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Contributions of interdisciplinary learning toward AE graduates' success: An industry perspective

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Abstract

Interdisciplinary learning plays an important role in the field of Architecture, Engineering and Construction (AEC). However, ingraining interdisciplinary learning into a curriculum is both an important and challenging need. Previous studies have found that interdisciplinary learning provides many benefits, including helping students obtain teamwork skills, developing a breadth of knowledge and professional mindset for students' future careers. Literature indicates that there is an important relationship between interdisciplinary learning and students' success. However, a research gap still exists in identifying the factors related to interdisciplinary learning and how they lead to the success of Architectural Engineering (AE) graduates. This study sought to understand the connection between interdisciplinary learning–relevant topics (or factors) and the success of AE graduates, specifically focusing on the importance of interdisciplinary learning-related topics (or factors) in the AEC industry. To achieve this objective, two sequential surveys were created and analyzed to investigate the factors related to interdisciplinary learning on the success of AE students, and perceptions across different industry disciplines regarding the importance of those factors. This paper –presents and discusses the related factors and their interaction with the success of graduates in the AEC industry. Within the results analyzed, it was found that by focusing on interdisciplinary learning, graduates are more likely to integrate theoretical knowledge in practice, where they are then more successful. Factors that contribute to the interdisciplinary "success" of AE graduates include meta-knowledge or metacognition skills, team interaction and collaboration skills, breadth of discipline understanding, and professional skills as they are significant for their duties post-graduation.

KEYWORDS: Interdisciplinary learning, Graduates, Success, AEC industry

Introduction

Interdisciplinary learning plays a vital role in the Architecture, Engineering, and Construction (AEC) field, and is a strong contributor to the success of Architectural Engineering (AE) graduates. Interdisciplinary learning provides many benefits, including helping students gain teamwork skills, expand their breadth of knowledge, and develop a professional mindset for their future careers. A justification for interdisciplinary skills comes from recent studies indicating that the silos of the AEC industry account for notable fragmentation problems within design and construction projects [1]. Many AE graduates are confronted with these fragmentation problems in real-world construction projects, such as poor communication and lack of cooperative consciousness or experience [2]. Compounding this, the problem of fragmentation also exists in the education field that leads to certain consequences and a cyclic education deficit problem. Studies from researchers illustrate that most engineering students were taught technical knowledge via isolated and, thus domain-specific courses with limited to no teaching of integrated approaches. This limited educational focus causes a lack of knowledge and experience in collaboration for students entering the workforce [3]. Moreover, the education model of the AEC industry has made slow progress in program organization and execution.

Given the importance of collaboration, there is a need to implement interdisciplinary learning that reflects core industry needs before graduation to improve students' communication skills, collaborative experiences, and facilitate their learning ability to work on real-world projects [4]. Interdisciplinary learning has been shown to help students build connections across disciplines, thus allowing them to develop innovative ideas and new solutions to different projects and problem types [5]. If successful, interdisciplinary learning can help students assess complex information to shape their thinking and formally construct their knowledge of ideas to be more holistic in nature [6].

While there is a link between interdisciplinary collaboration and career success, it is difficult to prove this link with currently documented evidence. To better understand interdisciplinary success, this study investigated, through industry surveys, which interdisciplinary learning factors influence AE students'

success, specifically targeting the importance of interdisciplinary education in AE curriculum and the perceptions of the importance of these factors by different industry disciplines. The factors involved and their interaction with the success of AEC industry graduates are presented and discussed. It focuses on the analysis and investigation on interdisciplinary learning, graduates are more likely to integrate theoretical knowledge into practice and thus achieve greater success. Factors contributing to the interdisciplinary 'success' of AE graduates include meta-knowledge or meta-cognitive skills, team interaction and collaboration skills, breadth of subject understanding, and professional skills as they are important for post-graduation responsibilities.

Significance of interdisciplinary learning in AEC industry

Howard et al. [7] proposed that the AEC industry in the US suffers from a high degree of fragmentation, which is usually divided into two types [8]: 1) horizontal fragmentation, also called internal fragmentation and 2) vertical fragmentation, also called external fragmentation. When horizontal and vertical fragmentation exist in the industry or within a project, they can lead to problems such as isolation of professionals, lack of coordination, low productivity, and wasted capital [8-9]. Nevertheless, interdisciplinary and multidisciplinary approaches also provide advantages to minimize the problem of fragmentation. Interdisciplinary and multidisciplinary methods allow AEC professionals to apply collaboration and knowledge integration rationally and can help people understand the contribution of others' and future work [10]. Therefore, interdisciplinary learning approaches are considered indispensable to addressing some of the fragmentation in the AEC industry.

