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One Path to Inspiration: Student Competitions in Engineering

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One Path to Inspiration: Student Competitions in Engineering

Abstract

There is a need to inspire, recruit, and retain prospective engineers to join the civil engineering profession and help them see the diversity of the occupation and the impact graduates can have on their communities. One way to do this is through student competitions, which are a popular extracurricular activity in many civil engineering programs in the United States. A host of different professional organizations and universities have created and organized these competitions for students. Some competitions, like the Concrete Canoe, have existed since the 1960's, while newer competitions related to Sustainability and Construction have been piloted or are now options for students. Due to the diversity of civil engineering, these competitions vary in topic and complexity.

While the civil engineering profession has developed many excellent design competitions, the reality is that other engineering professions have also continued to create new, cutting-edge, interesting competitions. The civil engineering profession may have an opportunity to create new competitions or amend current ones to make them more effective at attracting, retaining, and inspiring students. The goal of this study was to assess a sampling of the current student competitions available to all engineering students and compare their attributes. Seventy-five competitions were identified, and different aspects were compared, including the founding year, perceived student disciplines, mode and frequency of the competitions, resources required, team and participant characteristics, and participant incentives.

Results indicated that there are a significant number of student competitions across engineering disciplines. The civil engineering profession provides a plethora of competition options, similar to mechanical and electrical engineering, but the civil engineering competitions are much less likely to be cross disciplinary. Civil engineering has some of the oldest competitions, well developed regional symposiums hosted by the American Society of Civil Engineers (ASCE) and continues to add competitions on a regular basis. Unlike other engineering fields, civil engineering competitions offer fewer virtual competition options, exclude graduate students from participating, allow fewer teams per university to participate (and hence fewer students overall), and have fewer attractive incentives in the form of prize money, national travel for recognition, and established industry sponsorship.

Introduction

Civil engineering (CE) is currently challenged with declining student interest and decreasing workforce numbers, while societal needs for infrastructure continue to increase [1, 2]. There is an urgent need to inspire the next generation of CE students who can see the creativity needed to build resilient and sustainable infrastructure that serves the needs of diverse communities. Despite this need, CE continues to attract limited interest for reasons such as (i) the perception that CE focuses narrowly on construction and infrastructure and (ii) overlooking the diversity of CE through the lens of modeling, design, project delivery, and long term monitoring that enable major quality-of-life improvements for everyone, but especially for those in the most challenging environments. One approach (of many) to address this issue is to promote the profession and complex challenges that must be solved through university-level student competitions to inspire future professional civil engineers.

Student competitions are a very popular extracurricular activity in many CE programs in the United States. Since approximately 1987, a host of different professional organizations and universities have created and organized CE competitions for students; historic examples include the American Society of Civil Engineers (ASCE) Concrete Canoe and American Institute of Steel Construction (AISC) Steel Bridge. Newer competitions include the ASCE Sustainable Solutions (formed in 2019) and the American Concrete Institute (ACI) Concrete Bowling Ball (formed in 2002). Due to the diverse nature of the CE profession, these competitions vary in topic and complexity and have expanded into areas such as construction, sustainability, and architecture.

Annual participation in student competitions creates notoriety for the participants, their universities, and the profession. It is recognized that participating in one of these events is a high-impact educational experience, which can also lead to increased recruitment and retention. Students who engage with these types of competitive projects often develop skills in communication, teamwork, ethics, and public policy. Furthermore, collaborative cross-disciplinary projects have helped connect students across different CE subdisciplines and some projects even expose students to other fields of engineering.

The hypothesis of this study was that newer, innovative, and/or attractive student competitions may be able to serve as one of the primary mechanisms to solve the decline of student interest in CE. Student competitions that utilize modern (or future) technology, serve to address modern (or future) societal issues, and relate to the next generation(s) of CE students are critical to compete with similar cutting-edge interdisciplinary projects in other fields of engineering, such as the National Aeronautics and Space Administration (NASA) Lunar Autonomy Challenge, American Society of Agricultural and Biological Engineers (ASABE) Robotics Student Design Competition, or SAE GM Autodrive Challenge. The goal of this study was to assess the current student competitions available to CE students and compare their attributes to those from other disciplines.

