ZERO NET ENERGY EDUCATION: A SURVEY

relationship of course time spent on ZNE topics compared to the grading weight given to projects

Melissa Anderson, Thomas Collins, Alison Kwok
Department of Architecture
University of Oregon
Eugene, Oregon 97403
mthomas10@gmail.com, thomasc203@gmail.com, akwok@uoregon.edu

ABSTRACT

Six years ago, the 2010 Imperative was initiated to address the role of architecture education in responding to global climate change concerns. Meeting the Imperative requires that educators make significant curricular changes to address energy and resource issues in building design. Have schools adjusted their curricula to address the Imperative? What innovative modes of teaching building science and technology courses are being used? Are we providing the proper tools, skills, and resources to help students address the challenges and design a lower-carbon world?

We reviewed syllabi/schedules from required environmental technology courses from faculty of 29 accredited schools of architecture for demographics, resources used, and evidence of effective teaching and learning of zero net energy design topics.

Findings suggest that faculty are spending approximately a quarter of class time on zero net energy topics, roughly half the courses provide experiential learning through project and lab-based activities, and grades are weighted toward exams.

1. INTRODUCTION

In 1996, the Boyer Report envisioned incorporating goals of sustainable design into the methods and content of architectural education.(1) Ten years later, the American Institute of Architects adopted the 2030 Challenge— an initiative to reduce the building sector's dependence on fossil fuels and mitigate greenhouse gas emissions.(2) In 2007, a quarter of a million people from 47 countries participated in a Global Emergency Teach-in calling for architecture schools to make changes to their curricula by adding a requirement to all design studio problems: "the design shall engage the environment in a way that dramatically reduces or eliminates the need for fossil fuel" and that all courses should achieve ecological literacy in design education. (3) (4)

Are architectural curricula in the United States providing the students with the proper tools, skills, and resources to address ecological literacy? Do students understand how to reduce or eliminate fossil fuels by designing for passive solar heating, passive cooling, and the integration of renewable energy technologies to achieve zero net energy solutions?

Compounding the issue, analysis of job postings for faculty at accredited schools of architecture in North America reveals that nearly 54% of all schools were seeking positions in building science technology. (5) Expanding the net to capture other technical areas, including building construction and structures, yields even higher figures. These statistics reveal a critical shortage of qualified instructors who are prepared to teach technical topics that are critical to sustainability, ecological literacy, and zero net energy design.

It is crucial that architectural education place sustainable design at the center of their core values, rather than treating it as a specialized area of study. Evidence suggests that practitioners value energy efficient design skills even as many are still daunted by the task of tracking energy efficiency from design through the first decade of life of the building.(6) Currently, however, 86% of A/E firms say they have difficulty finding employees with green skills to hire. (7) Are new graduates equipped to fill that needs of design firms as well as to meet the goals of the 2030 Challenge and the 2010 Imperative? The field of building science technology is rapidly changing as new research is conducted and tools are developed. How are students prepared to deal with these ongoing changes?

2. THE PROBLEM & HYPOTHESIS

Meeting the 2030 Challenge requires that by 2030 all new buildings and major retrofits will be carbon neutral. Our primary questions were to determine what methods are used to teach environmental technology courses; how is student work being evaluated and does the method of evaluation support net zero energy design education? What tools, text books, and other resources are being used to support building science technology classes? How much time is spent on passive systems, active systems, benchmarks and standards, energy use, and zero net energy goals? Is student understanding evaluated primarily through projects, exams, or some other method?

The targets for zero net energy buildings include implementing innovative sustainable design strategies, generating on-site renewable power and/or purchasing a maximum of 20% renewable energy. Are students equipped to meet these goals? How are students learning to integrate sustainable design strategies into their projects?

We speculate that most schools use traditional modes of teaching building science concepts and principles, which may not be adequate to meet the immediate and future challenges facing our profession.

