Industry-Aligned Interdisciplinary Program Design

Dr. Morad Rachid Atif, Texas A&M University

Dr. Morad Atif is the Director of Architectural Engineering and Professor of Practice at Texas A&M University. He held executive positions at the National Research Council of Canada, including Director-General of the Institute of Research in Construction and of Canada’s National Building and Energy Codes; Director of the Indoor Environment Research Program and of the Canadian Center of Housing Technology. He served as Chairman of the International Energy Agency’s Executive Committee of Energy Conservation in Buildings & Community Systems; Vice-Chair of Continental Automated Building Association, and is currently the Vice-Chair of the Canadian Standard Association’s Construction & Infrastructure. He holds a PhD from Texas A&M University and a Master of Architectural Technology from University of California, Los Angeles. His research focus is on the energy efficiency and environmental control systems of buildings, and development of industry-driven innovation and educational programs for the built environment.

Mrs. Samantha Michele Shields, Texas A&M University

Samantha Shields is currently working on her doctorate in Curriculum and Instruction at Texas A&M University, where she is concentrating on Teacher Education and Technology. Mrs. Shields taught an adjunct lecturer in the College of Education’s Teaching, Learning, and Culture department before transitioning to serving as a graduate assistant in the Center for Teaching Excellence, where she helps to develop curriculum.

Dr. Debra A. Fowler, Texas A&M University

Dr. Debra Fowler serves the Director of the Center for Teaching Excellence at Texas A&M University. Following 16 years working in industry she completed a Ph.D. is in Interdisciplinary Engineering with a specific focus on engineering education from Texas A&M University. Her research areas of focus are faculty perspectives and growth through curriculum design and redesign, interdisciplinary teaching and learning, reflective eportfolios and professional development of graduate students related to teaching.

Prof. David E. Claridge P.E., Texas A&M University

David Claridge is the Director of the Energy Systems Laboratory and the Leland Jordan Professor of Mechanical Engineering at Texas A&M University and a Professional Engineer. He holds a B.S. in Engineering Physics from Walla Walla College and M.S. and Ph.D. degrees in physics from Stanford University. He is internationally known for his work on energy efficiency. He pioneered development of the process of existing building commissioning which is today generally recognized as THE most cost-effective way to reduce energy use in buildings, and accounts for several hundred million dollars of engineering effort annually. He was a major contributor to the methods used to measure energy savings in the International Performance Measurement and Verification Protocol and ASHRAE Guideline 14. These documents are used as the basis for determining the savings in billions of dollars of contracts held by Energy Service Companies. He is also the co-inventor of a disruptive new refrigerant-free air conditioner technology that promises to substantially increase air conditioning efficiency, while providing better comfort and producing pure water as a by-product. He holds 18 patents, is author of over 400 journal and conference papers, has been PI or Co-PI on over $40 million in projects, is a Fellow ASME and of ASHRAE, is an Honorary International Member of the Society of Heating, Air-conditioning and Sanitary Engineers of Japan in recognition of his contributions to energy efficiency in buildings, and received the Faculty Distinguished Achievement in Research Award from the Texas A&M Association of Former Students.
Industry-Aligned Interdisciplinary Program Design: A Case Study for Architectural Engineering

Abstract

The faculty at Texas A&M University anchored the development of a new architectural engineering program with industry consultation and feedback to enable its graduates to meet evolving demands of the building sector and societal expectations for the built environment. Architectural engineering is inherently an interdisciplinary field of study and profession that spans across several disciplines such as engineering, architecture, construction science and management, mathematics and physics. The program design brought together faculty from six departments housed in the College of Architecture and the College of Engineering, whose collective areas of expertise cover most of the key technical knowledge areas of architectural engineering. Industry input was collected from building engineering firms through consultation workshops early on in the process, as well as maintained throughout, using the ABET learning outcome requirements as a foundation for the development of the proposed knowledge and skills for each graduate. The data collected resulted in further industry engagement in program implementation and outreach and helped develop a learning program that will equip architectural engineering students with the ability to adjust to the evolving demands of the building sector. The paper will highlight experiences throughout the process, a review of similar programs, as well as examples of the program outcomes, rubrics, and curriculum map.

