DESIGNING A WAY OUT OF THE BOX: TEACHING SUSTAINABLE DESIGN WITH TECHNOLOGY

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ABSTRACT

The increased interest in sustainable design raises the question of how well are architecture schools preparing students for this approach? This paper describes the experience of current students in architecture school and the challenges they face as they try to learn more about sustainable design. Reflecting on what has worked well and what could work better in a range of academic disciplines, the author proposes some changes for the process of teaching sustainable design. These changes include applying the idea of "multiple scales" to building technology subjects, creating a sequence of problem sets to help improve quantitative problem solving skills and intuitive design ability, and integrating design problems in the curriculum of building technology classes. These methods could work toward developing an "ecological design process" that would help students and practitioners integrate energy efficiency sooner and more effectively into the design process.

Fig. 1: Evaluating an external shading device

1. INTRODUCTION

A professor at the University of Oregon recently asked a class of twenty or so graduate students how many of them had come to the school with a strong desire to learn about sustainable design. About 90 percent of us raised our hands. While cynics might say that few people in Eugene, Oregon would be caught dead saying they weren't interested in sustainability, the strong interest among the student body reflects a national and international trend. Although there is much interest and curiosity about the subject, no one would say it's easy to learn or apply in practice.

As an architecture student and graduate teaching fellow, I have experienced this challenge from both sides of the table. I've struggled with my own design assignments and watched other students learning and applying technical concepts. Experiencing a range of methods for teaching building technology and design skills prompted me to investigate this subject to see if there could be ways to promote even more integration. There is great respect at the University of Oregon for sustainable design and the development of architectural form that arises from an understanding of environmental and structural forces; this has made it possible for me to see examples of many things done well and imagine an approach that might be useful in many institutions.

The intent of this paper is to examine some of the challenges faced by current architecture students trying to learn sustainable design, to look at what works well and what could work better in architecture and in other disciplines, and to propose some changes in the teaching process that might aid any program interested in teaching sustainable design. This would hopefully encourage more discussion on the matter of how to teach sustainability in architecture schools.

2. CHALLENGES IN LEARNING SUSTAINABLE DESIGN

Challenges to learning sustainability arise in the society at large, within architecture departments, and in the realm of the students' experience. For the sake of this discussion, it may help to define the terms and scope of what will be discussed here.

Part of the challenge of even discussing sustainability is that not everyone even agrees on a definition. When you see the word appearing in ads for oil companies, you begin to wonder if the term has lost some of its meaning, but for this discussion we should use the common definition as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." For some, sustainable design is best embodied by buildings made primarily with natural materials such as earth, clay or straw; others are drawn more to the high-tech approach of buildings such as Norm Foster's Commerze Bank in Frankfurt, Germany or the 4 Times Square Building by Fox and Fowle. Others may dismiss sustainability as the latest fad, and thus not worthy of serious architectural study, but for the scope of this paper we'll assume that the change in availability of fossil fuels and the impact of current and forecasted resource use will have a significant impact on what, where, and how we build.

Whether in response to fad or reality, it has been pointed out that some current practices in green building appear to be guided more by a "checklist mentality" than the goal of creating a highly integrated efficient system. As LEED standards evolve and more knowledge is brought together, we can hope that standard practices will be closer to the intentions of sustainable thinking. Designers also have to address the criticism that green building techniques add to the cost of a project; some would counter that trying to inject sustainable criteria later, instead of earlier, in the design process is the cause of any added expense.

Sustainability touches on many issues that both directly and indirectly related to architecture. For the scope of this discussion, it makes sense to focus mainly on technology classes in architecture schools that deal with issues of energy efficiency – typically offered under the title of Environmental Control Systems, or ECS – and how they play a role in exploring issues of sustainable design.

2.1 The Academy

Many students are attracted to architecture not only for its creative appeal, but also for the possibility of promoting positive change. Sustainability appeals to these students on many levels. When they find fewer opportunities for learning sustainability than they might have hoped for, interested students often hear the following concerns:

- Adding sustainable design to the curriculum would require taking something away. Accredited architecture programs are already straining to cover what essential and required and are limited in what else they can offer.
- It's more important to learn how to be a capable designer first, and then learn sustainable techniques later, say, on the job. Schools should focus on teaching formal design skills, which have a steep learning curve, and leave the acquisition of specific knowledge for the three years of internship that usually follows graduation and leads up to the licensing exams.
- Students learning design should focus on "big ideas" or conceptual themes, and how to give those ideas physical form; energy efficiency doesn't make an interesting enough "big idea." Put another way, beginning design students are encouraged to only take on a couple of "generative ideas" at first – such as how a building organizes the activities inside, how it creates a connection between indoor and outdoor spaces, how it handles circulation, or how the building relates to the surrounding context. As they get more experienced, students can then try to incorporate more issues into their design projects, maybe then including energy issues into the design.