3. METHODOLOGY

This study relies on three data collection methods to examine building science technology courses at schools of architecture: public information available on websites, reviews of course syllabi and schedules, and interviews with course instructors. The use of multiple methods allows a triangulation of the data whereby the limitations of one method are compensated or addressed by two others. In addition, this approach allowed data collection to be conducted sequentially over a period of time beginning with data that could be analyzed somewhat 'objectively' by what is 'on paper' vs. qualitative interviews, which are more subjective and take a longer period of time to analyze. For this paper we focus on the central portion of the data collection process: the review of syllabi and schedules.

3.1 Document Request

The data collection method used for this portion of the study involved gathering course materials from building science technology instructors. Every accredited school of architecture in the United States is required to provide instruction in areas related to building systems, performance, and sustainability. This data collection method allowed us to examine the nature of building science technology instruction at specific schools, to compare the information across programs, and to assess the extent to which building science technology knowledge or concepts inform other areas of architecture education, for example, design studios.

We solicited responses from instructors using an e-mail message posted to the Society of Building Science Educators (SBSE) listserv. SBSE is an organization of educators, researchers, and professionals in architecture and related fields who "support excellence in the teaching of environmental science and building technologies." Members and non-members may subscribe to the SBSE listserv, which serves as a forum and a repository for building technology information, advice, and resources. (8)

The SBSE listserv provided two critical advantages over the traditional information request letter: it was less time consuming than obtaining contact information for one or more faculty at more than 120 accredited schools of architecture and the SBSE listserv membership encompasses a critical mass of building science educators. However, these advantages are also acknowledged as limitations because of the inherent bias in using a sample of educators that are already a part of an organization devoted to sharing information about building science technology information.

The request message briefly described the study, highlighted the areas of building science technology education that we intended to illuminate (course structure, resources, hands-on learning, sequences of courses, and faculty teaching in this area), and asked for faculty to submit course syllabi and schedules by a set date two weeks later. We also asked faculty if they were willing to participate in interviews after the completion of the syllabi and schedule review process. Finally, the message explained that the information contained in the syllabi and schedules would remain confidential and would not be shared without participants' permission, but that complete confidentiality could not be assured due to electronic distribution of documents to the researchers.

Since the solicitation occurred around a major holiday and a break from scheduled college and university classes, a number of instructors inquired whether they could submit documents after the deadline. In response, we extended the deadline by two weeks.

3.2 Syllabi and Schedule Review

The review of the syllabi and schedules focused on distilling comparable information across building science technology courses. We reviewed documents related to design studio and certain advanced technology elective course separately because they were less comparable with other courses and were few in number.

Syllabi and schedule sets were assigned unique identifiers consisting of an institution acronym and a course number. These identifiers were only used for internal analysis since the identity of the participants remained anonymous. We used a spreadsheet to log information extracted from the documents. The spreadsheet consisted of five categories of information.

The first category lists basic demographic information: institution, course name, course number, and the instructor(s) names. We used this information to determine statistical counts for the number of institutions, courses, and instructors represented in our data set.

In the second category we listed course information: number of credit hours; whether or not the course followed a lecture and activity lab format; involvement of teaching assistants; whether the course was for undergraduates, graduates, or was mixed; and where the course fell in building science technology sequence of courses. This data was more dichotomous in nature (yes or no) and provided a breakdown of course types.

Category three focused on information related to resources: required course textbooks or other tools as well as a separate spreadsheet listing recommended resources suggested by faculty, which were more extensive than could be accommodated in the primary spreadsheet.

The fourth category translated student assessment for grading purposes into percentages for common course components: exams, projects (including case studies), homework, lab participation and activities, and attendance. However, these areas of assessment are not exhaustive as criteria vary widely among courses and instructors. Therefore, we included an “other” category as a catchall for unique areas of student assessment.

Finally, the fifth category required the greatest amount of interpretation. We examined course schedules to determine how much course content (in weeks of instruction divided by the total length of the course in weeks) was related to content areas we determined were critical to supporting net-zero energy design. These content areas included: passive systems or strategies; active mechanical systems; performance benchmarks and standards (including rating systems such as LEED); and energy topics (including specific coverage of net-zero energy design).