Interdisciplinary research plays an important role in addressing the specific problems related to the AEC industry. Irizarry et al. [11] illustrated that recent trends in the AEC industry have focused on Integrated Project Delivery (IPD) and interdisciplinary-related collaboration, which further state that there is a continuous need for multidisciplinary and interdisciplinary learning in AEC-related educational programs. To enhance interdisciplinary research in the AEC industry, increasing the breadth of professional knowledge and collaboration through practice were identified as two advantageous ways [12]. Lines et al. [13] provided that training resources and better professional communication can enhance the adoption of change and also to help employees cope with changes within the AEC projects and industry [14]. Zhang et al. [15] also found that interdisciplinary information exchange could eventually improve project performance. Ultimately, the interdisciplinary application of core construction knowledge is essential to improve AEC industry issues and contribute to the success of construction projects. However, more research is needed on interdisciplinary education and its relationship to student success.

Interdisciplinary Learning Related to Education and Students' Success

Interactive collaboration between distributed multi- or interdisciplinary teams is expected to become a standard practice in the AEC industry, given students' post-graduation careers [16]. As students enter the industry, they will immediately be confronted with the collaborative realities of AEC practice, and the inadequacies of their education will become clear [11]. To counteract this, there is a need for collaboration-related teaching and learning in AEC programs and specifically AEC-related courses. Successful collaboration crossing different organizations is a key driver of the AEC industry to increase productivity [3,17].

Interdisciplinary engineering education has attracted the attention of the AEC industry [18] due to AEC projects requiring more disciplinary backgrounds to deliver successful projects [19]. The current interdisciplinary occurrence in the AEC industry, as documented by Badawi and Abdullah [12] focuses on helping students to assimilate depth of knowledge and become proficient in collaborative teamwork skills, students are expected to have multidisciplinary knowledge [20]. Meanwhile, the following table (Table 1) shows the research from different researchers related to interdisciplinary learning in the higher education institutions of the AEC industry.

Table 1: Summary of interdisciplinary learning- related research

Authors	Purpose	Summary Points
Leicht and Messner [21]	To conduct team projects with interactive workspaces	Conducting team projects with interactive workspaces improves teamwork and the work environment while using interdisciplinary teams to execution
Irizarry et al. [11]	To explore the needs and challenges of interdisciplinary education at AEC	Collaboration between multiple disciplines plays a vital role in the successful completion of projects
Solnosky et al. [22]	An overview of the development, implementation, and results of the multidisciplinary team pilot program within the AE department	Students need to improve their understanding of disciplinary and team knowledge before entering the industry as professionals
Solnosky et al. [23]	Create design projects in which multidisciplinary teams develop their own project-specific goals and then select the appropriate technologies, processes, and infrastructure	AEC projects with interdisciplinary, synchronous, and distributed curricula produced better outcomes than traditional AEC project models
Badawi and Abdullah [12]	To highlight the value of an interdisciplinary design course (IDC) and test the hypothesis	IDC makes students satisfied with working with other students, improves the understanding of the integrated design process, and provides more useful information than other disciplines' information

These representative research studies have demonstrated the importance of considering interdisciplinary settings, as AE courses and educational programs with interdisciplinary content can not only improve the quality of their own courses and content but also enhance the abilities of AE students to contribute to the development and success of their future careers. Recent research further shows that interdisciplinary learning is the starting point for providing students with pathways to success in academia and industry [4]. Because interdisciplinary learning can provide experiences and insights on how to apply academic knowledge to real-world projects [24]. Interdisciplinary learning can help students tailor their education to prepare them for their future career goals and be successful in the future. In addition, it can make students more likely to learn new things, develop new technologies, and build on innovations they already have [25]. The additional technical and professional skills gained from interdisciplinary learning help students to become more valuable potential employees [26]. Also, interdisciplinary learning creates an environment where people must 'think outside the box', allowing students to utilize different disciplinary knowledge to enhance their creativity and critical thinking [27].

Interdisciplinary learning is an effective way to overcome barriers among different disciplines, improve communication and collaboration skills, and promote the understanding and mastery of professional skills in future employment for future professionals and emphasized that interdisciplinary learning in the context of technology can add value to higher education students and benefit their skills development, thereby increasing student success [4]. Interdisciplinary learning has been shown to improve academic progress and general skill, and increase student engagement [28]. In addition, interdisciplinary learning is used in engineering to emphasize the importance of interpersonal skills and to enhance students' innovation [8,17,24]. Promoting interdisciplinary learning in higher education institutions is encouraged to enhance students' understanding of the differences among professions and to prepare them for successful careers [29]. These benefits suggest that interdisciplinary learning in engineering enables students to gain a greater understanding of different disciplines and prepares them for future success.

Based on the literature review of interdisciplinary learning, there is a need to establish a link between the significance of interdisciplinary learning and longevity or career success in the AEC industry.

Methodology

To understand the importance of student success with respect to interdisciplinary learning before graduation, a social science methodology was adopted to interact with employers to gain professional insights. Two consecutive surveys were created and analyzed to investigate the factors associated with interdisciplinary learning that influence the success of AE students and the perceptions of the importance of these factors across different industry disciplines. The career fair surveys are distributed to employers at career fairs where students are recruited, with a focus on alumni groups in relevant AEC sectors during two departmental career fairs, one year apart. The survey assesses industry perceptions of the factors influencing

students' careers and attempts to capture perspectives on characteristics that influence students' future career success.

