Integrating NACE Competencies into Architectural Engineering Curricula: A Pilot Approach for a Foundational Course

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Dr. Nadia Shuayto, DBA, MBA, BSBA, is an academician and business leader with a rich tapestry of experiences spanning education, entrepreneurship, and international collaboration. With a Doctorate of Business Administration in Marketing from Nova Southeastern University and a Master of Business Administration from Lawrence Technological University, Dr. Shuayto has cultivated a profound understanding of business dynamics and marketing strategies over the course of her career.

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Prior to her academic tenure, Dr. Shuayto co-founded Wingme Cosmetics, LLC, where she held the position of Chief Operating Officer. In this capacity, she provided visionary leadership, directing the company's overall administration and spearheading its mission-driven activities. Her responsibilities ranged from representing the CEO in business matters to overseeing operational functions, developing marketing strategies, and managing partnerships with manufacturers and retailers across the globe.

Dr. Shuayto's dedication to fostering international collaboration is exemplified through her roles as a Visiting Guest Lecturer at Lebanese American University in New York and Beirut, where she facilitated cross-cultural exchange programs and delivered courses on international business and marketing management. Additionally, her tenure at Lawrence Technological University saw her serve as Assistant Professor of Management, Chair, and Director of MBA and BSBA programs, where she played a pivotal role in program design, faculty development, and AACSB Accreditation initiatives.

As a researcher and author, Dr. Shuayto has contributed significantly to the body of knowledge in business and marketing. Her peer-reviewed publications and conference presentations underscore her expertise in areas such as marketing, management skills, and global branding strategies. Noteworthy among her achievements is the recognition received for her case study "ELIE SAAB: Growth of a Global Luxury Brand" by EFMD and her Outstanding Research Award at the Global Conference on Business and Finance. Her current research is focused on artificial intelligence (AI) in higher education.

Beyond academia, Dr. Shuayto's influence extends to consulting and training projects. Her dedication to professional development is evident through her active involvement in professional affiliations, editorial advisory roles, and participation in seminars and workshops focused on AACSB accreditation standards and pedagogical advancements.

Dr. Shuayto's multifaceted career is underscored by her unwavering commitment to excellence, innovation, and global engagement. With a passion for nurturing future business leaders and advancing knowledge in the field of marketing, she continues to inspire and empower individuals and organizations alike on their path to success.

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Abstract

Architectural engineering programs strive to equip their students with technical expertise and essential core competencies vital for success in the dynamic professional landscape. It is important to integrate such competencies in architectural engineering to prepare students for their future careers and make them lifelong learners. Although national policy documents, Accreditation Board for Engineering and Technology (ABET) Criteria, and 21st-century grand challenges highlight the importance of developing competencies in students, the current courses may not necessarily adhere to such necessities. Considering the importance of the competencies, this work-in-progress study considers the architectural engineering program at Texas A&M University. It focuses on two aspects: 1) identifying the core competencies using the University's architectural engineering Program Educational Outcomes (PEO) aspirations, ABET outcomes, and National Association of Colleges and Employers (NACE) competencies, and 2) providing a mechanism to integrate such competencies using a foundational architectural engineering course at the University as a pilot. In the paper, we provide future directions for such integrations for courses and probable suggestions for evaluating the effectiveness of these integrations on students' success and career readiness.

Introduction

Architectural engineering helps students gain practice and theoretical knowledge of the engineering design of high-performance buildings and their systems. The discipline's core principles suggest providing educational fundamentals that help students understand sustainable, safe, comfortable, productive, resilient, and economically feasible buildings [1]. Due to these educational fundamentals, the discipline unites the interdisciplinary expertise of structural, mechanical, electrical, acoustic, and construction engineering, which helps in conceptualization, design, construction, operation, and maintenance using creativity and education. However, to develop sustainable practices and design buildings that prioritize human conditions and society's well-being, other competencies exist alongside technical expertise.

These competencies, on one end, align with the requirements in national policy documents [2][3][4], ABET (Accreditation Board for Engineering and Technology) Criteria [5], and 21st-century grand engineering challenges [6], suggests the inclusion of these competencies for equipping the students to be "future ready". With this study, we hypothesize that including these competencies requires a systematic identification and integration process to prepare students for future careers and as lifelong learners. Also, the process requires evidence-based practices to investigate the effectiveness of the integration process and its impact on students learning and career preparation.