A theme that appears here is the idea that teaching sustainability adds content to the curriculum and takes away from other subjects being taught. What if sustainability could be a supportive part of the design process, and not a contrasting subject that distracts from it? Could basic sustainability principles help simplify the decision making process by suggesting some general guidelines for building form?

Students who nonetheless take on the challenge of incorporating sustainable issues into their schooling also face these common scenarios:

- As a relatively new field, students may have difficulty finding mentors or qualified faculty who teach the subject. The field is still so new.
- Courses in building technology are often seen as separate from the design process. Professors who teach ECS subjects at many schools do not also teach design studios, which can reinforce the notion that design and technology don't mix.
- Instructors for design studios may be less familiar with sustainable issues or ECS topics and less comfortable asking students to address those issues in their projects.
- Sustainable design incorporates subjects such as hydrology, botany, civil or mechanical engineering that are often outside of the scope of departmental course offerings, and some students, especially graduate students, might not have access to those offerings.

- Textbooks and curricula tend to emphasize technical knowledge or mechanical solutions to heating, cooling and lighting needs with limited discussion of design applications, alternative or passive strategies.
- Courses in Environmental Control Systems may address issues such as calculations of heat gains and losses, sizing of mechanical systems, and specifying luminaries to achieve desired lighting levels without looking at ways to reduce loads through design or daylighting.
- Introductory classes in ECS or Building Construction often have to cover a lot of ground, and may not provide many opportunities to apply the concepts presented. When students ask, "what are we supposed to know?" it may not be from laziness but from being overwhelmed by the quantity of information and little sense of what is most important.
- Students struggle to satisfy the core requirements of an architectural curriculum; many feel unable to take on what they see as an additional task.
- Students can feel overwhelmed by the depth or complexity of building technology or ECS material and shy away from trying to incorporate it in their studio projects.
- For energy efficiency to be effective, it needs to be considered early in the design process. Decisions made during schematic design can have far greater effects on the building's energy use that decisions made during design development or the construction documents phase. But students may not get instruction on what issues to consider at the early phases, or how to do so – much of the ECS material appears to focus on sizing of systems for a building whose design is complete.
- Students may have a strong interest in the subject, but aren't aware of a clear method or process to follow. One of the central themes of the design studio classes is the idea of developing a "design process," a systematic way of approaching design problems that provides structure and guidance. ECS classes present specific techniques for developing systems for heating, lighting, ventilating and cooling, but it is less clear how these systems fit into or inform the design process. Sustainable design may be so new that there is not a consensus yet on how to go about doing it.

Teaching sustainable design, then, may be less about adding content to the curriculum and more about adjusting and clarifying the process.

3. LESSONS FROM OTHER FIELDS

Other academic fields, including architecture, offer examples of methods that might be useful in teaching sustainable design. Architecture is by its nature an interdisciplinary subject: it sits at the juncture of art and technology, yet has a social responsibility and is subject to economic realities. Sustainable design is also interdisciplinary; some lessons on how to learn it better may come from examining other disciplines that also combine technical knowledge with artistic or analytical thinking.

3.1 Science and Engineering

Physics, Structures, Math and Engineering all assign large numbers of quantitative problems as part of weekly assignments. This quantity is essential for the mastery of this kind of material. Though many students dread them, "word problems" provide a bridge between computational skills and abstract problem solving. Architecture is a problem solving discipline. A teacher once summed up the architectural profession for me by saying, "Architects solve problems. They provide a three dimensional solution to some human need."

ECS classes already have a strong quantitative component. But assigning more quantitative problems might help students become more comfortable with techniques such as calculating heat gains and losses, sizing thermal mass, glazing areas, determining ventilation needs. Problem sets could help answer some of the questions of "why do we need to know this?" by showing real world applications of the concepts being taught. Problem sets could also help break down complex topics such as passive heating or natural ventilation into smaller, more manageable steps and make them more accessible. Experience with such problems would help students be more comfortable doing quick "rule of thumb" calculations that are often sufficient for schematic design. This familiarity would strengthen students' intuitive sense of energy efficient methods, making those concepts easier to apply in design studios. In sustainable design technical problem solving is especially critical because to be successful it must meet quantifiable goals for energy use and resource conservation.

3.2 The Humanities

Architecture requires an understanding of technology in order to artfully solve spatial, social, economic, and ecological challenges. Sustainable design brings those ideas that are already inherent in architecture into clearer focus when it talks about the "triple bottom line" of economy, ecology and community. As a humanistic endeavor, we can find useful approaches in how other humanities are taught.

Studying architecture is not unlike learning to write or speak another language. The student must assemble a jumble of thoughts into a coherent whole that expresses an idea clearly. Both writing and design give form to an idea, and rely on technique to express that idea clearly.