Survey Creation and Deployment

When developing the surveys, the detailed information for the two years is shown in Table 2.

Table 2: Survey Creation and Deployment

Survey Attribute	Survey 1	Survey 2
Survey title	Success of AE Graduate Recruitment	AE Recruitment
Year	2021	2022
Companies solicited	91	140
Response rate	67% (n=58)	43% (n=60)
Delivery mechanism	Paper	Paper
Types of questions	• Short answer questions • Multiple choice questions • 5-point Likert scale questions • Open-ended questions	• Short answer questions • Multiple choice questions • 5-point Likert scale questions • Open-ended questions
Number of questions	15	23
Key survey parts	• 5-point Likert scale questions • Open-ended questions	• 5-point Likert scale questions • Open-ended questions

The Fall 2021 Career Fair survey results comprised 61 respondents from 58 companies, with a response rate of 67%. Of these 58 firms, some multidisciplinary firms offered multiple design services and therefore employed all disciplines (n=6; 10.3%), while 29.3% (n=17) could be categorized as a single discipline and employed only in that discipline. The remaining 60.3% of companies established themselves as a single discipline but usually employed multiple disciplines.

Survey data was collected from employers at 60 companies participating in the Fall 2022 Career Fair. In total questionnaires were distributed to all companies participating in the career fair. During the survey, companies were asked about the possibility of completing the survey on the same day and also accepted a response via email within ten days. A total of 140 questionnaires were sent out, and 60 were returned, for a response rate of 43%, representing 60 company responses. These 60 companies were grouped into three tracks, namely the construction track (22 in total), the mechanical, electrical, and plumbing (MEP) track (23 in total), and the structural track (15 in total). Some of these interdisciplinary firms offer a variety of design services and therefore hire all disciplines, while others establish themselves as a single discipline, but often employ multiple disciplines. These groupings will be used when analyzing the data trends.

Data Interpretation

After the surveys were developed and deployed, the results of these surveys were used to establish a better understanding of the importance of interdisciplinary learning on student success in the AEC sector. Simple statistics and trends were recorded and documented given the open-ended questions and the Likert questions. For all open-ended questions, a pre-determined set of steps were used to extract meaningful trends; the process follows:

1. Identifying each response and listing all the information provided by the participant.
2. Extracting valid information from the data to support the classification process.
3. Categorizing the responses according to the different themes.
4. Sorting out keywords from each answer and aggregating them into different sorting groups.
5. Assessing trends in responses by discipline or association with other responses.

Survey Results

In this paper, a second, subsequent survey was deployed (Table 2) with a range of collected responses generated from the first survey. Based on the data collected from Fall 2021 and Fall 2022 career

fair surveys, this section of the paper presents a key summary of results. Specifically, the data presented here allows for the identification of AEC industry characteristics of students' success deemed important to interdisciplinary learning.

Survey 1: Fall 2021 Survey

Table 3 provides a summary breakdown of company recruitment across disciplines of graduates. When examining the data, there is a relatively equal demand for graduates in the different AE disciplines (construction, electrical, lighting, mechanical or structural). Acoustics is also listed as a recruitment discipline, yet it is an outlier. Seeing this equal distribution, the results to follow are relatively proportionate to each other and with limited bias towards a single discipline.

Table 3: Background information on Fall 2021 company discipline hiring efforts.

Survey	Respondents Number	Discipline Response Rate					
		Construction	Electrical	Lighting	Mechanical	Structural	Acoustics
Firm/Company	N = 61	25.2%	20.3%	14.6%	21.1%	17.9%	0.8%
The disciplines of Graduates that companies recruit		31	25	18	26	22	1

Survey 1 captured the opinions and assessments of student traits that may influence their success from the perspective of these different engineering companies. A summary of the results is provided in Figure 1. Here, it can be observed that breadth of knowledge and technical depth are rated the most important characteristics for students seeking employment in the AEC industry after graduation (bottom two rows in Figure 1). More than 60% of employers believe that successful AE graduates need to possess a breadth of knowledge and depth of technical skills, as well as collaboration and interpersonal skills (Figure 1). The importance of indicating that graduates have a strong depth of technical skills, breadth of knowledge, collaboration, and leadership skills is closely related, indicating the value of interdisciplinary techniques.