In this work-in-progress paper, we emphasize two aspects of the systematic process: a) identification and integration and provide a case study of this process as a pilot in architectural engineering. More specifically, the paper addresses two questions:

1. What are the core competencies for architectural engineering programs?
2. What is the mechanism for integrating competencies in a foundational architectural engineering course?

Literature Review

Competencies described in the literature [7], [8] include groups or clusters of knowledge, attitudes, and skills associated with one subject area and impact the job-related requirements or performance. Also, the literature supports that these skills can be improved and taught if introduced properly for students' training and development [8].

The ABET engineering criteria and engineering program in the United States require students to have specific outcomes and competencies [6]. With slight variations, most universities suggest the importance of these competencies as helping students become career-ready, lifelong learners. Each engineering program, including architectural engineering, requires faculty to consider, envision, articulate, conceptualize, and prioritize these competencies [9]. Also, prior research has highlighted the importance of these integrations at curriculum and course levels [10], [11]. Also, the literature highlights the importance of investigating the impact of such integration on students learning and career trajectories [11][12]. However, these integrations are usually either ad hoc or do not follow the evidence-based practice approach. These issues lead to a larger conversation of systematic and mindful integration of the competencies in engineering courses and faculty's inclination and step towards the same [13].

Like other engineering programs, the architectural engineering program curriculum is undergoing significant evolution to address contemporary challenges [14], including climate change, resilience, and the continuity of building operations, to prepare students to meet environmental challenges. This evolution necessitates equipping students with skills to address future complexities, a concept often called "future-ready" [15]. One important way to train students in these competencies is by considering the NACE (National Association of Colleges and Employers) competencies [16].

Integrating NACE competencies [16] into engineering education ensures students develop the necessary attributes to excel in their careers. NACE provides a comprehensive framework for identifying the skills and attributes required for success in the professional world. Integrating NACE competencies into engineering education ensures that students develop the necessary skills to thrive in their careers and contribute effectively to their respective fields. However, the challenge lies in effectively aligning these competencies with curricular objectives and assessment methods, particularly in disciplines like architectural engineering, where technical knowledge is paramount [16].

Considering the importance of these integrations and understanding that companies can be integrated into courses to teach students with the right principles and effective training, this paper considers the aligned approach of ABET Criteria [17], NACE competencies [16], and Program Education Objectives(PEOs) of the University and provides a case study of the integration.

University and College Introduction

Texas A&M, a large public R1 university, is the state's first public University of higher learning. The University provides educational opportunities with the highest quality education to undergraduate and graduate students within a wide range of academic and professional fields through discovery, development, communication, and application of knowledge. The University's mission is to support preparing students for leadership, responsibility, and service to society by providing the intellectual environment for a diverse student population.

College of Engineering (COE) has been part of the University since its inception and is the largest college on its main campus at College Station, Texas, USA. The college is ranked among the nation's top programs in the United States. The college mission focuses on educating well-grounded engineers for the multidisciplinary global environment and making them lifelong learners.

Program Introduction

Currently, ABET accredited, the Bachelor of Science (BS) in Architectural Engineering (AREN) degree program at Texas A&M University (TAMU) began on a provisional basis in 2017. The program was designed to meet expressed demand from the industry's thirst for talent to support the built environment and prospective students interested in studying the engineering of buildings and systems through an immersive and forward-thinking curriculum. At that time, a curriculum development team composed of multidisciplinary faculty, industry representatives, and curriculum design experts from TAMU's Center for Teaching Excellence (CTE) collaborated to write a multidisciplinary degree program drawing on strengths from an established College of Engineering (COE), in partnership with the College of Architecture (COA). To facilitate the rapid growth of the program's enrollment, making it one of the largest programs in the US currently, the program is situated within a Department of Multidisciplinary Engineering (MTDE) for administrative support and guidance. Once the program reaches a critical size, the college will be approached to consider creating a department in its namesake.

The AREN program has well-established PEOs, that are well-integrated with and supportive of the institutional mission. The department's mission was not mapped, as the aspirations are for the program to become its department judiciously. PEOs represent the collective input from all program constituents and state what the Architectural Engineering graduates will achieve within 3 to 5 years after graduation.

The PEOs of the University's architectural engineering program outline the expected outcomes for graduates. These objectives typically include statements regarding graduates' career success, professional development, leadership capabilities, and commitment to lifelong learning. Aligning curriculum and instructional practices with the program's PEOs ensures that students acquire the knowledge, skills, and attributes necessary to achieve these outcomes and excel in their careers.

