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Advancing Critical Building Code Education through Modularized Lectures

Dr. Ryan L. Solonsky P.E., Pennsylvania State University, University Park

Ryan Solnosky is an Assistant Teaching Professor in the Department of Architectural Engineering at The Pennsylvania State University at University Park. Dr. Solnosky started at Penn State in July of 2013 and has taught courses for Architectural Engineering, Civil Engineering, and Pre-Major Freshman in Engineering. He received his integrated Professional Bachelor of Architectural Engineering/Master of Architectural Engineering (BAE/MAE) degrees in architectural engineering from The Pennsylvania State University, University Park, PA, in 2009, and his Ph.D. in architectural engineering from The Pennsylvania State University, University Park, PA in 2013. Dr. Solnosky is also a licensed Professional Engineer in PA. His research interests include: integrated structural design methodologies and processes; Innovative methods for enhancing engineering education; and high performing wall enclosures. These three areas look towards the next generation of building engineering, including how systems are selected, configured and designed.

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Abstract

Traditional lecturing of building code related topics are commonly taught ad-hoc in courses, often get misinterpreted by faculty unfamiliar with code details, or left out entirely from courses. To improve dissemination of code knowledge in our department but also be applicable to two other associated departments, a project was undertaken to enhance mechanisms for faculty to better deliver building code knowledge in academic settings. Here, self-contained teaching modules were developed that can be incorporated within existing courses. Our code education enhancements take what has been traditionally perceived as passively learned content with little appeal that minimizes student engagement and immersion, to more active, relatable topics that showcase the importance of the building code related to their careers. This paper examines the critical needs and new mechanisms to convey code information in a meaningful way rather than the idealized representations. Results from pre- and post- surveys, interviews and assignments support the positive feedback and success of the modules. At this stage of module distribution, correlations between student perceptions and actual performance have not been studied yet. The basis of how the modules were structured, including their assessment on their effectiveness are detailed in this paper.

Introduction

The idea of a regulating building code that governs the design and construction of buildings is paramount to our industry. For the Architecture, Engineering, and Construction (AEC) Industry, the International Building code (IBC) is a powerful document that forces designers to adhere to an official position on acceptable building safety (Field & Rivkin 1975; Hutchings 1998). Students majoring in architecture, landscape architecture, civil engineering, architectural engineering, and construction management will become responsible to adhere to building code regulations upon graduation (Gerber 2009; Solnosky et al. 2017). The notion of understanding building codes within the context of actual building projects, with site and urban requirements, inherently supports effective interdisciplinary and cross-disciplinary collaboration and respect. To assure the competency of entry-level design professionals, adequate academic preparation is crucial in this area (Holladay 2005).

We as educators are responsible for ensuring that students receive an education that meets a certain standard of the profession that students will be entering (Dunham 1998). Some majors, specifically architecture and landscape architecture, have explicit requirements for teaching codes by accrediting bodies (NAAB 2016). Engineering and construction on the other hand is more open but necessary to meet certain ABET requirements (ABET 2016). Students need to know not just the code or parts of codes most applicable to their discipline, but also those that their systems interact with to promote and achieve integrated, inviting, and safe solutions. In an effort to enhance code efforts being taught in building based curricula, the authors studied multi-disciplinary approach to advancing code education that develops an engaging mechanism focusing on code details suitable to architectural engineering, landscape architecture, and architecture programs.

Current Deficiencies with Code Education

Curricula focusing on buildings in university settings provide students with limited comprehensive exposure on vital (and commonly misunderstood) building codes, if at all (Solnosky et al. 2017). Shealy et al. (2015) found that both industry and academia believe the topic of codes is valuable to students' career success and should be taught; yet, both realize that there are many potential barriers. Holladay (2005) presented arguments suggesting schools are not providing sufficient education regarding building science and code compliance while Shealy et al. (2015) reflects that many programs that attempt teach codes hold little importance in the mind of many faculty. When code is taught, these lecturing methods more often than not take a hands-off static teaching approach with little appeal, particularly to the more visual learns in these programs (Moon 2010). Building code education deficiencies include (Solnosky et al. 2017):