I. Introduction

The College of Architecture and the College of Engineering at Texas A&M University are partnering to develop an integrated program in Architectural Engineering (AREN). The new program’s development took root in early 2015 and is scheduled to be launched as a Bachelor of Science in Interdisciplinary Engineering, with a specialization in Architectural Engineering, beginning in the fall of 2017. The program design brought together faculty from six departments housed in the College of Architecture and the College of Engineering, whose collective expertise covers most of the key technical knowledge areas of architectural engineering. The interdisciplinary committee of faculty members, referred to as the Program Development Committee, assisted by educational developers from Texas A&M’s Center for Teaching Excellence, were tasked to develop a comprehensive program anchored with industry consultation and feedback to enable its graduates to meet evolving demands of the building sector and societal expectations for the built environment.

The entire process included three critical phases, aided by strong industry consultation:
- Validation of need for architectural engineers
- Definition of skills and competencies
- Rubric design & curriculum mapping

Over the course of the program’s development, industry input and engagement was sought and secured through surveys, interviews, and half-day workshops. The end state was the development of an Industry Advisory Panel, whose members are now fully engaged in the curriculum content and delivery, with scheduled plans on collaborative projects, site visits, and
internships. Historically, industry engagement in engineering education programs has largely been limited to financial leverage of research and education activities, participation in capstone projects and juries, advocacy tasks, and advisory roles to senior management on operations and efficiency. A review of the literature shows that industry engagement in curriculum development, review, and/or implementation of engineering education programs has not been common practice.

Architectural engineering is inherently an interdisciplinary field of study and a profession that spans across several disciplines, including engineering, architecture, construction science and management, mathematics and physics. In addition, the professional skill requirements for architectural engineers are very complex and relevant to employers. Architectural engineers are readily expected to operate effectively in the large and diverse value chain of the building sector and its complex business processes, such as architects, contractors, city and building code officials, other engineers, and developers.

In this specific case study, both the Program Development Committee and senior management sought the incorporation of industry advisement and feedback in the development and operation of Texas A&M’s new architectural engineering program. Their input proved a significant asset for the creation of a learner-centered, faculty-driven, interdisciplinary curriculum, aligned with ABET accreditation requirements and PE exam requirements, as well as calibrated against similar U.S. architectural engineering programs. Once the program’s need was validated by industry and a review of established architectural engineering programs, it was found that over 80% of the new program’s course requirements necessary to meet the established learning outcomes can be met using existing courses spread across the six included departments. This paper serves to explain the systematic process used to create a new architectural engineering program whose development was a cooperative effort between education and industry.

II. Objectives

The objectives of this paper are to:

a) Reinforce the importance of incorporating effective engagement of industry as stakeholders in the development, implementation, and operation of an interdisciplinary engineering curriculum.

b) Outline the systematic curriculum design model used to create a new interdisciplinary architectural engineering program.

III. Literature Review

Klein (1990), an interdisciplinarian, provides a basic and widely-cited definition of interdisciplinarity, “Interdisciplinarity is a means of solving problems and answering questions that cannot be satisfactorily addressed using single methods or approaches” (p. 196). This definition encapsulates the field of architectural engineering. In this particular study, the disciplines were housed in departments of architecture, construction science, civil engineering, electrical engineering, engineering technology and industrial distribution, and mechanical engineering. The faculty and senior management in the six departments, through a sustained
engagement approach, stepped out of their disciplinary silos to embrace an interdisciplinary approach to program development. In an interdisciplinary approach, individual discipline lines blur and overlap to create a new discipline, architectural engineering, whose discipline foundations integrate and fuse those that feed into it (Nissani, 1995; Lattuca, 2001; Borrego & Newswander, 2010). Investing time to develop a shared vision led each department to bring its unique discipline specific content and skills in order to meld and blend a comprehensive and integrated architectural engineering program that is unique, separate, and apart from each of the contributing disciplines.

