

Educating Students concerning Recent Trends in AEC: A Survey of ASC Member Programs

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The Architecture, Engineering, and Construction (AEC) industry is experiencing significant changes as a result of recent trends. To date, little is known about how the changes associated with these trends are being addressed by Construction Management (CM) programs. This research is a first step in addressing the problems faced by educators through an attempt to identify and describe activities of ASC member construction management programs relative to several recent trends (sustainability, building information modeling, jobsite field management, mechanical specialty contracting, electrical specialty contracting, Lean construction, and integrated project delivery). A survey was sent to 126 ASC administrators for member schools with a 34% response rate. The results indicate a wide range of adoption and treatment of the identified trends. Some trends that were lacking attention included Lean construction, mechanical specialty contracting and electrical specialty contracting. These data provide a broad overview of the state of educational efforts in CM programs.

Key Words: Construction Education, Accreditation, Trends in AEC

Introduction

The architecture, engineering and construction (AEC) industry is often criticized for a slow adoption of technology and unwillingness to change. In spite of this reputation, several trends have been taking hold and have, in many ways, begun to transform the industry. For example building information modeling or BIM has gained significant momentum in a relatively short period of time. This momentum is evidenced by the recent requirement by the General Services Administration (GSA) for a “special program BIM” on all major projects (GSA, 2006). Another example is the recent trend toward sustainable building efforts. The United States Green Building Council’s Leadership in Energy and Environmental Design (LEED) certification program has seen significant growth with 14,000 registered and 1,700 certified projects to date. Other notable trends include the movement toward integrated project delivery (IPD) and the implementation of Lean concepts into construction. In addition to, and partly a result of these trends, project complexity has increased, especially in the mechanical, electrical, and plumbing areas. The implementation of these trends and increased complexity require an increased awareness of the competencies required by project personnel. As required competencies continue to morph, the training to prepare current and future project personnel must follow.

Although these trends have generated significant attention, in many cases the definitions, concepts, stated benefits, and challenges vary widely and are often specific to an industry sector. The following discussion of BIM, and BIM enabled IPD will illustrate this challenge. Currently the leading definitions for BIM contain the common concept of horizontal integration throughout the lifecycle of the project including design, construction, and facilities management (FM). This concept implies the passing of information throughout building lifecycle instead of information re-creation from one industry sector to the next (NBIMS 2007). “The NBIMS [National BIM Standard] Initiative categorizes the Building Information Model (BIM), as [a] **product**, as an IT enabled, open standards based, **collaborative process**, and as a **facility lifecycle management requirement**” (NBIMS 2007 p.19). These definitions, including the concept of horizontal integration, are more of a vision than a reality with much of the BIM information still contained within industry silos. Reasons for these silos include; the current state of BIM technology

including lack of interoperability (Gallaher et.al. 2004), liability and ownership issues, education/experience, and many others (AGC n.d.). The successful implementation of BIM in AEC and FM will require a fundamental shift in the way projects are designed, constructed, and managed. Much of this shift includes significant collaboration among the many project participants which is a main focus of IPD.

There are three major accrediting organizations for construction education programs in the United States. Many ASC member organizations receive accreditation through the American Council for Construction Education (ACCE) which has an emphasis in management. Other construction education programs receive accreditation through the Accreditation Board for Engineering and Technology (ABET) or the National Association of Industrial Technology (NAIT). Academic programs that are accredited through ABET have an engineering emphasis, and programs that are accredited through NAIT have a technology emphasis. The Department of Education's CIP for Construction Management resides under CIP #52, Business, Management, Marketing, and Related Support Services, thereby putting the emphasis on management rather than architecture, engineering, or technology (Gunderson, 2005).

Statement of the Problem

The AEC industry is experiencing significant changes as a result of the recent trends. The industry will continue to evolve as these trends mature and new trends emerge. The industry has a legitimate expectation that graduates in AEC fields be versed in the latest information and communication technology to assist in technology integration (smit *et al.*, 2005). Additionally, graduates are expected to be versed in the latest project delivery methods as well as the latest material and methods available including those used for sustainable construction. To date, little is known about how the changes associated with these trends are being addressed by CM programs. The fact that these trends are still relatively new and will continue to evolve only increases the difficulty of this challenge. It is evident that pockets of expertise exist where research and teaching relative to these trends have been in operation for many years. However, the authors believe these efforts have not adequately addressed the challenge of preparing the thousands of AEC graduates. This research is a first step in addressing the problems faced by educators through an attempt to identify and describe activities of ASC member construction management programs relative to several recent trends. These data provide a broad overview of the state of educational efforts in CM programs.

