

# The AEC Employment Sector – Are Mechanical Engineering Programs Dropping the Ball?

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While many undergraduate engineering programs strive to prepare their students for graduate level education, all programs are, or should, be preparing their graduates to directly enter the profession. Although the conversation regarding “Masters or Equivalent” or “Bachelors plus Thirty” as emerging educational criteria for professional licensure is ongoing, the prevailing requirement nationwide is a Bachelor’s degree from an EAC ABET accredited program. In Mechanical Engineering, over 2/3 of the PE examinees elected exams that relate directly to the Architecture, Engineering and Construction (AEC) employment sector. While the employment statistics are somewhat cyclic, the AEC sector is one of the few where professional licensure is a necessary credential and the design related employment is readily available for recent graduates. The basic studies of Thermodynamics, Fluid Dynamics and Heat Transfer are staples of a Mechanical Engineering course of study, but the vast majority of programs relegate HVAC Systems courses to elective offerings that may not be offered on an annual basis. Also, few, if any, engineering programs offer instruction related to large scale plumbing systems. In addition, the CAD and graphics focus tends towards solid modeling and solid assemblies, while the AEC industry is dominated by building construction oriented software, such as Autodesk’s Revit. Graduates from traditional programs are certainly able to succeed in this market segment, but require significant employer investment in training, highlighting a need for graduates to be more “job ready” immediately after graduation. In contrast, Mechanical Engineering Technology and Construction Management programs more often include AEC related CAD and graphics preparation and mechanical building systems related courses in their curricula, but their “job ready” graduates are either unable to obtain licensure, or have a significantly greater experience requirement to be license eligible. This paper explores the apparent disconnect between preparation and professional practice in the mechanically oriented sector of the AEC employment segment. This research includes reviews of curricula from a cross-section of large, medium and small programs to determine the general availability of formalized undergraduate coursework relevant to ME graduates working in the AEC industry. A similar review of Engineering Technology and Construction Management programs is included for comparison purposes in an effort to ascertain the extent of disconnection between the profession needs and graduate preparation. While this study is preliminary, and not fully comprehensive, the intent is to initiate the conversation among ME program faculty to consider formal inclusion of AEC relevant courses as they work towards continuously improving their curricula and providing the best educational value to their students and the profession.

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## **Introduction/Background**

During a recent conversation with the talent acquisition manager for a major northeast design/build firm the topic of the mechanical engineering (ME) curriculum at my institution was discussed. The firm was beginning to perform more of their mechanical, electrical and plumbing (MEP) design work in house and the manager was interested in considering our graduates as candidates for their expanding design team. Of particular interest, however, was significant familiarity with commercial HVAC, plumbing and fire protection systems in addition to familiarity with Autodesk’s Revit® software [1]. Unfortunately, the program at my institution only offered an HVAC course

on occasions as an advanced topics technical elective and the CAD focus was on parametric solid modeling, assembly and simulations; essentially machine component design, a similar focus to other ME programs I was familiar with. Revit® is taught by the architecture and construction management programs since it “is specifically built for Building Information Modeling (BIM), including features for architectural design, MEP and structural engineering, and construction” [2]. Having recommended many graduates to MEP consultant firms while on faculty at a previous institution with a very similar curriculum, I explained it was common for employers in architectural, engineering and construction (AEC) industries to invest in the training of newly employed mechanical

engineers. Ultimately, I referred the manager to the chair of our construction management program, since course work in mechanical building systems and Revit® was required in that curriculum [3]. I had to caution that the construction management curriculum was not an engineering curriculum and would prevent or impede those graduates from becoming licensed professional engineers since most states required graduation from an ABET accredited engineering program [4].

