

Pedagogy for 21st Century Construction Education: Active and Collaborative Learning in Correlation with ACCE Student Learning Outcomes

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Construction Management programs are challenged to keep up with ever-changing construction environments, requiring higher education to research and implement best practices to assess and incorporate effective industry practices into curricula. There is a definitive need for high-level student cognition of many technical topics. Various pedagogical approaches to enhance the lecture-style classrooms (teacher-centered) and to improve student learning have been researched and developed over the past few decades. Collaborative and active learning are two products of this research and developments that are widely believed by educators to be techniques that can enhance student learning by encouraging student interactions with each other, the instructor, and the material. This study explored the use of collaborative and active learning strategies for construction education programs in the US. The survey gathered information from ASC faculty on the potentiality for collaborative and active learning methodologies to achieve the prescribed American Council on Construction Education student learning outcomes. Key findings from the research indicated that most programs have access to "active learning" spaces, a majority of programs use active and/or collaborative learning, and it is perceived by the faculty that student gains could be realized by utilizing collaborative and/or active learning to foster student learning outcomes.

Key Words: Construction Education, Pedagogy, Active Learning, Collaborative Learning

Introduction and Background

In the 21st century, the politics of higher education teaching quality can be overwhelming. Excellence in teaching is required as an institutional marketing tool to prospective students, to support faculty and administrator promotions, to respond to almost ubiquitous student feedback, and to provide accountability for public funding (Ramsden, 2003); all while a much greater emphasis is being placed on external funding and research. Institutions of higher education are constantly under pressure to improve student learning and to demonstrate that prescribed learning outcomes are being achieved to validate the effectiveness of accredited degree programs (O'Flaherty & Phillips, 2015). Because of these vast requirements, leaders in higher education are challenged to position their institutions to meet growing expectations and demands for higher quality learning experiences and outcomes (Garrison & Kanuka, 2004). It is within this lens that educators are often tasked with finding new and effective mechanisms to communicate technical information in a way that is retained at a much higher level than the traditional lecture format. Active learning and collaborative learning are two of the widely accepted techniques to enhance student learning and retention.

Active learning is a form of study in which teaching strives to involve students in the learning process more directly than in traditional methods – a "student centered" approach. Although the concepts of active learning have been around for centuries, English scholar R.W. Revans first described the term "active learning" in 1971, and continued to evolve the concept over the following two decades (Weltman & Whiteside, 2010). Active learning is any instructional method that engages the student as an active participant in the learning process in order to enhance cognition and knowledge. The core elements of active learning are student activity and student engagement. Active learning is often contrasted to the traditional, teacher-centered lecture style where students passively receive information from the instructor (Prince, 2004).

Collaborative Learning is an educational approach to teaching and learning that involves groups of students working together to solve a problem, complete a task, and/or create a product. As stated by Gerlach (1994) "Collaborative learning is based on the idea that learning is a natural social act in which the participants talk among themselves." This type of educational approach does not refer to *group work* where all of the tasks are divided up and everybody gets a task to complete, but refers to learning activities that are intentionally designed for and carried out through pairs or small interactive groups. Collaborative learning must include co-laboring by all participants and meaningful learning that increases knowledge and deepens understanding (Barkley, Cross, & Major, 2005).

Active and collaborative learning are well-researched pedagogical methodologies. The body of research on the increased efficacy of active and collaborative learning approaches versus traditional lecturing stretches back several decades (Bonwell et al.,1991, Brame, 2016). Teachers from languages, physical sciences and engineering disciplines claim that active/collaborative learning approaches improve academic achievement when compared with traditional classroom teaching (Stump et al., 2011) and results in stronger learner satisfaction (Springer et al., 1999; Chan et al., 2014). Considerable research substantiates the benefits of a collaborative/active learning environment when these strategies are properly implemented. Multiple studies suggest significant increases in students' grades and learning gains as well as increased student engagement in a "flipped classroom" model (Prince et al., 2004, Walker et al., 2011, Freeman et al., 2013, Gilboy et al., 2014, Brame, 2016). This is true of not only higher order cognitive skills (Stump et al., 2011), but also lower level cognition (Ryals, 2011; Derickson, 2017). There is a myriad of literature available regarding active and collaborative learning classrooms as well as many adaptations of the "flipped classroom model." (Schaffhauser et al., 2016). Although active and collaborative learning can be executed in a class of any size or layout, specially designed classroom spaces can be constructed to further facilitate this type of learning. These spaces often use technology enabled "pods" or grouped together, circular type tables, have multiple display units, and walls covered with glass or white boards, all in an effort to enhance collaboration and further enable active learning. A typical active learning space at Auburn University is shown below in Figure 1.