Course Introduction

The understudy course is sophomore level, Writing Intensive (W-intensive), a required engineering course. The course introduces architectural engineering as an academic program of study and career choice, covering the analysis, integration, and application of the engineering design process to solve problems associated with the design and operation of building systems. As a core curriculum requirement for all AREN degree-seeking students, the course also covers communication of solutions to technical problems through writing, presentations, and team interactions, typical for architectural engineers in the building industry. Due to the rise in demand, the course is offered each semester. It is recommended that enrollment be capped at 25 students for each section taught. Unfortunately, due to the program's accelerated growth, upwards of twenty-nine students have been enrolled, with additional sections being created to manage the enrollment at the recommended capacity.

Study Design

Considering the study's exploratory nature, this work-in progress paper considers 1) BS AREN program educational objectives (PEOs), closely aligned with the mission of the University, COE, and the MTDE department. 2) NACE competencies, and 3) ABET outcomes. This work-in-progress paper identifies which competencies must be considered using the elements of alignments. It describes the process of their integration using the ICAP (Interactive, Constructive, Active, Passive) framework [18][19].

1) Necessary core competencies

To identify the necessary core competencies, we used the mapping approach between PEOs, ABET criteria, and NACE competencies in this work-in-progress paper and developed the list of necessary skills undergraduate engineering students should demonstrate upon graduation.

We first created the mapping of PEOs to the University and COE mission and examined the alignment of the PEOs. Table 1 provides the mapping results.

Table 1. Mapping of PEOs to University and College Mission (adapted from initial program accreditation review and ABET Self-Study from Texas A&M's architectural engineering program)

PEO	Texas A&M University Mission	COE Mission
Actively engage in architectural engineering practice and pursue graduate programs in architectural engineering or related fields.	"… dedicated to the discovery, development, communication, and application of knowledge in a wide range of academic and professional fields."	"… [provide] engineering graduates who are well-founded in engineering fundamentals, instilled with the highest standards of professional and ethical behavior, and prepared to meet the complex technical

		challenges of society.”
Achieve technical competency and eligibility to become licensed professional engineers.	“… [prepare] students to assume roles of leadership, responsibility, and service to society.”	“…enhance our impact on the profession of engineering.”
Complement their education through advanced studies, professional development, and/or continuing education courses.	“…[develop] new understandings through research and creativity” and “[address] the needs of an increasingly diverse population and a global economy.”	“Ensur[e] an academic environment favorable for achieving the highest levels of academic and research excellence…. Encourag[e] and supporting opportunities for our students to grow beyond their chosen disciplines.”

The table indicates that PEOs fully align with the mission of the University and the department. We then compared the desired undergraduate skill PEOs with ABET’s student outcomes and NACE Competencies. Table 2 provides the mapping .

Table 2. Comparison of competency, student outcomes, PEO’s and NACE competency attributes

	Desired Skill for Undergraduates	ABET Student Outcomes (Upon Graduation)	PEO (3-5 Years)	NACE Competency
1	Career and Self-Development	Yes	Partial	Yes
2	Communication	Yes	No	Yes
3	Critical Thinking	Yes	No	Yes
4	Equity and Inclusion	Yes (ethics too)	No	Yes
5	Leadership	Yes	No	Yes
6	Professionalism	Yes	Yes “Technical”	Yes
7	Teamwork	Yes	No	Yes
8	Technology	No	No	Yes

We also examined how these competencies align with students' course outcomes and which outcomes are directed toward the competencies. Table 3 provides the mapping of the course outcomes with NACE competencies.

Table 3. Comparison of NACE competency and course outcomes

NACE Competencies	Course Outcomes
Career and Self-Development	Investigate one's own learning and thinking processes, as well as fundamental limitations, through a professional development plan exercise of a practicing architectural engineer. – AND – Identify the key steps for licensing architectural engineers.
Communication	Write in the style of accepted norms for technical writing, with proper referencing of all sources of information.
Critical Thinking	Explain the importance of and constraints that societal values, needs, and/or behaviors have on engineering projects, using an architectural engineering example.
Equity and Inclusion	Explain the importance of and constraints that societal values, needs, and/or behaviors have on engineering projects, using an architectural engineering example. – AND – Identify and categorize diverse architectural engineering problems by sub-disciplines, such as structure; heating, ventilating, air-conditioning; and electrical lighting and construction.
Leadership	There is no current course level learning outcome that fits this competency. However, there is a strong link to the outcome mapped to the Teamwork competency.
Professionalism	Explain the role and significance of sustainability in Code of Ethics of professional associations on buildings and list key sustainability recognition programs in buildings.
Teamwork	Define and list all the key characteristics of effective multidisciplinary and interdisciplinary teams and list attributes supportive of architectural engineering.
Technology	Interpret basic graphical representation of building systems and structures.