Background

Student competitions are defined as activities that provide an avenue for students to solve a problem and demonstrate the merits of their solution. Student competitions have existed for many decades and have become an essential part of engineering education [3]. ASCE uses competitions to excite students, provide them exceptional value, and encourage them to stay involved in the profession through lifelong membership. ASCE's Concrete Canoe Competition is one of the oldest competitions, beginning in the 1960s, and formally advertised as a competition since 1988 [4]. Likewise, the Steel Bridge Competition, sponsored by ASCE and AISC, began in 1987 and became a recognized national competition in 1992 [5]. Both are large, national competitions in which thousands of students partake each year, but they are not the only avenues for participation and inspiration. As the number of national-level competitions continues to increase, ASCE created the "ASCE Civil Engineering Student Championship" in 2023 to increase opportunities and excitement for their competitions [6, 7]. Numerous other societies and companies have introduced student competitions to recruit and inspire students [8]. As of the mid-2020's, there are competitions in a wide number of CE disciplines, including structural, environmental, geotechnical, transportation, surveying, and water resources.

The benefits of participating in student competitions can be extensive and long lasting. The competitions can promote interest and engagement in engineering that is not always seen in a classroom setting [9]. Many of the competitions present interdisciplinary, open-ended problems that require students to connect ideas from multiple classes and clearly communicate the solution [10, 3, 11]. Material learned in the classroom is put to practical use when solving design projects. The gaps between perceived and real-world applications can be closed with these projects, and the process of working through these projects is as important as the final product [12, 13]. Learning to produce a solution to a realistic problem is not easy and demands that students look beyond what they learn in the classroom [14, 11]. Many different design challenges have led to documented increases in technical and problem solving skills and can be used to foster an improved innovation mindset [15]. Participating in student competition design projects has also resulted in long-term retention of subject matter [12].

Many engineering curricula primarily focus on the attainment of technical knowledge and the relevant technical skills needed to solve problems. Competitions provide an avenue to learn many other 'soft skills' that are not the focus in most engineering curricula [16, 17, 9]. In addition, competition projects provide intrinsic benefits such as an increased sense of belonging and community, increased sense of self-efficacy and accomplishment, broadening participation of underrepresented groups (particularly women), increased self-drive, and improved management skills [18]. Furthermore, participation in innovative competitions has shown increases in creativity, initiative, leadership, and entrepreneurial spirit [19]. Students enjoy the opportunity to gain recognition for the work they have done and receive feedback from professional engineers [17]. Many students also have a competitive spirit, are highly motivated to compete against other students and universities, and benefit from adding competitions as part of their education [13, 20, 12].

Because of the open-ended problem statements in competitions, these projects may be used in classes or as part of an engineering curriculum. The student learning objectives, and more specifically CE program criteria for ABET, may be connected to student competitions. Some universities even implement student competitions in capstone-style or independent study courses to expose students to teamwork, communication skills, and application of design knowledge [10, 21]. Many of these skills are desired by industry and help students become career-ready [22].

Equipping graduates for the workforce is an important goal, but getting students to start and persist through college is even more important. Industry and academia are both faced with fewer students entering college and hence the workforce. Each engineering field is continuously trying to recruit new students to enter the major/profession and then retain those students. This has not proven trivial due to a drop in eligible college students, the perception that college may not be a good investment, or the perception that college may not be needed to start a career [23]. Competitions can be used to increase awareness among the public; awareness of the profession in all senses is, in many ways, one of the biggest benefits of incorporating creative, new resources into the competitions [24, 11]. Connections can also be made between industry and university programs when they work together to create and implement new design competitions

[25, 26, 27]. This is beneficial to both the employers who want competent employees with experience and students who want to be employed.

Unfortunately, there can also be downsides to participating in competitions. One of the biggest drawbacks is the fact that most competitions are extracurricular activities and take a substantial amount of time [28]. Additionally, it has been reported that women are not as represented in many competitions, can respond differently to the competitive project environment, and can feel excluded from the projects, particularly the hands-on aspects [29]. Another downside is that many competitions require significant financial, space, and equipment resources that can prevent some students and universities from participating or competing at the same level. While working with industry sponsors can help alleviate these needs, making the connections and having the time to work together is not a trivial task [27].

Student competitions are widely available to CE students and can provide significant benefits. Competitions can clearly create excitement, inspiration, and encourage students to enter the profession they promote. The question to consider is, how do the CE student competition options compare to those available to other engineering students—are there opportunities for the CE profession to revise or create new competitions that are more effective at attracting, retaining, and inspiring students while also educating the public? Answering this question may be one path to solving the larger issue within CE, which is the need to increase student interest and professional workforce numbers to align with current and future societal needs.