Methodology

A survey instrument was used for data collection. The survey questions were generated by the authors who are researching and teaching courses related to several of the trends investigated. A cover letter and invitation to participate in the survey was sent via email to all ASC administrators identified by the ASC website. A link to the online survey administered through a web based service (Survey Monkey) was contained in the cover letter. The invitation and subsequent reminder emails were sent to the participants a total of three times during a three week period. Survey data were collected through the online tool and downloaded to Microsoft Excel. The qualitative data were coded and then much of the data were exported to SPSS for analysis. Only descriptive statistics were used for analysis of survey responses.

Results

The survey was sent to 126 ASC Administrators with the intent that one member of each ASC member program would respond. The number of recipients actually receiving the email is believed to be close to this number as none of the emails were returned undeliverable. The response rate was approximately 34% ($N=43$). This is an acceptable response rate as no generalization to the population will be made as the purpose of the study is to provide insight into the activities relative to recent trends in the AEC industry for ASC member programs (Isreal, 2003). Researchers believe the results should be couched in the understanding that personal and written definitions of the trends may vary widely and thus impact survey responses and results.

Program Demographics

Data collected were specific to each ASC member program. Demographic information regarding the programs included accreditation, degrees offered, and institutional type regarding teaching and research. Of the 43 programs 28 (65.1%) were accredited by ACCE, 6 (14%) were ABET accredited, 2 (4.7%) were accredited by both ACCE and ABET, and 7 (16.3%) were not accredited. The degrees offered by the programs were as follows: 5 (11.6%) offer an associate degree only, 4 (9.3%) offer both associate and bachelor degrees, 16 (37.2%) offer a bachelor degree only, 11 (25.6%) offer bachelor and master degrees, 5 (11.6%) offer bachelor master and doctoral degrees, and 2 (4.7%) offer only a master degree. Respondents were asked if their institution was primarily a teaching or research institution. Thirty (69.8%) respondents reported their institutions to be primarily teaching, 12 (27.9%) reported primarily research and one participant did not respond to this question.

Sustainable Construction Material and Methods

Courses related to all measured trends were separated into two different categories. First, courses with the content focused solely on a specific trend were identified (sole focus). Second, courses with only a portion of the content related to a specific trend were identified (limited focus) along with the average percentage of content per course devoted to the specified content. Table 1 shows the number of courses for sole focus, limited focus, and combined focus levels.

Table 1
Sustainable courses by course focus level and combined

	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
Number of Classes	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	26	60.5	14	32.6	7	16.3
1 class	13	30.2	9	20.9	12	27.9
2 classes	1	2.3	10	23.3	8	18.6
3 classes	0	0	16	14	7	16.3
4 classes	1	2.3	2	4.7	5	11.6
5 classes	0	0	1	2.3	0	0
6 classes	0	0	1	2.3	2	4.7
8 Classes	2	4.7	0	0	1	2.3
13	0	0	0	0	1	2.3
Total	43	100	43	100	43	100

In addition to the number of courses, respondents were asked to identify the courses as required or elective and if they offered undergraduate, graduate, or both types of courses. Of the 17 programs that offered sole focus courses in sustainable materials and methods, 6 (35.3%) offered required courses only, 10 (58.8%) offered elective courses only and one offered both. These courses were mainly undergraduate level courses with 12 (70.6%) programs offering undergraduate courses only and only one offering only a graduate level course. Four (23.5%) offered both graduate and undergraduate level courses.

Of the 28 programs offering partial focus sustainable courses, 25 (89.3%) offered only required courses, one offered an elective course only, and 2 offered both. Again, the courses with a partial focus on sustainability were mainly undergraduate courses with 23 (82.1%) programs offering undergraduate courses only, and 5 (17.9%) offering both graduate and undergraduate courses.