3.3 Limitations

Limitations exist in using syllabi and schedules to distill information for course comparisons primarily because formatting and content vary. Syllabi and schedules present a brief overview of a course and appear to be the most commonly distributed materials among building science technology courses at schools of architecture. Nevertheless, it may be problematic to assume that information not included in course documents is not covered in the course content. For instance, a lecture topic or title may not include a mention of passive design, but the course may still cover such strategies. Therefore, the syllabi and schedule review provided more accurate and detailed information than the website review, but additional data collection may be necessary for more nuanced look at course coverage of net-zero energy design issues. Our study did not include information from complementary documents such as project requirements, assignments, activities, or exams, which might reveal a more qualitative understanding of course content

4. RESULTS & ANALYSIS

4.1 Demographics

We received 45 course syllabi and schedules from 38 faculty representing 29 schools of architecture (approximately one-quarter of the accredited schools in the U.S.).

Some faculty shared syllabi from more than one course, and some syllabi were sequenced courses such as Environmental Control Systems 1 and Environmental Control Systems 2.

Of the 45 courses, 34 were semester-long courses (average 15-weeks); the other 11 were on the quarter system (average 10-weeks). See Table 1.

TABLE 1: PARTICIPANT DEMOGRAPHICS

Number of schools represented	29
Number of schools from which we received syllabi of multiple courses	11
Number of instructors	38
Number of courses reviewed	45
Lecture only courses	22
Lecture/lab courses	23
Courses on the quarter system	11
Courses on the semester system	34

4.2 Time Spent on Zero Net Energy Topics

We examined course schedules and syllabi to determine how much course time is typically devoted to course content that supports zero net energy (ZNE) design education. The acronym "ZNE" is used broadly to cover content in four categories: passive systems, active systems, benchmarks and standards, and energy. Results of our analysis suggest that ZNE topics account for approximately 28% of the time devoted to material coverage in the building science technology course schedules reviewed (Fig. 1). Of this ZNE category, passive and active systems account for about two-thirds of the topics; benchmarks, standards, and energy account for about one-third of ZNE design topics (Fig. 2).

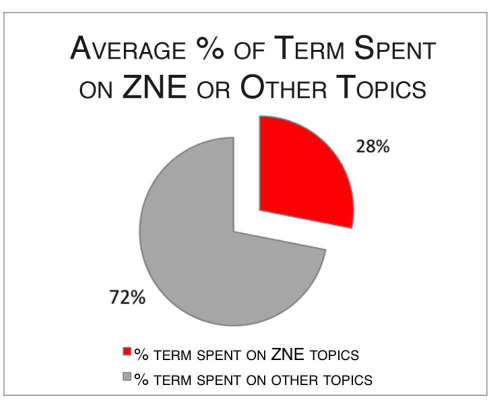

Fig. 1: Percent of course time spent on ZNE or other topics

Many of the building science technology courses reviewed are foundational courses, giving students broad exposure to fundamentals and principles of the subject area. The data indicate that in these beginning stages of learning about building science technology, zero net energy design issues do not predominate the lecture topics and course time.

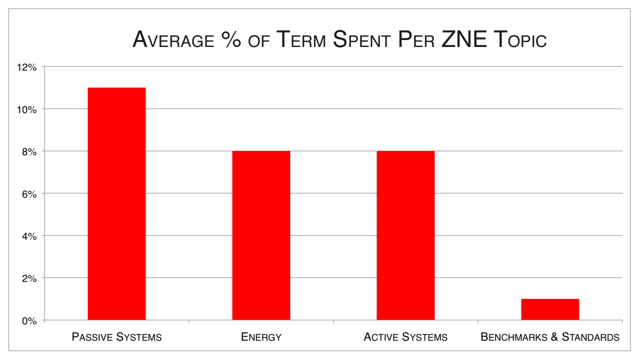

Fig. 2: Percentage of course spent on ZNE topic

On average, courses taught on the quarter system spend slightly more time on ZNE topics than courses taught on the semester system, as shown in Fig. 3. This seems to indicate that more available length of course time does not necessarily increase the amount of time spent on ZNE topics.

