A Comparison between the Different Accredited Architectural Engineering Programs through ABET and CEAB

Dr. Rachel Mosier, Oklahoma State University

Dr. Rachel Mosier is an Associate Professor in the Construction Engineering Technology program at Oklahoma State University, with a background in structural engineering and project management. Dr. Mosier has received regional and international teaching awards through the Associated Schools of Construction.

Dr. Rania Al-Hammoud, MpowerU Training & Consultancy Inc.

Rania Al-Hammoud is a lecturer and the current associate chair of undergraduate studies at the civil & environmental engineering department at university of waterloo. Dr. Al-Hammoud has a civil engineering background with research focusing on materials and the rehabilitation of reinforced concrete structures. She also has passion for engineering education and has published widely in this area. She cares about the success and well-being of her students, thus always being creative with the teaching methods in the classroom. Outside the classroom, she is an active person, with the following hobbies: hiking, biking and dancing.

A Comparison between the Different Accredited Architectural Engineering Programs through ABET & CEAB

Abstract: This paper endeavors to contribute to the ongoing discourse regarding the state of Architectural Engineering education in higher institutions. Expanding on previous studies, this paper specifically investigates architectural engineering programs accredited by CEAB and ABET in Canada, the United States and internationally. It aims to enable a comparative analysis, revealing notable differences among these accredited programs. One key observation is the diversity of *specializations* or areas of emphasis offered by different international universities within the field of architectural engineering. These specializations often reflect the unique strengths and priorities of each institution. Another notable difference lies in experiential learning provided by these programs either in *design studio* or through *internships* or *co-op programs*. These experiential components vary in duration and intensity, further contributing to the distinctiveness of each program. Architectural engineering program durations vary amongst institutions based on the experiential components. Some programs are designed to be completed in a traditional four-year timeline, while others, particularly those with extensive co-op or internship components, may extend to five years or more. These variations in program duration are reflective of the emphasis placed on practical experience and industry readiness, as well as the regional or institutional norms. This research provides a valuable resource for both educational institutions and industry stakeholders, providing insights into the strengths and areas of improvement in architectural engineering education. While the architectural engineering programs bear the same name, their interpretation varies across institutions and countries, based on the local needs, resulting in the different program requirements as found in this paper.

Keywords: Architectural Engineering Accreditation; Architectural Engineering Education; Architectural Engineering Studio; Architectural Engineering Co-op

Introduction/Background

Due to the growing recognition of the importance of sustainable and energy-efficient buildings, the field of building technology has been rapidly evolving. As a result, there has been a significant increase in the number of undergraduate architectural engineering programs being developed. By focusing on the accreditation programs provided by ABET (the Accreditation Board for Engineering and Technology) and CEAB (the Canadian Engineering Accreditation Board). In the U.S., the original accrediting body was the Engineers Council for Professional Development, which was founded in 1932. In 1980, the name was changed to the Accreditation Board for Engineering and Technology and in 2005, the name was changed to the acronym ABET [1], which is advised or sponsored by the Architectural Engineering Institute (AEI). CEAB was founded in 1965 as a subcommittee of Engineers Canada to ensure the quality of the engineering undergraduate programs delivered in the country [2].

Based on the programs identified by the accrediting bodies online, we discovered that within the past 10 years, 13 new programs have received accreditation, out of a total of 34 accredited programs. This represents a remarkable 38% increase in the number of programs within just a decade. This success indicates that the program is highly effective, and it is likely that other universities will follow suit and introduce similar new programs.

While examining these programs, we observed the following disparities:

- Various universities provide distinct specializations or areas of emphasis within architectural engineering.
- There are variations in educational experiences, such as mandatory studio courses and internships.

Consequently, the duration of these programs varies, resulting in different graduation timelines.

During the study, it was observed that the accreditation requirements for architectural engineering programs varied among different accreditation bodies. Specifically, this paper focuses on the requirements set by ABET and CEAB for the architectural engineering program. Similar reviews of U.S. Architectural Engineering requirements have been performed in the past [3, 4]. There are also existing reviews of the CEAB accreditation for Architectural Engineering programs [5]. However, this research is different in that it compares U.S. ABET accredited programs with International ABET accredited programs and Canadian CEAB accredited programs.