There are currently 19 ABET-accredited architectural engineering programs in the United States, out of which four four-year Bachelor’s programs were accredited in the last 10 years. It is anticipated that an additional four architectural engineering programs will seek accreditation within the next four years. A literature review conducted in 2005 on curriculum content in American architectural engineering programs shows significant agreement on five essential knowledge areas: mathematics and sciences, general education, engineering, architecture, and technical electives (Estrada, 2006). It also demonstrated that variations are mainly related to: a) the duration of the course of study – four-year versus five-year degree programs and b) where the program is being housed – in a college of engineering versus in a college of architecture. The difference in total credit hours between four-year and five-year architectural programs is heavily attributed to the emphasis on architecture and engineering related courses. In the last decade, there has been more emphasis on incorporating or increasing the amount of construction science and management, as well as Building Information Modeling, in the curriculum as courses and/or areas of specialization (Ziegler Baker et al. 2013; Solnosky et al. 2013, Davis, 2011).

There is little data on the approach to developing architectural engineering programs and associated curriculum. This is likely due to the differences in the existing faculty expertise that drove the various institutions to proceed with the development of an architectural engineering program and its curriculum. More than half of currently accredited architectural engineering programs are housed or were initiated in departments or colleges of civil engineering. This, in addition to other reasons, prompted the development of new ABET criteria for architectural engineering and clarified their differences with those of civil engineering (Estes, 2011). Most architectural engineering programs have an external industry board or committee that provides advisory and advocacy roles, and in some cases, engages in collaborative projects and fund raising activities. However, there is little information on documented effectiveness and case studies of industry engagement in the development of the architectural engineering programs and curriculum. The positive benefits of interdisciplinary industry advisory board engagement in the development of the curriculum in construction engineering and management technology programs were reported, which further led to their championing hands-on courses and hosting internships (Buchanan, 2009).

Program development, in and of itself, is an integrated process that draws together faculty, academic advisors, educational developers, and external expertise to produce a curriculum grounded in solid discipline foundations, relevant pedagogical practices, and current societal needs (Lattuca & Stark, 2009). To accomplish this, the architectural engineering Program Development Committee utilized a comprehensive Program (Re)Design (PRD) process developed by Texas A&M’s Center for Teaching Excellence (Fowler, Macik, Kaihatu,
Bakenhus, 2016). The PRD process, shown in Figure 1, provided eight steps that systematically guided the Committee, serving as a roadmap as they sought to develop a new architectural engineering program from conception to implementation.

Figure 1. The Program (Re) Design model followed to create a new interdisciplinary architectural engineering program. (Fowler, 2017)

In order to ensure the new architectural engineering program was responsive to current societal needs, program decisions could not be made until relevant data were available (Diamond, 2008). Wolf (2007) emphasized the need for curriculum development to be data-informed. Because of this, the PRD process required data to be gathered both internally, at the university, and externally, from program stakeholders. As the future employers of the program’s students, industry serves as a key stakeholder. Industry’s participation, input, and feedback as external experts allows a program to “remain competitive, current, and effective” (Fowler, Lazo, Turner, Hohenstein, 2015, p. 1). By seeking an outside perspective, both initially and during program development, the Committee was kept abreast of evolving demands of the building sector and societal expectations for the built environment. Industry brought an additional lens through which to view the program, identifying the knowledge, skills, and values that an ideal graduate would possess, as well as gaps and shortcomings in the curriculum as it was being developed (Diamond, 2008; Wolf, 2007; Fowler, Lazo, Turner, Hohenstein, 2015).

IV. Approach

The Program Development Committee adopted and implemented a systematic approach that led to the development of an interdisciplinary curriculum in architectural engineering. This
approach consisted of eight specific steps, spanning over 2014-2017, that fell into two broad phases:

Phase 1: Needs Assessment and Identification  
Phase 2: Program and Curriculum Development

V. Needs Assessment and Identification

Architectural Engineering Program Development Committee
In December 2013, a committee was formed by the Dean of the College of Architecture and the Dean of the College of Engineering to evaluate the potential for developing a joint program in architectural engineering. The six members of the committee then included: three faculty from engineering – mechanical and civil (2); two faculty from construction science and architecture; and one senior academic advisor. The committee has been chaired by the faculty member from mechanical engineering, with oversight and guidance from the Senior Associate Dean for Academic and Student Engineering Affairs. After the need for an architectural engineering program was identified in 2015, the committee membership was extended to ten, representing faculty from other engineering departments and experts in curriculum development.