When studying languages, technical subjects such as grammar and vocabulary by themselves cannot hold the attention of students for very long. When technique is applied to the expression of an idea or the desire to explore a question, however, the technique comes alive. Methods such as the famous "Rassias Method" for teaching language developed by John Rassias at Dartmouth College have made technical mastery of foreign languages both fun and efficient. The core of this method is described on the Rassias Foundation website *(http://www.dartmouth.edu/~rassias/):*

> The goal of the Rassias Method is to make the participant feel comfortable and natural with the language in a short period of time. This is accomplished through a specific series of teaching procedures and dramatic techniques which seek to eliminate inhibitions and create an atmosphere of free expression from the very first day of class…. The classroom techniques involved are rapid-paced, theatrical, highly creative, imaginative, and necessitate great quantities of enthusiasm. Positive reinforcement is immediate.

Could this be applied to design education? If architecture students feel inhibited to apply ECS concepts to a large design project, either from feeling overwhelmed or uninformed, perhaps a little theatrical immersion is in order. Small design problems that are fun and un-intimidating can provide a stage for that kind of positive experience. Nothing makes students eyes light up more than the chance to inject some of their creativity into something they thought would be drab and mechanical. Like language, good design requires a similar synthesis of technique and expression. It is noteworthy that the Rassias method doesn't add to the curriculum, it actually shortens the length of time to master a language by reinventing the process.

3.3 Experiential Education

One discipline that is especially concerned with the *process* of learning is Experiential Education, a field that is based on many of the principles of the progressive educator John Dewey. Paralleling the famous quote "I hear and I forget, I see and I remember, I do and I understand," it emphasizes "learning by doing." Although architecture schools have no shortage of "doing," perhaps some activities are more productive than others. Some themes appear in the literature that may be relevant to encouraging teaching methods and curriculum design that support the integration of sustainable design.

One theme that is often discussed in experiential circles is the idea of "must knows," the knowledge or skills that are most critical for the students success or safety. This requires the instructor to emphasize what are the most critical skills and make sure their students master those skills by prioritizing or defining a hierarchy among the large volume of material presented. Another theme is the idea of having a progression of difficulty and complexity so that people are challenged enough to stay interested and motivated, but not so frustrated that they give up.

Experiential education has often been applied in outdoor education programs that teach natural sciences, leadership skills, and personal growth. In order to emphasize the relevancy and the retention of what is taught, educators use carefully crafted introductions and debriefing sessions to tie the activity into the priorities or interests of the student. The significance for teaching sustainable design is that experiential education has successfully used an unfamiliar or non-traditional setting to integrate seemingly unrelated subjects. For many, "sustainable design" is unfamiliar territory, but it can provide fertile ground for teaching architectural relationships.

3.4 Architectural Education

Some of the common practices that are part of design education are already being used successfully in many ECS and building technology classes. These include:

- Clear visual examples of techniques applied skillfully.
- Examples of technology used artistically.
- Case studies that emphasize the connection between the designer's intent and the building's performance. These can provide hands-on experiences where students develop methods for evaluating buildings. This is a technique that has been promoted by the Vital Signs and Agents of Change project described elsewhere in these proceedings or at *http://aoc.uoregon.edu/*
- Having students talk to occupants of a building to understand the connection between design and the users experience.
- Requiring students to analyze buildings first hand to gain an understanding of how they work.
- Role-playing exercises where students advocate for a particular technique, such as using a trombe wall, while other students play the role of skeptical clients as a way of investigating all of a techniques strengths and weaknesses.
- Assigning major projects in technology classes such that have a strong design component. Examples include designing an external shading device, a luminaire, or a redesign of an existing space to improve its thermal, lighting, or acoustic properties.

These methods all provide a strong engagement with sustainable ideas that have been used successfully at the University of Oregon. These connections may be strengthened even further if we consider some of the following teaching methods that are currently used in the studio setting.

3.4.1 Methods in Design Education

Reflecting on practices that are commonly used in the design studio classes provides more inspiration. It suggests some additional methods that could be used in ECS classes to teach sustainable design.

Studio teaches the idea of "multiple scales." This comes from the notion that as a designer investigates a design problem he or she is asked to look at how that subject behaves on a range of scales, from the level of the region, to the site, the building, the room, the element, and finally to the user. In design, what happens at one scale will have consequences at other scales. Only in cycling up and down through the scales do the kinks get worked out and an integrative whole created. For an example of how this concept could be applied to the issues that inform the design of an external shading device, see Table 1. This will be examined more fully in section 4 below.

For teaching Environmental Control Systems (ECS), this concept of scale could provide an ordering system for a large amount of information that is rich in interrelationships. It can also provide a method of analysis for students as they approach design problems and need to think about energy issues. If they have been encouraged to think about ECS topics in a similar manner to how they've been taught to approach design, it should be easier to integrate the two disciplines.