- Courses do not provide adequate detail
- Material is isolated from other course and/or curriculum content
- Code knowledge is not reinforced in assignments
- There is limited available time to cover code material in existing courses
- Faculty experience varies considerably resulting in important provisions being skimmed over or ignored

Many of these identified issues largely stem from faculty experience with codes themselves. This is due to the background education of faculty and that most faculty do not or have not practiced in the industry where code knowledge is mandatory. Based on ill formatting and expertise, important provisions may be skimmed over or left out, or substituted by other work, and less stringent enforcement of codes in design adherence on projects. These can be compounded when a course gets migrated from one instructor to another for various reasons. Here, specific details change because department wide syllabus information do not exist generally or traditional lecturing of building code is done in rote fashion transmission with little appeal.

Room within the curricula structure is also a concern, particularly for the engineering focused building degrees. More often than not for code topics, they are taught ad-hoc in courses spread across the curriculum, with limited coordination over time as faculty change teaching loads or courses are redesigned without the bigger picture remaining. When taught ad-hock, sometimes code materials gets misinterpreted by faculty and students, or left out of courses entirely by faculty who are unfamiliar with codes and remove it the course due to its potentially small amount of time allotted to begin with.

In these types of situations, Iverson and Colky (2004) found that the lecture-based instruction produces students that either fixate on minute data crunching of codes and miss the bigger picture of why or they are completely disengaged and show no effort to learn it. Moon (2010) implies to these attempts that having limited student immersion with the topic keeps students surface level of learning. Due to codes not being sufficiently known by faculty and to make an integrated approach successful, this research study was conducted to formulate self-contained modules. The intent of the self-contained module was to have all necessary materials to teach and assess a particular code topic packaged that faculty can follow.

A Deployment Strategy to Educate Codes

Foundations to the Strategy

In engaging the students cognitively, the theoretical foundations of scenario-based learning suggest organizing topics around key concepts or 'big ideas' (Walther et al. 2011). These are supported by cognitive load theory and situated learning (Sweller 1988). Scenario-based learning allows students to acquire more conceptual knowledge, leading to expertise in scenarios that are developed properly. In looking at the IBC (2015), the code is organized into 35 chapters and 12 appendices, of which the chapters focus on specific areas/functions of the building. These can provide a good starting point for module scope and is discussed in a later section of this paper.

While the most common traditional approaches to content deployment in a curriculum settings have included: single courses, a set of courses, and an integrated curriculum (Andersen et al. 2007; Tomek 2011). Dedicated courses can be can be solitary courses that are standalone or series courses that build on prior courses, or concurrent paralleled courses. Having looked at these methods with the cramped 5 year curriculum within AE presently (avg. semester of 15-17 credits), it was decided to take an integrated curriculum approach. According to Jestrab et al. (2009), an integrated curricula strategically places the content across courses and years (as applicable) to where the material makes the most sense. This notion correlates well with scenario based learning.

To make an integrated approach successful, a self-contained module approach was selected based on literature supporting scenario based learning. The intent of the self-contained modules is to have all necessary materials to teach and assess a particular code topic developed and packaged with notes that faculty can follow without need to generate materials themselves. Here, at the department level the modules were created then are able to be distributed where applicable to those faculty and courses relevant to the IBC.

"Module" is used to describe each grouping of code-related content, based on its ability to be independently used and adopted within a curriculum. Alternatively, back-to-back topics could be taught together that would result in a 3 credit upper level undergraduate technical elective. This arrangement allows the faculty in the future to decide on if the modules remain in separate courses or as a new courses as the curriculum evolves.

Determining Module Topics

While the IBC has 35 chapters of very detailed content, not all are applicable to the careers that Architectural Engineers, Architects, and Landscape Architects may pursue. Additionally, many of these topics to not have a good correlation to the core of what the programs educate. Based on this, the researchers studied the scope of the IBC and the programs for the most relevant topics to turn into modules. The result was the selection 11 core modules that are the most fundamental to the programs. Table 1 shows the relationship between the module topics, IBC Chapter, the applicability to the Department, and lastly the relative multi-disciplinary importance the module can have in influencing designs that students might generate.