Motivation for an Engineering Program
The motivations for considering architectural engineering at the Institution included:

- Expressions of student interest in architectural engineering,
- Expressions of industry interest in architectural engineering,
- Support from both the College of Architecture and College of Engineering,
- The opportunity to offer an interdisciplinary degree that builds on the existing expertise and courses in the two colleges,
- The opportunity to provide more in-depth education in building systems, currently not available in Texas A&M’s existing degrees.

Methodology for Needs Assessment
The Program Development Committee developed an approach to determine whether a program in architectural engineering at Texas A&M would be appropriate, and if so, the desirable characteristics of such a program. The goal was to seek answers to the following questions:

- Is industry interested in hiring students with an architectural engineering degree? If so, which specific fields are of most interest, and which fields are not of interest?
- What degree program is most needed to address industry needs?
- Which certificate programs might be of interest?
- What are the necessary components of an architectural engineering curriculum? Which of those components are already in place at Texas A&M?
- What are the additional resources needed to build an architectural engineering program?
- Where would an architectural engineering program be housed, and how might it be administered?

With a committee in place, outfitted with a list of programmatic questions, deliberate steps were taken to begin seeking out and obtaining substantial answers from which to determine if the need existed for an architectural engineering program at Texas A&M. Steps taken include:
Collecting industry input,
Consultation with existing architectural engineering programs in the U.S.,
Assessing existing Texas A&M courses related to architectural engineering,
Informing faculty and assessing interest.

Collecting Industry Input - Industry Survey Approach and Results
In order to obtain input from southwest United States based Industry on the need for an architectural engineering program, a survey was administered. Survey respondents were asked a total of nine multiple choice questions. Four questions focused on the respondent’s employer, including the percentage of their employer’s work that falls within each of the major architectural engineering disciplines, as well as the size of their company. The respondents were also asked if their company currently hires architectural engineers and whether they would have interest in hiring architectural engineers in the future. Those who indicated interest in hiring architectural engineers were asked the following two questions:

- Which of the following degree options would be attractive?
  undergraduate minor, B.S., M.S., or a graduate certificate in Architectural Engineering

- Which of the following specific tracks within architectural engineering would be of interest to your company?
  architectural design, construction management, structural design in buildings, mechanical (HVAC)/plumbing design in buildings, electrical/lighting design in buildings, facilities management, historic preservation, or “other”

The respondents were also provided with the opportunity for general comments and contact information if they wished to be included in the planning and decision-making process.

Over 150 senior engineers and construction managers from submitted completed surveys. Table 1 shows the results of the survey by area. Results from the survey show that there is a very strong interest in architectural engineering, with 85% of the respondents expressing interest in hiring architectural engineers in the future, and 61% of the respondents currently hiring architectural engineers. The majority of the respondents (92%) interested in hiring architectural engineers expressed interest in the Bachelor of Science (B.S.) option, 31% in the Master of Science (M.S.), 26% in an undergraduate minor, and only 8% in a graduate certificate program. The four top choices for specific architectural engineering tracks were (in order): 1) mechanical, 2) electrical/lighting, 3) construction management, and 4) structural design in buildings. The higher percentages expressing interest in the mechanical and electrical areas may be at least partially due to more respondents from those areas.

Responses were then separated by the specialty areas of the respondents. The following may be observed in the table below:

- Current levels of employment of architectural engineers do not vary greatly by specialty area, ranging from a low of 59% in HVAC to a high of 75% in Structures.
• Interest in hiring architectural engineers is high in all areas, ranging from 79% to 93% by specialty area.

• Structural engineering significantly differs from the other three areas in terms of interest in the M.S. versus B.S. degrees.

• Interest in a specialty track within their own area also shows little variation, with a low of 71% in construction management to a high of 87% in HVAC.

• There is considerable variation in the portion of respondents asking to be contacted again across the areas, ranging from 47% in structures to 86% in HVAC.