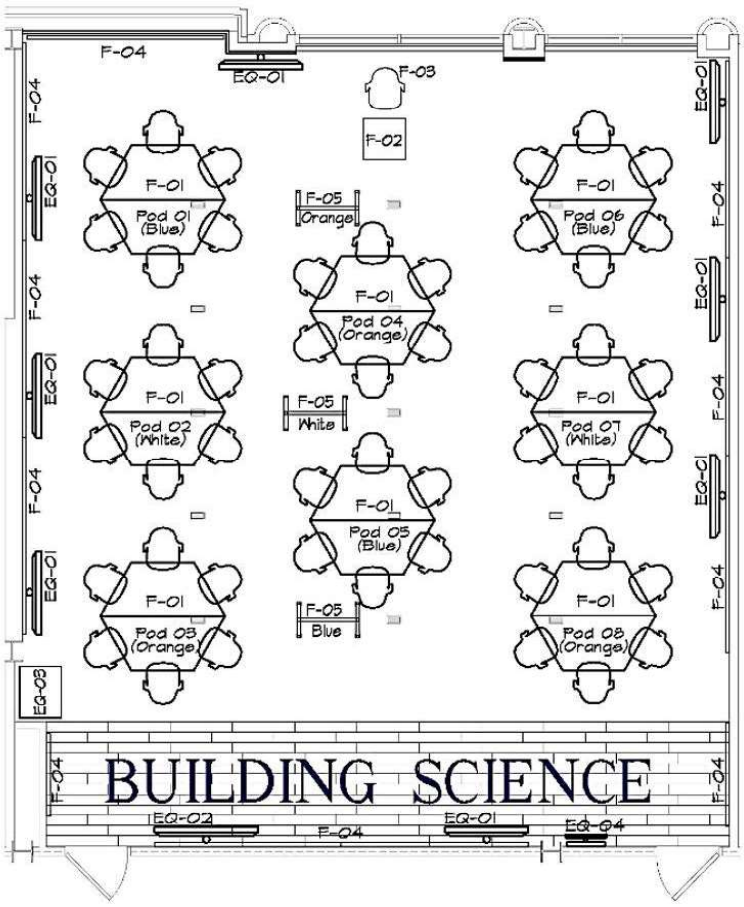

Figure 1. Floorplan of typical active learning space at Auburn University

The construction industry is inherently collaborative and requires construction managers and executives be able to disseminate technical information to individuals of various backgrounds and knowledge. The technical knowledge and soft skills that construction students obtain during their college tenures are of paramount importance to being productive entry level managers and is expected by industry. Research in construction education on collaborative/active learning is limited at this point. What has been identified is that construction students want less text-based learning and more experimental learning activities (Harfield et al., 2007; Farrow et al., 2011) that are authentic to what they will experience in the profession (Benhart and Shaurette, 2014; Bhattacharjee et al., 2013). Construction students believe this type of learning can improve their overall employability upon graduation (Chan et al., 2014). This sentiment is echoed by industry, indicating that "Construction Management programs must do more than provide institutional knowledge about past practices" (Lambeck, 2016).

Bachelors-degree awarding construction management programs in the United States are accredited by the American Council of Construction Education (ACCE). The ACCE has set out twenty specific students learning outcomes (SLOs), shown in Table 1, that programs must demonstrate student competency of by the time of graduation. These SLOs, developed in concert between academia and industry, are based on Bloom's revised taxonomy of learning objectives. The hierarchy of the model includes six levels of cognition: remembering, understanding, applying, analyzing, evaluating, and creating. Remembering is considered the lowest level of cognition, while creating is considered the highest level of cognition.