Washington Accord

Beginning in 1989 as six countries sought reciprocity for engineering accreditation and licensure, the Washington Accord was created and currently has 20 signatory countries. Canada and the U.S. were both signatories of the original agreement in 1989. Another eight are in provisional status [6]. The "Washington Accord Graduate Attribute Profile" includes 12 elements, the Knowledge Profile has another eight elements, and Engineering Activities includes another 5 elements. Graduate Attribute elements include engineering knowledge, problem analysis, investigation and more. Knowledge Profile attributes include natural sciences and mathematics [6]. Engineering Activities elements include the depth of knowledge and analysis [6].

Discussion of differences in requirements of ABET and CEAB

The Canadian Engineering Accreditation Board (CEAB) is responsible for accrediting engineering programs in Canada. The CEAB has a set of criteria and guidelines that programs must meet in order to be accredited [2]. These criteria cover various aspects of the program, including curriculum, faculty qualifications, facilities, and student outcomes. Accreditation ensures that programs meet certain standards of quality and prepares graduates for the engineering profession [2].

ABET recognizes four curriculum areas; building structures, building mechanical systems, building electrical systems, and construction/construction management [7]. While ABET student learning outcomes and curriculum requirements are the same across all engineering disciplines, there are some particular requirements for accreditation as an architectural engineering program. Students must be design-capable in one area, application able in a second area and comprehend the last two curriculum areas. In addition to having a curriculum to support all four areas, ABET accredited architectural engineering program graduates should be able to "discuss… architectural design and history" [7].

Table 1: Summary of Accredited Programs

Architectural Engineering programs; Canada (CEAB), International (ABET), USA (ABET)	Degree Options or Specializations	Required # of Co-op or Internship	Required # of Studios	Bach. Degree Duration in Years
University of Waterloo	3	5	8	4
Conestoga College	3	3	5	4
Concordia University	3	1	0	4
Carleton University	1	5 (optional)	0	4
Alfaisal University	2	1	3	4
An-Najah National University	5	0	0	5
King Fahd University of Petroleum and Minerals	3	1 (optional)	*Not Listed	4+prep yr
Sultan Qaboos University	1	1	* Not Listed	5
United Arab Emirates University	1	2	3	4
University of Ha'il	1	* Not Listed	3	4+prep year
University of Sharjah	1	1	* Not Listed	5
California Polytechnic State University, San Luis Obispo	1	0	5	4
Drexel University	1	1	2	4
Illinois Institute of Technology	4	0	1	4
Kansas State University	4	0	0	4
Milwaukee School of Engineering	4	0	2 AE Capstone	4
Missouri University of Science and Technology	5	1	2	4
North Carolina Agricultural and Technical State University	1	0	4	4
Oklahoma State University	4	0	3	5
Pennsylvania State University	4	0	3	5
Tennessee State University	1	0	2	4
Texas A&M University - Kingsville	1	0	1	4
The University of Alabama	1	0	2 CE Capstone	4
The University of Arizona	1	0	1	4
The University of Kansas	1	0	2	4
The University of Texas at Arlington	1	0	1	4
University of Cincinnati	1	3	2	4
University of Colorado Boulder	1	0	1	4
University of Detroit Mercy	1	2	2	5
University of Miami	1	0	2	4
University of Oklahoma	1	0	2	4
University of Texas at Austin	1	0	2	4
University of Wyoming	2	0	4	4
Worcester Polytechnic Institute	2	0	5	4

Architectural Engineering programs in turn include architectural coursework to meet the ABET accreditation. From this, two questions arise; 1) is studio a requirement for architects and 2) how should this type of learning be incorporated into the engineering curriculum? While the National Council of Architectural Accreditation Boards (NCARB) points to a requirement for architectural students to participate in a design studio course, which then in turn points to requirements of the National Architectural Accrediting Board (NAAB) [8]. However, NAAB only requires a space for studio based learning [9]. From these three accrediting agencies, studio is not defined or what studio is as part of the architectural education process.