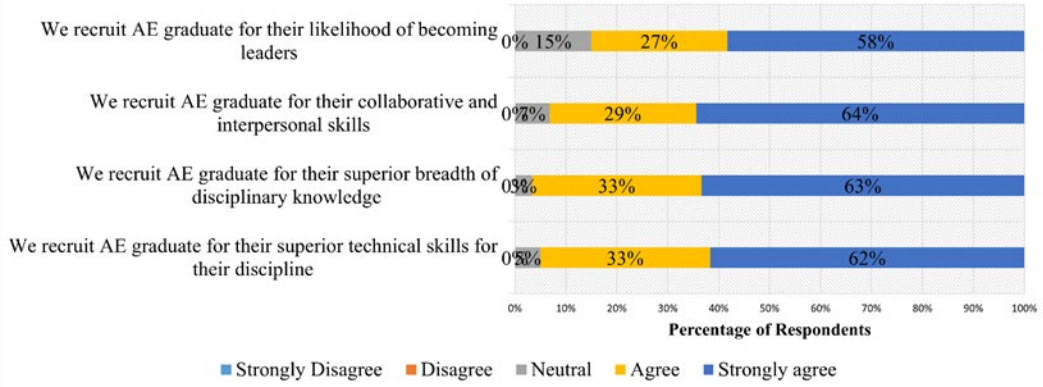


Figure 1: Career Fair Fall 2021 Evaluation of Agreement of graduates' characteristic for success.

Additional data were collected through three open-ended questions about the meaning of success within AEC companies by trying to establish characteristics that distinguish AE graduates. The questions are:

- What does success mean in your firm or sector of the industry?
- What differentiates AE graduates that you feel make them successful?
- What aspects of the AE curriculum or overall program do you think are critical in shaping this success?

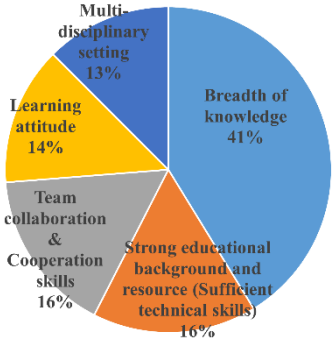
Based on the aggregated survey answers (Table 4), several main success foci can be observed both within each question, but also across questions. As can be seen from the results, good teamwork skills are one of the key components of interdisciplinary learning and are considered the most frequently cited success

factor by employers. The other result that tied for second place was repeat customers and work. Here, repeat client work can be seen as both a technical achievement and a professional trait, as both are necessary to keep clients coming back for more. To better understand these themes, the following core area groupings are explained.

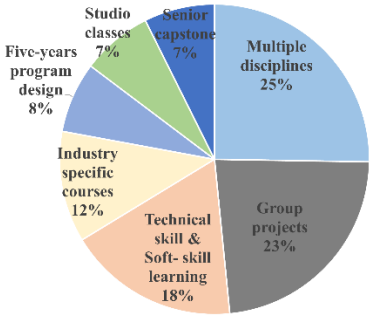
Table 4: Characteristics that distinguish AE graduates

Success means in your firm / sector.	**Differentiates AE graduates in their success.**	**Aspects of the AE curriculum that are critical in shaping success.**
• Good teamwork skills • Repeat work and satisfied clients • Delivering successful projects • Strong technical skills • Happy people • Contributing positively to the AEC industry • Providing a good work culture for a company • A passion for learning or a willingness to learn new things for projects	• Breadth of knowledge • Strong educational background and resources (Sufficient technical skills) • Team collaboration & Cooperation skills • Learning attitude • Multi-disciplinary setting	• Multiple disciplines • Group projects • Technical skill & Soft- skill learning • Industry-specific courses • Five-year program design • Studio classes • Senior Capstone

In addition, Figure 2a shows response percentages for the following question: What makes (department) graduates unique and successful? The depth of knowledge is shown across responses as indicated by a sufficient depth and breadth of knowledge and technical expertise comments. Other respondents mentioned technical rigor or examples of advanced skills, such as disciplinary engineering software. Attitude is reflected in the fact that a serious attitude to study or work can make graduates stand out and thus make them successful. The multidisciplinary setting replies suggest that students' exposure to different disciplines helps to build a holistic understanding of design and construction. Respondents felt that this 'exposure to different disciplines' setup would enable students to excel and succeed based on their ability to interact with others and to develop better solutions within their discipline. Figure 2b provides a summary of the following prompt's replies: Identify the different aspects of the curriculum that shape the success of the program's graduates. From the percentages listed we can see that exposure to multiple disciplines, group project work, and skill learning ranked most common. These are expected as they are broad and build disciplinary and interdisciplinary thinking. Other listed attributes as good to know as they make up the majority of the program but are specific to a particular item.



"What makes (department) graduates unique and successful?"
Fig: 2a



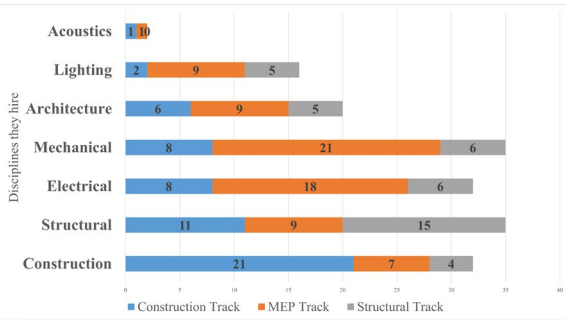
"What aspects of the AE curriculum or overall program do you think are critical in shaping this success?"
Fig: 2b

Figure 2: Surveyed Responses in % of firms regarding what industry thinks makes a graduate unique and successful.