Table 1
ACCE SLOs Required for Bachelor's Degree Programs (Taken from ACCE Document 103B – Standards and criteria for accreditation of Bachelor's degree construction education programs)

SLO	Description of SLO
1	Create written communications appropriate to the construction discipline
2	Create oral presentations appropriate to the construction discipline.
3	Create a construction project safety plan.
4	Create construction project cost estimates.
5	Create construction project schedules.
6	Analyze professional decisions based on ethical principles.
7	Analyze construction documents for planning and management of construction processes.
8	Analyze methods, materials, and equipment used to construct projects.
9	Apply construction management skills as a member of a multidisciplinary team.
10	Apply electronic-based technology to manage the construction process.
11	Apply basic surveying techniques for construction layout and control.
12	Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.
13	Understand construction risk management.
14	Understand construction accounting and cost control
15	Understand construction quality assurance and control.
16	Understand construction project control processes.
17	Understand the legal implications of contract, common, and regulatory law to manage a construction project.
18	Understand the basic principles of sustainable construction.
19	Understand the basic principles of structural behavior.
20	Understand the basic principles of mechanical, electrical and piping systems.

Empirically speaking, the incorporation of active learning and collaborative learning by construction management faculty as a pedagogical technique could better aid students in achieving the required SLOs. To date, no evidence is

available in the literature that specifically addresses (1) whether or not construction management faculty purposefully incorporate active learning and/or collaborative learning in their classes to aid students in meeting the stated ACCE SLOs, (2) if active learning and/or collaborative learning are incorporated, (3) to what scale are classroom environments specifically designed for active learning and/or collaborative learning available and utilized by construction management faculty, and (4) if specific course topics lend themselves more to active learning and/or collaborative learning than others.

Research Aim and Methodology

The research aim was to determine how the pedagogy of active learning and/or collaborative learning is integrated into coursework by faculty within Associated Schools of Construction (ASC) member programs to meet the ACCE SLO requirements. Specifically, the research sought to address the following questions:

1. What percentage of faculty in ASC member programs are incorporating active learning and/or collaborative learning into their courses, and have access to specially-designed learning environments that facilitate active and collaborative learning?
2. Which ACCE SLOs can best be fostered through active learning and/or collaborative learning methods?
3. What active learning and/or collaborative learning opportunities are offered in construction management programs?

The authors sought to obtain the requisite data to answer these questions through a survey of faculty members within ASC construction management programs within the United States. Faculty from ASC member programs were selected for the survey as these programs (149 in total, excluding region 8) represent the predominant group of construction education programs in the US.

A 25-question survey was developed based on a literature review of active learning, as well as discussions between the authors on active and collaborative learning techniques. The survey, titled "Flipping the Classroom for 21st Century Construction Education" was developed in the Qualtrics software platform, and was sent out via email to faculty on the ASC email list-serv (a total of 812 individuals) on May 29, 2018. A reminder to take the survey was sent out to the same email list on June 13, 2018. The survey was closed at the end of June, 2018. Participation in the survey was voluntary and the responses were anonymously collected.

Results

General survey respondent demographics

At the conclusion of the survey period, 59 respondents representing 40 of the 149 ASC programs (26.9 percent of programs) had completed the survey. Of the 59 survey participants, eighty-five percent held the title of Full Professor, Associate Professor, or Assistant Professor, with the remaining fifteen percent (holding a visiting, lecturer, administrator, or instructor title. Thirty-eight of the fifty-nine respondents, or 64 percent, had at least 10 years of teaching in higher education. The survey results pertaining to the stated research aim are provided in the next three sections. The complete survey results (i.e., the results to each of the 25 survey questions) have not been included due to space limitations.

Research Question 1: Access and Incorporation

Fifty-two of the fifty-nine survey respondents, or 88 percent, indicated that they have or are currently utilizing active learning and/or collaborative learning techniques in their classes. Fifty of the fifty-nine respondents, or eighty-five percent, stated that their university has collaborative/active learning spaces, and all but one of those responded that their academic unit has access to these spaces. Despite access to them, only 39 of the 50 indicated they had actually utilized these active learning environments.