Table 1: Correlation between Topic, IBC scope, Department, and Impact

Module Topics	Scope within Dept.		Multi-disciplinary	
	Program	IBC Chapter	Interaction	Impact
1. History of Building Codes	Arch, AE, Larch	N/A	N/A	N/A
2. Zoning and Land Development	Arch, AE, Larch	N/A	Med.	High
3. Materials and Fire Rating	Arch, AE	N/A	Med.	Med.
4. Types of Construction	Arch, AE	6	High	High
5. Use and Occupancy	Arch, AE	3	Med.	High
6. Building Height and Area	Arch, AE	5	High	Med.
7. Means of Egress	Arch	10	Med.	Med.
8. Accessibility	Arch	11	Med.	Med.
9. Enclosure	Arch, AE, Larch	14-15	High	High
10. Structural Design	AE	16-18	Low	Med.
11. Mechanical, Electrical, Plumbing	AE	27-29	Med.	Med.

Content Structuring in the Modules

When developing educational scenarios, Tucker (2012) and Blair (2012) supported that if structured correctly, students engage the content in a manner that requires higher order cognitive skills that advance and deepen concepts, leading to an increase in knowledge retention. Instructors can better gauge student progress in such scenarios, where measurement is not delayed until after testing (Chickering and Gamson 1987).

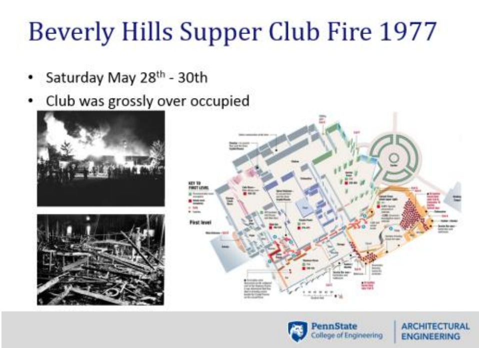
A standardized format was taken to generate each module after the topics were selected. This started with identifying the skills the program wanted to have students be successful at for each module. From here, primary code sections were identified and organized into groups. Lastly, examples and activities that would be applicable to the topic were identified. A module consists of: lecture materials, examples, and assignments. Details for each of these summarized in Table 2.

The starting point for the content was developed in PowerPoint with a standardized layout that carries throughout the modules. The format is straight forward that permits faculty to implement the entire module or segment it down to their needs. Additionally, the PowerPoints were in a configuration that led them to easily being converted into video lectures. A long term goal was to provide the faculty with pre-made videos lectures that they could use to flip a classroom if they so choose. Wording was minimized, when possible, to keep students engaged on the discussion and not reading slides. If possible images of text meanings were created, often with animations. A similar format was generated for the activities where students are given a scenario description and students are to complete as if they are in a professional setting. Figure 1 shows representative slides. Listed here is the format outline for a standard module:

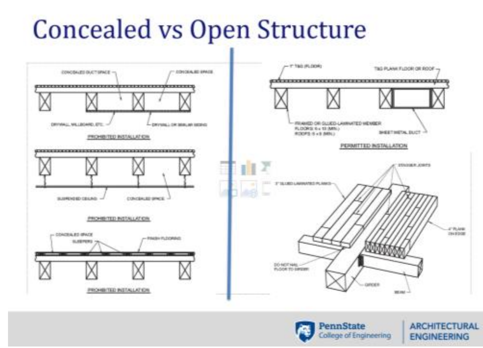
- Cover Title Slide
- Learning objective
- Graphical outline of the Module
- Sub Topic Group:
    - Basis of Topic
    - Code
    - Ideal Example(s) and /or Real Example(s)
    - Activity Slide
- Next Sub Topic Group
- Module Summary

Table 2: Structure of a Self-Contained Module

Main Component	Sub Component	Description of Content
Lecture Content	PowerPoint	• Slides with supplemental instructor notes on what to say and additional information for faculty only.
	Video-based	• A combination of voice over PowerPoints, supplemental videos, and computer animations. • Desired lengths are between 5-20min. interwoven with other materials.
	Expert guest speakers	• Video recordings of experts on specialty code topics around certain case study scenarios not commonly addressed in the IBC.
	Supplement Handouts	• Code excerpts (IBC and other), permitting forms, website links, building plans, specifications,
Examples	Ideal	• Utilized to first highlight what a provision means. • Idealized or simplified plans
	Real	• Real project photographs and plans Utilized to show how to expand a code provision to a real project that has complexity. • Material in a professional setting similar to what they would see upon graduation. • find where building codes were successfully adopted and/or where designs violate these provision or inconsistencies exist
Assignments & Activities	Code Investigations	• Graphical, numerical, or written code provision and their general interpretations.
	Design charrettes	• Generate designs based on certain code requirements.
	Design Investigations	• Code provision application to completed designs for review. • Proper solutions to violations.