A list of accredited ABET and CEAB architectural engineering programs was compiled across Canada, the U.S. and Internationally. Different program requirements identified in Table 1 are graduation requirements and durations, specializations, co-op or internship requirements, and studio requirements.

Graduation Requirements: Canada, International and U.S.

Just like the differences between universities that use quarter systems versus semester systems, there are also other alternative systems for counting hours. While the typical U.S. system counts only hours per week for traditional fall-spring semester courses, there were differences within the U.S. programs. California uses a system which accounts for time in class and expected time spent working on coursework outside of the classroom. The majority of the programs offer a 4-year degree. There are 6 programs which require 5-years for an undergraduate degree instead of the traditional 4-year degree.

Also identified were disparities in reporting Lab hours versus Tutorial hours. The U.S. semester system allows for up to 3 hours in a laboratory-style course to count as 1 hour. In Canada, the accreditation hours (AU's) count based on contact hours, where each lecture hour counts as 1 while tutorials and labs hours count as 0.5 (tutorial hour = 0.5 AU; 1 lab hour = 0.5 AU). When considering design studio courses, the course may be considered a lab-style or include a tutorial. Therefore the amount of time shown in the studio may not be obvious based on credit hours alone.

Co-ops and Internships

While not required, there are definitely programs which emphasize the need for work experience during university, it was predominantly the Canadian (CEAB) and International (ABET) accredited programs. While four U.S. ABET accredited programs identified required work experience, it is possible that many more encourage work experience during breaks from university. Cooperative Education or Co-ops have a long history [10]. Similar to the idea of an internship or practicum [11], all three rely upon a relationship between industry, the university and students.

In the U.S., there are requirements after passing the Fundamentals of Engineering exam (FE) for an extended post-graduate internship. After passing the FE, a title of Engineer Intern is conferred. The exam can be taken prior to graduation and any hours worked after the exam typically count towards the required internship for professional licensure.

The purpose of a co-op or internship has been described in literature as being a long-term job interview for both employer and employee [10], however co-ops and internships should be described as much more than that. Employers have expectations for student workers annually, including university required internships and the number of hours available during the semester or over the summer [11]. Higher maturation and motivation levels of students who have completed multiple co-ops has been observed [10].

Of the programs, 20 did not require any internship, 6 programs required one internship, 2 programs required two internships, 2 required three and 1 program required 5 (Figure 1). There is one international program that does not have course names identified online and therefore it is not clear if work experience is required. One program identifies 1 optional internship and another program identifies 5 optional internships.