Research Question 2: Fostering of SLOs

Survey respondents were asked to rank their perceptions (ranging from definitely to unlikely) on the likelihood that the ACCE-prescribed SLOs could be fostered using active learning and/or collaborative learning methods. Fifty-eight of the fifty-nine total participants responded to this portion of the survey, the results of which are provided in Table 2**.** Overall, the survey respondents indicated that all 20 of the SLOs can be achieved using active learning and/or collaborative learning methods. Larger numbers of respondents indicated that SLOs requiring higher orders of cognition such as "create" and "analyze" could "very likely" to "definitely" be fostered using active learning and/or collaborative learning. Conversely, larger numbers of respondents indicated that SLOs requiring lower orders of cognitions such as "apply" and "understand" could only likely be fostered using these pedagogies.

Table 2

ACCE SLO Fostering Potential Using Active and/or Collaborative Learning Methods

SLO	Description of SLO	Definitely	Very Likely	Likely	Slightly Likely	Unlikely	Mean
1	Create written communications appropriate to the construction discipline	**17**	15	12	9	5	3.52
2	Create oral presentations appropriate to the construction discipline.	**25**	20	4	6	3	4.00
3	Create a construction project safety plan.	14	**17**	16	8	3	3.53
4	Create construction project cost estimates.	**19**	15	18	2	4	3.74
5	Create construction project schedules.	**22**	16	16	1	3	3.91
6	Analyze professional decisions based on ethical principles.	**20**	19	12	4	3	3.84
7	Analyze construction documents for planning and management of construction processes.	**20**	18	14	3	3	3.84
8	Analyze methods, materials, and equipment used to construct projects.	19	**21**	13	2	3	3.88
9	Apply construction management skills as a member of a multidisciplinary team.	**34**	17	5	0	2	4.40
10	Apply electronic-based technology to manage the construction process.	**18**	16	13	7	4	3.64
11	Apply basic surveying techniques for construction layout and control.	**20**	15	14	4	5	3.71
12	Understand different methods of project delivery and the roles and responsibilities of all constituencies involved in the design and construction process.	13	**20**	13	8	4	3.52
13	Understand construction risk management.	12	15	**17**	11	3	3.38
14	Understand construction accounting and cost control	10	14	**17**	12	5	3.21
15	Understand construction quality assurance and control.	11	**18**	15	10	4	3.38
16	Understand construction project control processes.	13	12	**23**	7	3	3.43
17	Understand the legal implications of contract, common, and regulatory law to manage a construction project.	10	13	**19**	11	5	3.21

18	Understand the basic principles of sustainable construction.	11	16	**18**	8	5	3.34
19	Understand the basic principles of structural behavior.	12	14	**15**	10	7	3.24
20	Understand the basic principles of mechanical, electrical and piping systems.	15	12	**18**	6	7	3.38

Note. Highest ranking score for each of the SLOs are shown in **bold**

Research Question 3: Collaborative/Active Opportunities Offered

Survey respondents were asked to note what active and/or collaborative learning opportunities were offered in the construction management program, the results of which are shown in Figure 2. As shown, over half of the 59 survey respondents indicated that lab and simulation-type opportunities such as thesis/capstone, demonstration labs, estimating labs, surveying, and BIM courses that lend themselves to active learning and/or collaborative learning are offered in the program.