c) Code Evolution Example



d) Clarification of Code Terminology

Figure 1: Sample shots of slides

Other video content was created to supplement instructor teaching, these included: explanations of codes by building officials, plan review process to obtain permits, public zoning hearing to better understand the process, and videos showing code performance. Two types of examples were created (Table 2), ideal and real. Ideal examples were used first to convey code provisions, these were often more visual in nature and of very simplified buildings. From here, code application example to real projects were developed using actual projects. These projects were of campus projects were documents and site visits are easily doable.

Possible Location of Modules in the Curricula

Each module topic was developed so that it could be deployed within current courses by faculty as they choose. This was accomplished by correlating topics to current courses to look for overlaps and gaps. All topics fit within at least one class but several can/could be implemented in multiple classes. To be applicable within crowded curriculums, each of the 11 topics (Table 1) correlate to one-two weeks of equivalent class material (this considers both in- and out-of-class activities). This allows for enough in-depth learning to supplement courses but not force out critical other areas.

Given the study of the architectural engineering curriculum at Penn State University, Table 3 showcases the possible locations of the 11 modules. Locations were divided into ideal locations and possible alternative locations. While the ideal locations are preferred to keep the most relevant together, other locations were identified in the event that faculty member chose to not deploy the modules.

Table 3: Correlation between Module and Course

Module Topics	Ideal Program Year	Ideal Class	Alternative Classes
1. History of Building Codes	1st	Intro to Arch Engr. Seminar	AE Systems
2. Zoning and Land Development	2nd	Studio 1	Capstone
3. Materials and Fire Rating	2nd	Building Materials	
4. Types of Construction	2nd	Building Materials	Working Drawings
5. Use and Occupancy	2nd	Arch. Studio 2	Arch. Studio 1 or 3
6. Building Height and Area	3rd or 4th	Arch. Studio 2	Arch. Studio 3
7. Means of Egress	4th	Arch. Studio 3	Arch. Studio 4
8. Accessibility	4th	Arch. Studio 4	Arch. Studio 4
9. Enclosure	4th or 5th	AE Systems	Enclosure Grad. Class
10. Structural Design	4th	Structural Analysis	Any Structural Design Class
11. Mechanical, Electrical, Plumbing	3rd	Intro to HVAC Class Intro to Electrical Class	Advanced HVAC and Electrical Classes

Assessment of the Modular Materials

Scope of Assessment

While there are 11 Modules that were developed, only one module will be discussed here as the other modules were either not adopted by faculty at the time of writing or were still in the data collection stage. Before permanent adoption into the curriculum, all modules will undergo similar assessment techniques. The module of focus here will be The History of Codes Module. This module was tested in AE 124: Introduction to Architectural Engineering Course. AE 124 focuses a large view of what architectural engineering is and the scope that the profession has within the larger building industry. This class is the first exposure that students get with architectural engineering as it is a 1 credit freshman seminar. Here the module was done pre-recorded video segments being given to the class to watch then apply their knowledge to an in-class activity. The student outcomes for this module are listed here:

- Ability to select the proper code provisions when disagreements exist between code and standard
- Recognize the overarching purpose of building codes and standards
- Understand how building codes are adopted and enforced

To assess the impact of the modules, a pre- and post-survey was administered. The pre-survey was administered the two days prior to the module; the post-survey was administered the week following the module. In addition to these, open-ended questions were included to allow students to provide additional thoughts on the modules. Within AE 124, students voluntarily completed pre-and post- surveys. 24 students completed the pre-survey while 17 completed the post survey. Additional data in the upper level engineering classes is being collected presently, including: thoughts on the surveys and grade data to be able to do correlations between actual and perceived abilities.