Research Questions

The focus of this study was to gather data on common design competitions available to engineering students in a variety of disciplines, including CE. In particular, answers to the following research questions were sought:

1) What are the common types of competitions available to engineering students?
2) What resources are required (time, money, materials, space, external support, travel, etc.) to participate in student design competitions?
3) What type (field of study and educational level) and how many students participate in each competition?
4) In what form and quantity are prizes awarded in each competition?
5) Are there unique or attractive styles / types of competitions that are currently not common or available to CE students?

Research Methods

This study investigated common engineering competitions available to university-level students during the 2024-2025 academic year; unofficial pilot competitions and competitions not offered during the academic year of investigation (i.e., those offered sporadically) were not considered. Furthermore, the plethora of K-12 student competitions were also not investigated in this study. Many types of university-level competitions and sponsoring agencies were identified, including those from common engineering professional societies; furthermore, competitions sponsored by industry groups, nonprofits, and government organizations were identified. Advertisements, internet searches, personal interviews/inquiries, and previous experience were used to identify the competition sponsors listed in Table 1.

Table 1—Sponsor names and acronyms for university-level student competitions investigated in this study.

	Sponsor	Acronym (alphabetical)	No. of Comp.
1	American Concrete Institute	ACI	2
2	Architectural Engineering Institute	AEI	1
3	Audio Engineering Society	AES	2
4	American Institute of Aeronautics and Astronautics	AIAA	7
5	American Institute of Steel Construction	AISC	1
6	American Society of Agricultural and Biological Engineers	ASABE	3
7	American Society of Civil Engineers	ASCE	6
8	American Society of Heating, Refrigerating and Air-Conditioning Engineers	ASHRAE	4
9	American Society of Metals	ASM Intl.	1
10	American Society of Mechanical Engineers	ASME	9
11	Biomedical Engineering Society	BMES	1
12	Council on Tall Buildings and Urban Habitat	CTBUH	2
13	U.S. Department of Energy	DOE	2
14	Institute of Electrical and Electronics Engineers	IEEE	18
15	Kern Entrepreneurial Engineering Network	KEEN	1
16	National Aeronautics and Space Administration	NASA	4
17	Precast/Prestressed Concrete Institute	PCI	1
18	Society of Automotive Engineers	SAE	7
19	Society for Mining, Metallurgy, and Exploration	SME	1
20	Vertical Flight Society	VTOL	1
21	Water Environment Federation	WEF	1
		Total	*75*

The 21 sponsors listed in Table 1 are responsible for hosting and maintaining a total of 75 competitions that were included in this study, as listed in Table 2. While the list is not exhaustive, it was deemed to include an appropriate amount of common competitions that were readily available for comparison, commonly advertised, and taking place in the 2024-2025 academic year. The list in Table 2 shows that many of the sponsors are responsible for organizing multiple competitions, ranging from 1 to 18+ competitions (IEEE).

Table 2—Sponsor and name of the 75 university-level student competitions investigated in this study.

Sponsor		Competition (Comp.) Name	Sponsor		Competition (Comp.) Name
1	ACI	FRC Bowling Ball	38	CTBUH	Mass Timber Student Design Comp.
2		Pervious Concrete Cylinder	39		International Student Tall Building Design
3	AEI	International Student Design Comp.	40	DOE	Solar Decathlon - Design Challenge
4	AES	Saul Walker Student Design Comp.	41		Solar Decathlon - Build Challenge
5		Matlab Hackathon	42	IEEE	Student Design Challenge
6	AIAA	Undergraduate Team Space Transportation	43		AP-S Student Design Contest
7		Open Division Missile Systems Design	44		Lance Stafford Larson Paper Contest
8		Undergraduate Individual Aircraft Design	45		App. Comp. for Intelligent Reality (ACIR)
9		Undergraduate Team Aircraft Design	46		WIE Manga Story Contest
10		Graduate Team Aircraft Design	47		International Future Energy Challenge (IFEC)
11		Design/build/fly	48		Maiman Student Paper Comp.
12		Intercollegiate Rocket Engineering Comp.	49		Singapore AUV Challenge
13	AISC	Steel Bridge	50		MTT-Sat Challenge
14	ASABE	Robotics Student Design Comp.	51		Intl. Contest Sensors and Measurement Sys.
15		AGCO National Student Design Comp.	52		Radar Challenge
16		KK Barnes Student Paper Award	53		VTS Motor Vehicles Challenge
17	ASCE	Concrete Canoe	54		RoboCup
18		Sustainable Solutions	55		Signal Processing Cup (SP Cup)
19		Surveying	56		ComSoc Student Comp.
20		Timber Strong	57		IEEEXtreme
21		Construction Institute Student Symposium	58		IEEEmadC
22		Mead Paper	59		Student Ethics
23	ASHRAE	Design Comp.	60	KEEN	Styrofoam Bridge
24		Applied Engineering Challenge	61	NASA	Student Launch
25		Building EQ (Building Energy Quotient)	62		Human Exploration Rover Challenge
26		HVAC&R Student Paper Comp.	63		Lunar Autonomy Challenge
27	ASM Intl	Undergraduate Design Comp.	64		Lunabotics
28	ASME	e-Human Powered Vehicle (e-HPVC)	65	PCI	Big Beam
29		Student Design Comp. (SDC)	66	SAE	BAJA SAE Series
30		Innovative Additive Manufacturing 3D	67		SAE Aero Design
31		Oral Comp.	68		GM Autodrive Challenge
32		Elevator Pitch	69		Clean Snowmobile Challenge
33		XRC Lunar Lander	70		Formula Hybrid+Electric
34		XRC Autonomous Vehicles	71		Formula SAE
35		Technical Digital Poster	72		Formula Electric
36		Old Guard Graduate Student Video	73	SME	Student Design Comp.
37	BMES	Medtronic Student Design Comp.	74	VTOL	Student Design Comp.
			75	WEF	Student Design Comp.

