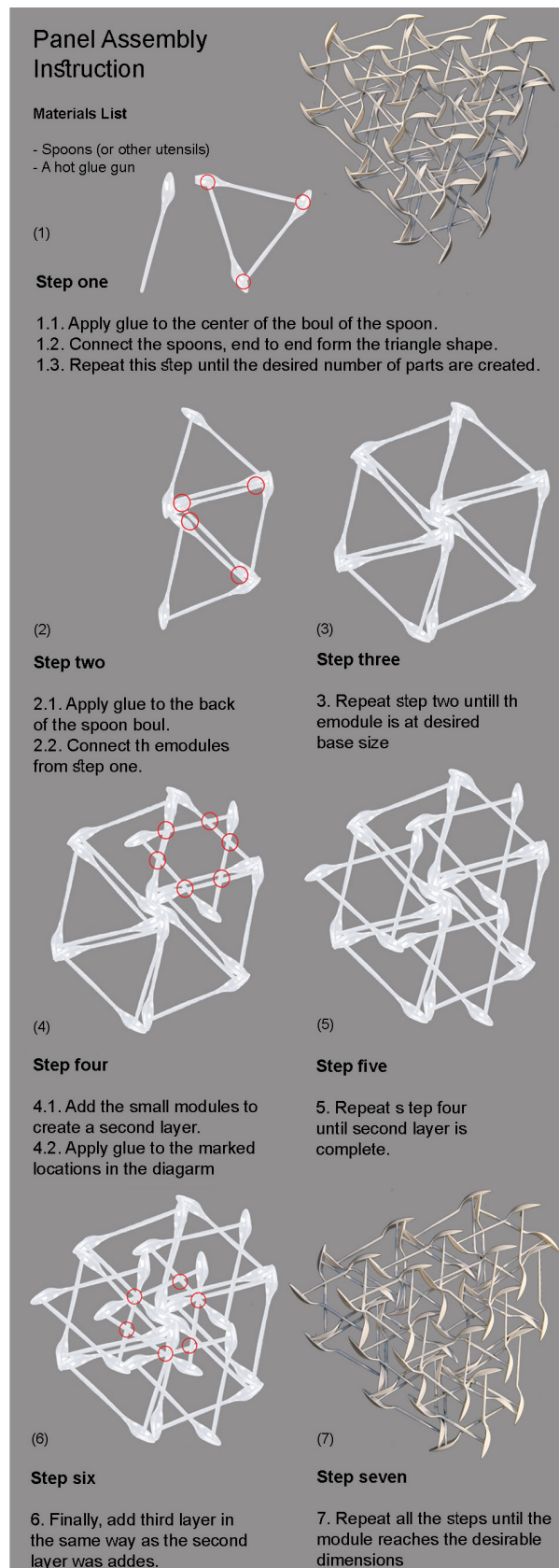


Figure 2. The assembly instructions of the one of the artifacts created by Nate Mason. Image credit: Anahita Khodadadi.

leads students to in-depth study and enhances their problem-solving and leadership skills.

Furthermore, an authentic instructional practice can support a student's learning and design process. The instructor is expected to create a culture that encourages agentic problem-solvers to take actions, to design with, and design for community members. The instructor may also prompt students to link the foundational theories and scientific concepts, reflect on the productive failure, and lead the collaborative work to the last step. The instructor may also guide students regarding appropriate methods of documentation, resolving contradictory design objectives, and decision-making. Furthermore, occasional prompts may help students to reconsider structure of the defined problem, and become aware of possible mistakes in application of a certain technical theory.

Partnerships with maker spaces and themed training workshops will help students acquire the knowledge or experience they cannot obtain through conventional lecture-based courses.

5. FUTURE OBJECTIVES

Future works may focus on the logic of production based on a completely closed resource cycle. Through this approach any non-recyclable material can be initially designed for two or more sets of life cycles.

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ENDNOTES

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