The average content per course was provided for 21 of the 28 programs offering partial focus sustainable courses. Of the 21, 6 (28.6%) reported less than 10% of course content was devoted to the topic, 10 (47.6%) reported from 10% to 25%, 3 (14.3%) reported from 25% to 50%, and 2 (9.5%) reported more than 50% average content focused on sustainable materials and methods per course.

Building Information Modeling. BIM is likely the most recent trend to be addressed by construction education programs and it could be argued to be one of the most challenging. Table 2 shows the number of courses for sole focus, limited focus, and combined focus levels.

Table 2

Building information modeling courses by course focus level and combined

	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
Number of Classes	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	31	72.1	21	48.8	15	34.9
1 class	7	16.3	12	27.9	13	30.2
2 classes	3	7.0	5	11.6	5	11.6
3 classes	2	4.7	2	4.7	5	11.6
4 classes	0	0	1	2.3	2	4.7
5 classes	0	0	0	0	1	2.3
6 classes	0	0	1	2.3	1	2.3
8 Classes	0	0	1	2.3	1	2.3
Total	43	100	43	100	43	100

Of the 12 programs that offered sole focus courses in BIM, 5 (41.7%) offered required courses only, 4 (33.3%) offered elective courses only and 3 (25%) offered both. These courses were mainly undergraduate level courses with 8 (66.7%) programs offering undergraduate courses only and only 1 offering only a graduate level course. Three (25%) offered both graduate and undergraduate level courses.

Of the 22 programs offering partial focus BIM courses, one did not provide information regarding the type of course or course level offered. Of the 22 courses 16 (72.7%) offered only required courses, 3 (13.6%) offered only an elective course, and 2 offered both. Of the courses with a partial focus on BIM, 16 (72.7%) were undergraduate courses, and 5 (22.7%) programs offered both graduate and undergraduate courses. No programs offered only a graduate level course in BIM.

The average content per course was provided for 16 of the 22 programs offering partial focus BIM courses. Of the 16, 5 (31.2%) reported less than 10% of course content was devoted to the topic, 8 (50%) reported from 10% to 25%, 2 (12.5%) reported from 25% to 50%, and one reported more than 50% average content focused on BIM per course.

Jobsite Field Management. There has been a recent trend of superintendents coming from construction management programs instead of coming up through the trades (Gould and Joyce 2002). It is thus important that construction education programs prepare students for this important occupation. Table 3 shows the number of jobsite field management courses with sole focus, limited focus, and combined focus levels.

Nineteen programs offered sole focus courses in jobsite field management. Of the 19, 16 (84.2%) offered required courses only, 1 (5.3%) offered elective courses only, and 2 (10.5%) did not provide information on course type. Of the 19, 14 (73.7%) programs offered undergraduate courses only, and 2 offered both graduate and undergraduate level courses. Three (15.8%) did not provide information on course level.

Of the 27 programs offering partial focus jobsite field management courses, one did not provide information regarding the type of course or course level offered. Of these 27 courses, 24 (88.9%) offered only required courses, and 2 (7.4%) offered only an elective course. Concerning course level, 21 (77.8%) programs offered undergraduate courses only, one program offered only graduate level courses, and 4 (14.8%) programs offered both graduate and undergraduate courses.

Table 3

Jobsite field management courses by course focus level and combined

Number of Classes	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	24	55.8	16	37.2	8	18.6
1 class	13	30.2	12	27.9	15	34.9
2 classes	5	11.6	11	25.6	8	18.6
3 classes	1	2.3	1	2.3	6	14
4 classes	0	0	2	4.7	5	11.6
8 Classes	0	0	1	2.3	0	0
10 Classes	0	0	0	0	1	2.3
Total	43	100	43	100	43	100

The average content per course was provided for 18 of the 27 programs offering partial focus jobsite field management courses. Of the 18, 3 (16.7%) reported less than 10% of course content devoted to the topic, 7 (38.9%) reported from 10% to 25%, 2 (11.1%) reported from 25% to 50%, and 6 (33.3%) reported more than 50% average content focused on jobsite field management per course.

Mechanical Specialty Contracting. Mechanical systems have increased in complexity to the point that often the mechanical contractor is a prime contractor on many projects. Major mechanical contractors are continuing to hire construction management students to manage and execute their projects. Table 4 shows the number of mechanical specialty contracting courses with sole focus, limited focus, and combined focus levels.