<table>
<thead>
<tr>
<th>Description</th>
<th>Const.</th>
<th>Elect.</th>
<th>HVAC</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Respondents</td>
<td>14</td>
<td>14</td>
<td>69</td>
<td>36</td>
</tr>
<tr>
<td>Currently Hire Architectural Engineers</td>
<td>64%</td>
<td>64%</td>
<td>59%</td>
<td>75%</td>
</tr>
<tr>
<td>Interested in Hiring Architectural Engineers</td>
<td>79%</td>
<td>93%</td>
<td>88%</td>
<td>89%</td>
</tr>
<tr>
<td>Interest in Architectural Engineering Minor</td>
<td>36%</td>
<td>7%</td>
<td>23%</td>
<td>17%</td>
</tr>
<tr>
<td>Interest in Architectural Engineering BS</td>
<td>71%</td>
<td>86%</td>
<td>83%</td>
<td>50%</td>
</tr>
<tr>
<td>Interest in Architectural Engineering MS</td>
<td>36%</td>
<td>29%</td>
<td>22%</td>
<td>61%</td>
</tr>
<tr>
<td>Interest in Architectural Engineering Certificate</td>
<td>14%</td>
<td>0%</td>
<td>7%</td>
<td>11%</td>
</tr>
<tr>
<td>Interest in Construction Management Track</td>
<td>71%</td>
<td>14%</td>
<td>23%</td>
<td>19%</td>
</tr>
<tr>
<td>Interest in Electrical Track</td>
<td>21%</td>
<td>79%</td>
<td>57%</td>
<td>11%</td>
</tr>
<tr>
<td>Interest in Mechanical/HVAC Track</td>
<td>43%</td>
<td>79%</td>
<td>87%</td>
<td>19%</td>
</tr>
<tr>
<td>Interest in Structures Track</td>
<td>21%</td>
<td>21%</td>
<td>9%</td>
<td>78%</td>
</tr>
<tr>
<td>Asked to be Contacted Again</td>
<td>57%</td>
<td>71%</td>
<td>86%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Table 1. Overview of Survey Responses by Area

Consultation with Existing Architectural Engineering Programs in the U.S.
Phone interviews were conducted to gain insight into the characteristics, strengths and areas for improvement in 12 existing and ABET-accredited architectural engineering programs in the U.S. The input was consistent with the industry survey results, with all programs but one reporting strong hiring for their graduates.

Assessing Existing University Courses Related to Architectural Engineering
Relevant courses currently offered at Texas A&M were summarized. Curriculum from the above mentioned existing U.S. architectural engineering programs were compared with the existing Texas A&M courses to identify current capabilities and gaps that would need to be filled.
Informing Faculty and Assessing Interest
Meetings were held by Program Development committee members in their home departments to inform faculty of the ongoing discussions relevant to architectural engineering. The meetings were also used to gage faculty interest in supporting the development and implementation of a new architectural engineering program.

Needs Assessment Results
The Program Development Committee presented its findings to both College’s Deans, Architecture and Engineering, who further approved the recommendation to proceed in the development of an architectural engineering program and curriculum, with the following considerations:

- Develop a four-year B.S. degree in Architectural Engineering as the first milestone.
- Offer three tracks in the architectural engineering degree: Mechanical/HVAC, Electrical/Lighting, and Structures, as well as investigate the possibility of future track options. The timeline for the electrical/lighting track option was deferred to 2019.
- The program should be built around tenured/tenure track faculty, with Professors of Practice used to meet the needs for relevant faculty design experience.
- The program should begin offering graduate degree(s) within 2-3 years after starting.

As a result, the following next steps were approved for the program’s implementation:

- Create a formal Industry Advisory Panel (IAP) with a sub-group in each of the three track option areas: Mechanical/HVAC, Electrical/Lighting, and Structures.
- Develop a detailed plan for the program’s curriculum, jointly with the Program Development Committee, Texas A&M’s Center for Teaching Excellence, and the IAP.
- Investigate the extent to which existing courses can be used initially in the curriculum, including the impact the inclusion of prospective architectural engineering students would have on those courses, and develop a transition plan to dedicated architectural engineering courses where needed.
- Develop a plan for administering the program, including filling dedicated faculty positions and establishing a program implementation timeline.
- Investigate and plan for student internship programs with the IAP.