Demographics

All 24 students reported that they were only enrolled in AE 124 in the fall semester. Of the 24 students, 23 were first-year students and 1 was a second-year student. The breakdown of students' majors was as follows: Architecture (1), Architectural Engineering (12), Civil Engineering (3), and Other (9). Other was reported as including Computer Engineering (3), Science (1), and Biomedical Engineering (1). All 12 students who selected Architectural Engineering as their major reported the Pre-Option category (they don't yet know their discipline focus they want to pursue).

Results

In both the pre- and post-surveys the students were asked to rate their confidence in their ability to perform certain tasks related to the module content. Confidence was measure in 11 areas that pertained to the intent of Module 1: building code background, significance, and structure. To measure confidence, students rated their level of confidence on a scale of 1 (Cannot do at all) to 5 (Highly certain can do). As seen in Figure 2, the distribution of responses for each question on the pre- and post-tests changed significantly. In all cases the distribution of students having no confidence in their ability to the 11 items dropped (indicated by the dark blue). While very confident was not largely increased the area of neutral increase to average confidence was considerable increased.

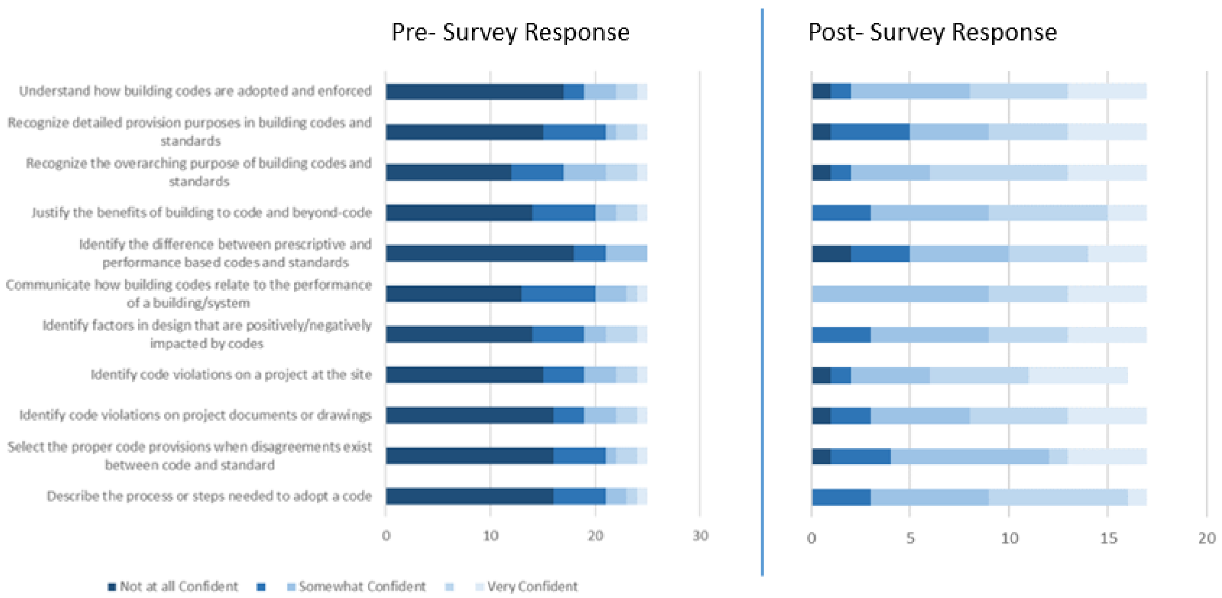


Figure 2: Pre to Post Module Confidence in their Ability to Perform Certain Code Tasks

In addition to a descriptive comparison of results in Figure 2, the pre- and post-survey results were compared using an item level analysis (Wilcoxon Signed-Rank Test) for each of the questions.

Upon analysis for each question, there was statistically significant improvement in the students reported confidence levels for every question included in the pre- and post-survey scales as indicated in Table 4.

