

Methods for Developing Flexible Technical Knowledge in Architectural Education

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ABSTRACT: Building technology is often the focus of required courses in architecture programs where there is an expectation that technical knowledge will help inform a student's design process. The authors' surveys of architecture faculty suggest programs desire students to integrate skills from technology courses into the studio setting, yet research reveals poor to mixed results. Research in other technical academic fields suggests traditional lecture course formats result in lower student retention of course content. Evidence shows content learned via lecture methods alone tends to be highly compartmentalized and inflexible, thus reducing the successful application of technical knowledge to other contexts, such as the technical courses and design studios found in architecture education.

This paper examines active learning methodologies used in other technical academic curricula and considers how they may be applied to technical curricula in architecture. The paper proposes student's difficulty in applying technical knowledge to design can be attributed to passive teaching methodologies used in lecture-based technology courses. To explore this proposition the authors reviewed pertinent literature from other disciplines and surveyed instructors experienced in employing laboratory type activities in their curriculum. The results of this research suggest hybridized problem-based learning (PBL) methodologies can be integrated into high content technical curricula to increase students' problem solving skills with the aim of developing long-term flexible knowledge.

The research also examines the architecture curriculum at the researchers' institution. There, building technology courses were traditionally passive and lecture-based but the curriculum is currently under revision. The research considers class size, student-faculty ratios, course content, accreditation requirements and assessment methods to propose incorporation of PBL-type activities into existing lecture-based courses. The paper concludes by proposing a methodology for pre- and post-class learning assessment to evaluate the success of curriculum changes.

KEYWORDS: problem-based learning, architectural education, building technology lectures, pedagogy, self-directed learning

1.0 INTRODUCTION

Many professional architecture programs organize their curriculum around a sequence of core design studios and lecture-based support courses focusing on specific architectural topics such as history, theory, digital modeling, building technology and structural performance. It is the goal of many architecture programs for students to integrate the knowledge from support courses into the design studios setting, becoming more sophisticated designers as they incorporate more content from their support courses into their design process (Banerjee, 1996).

While specific methodologies vary, academics generally agree (as found in the authors' instructors survey) that design studios, given their activity type, student generated research, individualized projects, and low student-faculty ratios, are active, student centered learning experiences. In contrast, the building technology courses being researched are often considered a passive learning methodology, employing a lecture-based format that is less interactive. The lecture format is often criticized for not requiring students to be actively engaged in their learning process. Often only a small portion of class time is available for interaction with students, clarification of questions, or advanced topical discussions. As a result, research suggests the percentage of information retained by students is low. Furthermore, the information retained is highly compartmentalized and not successfully transferable to new situations such as design studio (Michel 2009). Despite concerns benefits to traditional lecture settings for building technology courses are significant. They provide a medium for the distribution of large amounts of content (typically required to fulfill professional accreditation requirements), over a short period of time. Faculty to student ratios can be larger in such a class setting. Survey results showed that assessment typically done through multiple-choice or fill-in-the-blank examinations are considered time efficient and easily documented for accrediting bodies.

In contrast to lecture-based learning, active learning methods attempt to create a more engaging learning environment that requires students to develop critical thinking and problem solving skills. Research suggests knowledge acquired via active learning methods is more transferrable, meaning that content is not only recalled but can be applied to new and varied contexts (Michel 2009). These methods though often positively regarded in pedagogical research also come with challenges to consider. A reduction in the quantity of delivered content is one key problem associated with active learning methods, where activities and in-class problems consume more class time than versus the same content delivered in a lecture format. Building technology courses with accreditation criteria require a large and specific set of content to be completed in each course. Additionally instructors surveyed believe that assessing problem-based learning activities, such as providing critical feedback and evaluation of unique projects and presentations, requires more time than assessment of traditional quizzes and exams.

2.0 ACTIVE LEARNING METHODS FOR TECHNICAL CURRICULA

2.1 Technical lectures as passive learning/nontransferable knowledge

Building technology courses in a design curriculum are intended to help students gain a deeper understanding of performance parameters related to design so that they can develop technically-performative, informed design decisions. Traditionally, content delivery in such courses is lecture-based, employing an instructional paradigm where the faculty delivers new information while assuming little to no previous knowledge of the subject matter by the students (Barr 1995). A lecturer may provide fifty-minute presentations including visual slides along with key terminology on a specific topic. The accompanying assessment is often exam-based, requiring identification of slides or terminology covered in the lectures. This system allows for a large amount of curriculum content to be covered efficiently and focuses assessment methods on students' ability to recall lectured material (Schwartz 1998).