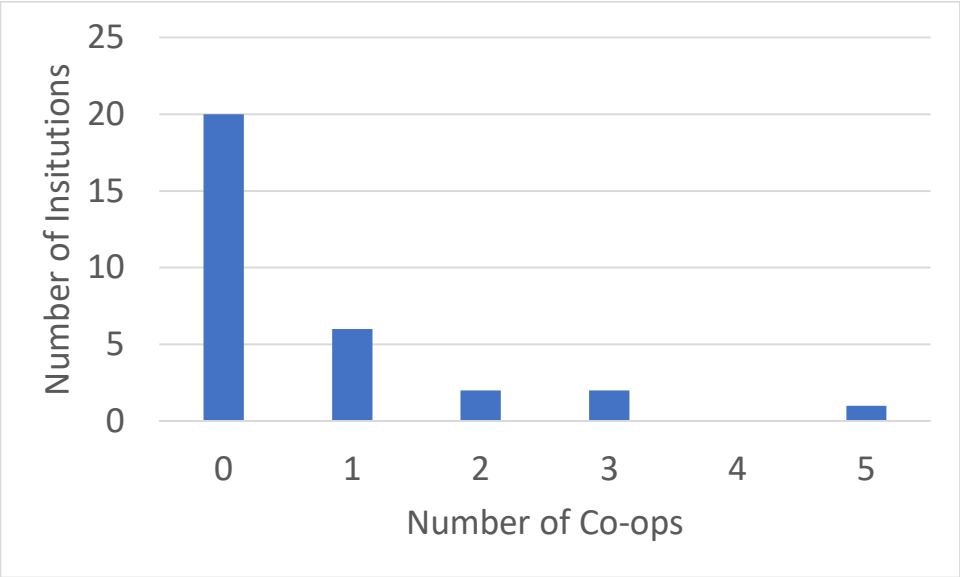

Figure 1: Number of Co-ops Required by Program

Difference between focus, options, specializations

The accreditation process in Canada does not require a specialization identification for Architectural Engineering or within the discipline. This is quite different to the requirements in the U.S. under the ABET accreditation. Within the ABET accreditation, one of four curriculum areas; building structures, building mechanical systems, building electrical systems, and construction/construction management. While not all of the ABET accredited programs have a curriculum area identified online, many do.

There are 26 Canadian (CEAB), International (ABET), and U.S. (ABET) programs which either do not have a sub-discipline specified or have one outside of the ABET listed curriculum areas. There are programs with identified curriculum areas in Structures (13), Mechanical (12), Electrical (8), and Construction (9). Fourteen of the programs include two or more curriculum areas. Twenty programs have more than one specialization (Figure 2).