Table 4: Item Level Analysis Results

Survey Question	*Z*	p-Value
Describe the process or steps needed to adopt a code	3.047	0.002
Select the proper code provisions when disagreements exist between code and standard	2.956	0.003
Identify code violations on project documents or drawings	3.001	0.003
Identify code violations on a project at the site	3.082	0.002
Identify factors in design that are positively/negatively impacted by codes	3.225	0.001
Communicate how building codes relate to the performance of a building/system	3.272	0.001
Identify the difference between prescriptive and performance based codes and standards	3.22	0.001
Justify the benefits of building to code and beyond-code	3.222	0.001
Recognize the overarching purpose of building codes and standards	3.086	0.002
Recognize detailed provision purposes in building codes and standards	2.821	0.005
Understand how building codes are adopted and enforced	2.971	0.003

Beside students reporting their confidence levels on module one topics, student were also asked their perceptions on the delivery method of the material. Here, students were asked to rate their agreement with the following items that assess the design of the module(s) and accompanying assignments on 11 items listed in Figure 3. To measure perceptions, students rated 11 items on a scale of 1 (strongly disagree), 3 (neither agree nor disagree), to 5 (strong agree). Between 8-9 students felt lectures like this format would be welcome and enjoyed in other classes with similar content. All but three students felt this material would be helpful in their career, this is particularly positive given the diverse makeup of the majors. 13 of 17 students felt the examples were sufficient to solidify the findings. 10 of 17 students felt the code material was engaging, while 11 of 17 felt the code illustrations were of a fashion to allow complex provisions to be easily understood.

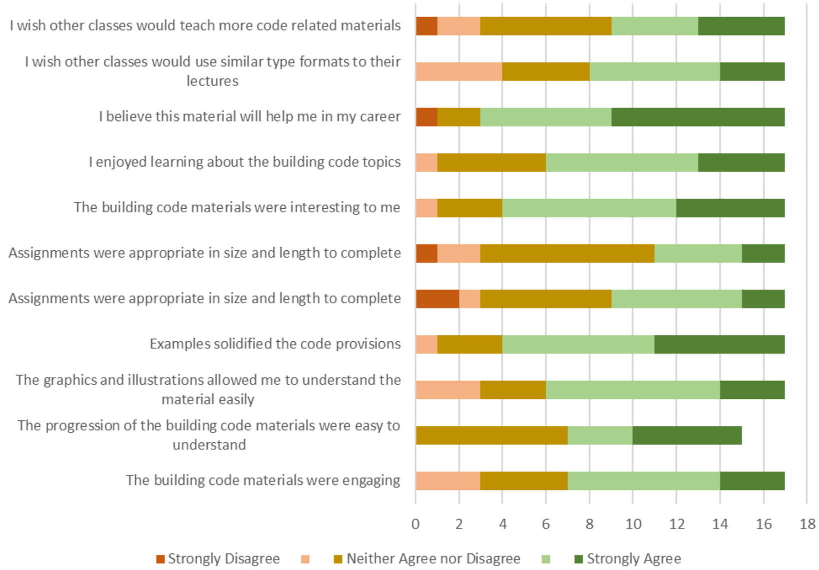


Figure 3: AE 124 Student Perceptions of Module 1

There were several additional questions of interest to the research as about content. 15 of 17 students indicated that the graphics and illustrations were sufficient in quality to explain the intent of the code and that the examples were clear and easy to understand. When asked if students would prefer more code citations (chapter and section in the lectures), 7 students said it was okay as is, 7 wanted more, 2 students wanted less. In asking the depth/complexity of code coverage in this modules, no student said there was too many details, 3 students said there were too few details while the remainder 13 students felt there was an appropriate level of detail. 12 of the 17 students felt the assignments were sufficient to test their ability to apply codes. Compared to other courses the students have taken, with the same code material taught, 3 students felt ours was better, 1 student felt it was worse, and 2 students felt it was the same (other 11 skipped the question).

Summary and Conclusions

Students perceived themselves to be more confident in their own abilities to do all eleven of the specified tasks after completing the module and assignments. This is something the authors and the faculty member of the course felt could not be done easily without the module. Also, the structuring of the modules and formulation of content, in regards to depth, graphics and recording style has positive indicators. This is useful, especially in the creation of future modules and content regarding codes, in that the base structure generated works and does not need overhauled. Now this assessment does have some inherent limitations that need to be addressed and refined. First and foremost, the assessment data only focuses on students' perceptions of their abilities, not on direct measures of student learning. While students feel more confident in their ability to complete the tasks, we do not have data presently that shows whether the module did indeed impact their abilities.

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