In addition to the alignment approach, we asked students to self-identify which core competencies they consider most critical for their development and career success; they were asked to rank the competencies. Results indicated that although there was differentiation between individual students, the specific competencies ranked amongst the most important were consistent.

Next, students had the opportunity to interview young professionals (one to five years post-graduation) and, through a series of questions, could gauge which of the competencies the emerging leaders considered most important. Finally, students conducted another interview with seasoned professionals who are leaders in their respective fields through an inquiry process consisting of prepared questions. Again, the responses were not necessarily consistent with the specific competency rankings; nevertheless, the specific feedback and recommendations provided by the seasoned professionals provided students with a meaningful context from which they could make future decisions.

The competencies include critical thinking, communication, teamwork, leadership, and professional ethics. These competencies were consistently aligned with students' perspectives, program objectives, ABET criteria, and NACE competencies.

2) Mechanism to integrate competencies

To integrate the identified competencies, we used the ICAP Framework [18][19], which offers a nuanced perspective on cognitive engagement and learning outcomes [20]. The framework suggests the use of four modes which are interactive, constructive, active, and passive [18] [19]. Passive mode indicates that students show no physical activity of processing. Active mode indicates that students physically do some tasks while listening such as taking notes. Constructive mode indicates that students generate explicit outputs such as creating an interview protocol. Interactive mode involves social interaction with another person (e.g., industry professional, peer, teacher, parent, computer system). Using these modes the ICAP Framework offers a systematic approach to assessing students' cognitive engagement and learning outcomes using a built-in- hypothesis. The hypothesis suggests that students become more engaged [21] and will have better learning with the materials from passive to active to constructive to interactive modes. Also, these modes subsume the previous levels [22]. The framework provides a robust model for assessing and enhancing students' critical thinking and problem-solving abilities by categorizing engagement into four levels and emphasizing contextualized learning [23].

Table 4 shows ways in which class activities aligned with various ICAP levels, including interactive, constructive, active, and passive engagement by students.

Table 4. Comparison of NACE competency, ICAP framework, and course designed activities

NACE Competency	ICAP framework	Description of course activity (individual or team)	Student activities and engagement
Career and Self-Development	Active	Student participation: individual Activity: students attended a professional organization meeting and career fair	Students listened to one or more industry professionals provide an overview of a project, their experiences, and information about the firm, students request and obtained business cards, inquire about internship possibilities and what a typical day might look like for an architectural engineer
Communication	Interactive	Student participation: individual and in teams Activity: students interview industry professionals in	Students formulate questions, set up the meeting and engage in written communications to set up the meeting. During

		person (or via teleconference) who are young professionals and seasoned professionals	meetings they acquire information, images and take notes. Using material from their interactions, they prepare individual writing reflections of their experience and lessons learned in addition to preparing and giving an oral presentation accompanied by PPT slides
Critical Thinking	Constructive	Student participation: individual Activity: students were shown artists sketches of building systems from campus buildings and asked to identify the system, its use and classification (e.g., structural, mechanical, electrical, construction, architecture, etc.)	Students used their prior knowledge to identify, then critically evaluated each system to identify if the system has a dual function and how it could fall into other multiple classification areas depending on its use and purpose.
Equity and Inclusion	Interactive	Student participation: individual and in teams Activity: students interview a diverse set of industry professionals in person (or via teleconference) who are young professionals and seasoned professionals	Students formulate questions, set up meetings and engage with a diverse set of industry mentors. They share their mentors' reflections and their own through a written report and an oral presentation accompanied by PPT slides
Leadership	Interactive	Student participation: individual and in teams Activity: students interview a diverse set of industry professionals in person (or via teleconference) who are young professionals and seasoned professionals	Students formulate questions, set up meetings and engage with industry professionals who have achieved leadership positions and those early in their careers. They share their mentors' reflections of the career path and progress through a written report and an oral presentation accompanied by PPT slides
Professionalism	Interactive	Student participation: individual and in teams Activity: students interview a diverse set of industry professionals in person (or via teleconference) who are	Students formulate questions, set up meetings and engage with industry professionals who have achieved leadership positions and those early in their careers. They share their