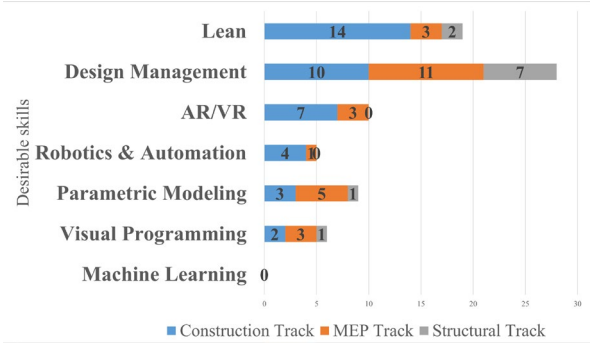
Survey 2: Fall 2022 Survey

Figures 3a and 3b provide a detailed summary of company backgrounds within three distinct, defined tracks from the perspective of what disciplines they recruit and the skills they desire when recruiting. When looking at the data, the discipline hiring demand is generally even across the tracks. That said,

employers' desire for skills vary slightly from track to track. As Figure 3b shows, companies in the construction track are more interested in lean skills, while in the MEP and structural tracks, there is more interest in skills such as design management. Figure 3b also shows that more cutting-edge technology, such as AR/VR technology, is much smaller and not important for some disciplines (i.e., structural).



Comparison of Hired Disciplines
Fig: 3a



Comparison of Desired skills
Fig: 3b

Figure 3: Surveyed Responses of hired disciplines and their desired skills group by three discipline tracks.

The next part of Survey 2's data collected looked at characteristics that may affect success and how the AE curriculum creates competencies. As Figure 4 shows, it is evident that collaboration and interpersonal skills, as well as, breadth of interdisciplinary knowledge coupled with a depth of technical knowledge, are the most important characteristics. Over 70% of employers in companies within the construction and MEP tracks believe that successful graduates need to have good collaboration and interpersonal skills. Additionally, over 65% of employers believe interdisciplinary breadth of knowledge and depth of technical skills are more likely to impact student success in their futures (Figures 4). Unique from construction and MEP tracks are the important rankings for the structural track (Figure 4). Here over 70% of structural employers believe that graduates with a depth of technical skills are more likely to succeed, followed by a breadth of interdisciplinary knowledge and good collaboration skills.

Among those surveyed, it is obvious that construction companies also seek to recruit graduates with written and oral communication skills, an underlying quality considered equally important to the future success of graduates in their careers. The need for graduates to have good collaborative and interpersonal skills, interdisciplinary breadth of knowledge, depth of technical skills, strong written and oral communication skills, and their importance to the future success of the graduate are closely linked, demonstrating the importance and value of interdisciplinarity in the AEC industry. It is also important to emphasize that no companies disagreed or strongly disagreed with the issues associated with technical and collaborative skills (Figure 4).

The next evaluation highlights employers' perceptions of the AE curriculum's contribution to graduate competencies. To capture these results, Survey 1 provided the basis for the question wording in Survey 2. Employers' perceptions of the curriculum varied track to track. According to Figure 5, more than 50% of respondents in the construction track believe that the AE curriculum needs to include successful project delivery (quality, cost, schedule, safety, and sustainability) and skills that can improve a company's reputation as a leader. In the MEP track, over 40% of respondents felt that the inclusion of topics such as developing client relationships and repeat business strategies was. For the structural track, more than 60% of respondents felt that the emphasis on enhancing the company's reputation as a leader in the industry should be taught. These results show that the inclusion of these four professional skills set components can broadly enhance AE graduates.