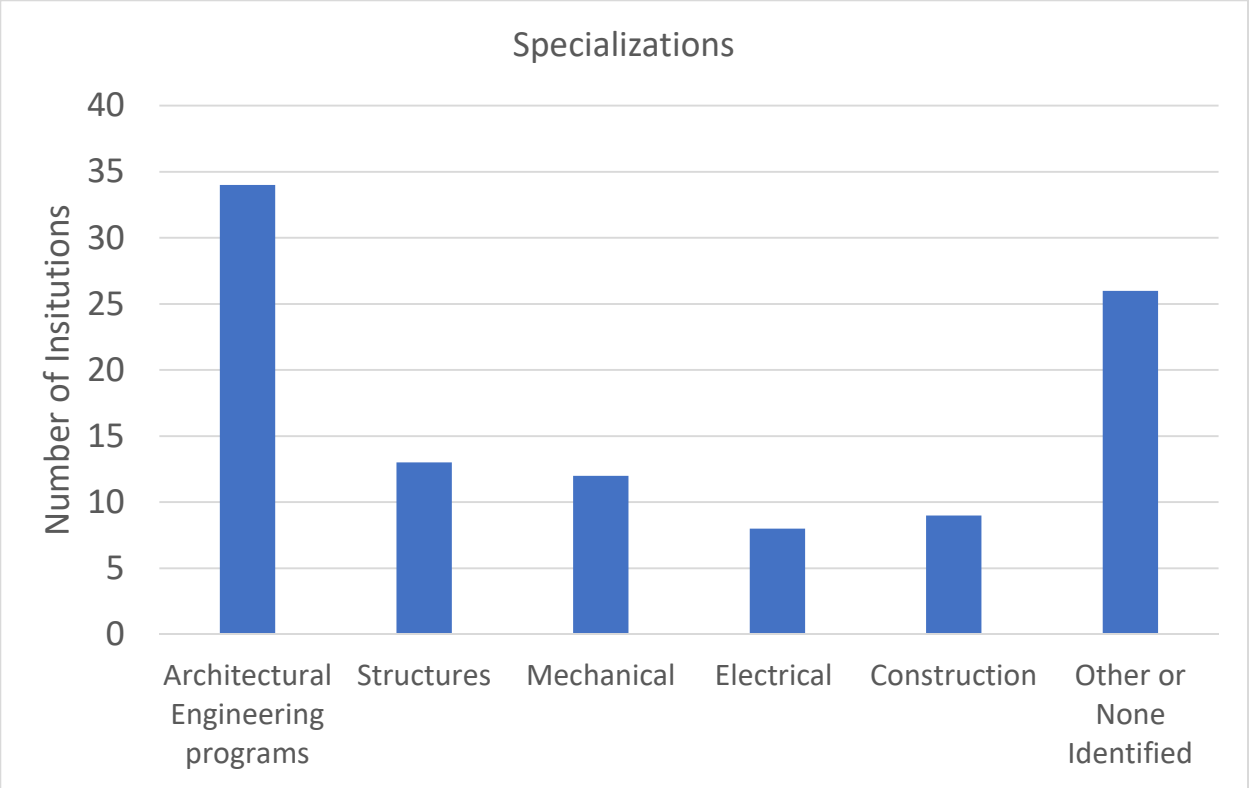

Figure 2: Architectural Engineering Specializations (Based on ABET Sub-Disciplines)

What is a Design Studio?

While ABET, NAAB, or NCARB do not define what studio courses are, they do point to the studio as integral for an architecture degree [8, 9] or architectural engineering degree [7]. But as NAAB suggests, is a studio just a space? Design studio using an active learning pedagogy, which can also be described as 'learning-by-doing' [12]. There is also much literature that points to the instructor-student dialogue and peer to peer dialogue, both of which support learning [13, 14]. There is also discussion of the space itself supporting the style of learning by acting as a "social culture" or "social space" [13, 14]. While the concept of a design studio exists in theoretical discussions, there is little research published or descriptions of the "atelier" or master-student relationship. The literature review presented here documents the basic definition of studio and is not intended to be a state of the industry.

To determine how "studio" is defined within Architectural Engineering, a brief poll was taken amongst faculty at University of Waterloo.

Five engineering instructors who have experience teaching studio to architectural engineering students were asked to reflect on the following questions in regards to the studio courses:

1. How do you define a studio?
2. What are the characteristics of a studio classroom?
3. What makes it more or less desirable over other forms of teaching and learning?
4. In your opinion, what are the students skills that are most developed in a studio course?

Their answers to the four questions are collated and summarized below:
A studio in architectural education and design is a guided project-based course that emphasizes hands-on learning and problem-solving. It typically takes place in an open and collaborative space, enabling peer learning and the construction of physical models. This learning environment involves continuous feedback from both peers and instructors and follows a circular, iterative approach. Students tackle projects with intentionally ill-defined problem statements, encouraging critical thinking and creativity. These projects often build on each other, allowing students to apply knowledge from other courses to industry-specific challenges. The studio combines lectures, self-study, examination of precedents, experimentation, and reflection, all centered around project-based activities. In essence, it's a dynamic setting where students apply design knowledge to open-ended problems, fostering creativity and practical skills.

A studio classroom is characterized by project-based learning with open-ended design challenges, often involving physical model construction. It takes place in an open space that promotes peer interaction and continuous feedback from instructors. Studio courses have a steep learning curve compared to traditional ones, focusing on applied engineering science rather than fundamentals. Ideal studios provide individual workspaces for students equipped with necessary tools and encourage collaboration and learning from peers. The space should also be adaptable to accommodate various activities like lectures, group work, and testing.

Studio courses are desirable because they promote peer learning, simulate real-world design processes, and enable practical application of theoretical knowledge. However, they can be demanding for both students and instructors due to extensive preparation and grading. The instructor's industry experience is valuable for crafting applicable design briefs. While energizing for some, studio courses can lead to burnout for others. They offer unparalleled opportunities for deep learning and integration of theoretical and practical knowledge, bridging the gap between theory and practice.

In studio courses, students develop communication skills, particularly for open-ended design challenges. Teamwork, conflict resolution, and effective collaboration are emphasized. Students also improve time and project management, learn to accept constructive feedback, and avoid taking it personally. Studio courses prepare students for the workforce with intensive, long days.

Critical thinking is a central skill in studio courses, as students engage in iterative design thinking and problem-solving. They refine communication skills, whether visual, oral, or written, and practice collaboration and teamwork. Studios offer opportunities to explore professionalism, user-centered design, and workplace ethics, depending on the instructor's approach. In summary, studio courses effectively cultivate critical thinking, problem-solving, collaboration, and communication skills, alongside a deep understanding of the design process.