Research suggests that employing this type of lecture-based methodology results in inflexible knowledge that students struggle to transfer to different contexts. Students develop only a shallow understanding of the lectured material and often rely on rote memorization of new material. (Van Dijk 1999). New knowledge is not integrated with student's existing knowledge base and becomes isolated, inflexible and not transferrable to other settings. (Schneps 1988). Furthermore, students are often unable to develop a personal context to the new information presented in lecture and may have competing existing experiences or information that reduces their ability to comprehend the new information. Research suggests the inflexibility of new knowledge is partially due to a lack of self-reflective critical thinking moments for students when integrating the new information. Assessment also tends to lack evaluation of reflection and analysis, which research shows is critical to the integration of long-term flexible knowledge (Schneps 1988 & Schwartz 1998).

2.2 Active learning methodologies

Pedagogical research in the sciences, medicine and engineering have fostered methodologies for increasing in-class active problem solving skills and self-directed learning to encourage students to have a stronger investment in their learning process with the aim of developing long term flexible knowledge (Hmelo-Silver 2004). Active learning techniques that involve developing problem-solving skills can provide students with greater context to assimilate new information through meaningful practical experience and increase long term learning outcomes (Hmelo-Silver 2004). As a facilitator, the faculty guides students through a process which includes problem identification, outlining of goals and strategies, problem solving, and concluding moments of reflection and self-evaluation in solving problems that require critical thinking skills (Hemlo-Silver 2004). The key in these student-centered paradigms is the focus on creating meaningful mental engagements during class for students to incorporate and appropriately utilize new information. This is an aspect that is critically absent in most technical lecture presentations which often quickly summarize and condense contextual information in order to cover more content and do not require students to synthesize the material or provide them reflective opportunities necessary for long-term learning.

2.3 Problem-based learning methods

Problem-based Learning (PBL) is one active learning methodology employed in many science and engineering curricula as a method of increasing critical thinking and problem solving skills in a similar manner as they would in practice (Ditzler 1995). In PBL, students identify their own pre-existing knowledge related to the subject matter, frame the problem, determine their gaps in knowledge, self-direct their learning to solve the problem, and reflectively evaluate their success (Schwartz 1998 & Hemlo-Silver 2004). Reflection on new knowledge and existing knowledge allows for correction or modification of pre-existing information and enhances student's ability to apply new knowledge in future scenarios. In course sequences such as those found in architectural building technology courses, this process of identification of gaps, seeking of new knowledge, and self-reflection, may greatly enhance the transfer of knowledge from course to course, course to design studio, and semester to semester.

2.4 Integrating PBL with high content technical material

An integrated PBL/Lecture-based course methodology, as proposed by Schwartz and Bransford, attempts to create an enhanced environment in traditional class lectures through student activities before and after class, seeking to optimize content delivery and transferrable knowledge. In this hybrid method, class assignments are structured to maximize analysis and reflection of information before and after class by taking portions of the lecture material and coupling them with student activities outside of the classroom.

These integrated assignments do not merely practice new knowledge but are designed to help students prepare for forthcoming knowledge, and analyze and reflect upon new material presented in class. Rather than a reading assignment that parallels class lecture, the reading is part of an analytical problem that requires the students to utilize existing knowledge, readings, and forthcoming lectures to solve the problem, thus integrating content from multiple sources. Students identify what information is needed to solve the problem, find partial content in reading material, then come to class prepared to learn additional content via lecture. After the lecture students return to the assigned problem equipped with knowledge from various sources to solve the problem (Schwarz 1998). This methodology attempts to create moments for critical thinking before, during and after class with a goal of students actively searching for the knowledge that they have identified as a gap in their existing knowledge base.

2.5 PBL outcomes / survey research

In 2012, the authors interviewed and surveyed multiple instructors experienced in implementing student-centered activities such as PBL and others to determine what benefits and difficulties they found in implementing these methods into a traditional lecture course curriculum.

Positively, instructors confirmed that these student-based activities facilitate a structured method for integration of new knowledge and self-reflection that has a lasting and meaningful effect on student learning. Concerns include the time required for these student-centered activities given the large amount of content in their technical courses. There is added concern when the course is a part of a multi-course sequence that teaches sequential content. While instructors value engaging student activities in class, they realize that these activities cannot cover as much content as a lecture in the same amount of time. Instructors stated that assessment of student learning can also be more difficult in PBL. Exams and quizzes used in traditional lecture courses are more readily standardized and assessed than laboratory activities involving in-class student engagement. Instructors further stated that moving towards PBL increased the course preparation time for activity-based sessions. Student to faculty ratio is of equally significant concern among those surveyed. In general faculty agreed that a ratio of 8:1 is ideal, 12:1 is acceptable, 15:1 is functional, and any higher ratio becomes very difficult to administer.