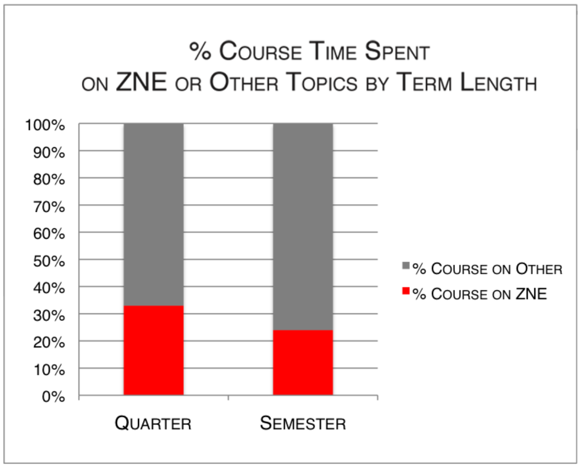

Fig. 3: Percent of course time spent on ZNE or other topics, by length of term

4.3 Student Assessments

The grading weight/criteria for the activities in a course can represent the relative value that an instructor places on a type of knowledge or skill. The caveat, however, is that grading criteria can be affected by administrative requirements of the department or university or college. Figure 4 shows that the majority of instructors rely on exams as a primary category for student assessment.

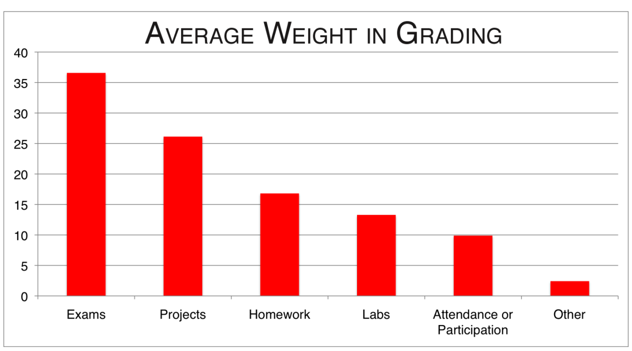

Fig. 4: Weight given to various activities in courses

4.4 Projects and Student Assessments

Fifty-two percent (52%) of the syllabi reviewed, showed that instructors weighted project work as more than half the final grade.Figure 5 shows the course time spent on ZNE topics versus the weight given to project work. The cluster of points on the upper left area of the graph indicates that there is a tendency for instructors who spend more time on fundamentals/traditional building science technology topics to give more weight to project activities. Yet, as more course time is devoted to ZNE topics, instructors tend to give less grade weight to projects. This was surprising, as we expected that, as more time is spent on talking/lecturing about ZNE topics, there would be equivalent project activity engaged by the students. However, our assumptions may have superseded the kind of information that could actually be extracted from syllabi and schedule documents.

What appears to be the case, however, is that project-based learning is a common method of instruction and evaluation of student understanding in building technology courses, but there was not sufficient evidence to support our original idea that courses with a greater ZNE focus would in turn give more weight to project-based activity.

Also, it cannot be assumed from these data, that the time spent in lecture and the types of projects assigned are directly related. For instance, instructors may be lecturing more on traditional building science technology topics or concepts, but assigning projects that are more related to ZNE topics. It seems entirely possible that instructors may find it more effective to lecture on the newer subjects of ZNE topics than to assign projects based on those topics. However, the syllabi and schedule data are unable to address this subtlety.

Why does this relationship exist? This question will be explored further through analysis of interviews with instructors and with a more in-depth review of the content of the lectures and projects. In future research it may be helpful to understand to what degree instructors themselves feel prepared to lecture on or assign student work on ZNE topics.