How Important is Design Studio?
Due to the varied design studio requirements, course names, semester hours, and actual in class time, some additional discussion will need to be provided. Not all universities require a design studio. Based on the ABET requirements, to “discuss… architectural design and history, ” it is difficult to determine how one university compares to another. For the purpose of this discussion,

the design requirement will be defined as either Studio or Design courses. Architectural history courses were not considered.

There are 6 Canadian (CEAB), International (ABET), and U.S. (ABET) programs which do not show any design studio requirements in their online curriculum. As not all online curricula are complete with course descriptions, this does not mean that they do not require the studio courses, only that they were not located. Five programs require only 1 studio course before graduation, nine require 2 courses, five require 3 courses, two require 4, three require 5 and one requires 8. An additional three programs appeared to use alternate coursework for this requirement, like a "capstone" course. It is unclear as to whether these courses meet the architectural knowledge definition (Figure 3).

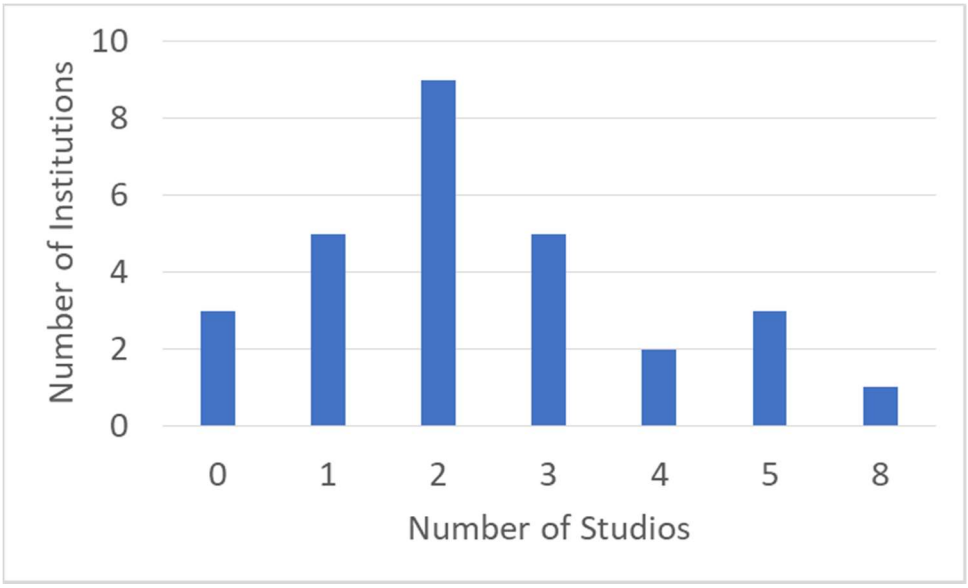

Figure 3: Number of Studio Courses Required by Program

Another consideration is how much time is actually spent in the studio. Again, due to the difference in course calculation, there is not a direct comparison that can be accurately made. Using the university websites, the hours were converted into an "hours per week" of course time. Schools with quarters or other alternate means for determining hours were included in the calculated hours. There are some unusual values presented for weekly hours of class, for calculated hours based on average per semester. For 9 schools, there were no calculable hours for studio, which compares with the totals above for no known required studio courses. One program requires 1.67 hours per week, another requires 2.5 hours per week. Thirteen programs require 3 hours per week, four require 4, 1 requires 4.8 (on average), two require 5 hours per week, 2 require 6, and 1 requires 12 labs.

Limitations and Future Research:
This paper is limited to accreditation agencies within North America, which are internationally used. ABET is used in countries such as the United Arab Emirates (Table 1) presented in the results. Additional accreditation agencies are present, but are beyond the scope of this paper. This is an opportunity for expansion of the research into additional countries and their accreditation requirements.