3.0 PROPOSED APPLICATION OF RESEARCH

3.1 Architectural building technology curriculum at Philadelphia University

In the fall of 2010, the authors and collaborating faculty in the architecture program at Philadelphia University began redesign of the five-course building technology sequence, updating the courses in response to emerging and shifting trends in sustainable technologies, digital media and building performance criteria. The Bachelor of Architecture program is a 5-year professionally-accredited (NAAB) undergraduate degree, with a total of approximately 350 students enrolled in the program. The academic timetable is two semesters of 15 weeks each, per year. Building Technology (BT) courses are taught sequentially each semester, beginning with BT1 in the fall semester of a student's second year. The BT course sequence, which is required for program accreditation, is primarily directed to architecture majors but also offered to students majoring in related programs. A primary goal of the course sequence is student development of technological knowledge enabling informed architectural design decisions.

The five courses in the BT sequence vary with regard to content; yet share similarities including the lecture/lab credit structure (2-2-3), technical accreditation requirements, fulltime to adjunct faculty ratio (1:2-3), faculty to student ratio (1:25), and zero laboratory or grading assistance. The courses are scheduled as two, one-hour and fifty-minute meetings per week; resulting in approximately 60 hours of class time per semester. Assessment is based primarily on exams and quizzes (on average 60% of the grading) with class participation and projects constituting the remainder (40% of the grading).

3.2 Building technology curriculum considerations regarding implementation

On examination of the Building Technology course sequence, the following significant issues come to light related to integrating active learning methods into the traditionally lecture focused courses:

- Despite their lecture/lab credit structure, the courses were primarily lecture based. Laboratory, "hands-on" learning moments ranged from 10-20% of class time and were not integrated into the lecture material.
- Faculty to student ratios are larger than are recommended for effective PBL methodologies.

- The ratio of adjunct faculty to full-time faculty is very high, leading to significant challenges regarding the training of faculty in PBL methods.
- The student-faculty ratio is prohibitively high for in-class instructor guidance of complex student projects.
- Quantitative assessment techniques do not foster establishment of goals, process, and post-problem reflection and self-assessment critical to PBL methods.

3.3 Proposed methods and examples for enhancing technical lectures

Given the benefits and draw backs of both passive and active learning methods the authors propose a framework for the Building Technology (BT) curriculum wherein lectures embedded with in-class laboratory activities enhance learning opportunities while delivering high levels of technical content.

1. *Student-centered activity will increase in all courses, and increase sequentially from course to course.*
The implementation of student-centered learning in high content, sequential courses requires staged integration to insure that required content is delivered in each course before advancing to the next (Banjaree 1996). Using that framework, the distribution of lecture and student-centered activity is shown in Table 1.

Table 1: Teaching method distribution in hybridized building technology courses.

Course	Lecture	Student-centered activity
Building Technology 1	70%	30%
Building Technology 2	60%	40%
Building Technology 3	50%	50%
Building Technology 4	40%	60%
Building Technology 5	30%	70%

2. *Student-centered activities such as laboratory sessions and problem assignments will be required to assimilate new knowledge from reading and lectures with existing student knowledge to enhance the development of flexible knowledge and critical thinking related to the course content.*

Problem-solving assignments will be used to prepare the students for forthcoming lecture or laboratory content, not only for review of previously delivered content. The goal is students will then create a mental context for the assimilation of new information and be more prepared to reflect on their learning during class discussion. This is similar to the method described by D.L. Schwartz in the article “A time for telling. Cognitive Instruction, vol. 16, 1998” where students prepare for lectures by performing a comparative analysis of multiple readings and similar to the PBL method (Hemlo-Silver 2004) where student identify gaps in their own knowledge related to solving a problem and then use lecture content to fill those gaps.

3. *Shift high level course content from in-class lecture to readings or online lectures.*

To meet content, accreditation and sequential curricular outcomes, some content traditionally covered in lecture must be shifted outside of class to enable increased class-time for active learning opportunities and integration of knowledge from multiple sources.

4. *Reduce instructor to student ratio for active learning settings to 1:8-15 using teaching assistants*

Research highly suggests meaningful faculty interaction and guidance in active learning settings require student to faculty ratios of 8 to 15 per instructor, thus modification of the course structure or utilization of teaching assistants during the lab sessions is essential. Interviewed instructors note that upper-class student teaching assistants made excellent activity assistants because students felt more comfortable asking questions to fellow students than to instructors.

5. *Utilize traditional quantitative testing methods as primary means of assessment*

While it is critical for students to actively participate in student-centered activities, our research recognizes significantly increased assessment as a challenge. Additionally, given the quantitative nature of existing accreditation criteria, testing remains an efficient means of technical content assessment.