4.5 Textbooks and Resources

Many instructors require a combination of required texts and resources for the course, in addition to long lists of recommending readings and resources. Figure 6 shows the ranking of "required readings" as noted by the instructor. The top three most required texts are *Mechanical and Electrical Equipment for Buildings*, *Heating, Cooling,*

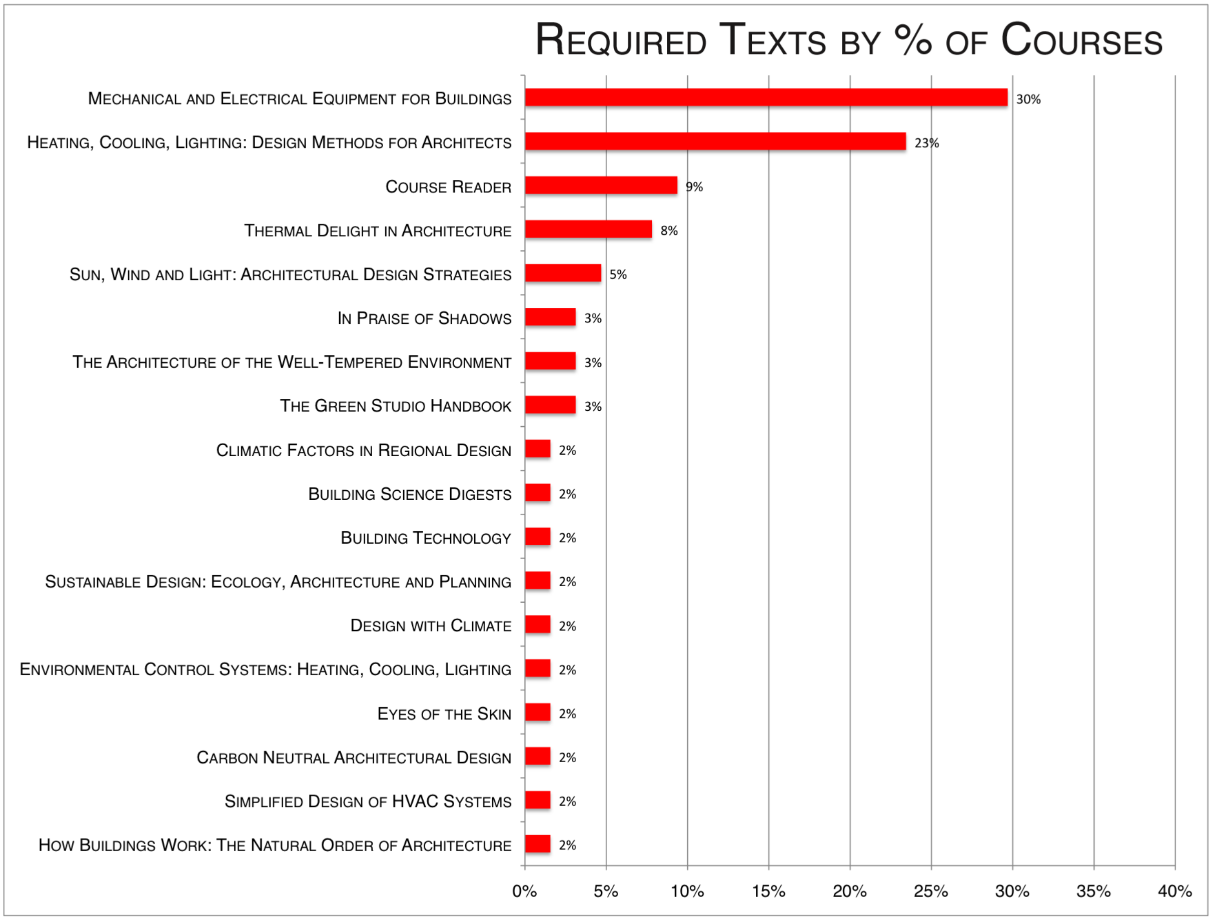

Fig. 6: Required texts specified by instructors in course syllabi

Websites, online tools, videos, magazine articles, and a number of green guides and resources comprised a long list of recommended/suggested resources. The data suggests that many building science technology courses use a small number of the same primary texts, but that most instructors supplement these books with a wide variety of other materials.