Table 4

Mechanical specialty contracting courses by course focus level and combined

Number of Classes	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	19	44.2	28	65.1	13	30.2
1 class	20	46.5	11	25.6	18	41.9
2 classes	3	7	4	9.3	8	18.6
3 classes	1	2.3	0	0	2	4.7
4 classes	0	0	0	0	2	4.7
Total	43	100	43	100	43	100

Twenty four programs offered sole focus courses in mechanical specialty contracting. Of the 24, 17 (70.8%) offered required courses only, 2 (8.3%) offered elective courses only, and 2 (8.3%) offered both. Two respondents (8.3%) did not provide information on course type. Of the 24, 19 (79.2%) programs offered undergraduate courses only and 2 (8.3%) offered both graduate and undergraduate level courses. Three (12.5%) did not provide information on course level.

Of the 15 programs offering partial focus mechanical specialty contracting courses, one did not provide information regarding the type of course or course level offered. Of these 15 courses 13 (86.7%) offered only required courses, and one offered only elective courses. Concerning course level, 13 (86.7%) programs offered undergraduate courses only, and one program offered both graduate and undergraduate courses.

The average content per course was provided for 12 of the 15 programs offering partial focus mechanical specialty contracting courses. Of the 12, 3 (25%) reported less than 10% of course content devoted to the topic, 4 (33.3%) reported from 10% to 25%, 1 (8.3%) reported from 25% to 50%, and 4 (33.3%) reported more than 50% average content focused on mechanical specialty contracting per course.

Electrical Specialty Contracting. Electrical systems, like mechanical systems, have also increased in complexity. Major electrical contractors also hire construction management students to manage and execute their

projects. Table 5 shows the number of electrical specialty contracting courses with sole focus, limited focus, and combined focus levels.

Table 5

Electrical specialty contracting courses by course focus level and combined

Number of Classes	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	24	55.8	29	67.4	16	37.2
1 class	17	39.5	10	23.3	19	44.2
2 classes	2	4.7	4	9.3	5	11.6
3 classes	0	0	0	0	2	4.7
4 classes	0	0	0	0	1	2.3
Total	43	100	43	100	43	100

Nineteen programs offered sole focus courses in electrical specialty contracting. Of the 19, 12 (63.2%) offered required courses only, 4 (21.1%) offered elective courses only and 2 (10.5%) offered both. One respondent did not provide information on course type. Of the 19, 15 (78.9%) programs offered undergraduate courses only and 2 (10.5%) offered both graduate and undergraduate level courses. Two (10.5%) did not provide information on course level.

Of the 14 programs offering partial focus electrical specialty contracting courses one did not provide information regarding the type of course or course level offered. Of these 14 courses 12 (85.7%) offered only required courses, and one offered only an elective course. Concerning course level, 12 (85.7%) were undergraduate courses, and one program offered both graduate and undergraduate courses.

The average content per course was provided for 10 of the 14 programs offering partial focus electrical specialty contracting courses. Of the 10, 2 (14.3%) reported less than 10% of course content devoted to the topic, 3 (21.4%) reported from 10% to 25%, 3 (21.4%) reported from 25% to 50%, and 2 (14.3%) reported more than 50% average content focused on electrical specialty contracting per course.

Lean Construction. Lean construction has been discussed for many years with little real progress toward significant implementation. The recent trend toward BIM implementation will likely facilitate an increased ability to implement Lean construction concepts. With the amount of waste identified in the construction process, Lean concepts need to continue to be explored and presented to construction management students. Table 6 shows the number of Lean construction courses with sole focus, limited focus, and combined focus levels.

Only 3 programs offered a sole focus course in Lean construction and all three were elective courses. Of the 3 programs, 1 offered undergraduate courses only and 2 offered both undergraduate and graduate courses.

Sixteen programs offered partial focus Lean construction courses. Of the 16, one did not provide information regarding the type of course and 2 did not provide information on course level. Of these 16 courses 13 (81.2%) offered only required courses, and one offered only an elective course and one offered both. Concerning course level, 9 (56.2%) programs offered undergraduate courses only, one program offered graduate courses only, and one program offered both graduate and undergraduate courses.