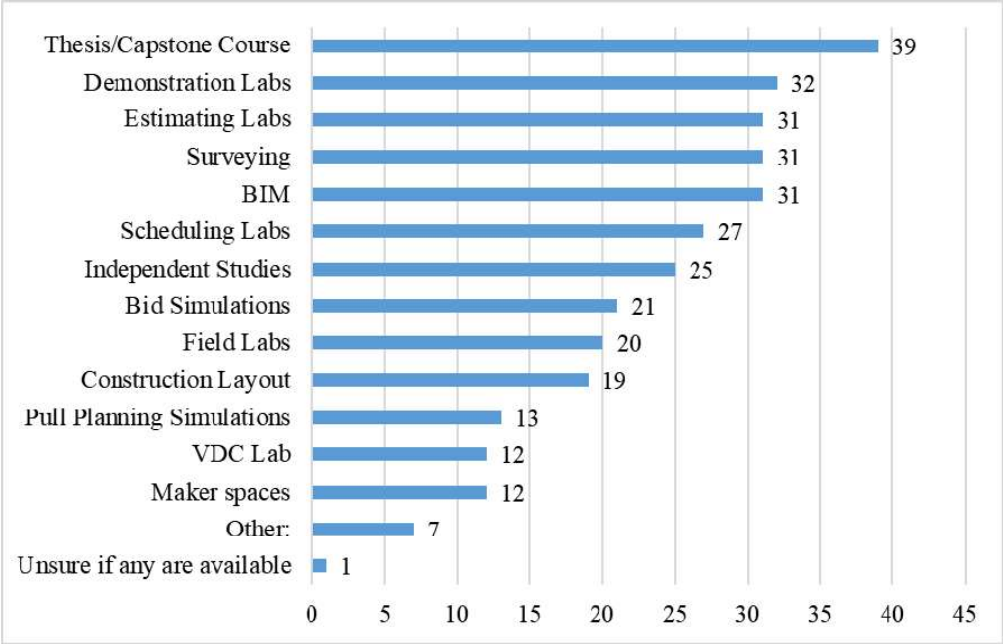

Figure 4: Active and/or Collaborative learning opportunities offered in construction management programs

Discussion of results

The construction industry, and consequently the construction education discipline, generally tend to linger behind when it comes to embracing technology and other advancements. However, the results from this study suggest that ASC programs in the United States seem to be aligned with other higher learning educational programs that are utilizing active learning and/or collaborative learning pedagogies. Courses that foster SLOs positioned at the higher cognitive levels of "create", "analyze", and "apply" were recognized as having the most benefit from this type of learning. These results are consistent with current literature which asserts that in terms of Bloom's taxonomy, active learning techniques, like a flipped classroom, allow students to do the lower level cognitive work (memorizing and basic understanding without reflection) outside of the classroom and focus on higher forms of cognitive work (application, analysis, synthesis, evaluation, create) in the classroom where they have the support of their peers and instructor (Brame, 2013). Many construction education courses, by nature of requiring hands-on interactions and

team collaborations, likely have the advantage to innately foster this style of teaching and learning. Moreover, construction courses that inherently support collaborative/active learning may not necessarily require a physical classroom transformation; therefore, implementation is easier. The responses indicating active and/or collaborative opportunities already being offered in programs, support this notion. Furthermore, the number of respondents showing offerings of thesis/capstone courses, estimating labs, and scheduling labs supports the idea that many of these higher-level construction topics such as construction estimating and scheduling are most naturally taught by having students engage in the activity.

Active learning and/or collaborative learning pedagogies were felt to offer less benefit to courses where lower-level cognitive SLOs are promoted. While the survey did not seek to understand why, it could be presumed that the perception is these lower level cognitive abilities cannot be taught in this type of format. As an example, developing "understanding" of a topic might be perceived as a cognitive ability that requires learning through more traditional means. As well, developing one's ability to understand something like "basic principles of mechanical, electrical, and piping systems" may not inherently command active learning and/or collaborative learning like the previously mentioned topics do. However, using this pedagogy type on the lower level cognitive SLOs is still feasible and has been shown in other disciplines to have benefit, especially when taught in learning spaces specifically designed for active learning and/or collaborative learning. Although many programs have access to these types of spaces, fewer faculty were utilizing them. This could be due to lack of understanding of the technology, perceived extra time it would take to familiarize with the new spaces, time required to change teaching materials, or disinterest in trying new approaches.

Conclusions and future research

Research shows that collaborative skills and learning environments are desired by construction education students as well as increasingly necessary to be successful in the AEC industry (Valdes et al., 2015). Research supports, for various academic disciplines, that active learning classrooms result in more engaged students, higher student retention, and better grades. Research further indicates that poorly designed building/spaces can vastly influence whether or not students choose one construction education program over another (Rutherfoord et al., 2013). Improved ways to teach/learn must be followed up with changes to the physical learning environments. In order to transform construction education classes to better align with and to satisfy students' learning styles, instructors need to better understand how students feel about learning as well as how to develop more effective courses.

The results suggest that construction education appears to be trending higher than other disciplines. However, the discipline has room to grow in the adoption of collaborative/active learning – especially as it relates to learning lower level cognitive abilities. Further research is needed to fully understand the challenges and barriers limiting adoption. Future areas of study should look to gaining understanding of perceived barriers by faculty toward adoption of the approach, training available in the use of new classroom environments geared towards active/collaborative learning, and understanding of how learning lower level cognitive abilities can benefit from this type of approach.

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