6. *Utilize alternative forms of assessment to gauge progress of student-centered activities*

Self-reflective, peer, and verbal instructor assessment, combined with online submissions such as blogs, Blackboard, and other web-based centers, is the proposed method for gauging student work while addressing the time intensive concerns of assessing student-centered activities. Students will post weekly progress of activities, time-stamped to insure participation; this work will be formally assessed at only a few significant moments in the semester, such as midterm and final grading. Peer assessment and group assessment will also be employed and recognized as significant opportunities for student development.

7. *Train faculty in active learning methodologies*

While architecture faculty often use hands-on or active teaching methods in their studio courses, training on the critical steps in active learning methods (intent, process, expected outcomes and student reflection), is critical to ensure student development of long term flexible knowledge. Training on assessment and methods of effective in-class activities will ensure administrative success.

3.4 Proposal example

An example of these guidelines in use is a learning module examining exterior wall systems. A pre-class assignment will be written to ask students to provide graphic comparative analysis of two different exterior wall systems. With students first reading about and then comparing and contrasting each building system in the form of a drawing assignment, the readings are utilized to develop broader context and encourage critical thinking related to the material. The pre-class assignment also requires additional lecture content to solve the problem. This prepares students to receive new information in class by creating a context for the lecture information. Although a few students are able to complete the exercise without the lecture or reading content these steps in the learning process will provide enhanced techniques on the use and assembly of external wall systems. These embedded in-class activities will target not only technical demonstration but highlight design relevance beyond performative issues.

3.5 Implementing surveys and assessing learning gains

To help instructors design their courses to effectively utilize active learning methods some instructors utilize pre-class and post-class surveys to assess their students' progress and gauge desired learning outcomes. Pre- and post-class online surveys assess the effectiveness of implementing new pedagogical techniques and providing rapid feedback for the instructor's use during the semester.

Measuring student confidence in the integration of course materials is a key metric in studying the impact of learning methods and the creation of long term flexible knowledge and skills. The format of survey questions should target specific content knowledge and measure whether students believe the material has become integrated into their knowledge base well enough to be transferred to different contexts. For instance Bower and Ashley (2007) asked students to rate how likely they would be to read an article on a topic related to the material covered in class and how likely they would be to engage in conversations regarding the class topics outside of class with their families or friends. Higher confidence levels often inferred a more fundamental integration into the student's knowledge base. One resource that is readily available to implement these surveys is the "Student Assessment of Their Learning Gains" website (www.salgsite.org). The tools available enable academics to survey student assessment of learning gains.

4.0 CONCLUSION

While assessing student learning relative to accreditation criteria is a requirement of professional programs, a critical goal of architecture programs is to assess students' ability to transfer and apply technical knowledge to their own design work, both in the academy and profession. Enhanced active learning methodologies in building technology courses is the first step to integration of technical content and design. Through the establishment of guidelines for student-centered learning implementation, the authors predict an improved learning environment and increased flexible, transferable knowledge in students.

5.0 DISCUSSION

Active student centered learning such as PBL is an important existing aspect of architectural education commonly found in design studios. Adapting and developing these methods for use in high-content technical courses can greatly enhance desired long-term learning outcomes and students ability to transfer technical knowledge into the design studio setting. Our research and proposal for methods of enhancing technical lectures through short duration student-centered activities are being implemented in our building technology courses.

Some have suggested reversing the distribution of lecture-based versus active-learning activities through the curriculum; proposing a higher concentration of learner centered activities in earlier stages of the curriculum. While this proposal has merits, our proposal is based on two rationale, one pragmatic, and one research-based. Pragmatically, BT1 has traditionally been 90% lecture-based, 10% active-learning based. Given the five sections of the course, taught by one full time faculty and four adjunct faculty, a gradual implementation of active-learning methods is more likely to succeed. Furthermore, research suggests students need some level of existing knowledge from which to solve the problems we propose. (Banjaree, 1996). While this knowledge can be gain in multiple manners, a lecture-based approach for BT1 allows us to cover a large amount of information and helps create a common knowledge base for all first year students for future active learning methods in their subsequent BT classes.

The most difficult aspects related to successful implementation appear to be student faculty ratios and assessment challenges, yet essential to our research is determining the transference of technical knowledge from building technology courses to design studio settings, and that process is underway. It is an added challenge to this research, where evaluation of flexible learning requires coordination between the BT course and concurrent design studios, which are generally outside of the control of technology course instructors. Efforts in assessment will required coordination with studio faculty to target transference of technical knowledge into studios.

As we implement these changes in the BT curricula pre- and post-class surveys are planned for the technology courses and related upper level design studios to measure student gains and learning outcomes over the course of each semester. It will be interesting to see if these methods and outcomes can be successfully mapped across multiple semesters, not only targeting concurrent studios but future studios as well.

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