In design studios, students are encouraged to cycle through multiple rounds of the design process. This often means cycling through the different scales of a project and revisiting the decisions that were made at each scale to see if they still make sense. If ECS principles are also ordered by levels of scale it can be easier to assess the environmental issues that pertain to each scale as well. This may also help student recognize the interrelatedness of many environmental issues, where what happens at one scale is quite often determined by what happens at other scales.

Studio classes encourage you to revisit a difficult idea several times so that it becomes clearer with each visit. In ECS, some topics such as the psychrometric chart don't make sense until you've studied them from several different angles on several occasions. If such redundancy can be more intentional, it can go a long way towards improving the retention and comprehension of technical topics. Creating a series of problem sets with increasing complexity is one way to encourage this revisiting – students return to a concept but are forced to look at it slightly differently each time.

TABLE 1: MULTIPLE SCALES APPLIED TO THE DESIGN OF AN EXTERNAL SHADING DEVICE.

Global	Region	Microregion	Site	Building	Room	Element	User
Solar orbit	Latitude	Microclimate	Aspect	Orientation	Floor area	User control	Schedule
Tilt of earth axis	Climate: temperature, humidity,	Topography	Slope	Form, massing	Depth/ height	Maintenance	Activity
Declination	Sun path	Winds	Landforms	Glazing area	Equipment	Materials	Accessibility needs
Seasons	Solar Load: direct, diffuse	Bodies of water	Vegetation, plantings	Wall U-value	Surface reflectivity	Cost	Equipment use
Energy availability, use, and potential savings	Degree days	Local variations	Solar envelope	Heat gains, losses	Views	Transparency	Comfort level
		Sky cover	Solar load: reflected	Passive systems	Outdoor rooms	Seasonal adjustability	Lighting needs
		Environmental impacts	Albedo	Mechanical systems	Building edge		View needs

4. PROPOSED CHANGES

These proposed additions or changes to how architecture schools approach sustainable design arose from the above reflections on the student's experience and the examination of related teaching methods. It is presented in the spirit of a general proposal that would hopefully spark lively discussions in any institution on how sustainable design could be better integrated in to architectural education. The suggestions are:

Show many examples of how ECS principles can specifically influence **building form**. These can provide precedents and inspiration for a student's work in design studio projects. Rather than hide the energy efficiency in the ductwork, let the ideas shape the building. At the very least, the final reviewers will be forced to talk about it. If possible, find architects and designers who are able to discuss how energy use or sustainability issues informed their design process and affected their decisions about the building's form and not just its function.

Provide a series of weekly or bi-weekly **problem sets** that give the student more practice with quantitative problem solving. These can reinforce concepts from lectures and the assigned reading and filter that information in such a way that critical points are highlighted and a problem solving method is laid out. By breaking the material into discreet steps this method becomes more visible and accessible. It also can reduce the aversion design students may feel toward quantitative assignments by giving them experience at successfully solving manageable problems. To keep the assignments relevant and interesting, include small design problems that apply only a few concepts at a time.

Provide a series of **small design assignments** that lead up to the larger ones so students apply technical skills incrementally instead of all at once. These can be part of or separate from the problem sets. They might draw on issues that are from current or past design studio classes, or be taken from case studies of actual buildings. It can be very useful to revisit past studio projects, but rather than redesigning the whole building, consider redesigning one element such as a window or wall section in accordance with a relevant topic. The goal is to provide a progressive level of complexity, and to reinforce the application of technical concepts to solve design problems.

Apply the idea of **multiple scales** to ECS subjects as a way of ordering the information and emphasizing the interrelationships between the concepts. Point out how the different scales appear as concepts are introduced. Show how decisions at one scale affect the outcomes at other scales. Suggest using multiple scales as an analysis tool for case studies or evaluating a project. Table 1 shown above is an example of how many of the concepts that relate to the design of an external shading device can be grouped by scale as a way to organize the information and clarify the relationships.

Expand the **definitions of** what we consider relevant at each **scale** of a project. For example, when we talk about the region we can ask what are the implications of a design in terms of transportation needs. We can also add a level of scale to the spectrum, a global scale. We already use this scale when we discuss shading devices to see how the tilt of the earth's axis determines the sun's altitude and azimuth. We could also recognize other issues at the global level such as energy consumption or pollution that are affected by architectural choices.

Develop an **ecological design process** that outlines which ECS concepts are useful and relevant at different stages or scales of the design process. Encourage students to use that process in their design studios by bringing studio assignments into the technical class discussion. Perform case histories of notable sustainable design projects to discover which issues became relevant at which stages and scales.

5. REFERENCES

(1) Warren, Karen, Sakofs, Mitchell and Hunt, Jr., Jasper S.: *The Theory of Experiential Education, (Third Edition),* Dubuque: Kendall/Hunt, 1995