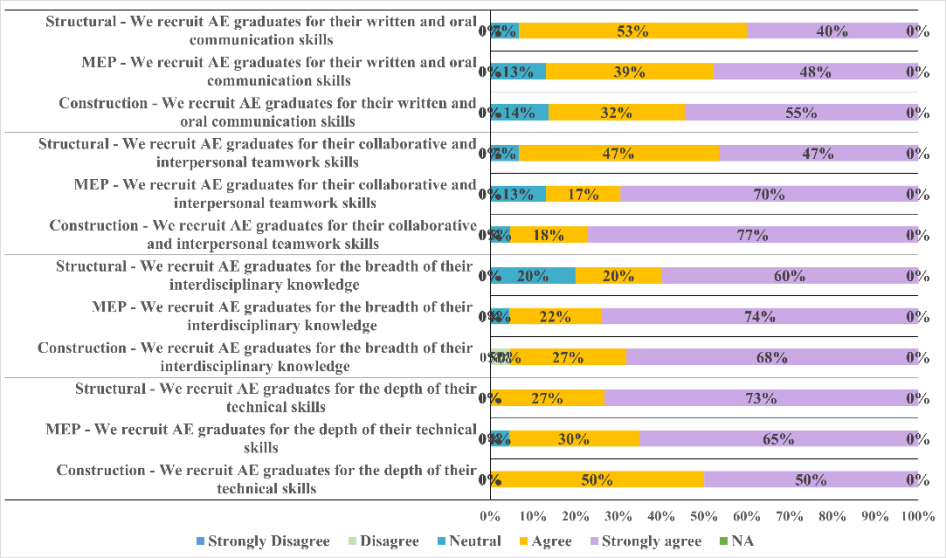


Figure 4: Career Fair Fall 2022 Evaluation of Agreement of graduates' characteristic for success – From Three Tracks.

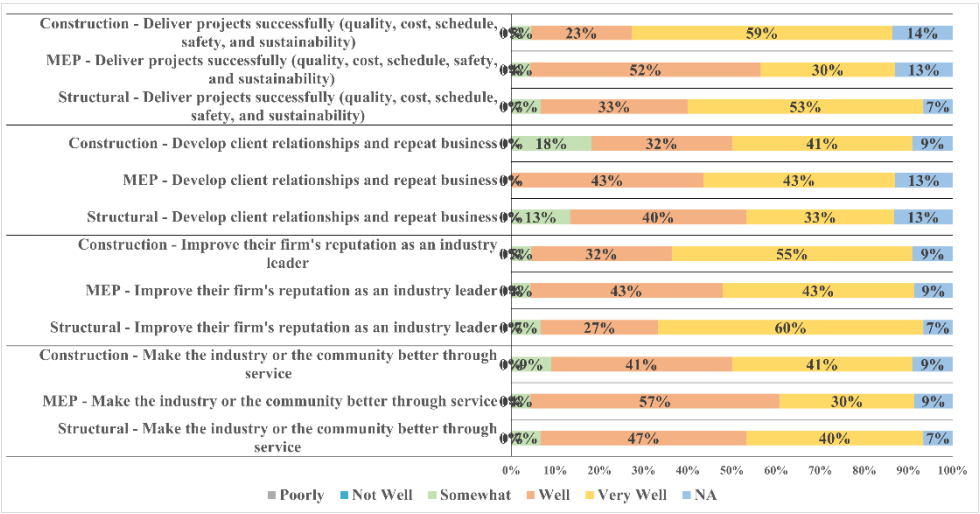


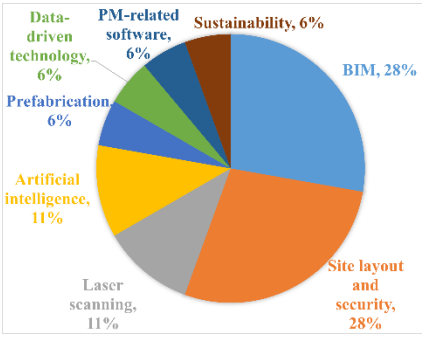
Figure 5: Comparison analysis of Evaluation of "How well does AE curriculums contribute to our graduates' abilities to:" – From Three Tracks.

The last data collected in Survey 2 was through four open-ended questions about the meaning of success in the AEC industry. These questions revolved around establishing the characteristics and possible technology skills. Knowing these answers, AE departments can reflect on what needs improvement to better prepare students.

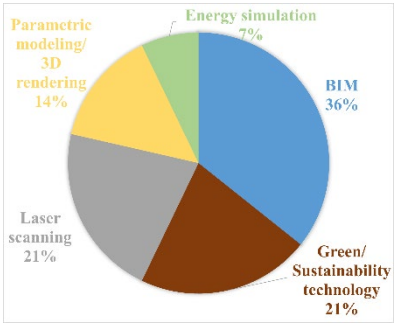
- What emerging technology is influencing the way your firm performs its tasks?
- How is emerging technology influencing the way you work in integrated design/construction processes?
- What knowledge or skills related to technology should students develop?
- Please suggest any changing needs or directions the AE department should consider for our students to effectively work as they move into industry positions.

According to the compiled answers, the three different tracks have a different emphasis to these four open-ended questions. First, the technology side of what influences firms' work was summarized

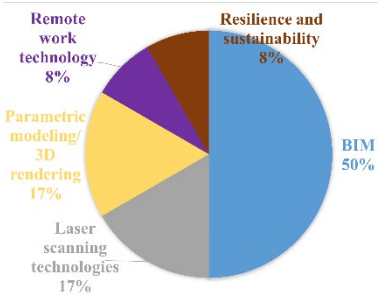
(Figure 6a-c). For construction track firms (Figure 6a), building information modeling (BIM), site layout, security, and laser scanning technologies were mentioned most often. Moving to the MEP track (Figure 6b), BIM and laser scanning were mentioned the most, while sustainability-related technologies were also recorded. The employers in the structural track (Figure 6c) consider BIM and laser scanning to be particularly significant, but they also emphasized the importance of parametric modeling/3D Rendering as future needs. To summarize, technology, notably BIM and laser scanning technologies, have been shown to be very important in the AEC industry in terms of their contribution to different project work thus, their inclusion was expected.