Table 6

Lean construction courses by course focus level and combined

	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
Number of Classes	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	40	93	27	62.8	24	55.8
1 class	3	7	12	27.9	15	34.9
2 classes	0	0	2	4.7	2	4.7
3 classes	0	0	2	4.7	2	4.7
Total	43	100	43	100	43	100

The average content per course was provided for 12 of the 16 programs offering partial focus Lean construction courses. Of the 12, 8 (66.7%) reported less than 10% of course content devoted to the topic, 3 (25%) reported from 10% to 25%, one reported from 25% to 50%, and none reported more than 50% average content focused on Lean construction per course.

Integrated Project Delivery. Integrated project delivery is associated with at least three of the above trends (BIM, Lean construction, and sustainability). This trend represents a significant change in the way projects are administered and requires changes to the contracts as risk is shared among project participants at an unprecedented level. Table 7 shows the number of integrated project delivery courses with sole focus, limited focus, and combined focus levels.

Table 7

Integrated project delivery courses by course focus level and combined

	Sole Focus Courses		Limited Focus Courses		Sole and Limited Focus Courses Combined	
Number of Classes	Frequency	Percent	Frequency	Percent	Frequency	Percent
No classes	20	46.5	14	32.6	5	11.6
1 class	18	41.9	11	25.6	15	34.9
2 classes	3	7	8	18.6	7	16.3
3 classes	1	2.3	7	16.3	9	20.9
4 classes	0	0	2	4.7	2	4.7
5 classes	0	0	1	2.3	2	4.7
6 classes	0	0	0	0	2	4.7
8 Classes	1	2.3	0	0	0	0
10 Classes	0	0	0	0	1	2.3
Total	43	100	43	100	43	100

Twenty three programs offered sole focus courses in integrated project delivery. Of the 23, 18 (78.3%) offered required courses only, 3 (13%) offered elective courses only, and one offered both. One did not provide information on course type. Of the 23, 13 (56.5%) programs offered undergraduate courses only, 5 (21.7%) offered graduate courses only, and 3 (13%) offered both graduate and undergraduate level courses. Two (8.7%) did not provide information on course level.

Twenty nine programs offered courses with a partial focus on integrated project delivery. Of these 29 courses, 26 (89.7%) offered only required courses, and 3 (10.3%) offered both required and elective courses. Concerning course level, 23 (79.3%) programs offered undergraduate courses only, and 3 (20.7%) programs offered both graduate and undergraduate courses.

The average content per course was provided for 21 of the 29 programs offering partial focus integrated project delivery courses. Of the 21, 5 (23.8%) reported less than 10% of course content devoted to the topic, 8 (38.1%) reported from 10% to 25%, 7 (33.3%) reported from 25% to 50%, and one reported more than 50% average content focused on integrated project delivery per course.

Discussion

It seems the activities in construction education related to the measured trends are as varied as the trends themselves. It is interesting that every trend measured had programs that were not discussing the trend at all in their programs. The trend with the most programs (55%) not instructing students about the content is Lean construction. The trends not far behind in not being taught are the trends of electrical specialty contracting (37.2%), BIM (34.9%), and mechanical specialty contracting (30.2%). Further research and discussion are needed to determine the implications of these trends in CM as well as AE/FM education. Questions to be addressed include the following:

- Are the current accreditation requirements appropriate or will they cause programs to become antiquated and out of touch with industry?
- Should accreditation requirements be updated to require programs to educate students about specific industry trends?

The authors believe there are many challenges related to implementation of a comprehensive curriculum relative to the measured trends. These challenges are magnified by a lack of expertise within many programs due in part to the relative newness of some of the trends. Some trends require integration of content throughout the curriculum. Thus, even if a content expert is found in a program, this single point of expertise may not be sufficient. Another significant challenge is the fact that Universities are not structured to easily facilitate collaboration across disciplines nor do all universities have each of the requisite programs. Additional challenges are related to the complexity of the relatively new software tools. Additional research needs to be conducted to identify sound learning objectives for each of the trends. As stated above, we suggest that numerous faculty with expertise spanning multiple disciplines will be required to work with these and future trends to prepare students for the future of construction management.

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