		young professionals and seasoned professionals	mentors' reflections of the career path and progress through a written report and an oral presentation accompanied by PPT slides
Teamwork	Interactive	Student participation: in teams Activity: students interview industry professionals and prepare a presentation for their peers. Students also engage in a semester-long research project on am exemplary building and work as a team to prepare written summaries of their learnings and execute an oral presentation for an end of semester	Students are provided with fifteen attributes of successful teamwork and are asked to assess themselves and their teammates at two intervals during the course to initially identify any gaps and to institute any required interventions
Technology	Interactive	Student participation: in teams Activity: students ask industry professionals what software programs they use on a regular basis and which programs would be beneficial for students to learn prior to obtaining an internship	Students formulate questions, set up meetings and engage with industry professionals who are at various levels of their professional careers. They share and reflect on the use and changes in technologies in industry and in their own career paths. The students reflect on their learnings and plans on how they plan to learn and master various technologies for the built environment.

Employing an active, collaborative learning environment for the inquiry was well received by the students, young professionals, and seasoned industry mentors. However, it was important to continue a dialogue with the students on recognizing that certain courses' curricula are designed to address career competencies. The feedback from the prospective employers helped the faculty reinforce the competencies' significance in achieving career readiness and future industry success.

Additionally, including a self- and team-assessment at various intervals during the semester ensured individuals within teams understood their self-dependency on being successful. Students were provided opportunities during the semester to converse and share their reflections with other teammates to course correct and identify teamwork challenges early before they became issues leading to dissatisfaction or negative team dynamics.

Conclusion

While the ICAP Framework focuses on cognitive engagement, it may not explicitly address professional competencies essential for success in the workforce, such as communication and leadership skills. However, it provides a mechanism to examine the classroom activities, lesson design, and implementation in an effective way [24]. Also, ICAP helps to contextualize learning tasks within meaningful and authentic contexts including interactive, constructive, active, and passive engagement by students.

Overall, while each framework and competency offer valuable insights and guidance for architectural engineering education, there are gaps and discrepancies that need to be addressed. These include the need for a more comprehensive approach that integrates cognitive engagement with professional competencies, as well as ensuring alignment between program objectives, curricular content, and assessment methods.

Future Research

Future research should focus on bridging these gaps and developing a more comprehensive approach to engineering education that prepares students to address the multifaceted challenges of the future. Additionally, the authors have work in progress to dive deeper into the Teamwork and Professional Development dimensions of the competencies separately, and to study the correlation and interdependence of these components in student success in higher education and in the workplace. Future collaborations are expected to include the American Society of Engineering Education's (ASEE), Engineering Management Division (EMD) and other complementary divisions.

It would be interesting to create a survey to measure how employers of summer interns rate the importance of the competencies for intern's vs how employers of new hires rank the importance. There could be a survey to allow the companies to be able to identify how their interns and new hires rate and what areas need improvement. These competencies needing improvement can be discussed by faculty to create course content and instruction or exercises to allow students to exercise those competencies.

Certain competencies may be better developed through other cocurricular activities such as active participation in professional development activities [25]. A longitudinal study could be used to compare the employer's vs employees hierarchically priorities and levels of perceived importance for effective employment.

Self-reflections by the employee could measure the employees' own reflections of the competencies they believe they have mastered, and a similar survey could be administered to the employers [26] to determine which competencies they value the most and how well the employee excels in those areas. This would help programs to align their coursework deliverables to integrate these competencies at a higher level of Blooms taxonomy.

Future improvement for the course syllabus includes adding a course level learning outcome to address leadership. It may not have been originally added due to the formative nature of the course at the sophomore level, nevertheless, by reviewing ABETs definition of teamwork and leadership it is quite possible to add this per the author.

Certainly, there is a clear need to review the PEOs with the program constituents and although PEOs are not measured nor assessed for accreditation purposes, they should be revisited to better align and harmonize with the competencies, attributes and learning outcomes imbedded in the curriculum. This paper will serve as foundational research to inform the review of the PEOs.

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