Construction Track
Fig: 6a



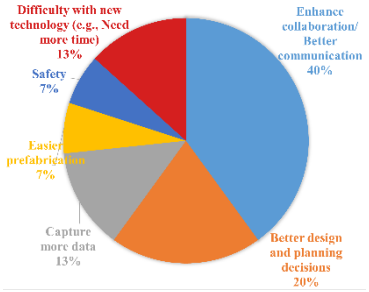
MEP Track
Fig: 6b



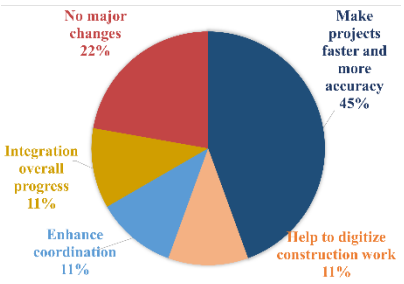
Structural Track
Fig: 6c

Figure 6: Summary of research question: 'What emerging technology is influencing the way your firm performs its tasks?'.

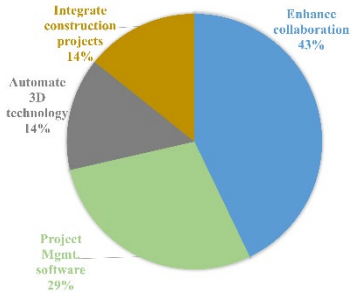
The second question explored how emerging technologies would affect the way AEC companies work on integration design/construction processes. More than 40% of the respondents in the construction track (Figure 7a) believe that emerging technologies can facilitate collaboration and the ability to communicate with each other. It is also vital to note that two respondents felt that emerging technologies would cause AEC firms to take more time to learn and would be somewhat difficult to implement (Figure 7a). For the MEP Track (Figure 7b), over 40% of respondents believe that these technologies make the design process faster and/or more accurate. That said, there are also two respondents who felt that emerging technologies do not have a major contributing role. Lastly, for the structural track (Figure 7c), more than 40% of respondents believe that emerging technologies could enable structural companies to collaborate more. Moreover, Figure 7a and 7c indicate that respondents in the construction and structural tracks think very similarly to each other compared to the MEP track. It is clear from this that emerging technologies in the AEC industry are a strong catalyst for industry collaboration, allowing AEC projects to be completed more accurately and quickly.



Construction Track
Fig: 7a



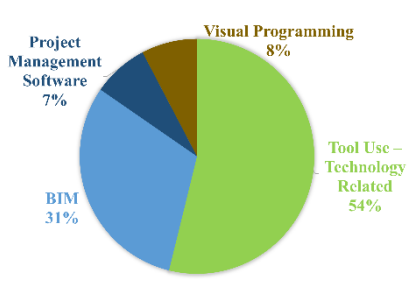
MEP Track
Fig: 7b



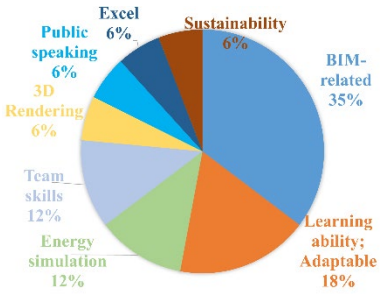
Structural Track
Fig: 7c

Figure 7: Summary to research question: 'How is emerging technology influencing the way you work in integrated design/construction processes?'.

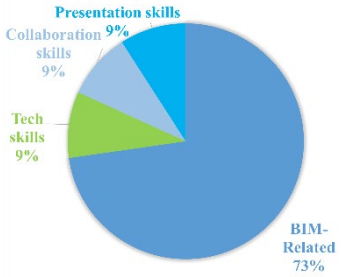
Third, when it comes to the technology-related knowledge or skills that students should develop, companies with different tracks had different answer priorities. The construction track (Figure 8a) suggested that students should “select appropriate tools”, “connect with current tech. skills”, and "be adaptive to learning how to learn a new technology/system." These responses showed that being able to adapt and self-learn technology-related was more important than a particular version or software. Furthermore, in both the MEP and structural tracks (Figure 8b and 8c), firms emphasized that AEC students should develop BIM-related skills such as "Dynamo (Visual programming)", "Revit", "BIM", and "MEP drafting in Revit" to design with and document with appropriate coordination, documentation, and collaboration software.