4.6 Experiential Activity

Many factors affect whether a course has a lab section, but we were curious about the kind of experiential activity that students are involved in (if at all) during lab sections. Of the 45 courses reviewed in this study, approximately half are lecture-based only, and the others are lecture-lab courses. Most syllabi did not indicate the nature of the activity in lab sections, although the ones that did described activities such as design charrettes, tours, hands-on experiments, use of tools to gather information, games, measurement verification, calculations, and peer-to-peer collaboration.

4.7 Inconsistencies

A number of inconsistencies in the data left us with some unanswered questions at the conclusion of the document review process. Many courses reference climate and building analysis tools in their syllabi. However, the role that such tools play in the courses reviewed remains unclear. Are these resources being used to inform or support

homework assignments and projects, or simply as recommended as resources for future reference?
It was also unclear from online sources or from the syllabi when in the sequence of architectural education most departments suggest or require that students take building science technology courses. In some cases, it was also difficult to determine whether teaching assistants were employed and what role they play in the courses. Finally, the mixture of graduate and undergraduate students in courses was challenging to distill from he data, largely due to the varied course nomenclature used by different schools of architecture.

5. CONCLUSIONS

In this limited snapshot of 45 courses at 29 institutions, we found a number of intriguing facts, trends, and relationships. On average, approximately 25% of course time (over the term) supports ZNE concepts and topics through lectures and project-based learning. Faculty are placing both traditional required readings from books and more current readings on emerging building science technology topics on required and recommended reading lists. However, The syllabi and schedules alone were unable to sufficiently answer all of our questions about whether courses are providing students with the experience, skills, and abilities to address the goals of the 2030 Challenge and the 2010 Imperative.

The movement within the profession is toward a more sustainable approach to design, including net-zero energy issues. The courses in our review also appear to maintain a division between traditional design and zero net energy design. Since syllabi are not an exhaustive exploration of a course's content, this hypothesis must be tested with further evaluation. Ongoing data collection and analysis of interviews with instructors will investigate current pedagogical methods and find areas where traditional and zero net energy design are being integrated that our syllabi and schedule review was unable to capture. In addition, future research should also address student impressions of their abilities and preparedness for low-carbon design challenges.

Our review of syllabi and schedules was intended to begin a conversation about how courses across a number of schools of architecture are preparing students for designing buildings that address the very real concerns of global climate change. We expect that additional data collection and analysis methods can be used to build upon this initial exploration and to better reveal the true state of building science education.

7. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the willingness of faculty to share their course syllabi and to volunteer to participate in future interviews. We may have studied the "choir" but feel that the information provided via these courses is likely at the cutting edge of curriculum nationwide.

8. REFERENCES

(1) Boyer, Ernest L, and Lee D. Mitgang. *Building Community: A New Future for Architecture Education and Practice: a Special Report*. Princeton, N.J: Carnegie Foundation for the Advancement of Teaching, 1996. Print

(2) *The 2030 Commitment*. The American Institute of Architects (AIA), 2013. Web. 10 Feb. 2013

(3) *2010 Imperative Global Emergency Teach-In.* Architecture 2030, 2013. Web. 09 Feb. 2013

(4) *Strategies for Design Schools.* Architecture 2030, 2013. Web. 10 Feb. 2013

(5) Preliminary study for U.S. Department of Education, FIPSE grant report. NetZED Laboratory, 2009

(6) Singer, Mike. *The 18-Year Itch: How Close is Architecture to Carbon Neutrality?* Architect, 2013. Web. 11 Feb. 2013

(7) *Construction Industry Workforce Shortages: Role of Certification, Training and Green Jobs in Filling the Gaps*. Rep. Bedford, MA: McGraw-Hill Construction Research Analytics, 2012. Print.

(8) "SBSE Listserv." Email distribution. *SBSE Listerv*. Society of Building Science Educators, Web. 27 Dec. 2012.

(9) Grondzik, Walter T., A. Kwok, J. Reynolds, and B. Stein.*Mechanical a Buildings.* Wiley & Sons Canada, Limited, 2009. Print

(10) Lechner, Norbert. *Heating, Cooling, Lighting: Sustainable Design Methods for Architects.* Hoboken, NJ: John Wiley & Sons, 2009. Print