Conclusions:
There are two main lessons from this research. Co-ops or work experience appears to be an integral part of the architectural engineering degree in Canada CEAB and for International ABET accredited schools. The number of co-ops required in these programs, as compared to the number of studio-based courses, indicates a strong preference for studio-based courses in U.S. ABET accredited schools. The U.S. ABET schools appear to be more focused on student knowledge of architecture and architectural history, based on their accreditation requirements.

The CEAB accreditation does not require a specialization. However, the coursework may be inherently different with a strong focus on building science and the building envelope. With the difference in coursework and tendency towards co-ops, there is a question of whether employers have different expectations for students graduating from CEAB accredited programs, as compared to ABET programs.

The duration of architectural engineering programs in U.S. and Canadian institutions varies based on the focus of either design studio or a work experience like a co-op or internship. These are core curricular differences, which may also be seen in the recent graduate. From identifying the differences between ABET and CEAB accredited programs, it is evident that future research needs to identify how these differences are overcome. A similar question to resolve is what employers seek from the different programs which cause these differences. An additional question is; why do some programs have a strong preference for co-ops, while other programs have a strong preference for co-operative learning.

This paper delves deeper into differences and similarities among accredited architectural engineering programs in the U.S. and Canada. By doing so, program alignment with the evolving needs of the architectural engineering industry is highlighted. This analysis is crucial in ensuring graduates from these programs are well-prepared to address the challenges posed by the ever-changing landscape of the construction and design sectors.

References:

[1] ABET. (2021). “At a Glance.” Retrieved Sept. 19, 2023. <https://www.abet.org/about-abet/at-a-glance/>

[2] Engineers Canada, “Accredited Programs,” Engineers Canada, [online]. Available: https://engineerscanada.ca/accreditation/accredited-programs. [Accessed: November 25, 2023]

[3] Estes and Estrada. (2007). “Architectural Engineering Programs: Finding Common Ground.” Paper presented at 2007 Annual Conference & Exposition. Honolulu, Hawaii. DOI: 10.18260/1-2--1966

[4] Phillips, J. (2018). “Current Trends in Architectural Engineering Education.” Paper presented at 2018 ASEE Annual Conference & Exposition. Salt Lake City, Utah. DOI: 10.18260/1-2--30246

[5] Walbridge, S., and Al-Hammoud, R. (2020). “Challenges and Opportunities Observed in the Implementation of a New Architectural Engineering Undergraduate Academic Program.” Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . DOI: 10.18260/1-2--34267

[6] International Engineering Alliance Secretariat (IEA). (2023). “25 Years of the Washington Accord.” New Zealand. <https://www.ieagreements.org/accords/washington/ >

[7] ABET Engineering Accreditation Commission (ABET-EAC). (2022). “2023-2024 Criteria for Accrediting Engineering Programs.” Baltimore, MD.

[8] National Council of Architectural Accreditation Boards (NCARB). (2021). “Educational Guidelines: The NCARB Education Standard.” Washington, DC. pp. 1-40.

[9] National Architectural Accrediting Board (NAAB). (2020). “Conditions for Accreditation: 2020 Edition.” pp. 1-15.

[10] Castro-Cedeno, M., and Mazumder, Q. (2010). “Motivation And Maturity Of Engineering And Engineering Technology Students With And Without Coop Experience.” Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. 10.18260/1-2--15686

[11] Mosier, R., Yates, H. N., and Adhikari, S. (2021). “Student Internships During Times of Pandemic: A Historical View of Pandemics, Recession and Their Effect on Education.” Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. https://peer.asee.org/37745

[12] Schon, D. A. (1987). “Educating the Reflective Practitioner: Toward a New Design forTeaching and Learning in the Professions.” San Francisco: Jossey-Bass.

[13] Wagner, M. & Gansemer-Topf, A. (2005). “Learning by teaching others: a qualitative study exploring the benefits of peer teaching.” Landscape Journal. Vol. 24, No. 2, pp. 198–208.

[14] Yorgancıoglu, D. (2020). “Critical reflections on the surface, pedagogical and epistemological features of the design studio under the “new normal” conditions.” Journal of Design Studio. 2(1): 25–36.