VI. Program and Curriculum Development

Overview on Process
Once the institutional need for an architectural engineering program was established, the Program Development Committee moved forward with the formal program design. Figure 2 below diagrams the parameters that the Committee identified and analyzed throughout the program and curriculum design process. As an initial planning step, the Program Development Committee identified five key influences that weighed in on the design of the new architectural engineering program and its accompanied curriculum. The five key influences included:

1. Industry consultations on curriculum. Data from industry consultations on curriculum were collected through two half-day workshops: one workshop included a dozen experts from mechanical systems and plumbing, while the other workshop included 8 experts
from electrical power and lighting systems. Curriculum consultations on structural systems was done by phone interviews. The consultation’s objectives focused on validating proposed target knowledge and skills for each of the ABET a-k student outcomes used to accredit engineering programs, as well as seeking further guidance on emerging technologies and skills. The ABET student outcomes served as the guide for Industry’s input into the development of the proposed program knowledge and skills deemed necessary for an ideal architectural engineering graduate. Also as part of each consultation, industry experts were provided with both background information and a status update on the program requirements and its curriculum design process.

2. Internal Input. Input was gathered from faculty and management in six of Texas A&M’s departments housed in two colleges: a) the College of Architecture – Architecture and Construction Science and b) the College of Engineering – Civil, Electrical, Engineering Technology and Industrial Distribution, and Mechanical. These six departments are each represented on the interdisciplinary Program Development Committee, in addition to experts from Texas A&M’s Center for Teaching Excellence.

3. Consultation with and review of existing U.S. architectural engineering programs. A comprehensive curriculum review of over 23 existing U.S. architectural engineering programs, as well as phone interviews with several, demonstrated what is currently being done in the field and provided a benchmark for the development of Texas A&M’s new architectural engineering program.

4. Analysis of the related ABET accreditation requirements and PE Examinations. ABET’s student outcomes a-k, as well as the requirements for the PE examination, served as the foundational knowledge and skills the developing architectural engineering program will contain once launched. Input from the industry experts was consolidated and mapped to the ABET a-k student outcomes as a means for developing a solid content base upon which the new curriculum was built.

5. Gap-analysis of faculty expertise and courses related to the program. An internal inventory was taken of the existing faculty expertise and related courses to determine the potential gaps in a new architectural engineering program.
Key Knowledge Areas & Curriculum Framework
The data collected from the five key influences described above grounded the development of a learning program that will equip architectural engineering students with the ability to adjust to the evolving demands of the building sector.

Each key influence contributed to the development of the program’s mission, its objectives for the course of study, as well as the technical knowledge areas that formed the basis of the four-year, 128 credit-hour Bachelor of Science degree. The Program Development Committee agreed that the program’s primary emphasis is to provide its students with an interdisciplinary learning environment, through courses, an internship, and other program experiences, in order to develop architectural engineers ready to meet the industry demands for high-performance, green and safe buildings. Figure 3 below shows the curriculum framework of the interdisciplinary architectural engineering program that integrates:
- Foundational learning of engineering principles and science,
- Technical knowledge areas of architectural engineering,
- Architectural engineering systems for proficiency and specialization levels,
- Application and culminating experiences through a capstone and internship.
Competency Rubric Development
Following the data gathering phase, including both external and internal input from those identified as key program influences, the faculty moved to begin developing the program’s learning outcomes. These learning outcomes encompass the content deemed necessary to develop the knowledge and skills defined for an ideal architectural engineering graduate. The identified program learning outcomes are:

1. Mathematics
2. Physical Sciences
3. Humanities and Social Sciences
4. Engineering Sciences
5. Experiments, Data Analysis, and Interpretation
6. Design of Building Systems
7. Tools for Architectural Engineering Problems
8. Architectural Design and History
9. Project and Construction Management
10. Integration of Building Systems
11. Principles of Sustainable and High-Performance Buildings
12. Technical Specialization
13. Communication
14. Interdisciplinary Teams
15. Continuous Learning
16. Professional Practice

To further support and expand the program’s learning outcomes, detailed developmental competency rubrics were created containing clearly defined performance criteria. The competency rubrics delineate the levels of desired student learning to be achieved throughout the four years of study. Figure 4 shows a sample rubric taken from Program Learning Outcome #10 on Integration of Building Systems.
Curriculum Mapping
Using the competency rubrics as a guide, the faculty created the program’s curriculum map, accounting for each performance indicator and where they will be introduced, reinforced, strengthened, and demonstrated. The curriculum mapping process helps to ensure that all the performance indicators initially set out to be included in the curriculum actually are contained and assessed somewhere throughout the students’ four years of coursework or experiences. This step also allows for all faculty to have a common understanding of the program’s essential knowledge and skills, as well as where those knowledge and skills are taught and assessed.