While many undergraduate engineering programs strive to prepare their students for graduate level education, all programs are, or should, be preparing their graduates to directly enter the profession. Although there are many industrial employers of mechanical engineers that are exempt from professional licensing, the AEC sector is one of the few where professional licensure is a necessary credential and the design related employment is readily available for recent graduates. Although the conversation regarding “Masters or Equivalent” or “Bachelors plus Thirty” as emerging educational criteria for professional licensure is ongoing, the prevailing requirement nationwide is a Bachelor’s degree from an EAC ABET accredited program [4]. In Mechanical Engineering, over 2/3 of the PE examinees elected exams that relate directly to the Architecture, Engineering and Construction (AEC) employment sector [5].

The basic studies of Thermodynamics, Fluid Dynamics and Heat Transfer are staples of a Mechanical Engineering course of study, but it was suspected that most ME programs relegate an HVAC Systems course to an elective offering that may not be offered on an annual basis. Also, few, if any, engineering programs would offer instruction related to large scale plumbing systems. Graduates from traditional ME programs are certainly able to succeed in this market segment, but would require significant employer investment in training, highlighting a need for graduates to be more “job ready” immediately after graduation. Given that the AEC industry is a primary employer of licensable graduate engineers, it seemed as if many mechanical engineering programs were “dropping the ball” in their preparation of graduates to enter this employment sector. Further, it was suspected that the best prepared graduates to directly contribute to an AEC firm, would have degrees that had the least ability to become professionally licensed in a timely manner; although the relatively uncommon degree program in architectural engineering is considered an option for prospective AEC focused engineering firms [6,7]. This apparent disconnect between academic preparation of recent ME graduates and the professional practice needs in the mechanically oriented sector of the AEC employment segment needs to be explored.

In order to confirm or deny these suspicions, a review of mechanical engineering (ME), mechanical

engineering technology (MET) and construction management (CM) programs was conducted. Of specific interest was availability of coursework related to HVAC, plumbing and fire protection systems and whether the coursework was required or optional.

Although it was further suspected that the CAD and graphics focus tends towards solid modeling and solid assemblies in most ME programs, this review did not consider specific instruction in building construction oriented software, such as Autodesk’s Revit®, as necessary to the readiness of recent graduates. There are too many CAD systems available to the engineering profession. All ME programs that offer CAD related coursework provide a basic understanding of the CAD modeling and graphic representation. Expertise and proficiency with a specific CAD software system is still considered a part of new employee training.

### Methodology

A comprehensive study of all ME, MET and CM programs was not considered a practical approach for this study. Consequently, a sample of residential undergraduate ME programs was reviewed for this preliminary investigation. Since many of these institutions also hosted MET and/or CM programs, a review of those programs was also included. The institutions included large, medium and small colleges and universities; both public and private. In addition, the somewhat randomly selected universities are geographically representative of the continental United States. Table 1 provides a “demographic” breakdown of the institutions.

Table 1: Demographic analysis of subject institutions.

Mechanical Engineering Programs			
Size	Small	Medium	Large
Private	7	4	1
Public	1	5	11
Mechanical Engineering Technology Programs			
Private		2	
Public	1	3	6
Construction Management Programs			
Private	1		
Public		3	5
Geographic Location			
	West	Central	East
North	1	8	7
South	4	5	4

For the purposes of this paper, overall student enrollments were used to define institutional size. Table

2 provides the size definitions used to categorize Table 1.

Table 2: Institutional size criteria.

Small Institution	$n < 7,499$
Medium Institution	$7,500 < n < 24,999$
Large Institution	$25,000 < n$

Table 3 is a listing of the colleges and universities reviewed in this study. It needs to be noted that Florida State University, a large public institution, and Florida A&M University, a medium public institution, share a college of engineering. Since there is also a CM program associated with Florida A&M, both programs were categorized as being medium sized.

Table 3: Institutions reviewed during this study.