Construction Track
Fig: 8a



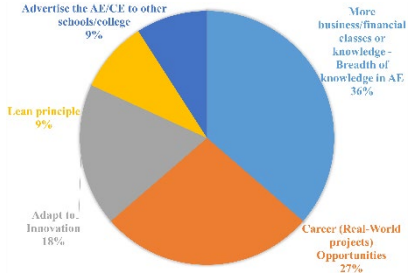
MEP Track
Fig: 8b



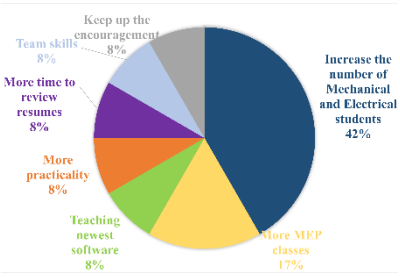
Structural Track
Fig: 8c

Figure 8: Summary replies to ‘What knowledge or skills related to technology should students develop?’.

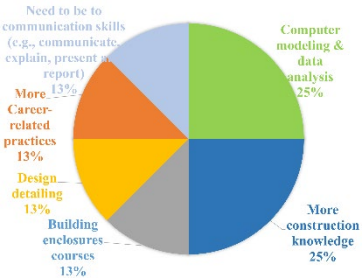
Lastly, firms were able to provide suggestions for changes in the AE department that would facilitate effective work culture for students. Employers in the construction track believed that more emphasis on interdisciplinary course content should be created while also providing further opportunities for students to practice with real-world engineering projects (Figure 9a). In the MEP track (Figure 9b), new emphasis should be added with more mechanical and electrical content/courses for more robust understanding of systems and comprehensive design. In the structure track, employers suggested adding more computer modeling, data analysis, and construction-related knowledge (Figure 9c).



Construction Track
Fig: 9a



MEP Track
Fig: 9b



Structural Track
Fig: 9c

Figure 9: Summary replies to ‘Please suggest any changing needs or directions the AE department should consider for our students to effectively work as they move into industry positions.’.

Discussion

Based on the previously mentioned and cited literature, the current foundational knowledge taught within engineering and specifically within AE provides conventional thinking philosophies regarding interdisciplinary learning. Here, initially identified relationships across our data and literature suggest that breadth of knowledge and teamwork are two essential factors that facilitate interdisciplinary learning. Our major takeaways from these two sets of similar yet slightly different data is divided into two sections: 1) company perceptions of interdisciplinary success and 2) company perceptions of interdisciplinary education in the curriculum.

Of particular note is that construction firms want AE graduates with interdisciplinary experience, giving students both exposure to interdisciplinary perspectives and the opportunity to build these professional skills working in a collaborative environment. Likewise, MEP and lighting companies strongly agree with these exposure ideas. Notably, AEC industry prefers graduates who have a breadth of disciplinary and interdisciplinary knowledge and who can quickly understand and become proficient collaborators and integrators within project teams. Excellent collaboration skills coupled with a comprehensive breadth of knowledge are two key factors that continued to recur in the data.

A key takeaway for educators is the effort to reflect on if they provide this experiences, knowledge, and enhancements to their interdisciplinary education. An interesting finding here is that what many students consider most valuable (e.g., technical skills) is listed the least, while interdisciplinary collaboration is listed the most. While it is not feasible to add all emerging technologies directly to the packaged curriculum, it is possible to do so through formal and informal discussions, lessons, topics, and some introduction to these elements. For educators who need guidance on what content to review in their current courses, Figures 6 and 7 provide a list of skills, emerging technologies, and characteristics that the industry considers as success factors based on the different disciplines in the AEC industry. A color scheme was used so as to show the frequency of factors on students' successful future career based on different disciplines.

Conclusion

Industry 'success' is, to some extent, a universal aspiration for all aspects of the AEC industry, and the success of graduates is indicative of the growth and success of the architectural, engineering and construction industry and its academics. For academics to produce high-quality graduates, it is important to identify the specific factors that influence student success and to determine how a curriculum contributes. Based on the results of two industry surveys, it was found that interdisciplinary learning, including an interdisciplinary-based curriculum that provides these educational opportunities within a strategic context, is important for graduation and should be included in relevant AE departments. Furthermore, the results show that the success of AE graduates is directly linked to the growth and success of the AEC sector, which consolidates the company's reputation, competence, and responsiveness to the needs of its owners.

Results show that interdisciplinary and multidisciplinary settings provide a wide range of knowledge from different disciplines, thus enabling graduates to gain a more comprehensive working understanding of the AEC industry, which can benefit their practical careers on projects. At the same time, their ability to work in teams and their breadth of knowledge across disciplines should contribute more to interdisciplinary learning while striving to maintain their theoretical and technical skills, thus enabling them to achieve greater success. Interdisciplinary learning contributes to success, as indicated by firms from a project and firm perspective. The theory and practice of working through interdisciplinary topics can jumpstart their careers. If greater emphasis on interdisciplinary learning is placed within a curriculum, perhaps team and peer collaboration can be improved also. Future research should examine more factors that contribute to the 'success' of engineering graduates, such as the relationship between metacognition and interdisciplinary learning and the impact on the future success of AE students.

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