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Demonstrate A–D</th>
<th>Strengthen 3–5</th>
<th>Reinforce 2–R</th>
<th>Introduce 1–1</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Building system design areas in architectural engineering</td>
<td>10.a.4 Solve problems in at least two building system areas in architectural engineering.</td>
<td>10.a.5 Analyze well-defined problems in at least two building system areas in architectural engineering.</td>
<td>10.a.2 Explain key concepts and problem-solving processes in at least two building system areas in architectural engineering.</td>
<td>10.a.1 Identify the four specialty areas in architectural engineering.</td>
</tr>
</tbody>
</table>

Figure 4. A sample competency rubric on Integration of Building Systems.

VII. The Role of the Industry Advisory Panel
The involvement of industry in establishing the need for an architectural engineering program, as well as its curriculum development, has reinforced the benefits and merit of including industry in the delivery and operation of this interdisciplinary program. The industry’s engagement throughout helped identify seven industry leaders from four architectural engineering segments, who currently serve as members on the program’s Industry Advisory Panel (IAP). The IAP provides advice and guidance in program management on academic excellence, recruiting and retention, outreach and partnership, and management of teaching and advising resources. The IAP was formed over a year before the launch date of the program, which is scheduled for fall of 2017. This was done intentionally to further validate curriculum design and requirements, as well as secure best practices for student recruiting and program operation matters. To this end, three face-to-face IAP meetings occurred between June 2016 to February 2017, which further resulted in many of the IAP members championing program initiatives such as endowments, outreach, and internship programs with their respective firms. Each IAP member serves in a senior management position at a firm in either structural design; contracting and installation of mechanical and electrical systems; architectural and engineering design; or design and commissioning of mechanical systems, including HVAC and fire protection. Plans are in place to bring on additional IAP members to include experts from electrical systems and building automation, among others.

VIII. Lessons Learned
The deliberate engagement and involvement of industry experts proved invaluable to anchoring an architectural engineering program in societal and discipline specific needs. For future replicability of related endeavors, the key lessons learned to achieve successful outcomes were:
1. *Industry’s involvement needs to be fully integrated and throughout.* By consistently seeking and listening to industry experts’ opinions, their collective input was implemented as a driver in both program and curriculum design processes.

2. *Faculty presence, buy in, and active engagement in the program and curriculum design processes is instrumental.* The deliberate and intentional formation of the Program Development Committee helped to form a cohesive team. A true-to-definition interdisciplinary program is more than just a collection of existing courses. It requires faculty to step out of their disciplinary silos to create a new, unique program. In this particular case, it required establishing a collaborative process that enabled the Program Development Committee members to not only step out of silos from diverse disciplines within each of architecture and engineering, but also between architecture and engineering. While this process is not always initially comfortable for the faculty involved, it is one that cannot be accomplished without their vision and commitment. Therefore, securing a shared vision in the front-end of the process is a must.

3. *Pedagogical expertise is a necessary piece of the process.* While industry and faculty bring content expertise, program and curriculum development requires a pedagogical and facilitation expertise to add to the process best practices in teaching, curriculum design, and student learning. The contributions made by Texas A&M’s Center for Teaching Excellence brought a cohesiveness to the program’s development.

**IX. Conclusion**

The systematic process used to create a new architectural engineering program was truly a cooperative effort between education and industry. In each of the developmental stages, industry input and feedback were sought in ensure a program rooted in relevant content that will enable its graduates to meet evolving demands of the building sector and societal expectations for the built environment. Historically, industry engagement in engineering education programs has largely been superficial. The Program Development Committee recognized the potential of a true partnership with industry had on the development of a new architectural engineering program and strove to forge meaningful relationships that would bring true commitment to the students whom the program will serve.

**X. Acknowledgements**

The authors would like to express their appreciation to the members of both the Program Development Committee and the Industry Advisory Panel, as well as the college deans and department heads, whose tireless efforts and support helped to make the development of a new architectural engineering program possible. This faculty-led, evidence-based, interdisciplinary curriculum will serve its students well as they pursue their goal of becoming an architectural engineer.
References