Boston University
Bucknell University
California Polytechnic University Pomona
California State University - Northridge
Cooper Union
Florida State University/Florida A&M University
Georgia Tech
Gonzaga University
Indiana University Purdue University Indianapolis
Iowa State University
Kennesaw State University
Lafayette College
Northeastern University
Norwich University
Oklahoma State University
Penn State University - Erie, The Behrend College
St. Mary's University – San Antonio
Texas A&M University – College Station
University California - Irvine
University California - San Diego
University North Carolina - Charlotte
University of Cincinnati
University of Dayton
University of Houston
University of Illinois at Urbana-Champaign
University of North Texas
University of Pennsylvania
Valparaiso University
Washington University in St. Louis

Depending on the institution, exhibits reviewed included undergraduate catalogs, curriculum flowcharts, course listings or currently scheduled courses [3, 8-61]. A summary of the AEC related coursework is presented in the section that follows.

### Analysis

All of the institutions listed in Table 3 have ME programs while several also have programs in MET or CM; six institutions have all three programs. The course offerings were reviewed for the availability of an HVAC course and/or a building systems course that included plumbing systems (MEP). If such a course was available, the curricula were reviewed to determine if the courses were required or offered as electives.

Table 4 summarizes the availability of AEC related courses in the engineering programs investigated in this study.

Table 4: Availability of AEC related courses in mechanical engineering programs. (n = 29)

Course type	Required	Elective
HVAC	0	10*
MEP	0	0

\*In one program, an HVAC course is required as part of an elected program concentration option and is an elective in the other concentrations.

Table 5 summarizes the AEC related course offerings at the investigated institutions with mechanical engineering technology programs or engineering technology programs with mechanical concentrations.

Table 5: Availability of AEC related courses in mechanical engineering technology programs. (n = 12)

Course type	Required	Elective
HVAC	1	4**
MEP	1	1

\*\*A blank course description in the current catalog indicates that one of these programs may no longer support an elective HVAC course.

Table 6 summarizes the AEC related course offerings at the investigated institutions with construction management programs.

Table 6: Availability of AEC related courses in construction management programs. (n = 8)

Course type	Required	Elective
HVAC	0	0
MEP	5	2

While approximately 1/3 of the engineering programs provided access to HVAC courses, all were offered as electives or an elective concentration. There were no

MEP courses offered within the mechanical engineering program at any of these institutions. Approximately ½ of the mechanical engineering technology programs offered HVAC and/or MEP coursework and some of these courses were required in the curriculum. Although no HVAC specific courses were offered in the reviewed construction management programs, the MEP or building systems courses included HVAC and plumbing systems, and often included fire protection. Over 87% of the CM programs offered MEP coursework and 70% of those programs required the MEP courses.

### Conclusions

Preparation for an employment segment that hires mechanical engineering graduates, and frequently requires professional licensing (or registration), appears to be lacking in the curricula of a significant percentage of ME programs. While greater access to relevant course work appears more widely available in mechanical engineering technology programs, a high percentage of these programs do not offer AEC relevant courses. The greatest availability to relevant coursework is offered in construction management programs, which produces graduates that are least likely to meet licensing requirements in a timely manner.

These conclusions were based on a review of curricula and course descriptions from a cross-sectional sample of institutions. Although far from comprehensive, this preliminary study indicates that a significant number of ME curricula do not fully support the AEC industry segment. Given the extensive need for licensable engineers in this employment segment, there appears to be a discontinuity between the programs offering relevant coursework and the professional needs of the industry.

Although it has been standard practice to leverage the general academic background and problem solving skills of typical ME graduates, the significant investment required for the training of recent graduates has become less attractive in the current economic climate. The addition of one, or more, elective courses will not eliminate the need for entry level training, but it could readily reduce the time to productivity and the associated costs for prospective AEC employers if AEC related coursework were readily available to mechanical engineering students.

The intent of this study was to determine if a discrepancy existed between the preparation needs of an industry segment that highly values licensable mechanical engineering graduates and the ME program offerings that attempt to meet those needs. It is apparent that the discrepancy exists and that the immediate preparation needs are being met by program graduates that are not eligible to become licensed professional engineers in the most timely manner. As ME programs

continuously assess, evaluate and improve their curricula, an opportunity exists for industry and academia to reflect on the needs and develop curricula that better serve the students, industry and the public well into the future.

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