The website, rules, and registration information for each competition were reviewed and common data were compiled based on the list of 17 categories in Table 3; the list included an "other" category to capture unique information about a specific competition. These categories were chosen to compare the mode of the competition, recurrence interval, resources needed, unique skills gained, teams per university, students per team, total number of participating teams, accessibility to students, prizes, and notoriety. The goal was to find similarities and differences among competitions.

Table 3—Categories and types of data collected for each university-level competition investigated in this study.

Category		Type of Data Collected
1	Sponsor	Acronym (Table 1)
2	Name	Competition name (Table 2)
3	Year	Founding year of competition
4	Perceived Student Discipline	Architecture (A), Aerospace Engineering (Aero), Architectural Engineering (AE), Agricultural Engineering (AgE), Biomedical Engineering (BE), Construction (CM), Civil Engineering (CE), Chemical Engineering (ChE), Computer Science (CS), Electrical Engineering (EE), Mechanical Engineering (ME), Mining Engineering (MIE), Materials Science (MS)
5	Description	Summary of competition type (e.g., hands-on build, design, paper, computer-based)
6	Mode	In-person at competition site (IP), initial judging of online submission (IO), asynchronous online (O), synchronous virtual (V), local testing (L)
7	Recurrence	Annual, biennial (every-other year), less frequent
8	Cost types	Materials (M), travel (T), registration (R), not available (n/a)
9	Resources	Not available (n/a), financial stipend ($), software, industry advisors
10	Skills	Listed skills that may be obtained by participants
11	Teams per university	Number (e.g., 1, 2, no limit)
12	Maximum team size	Maximum number of students per team (e.g., 1, 5, 10, no limit)
13	No. participating teams	Number of finalist teams participating in the most recent competition
14	Level	Student participant enrollment level: undergraduate (UG) or graduate (G)
15	Prizes	Money ($), travel stipends, award certificate, scholarship for courses
16	Notoriety	Online (e.g., sponsor website), conference (e.g., recognition at annual sponsor conference), mass media/news outlets (e.g., newspapers, television news, magazines)
17	Other	Additional unique information

Results and Discussion

<u>Founding year of competitions</u>

The year each competition was founded (created) was used as a metric to compare how the competition topic aligns with societal issues, with the basic assumption that older competitions may be associated with older societal topics while new competitions may be more associated with modern societal topics; updates within the rules of individual competitions to adjust to modern societal issues were not investigated as part of this metric. Date ranges in Figure 1 indicate that four of the competition sponsors did not report any founding dates for their competitions, which equated to 30 of 75 competitions (40%) not having founding data information publicly available. Data in Figure 1 indicate that student competitions date back to the decade between 1975-1985 and were created as recently as 2024; the ASCE Mead Paper competition was created in 1939, but this date was not used in Figure 1 for clarity. Overall, the highest number of student competitions were created between 1995-2005, and the number of student competitions created since the year 2000 are much greater than those created prior to 2000. However, only 5 of the 21 sponsors with publicly available information have created a student competition after 2020, which corresponds with the creation of 7 competitions.

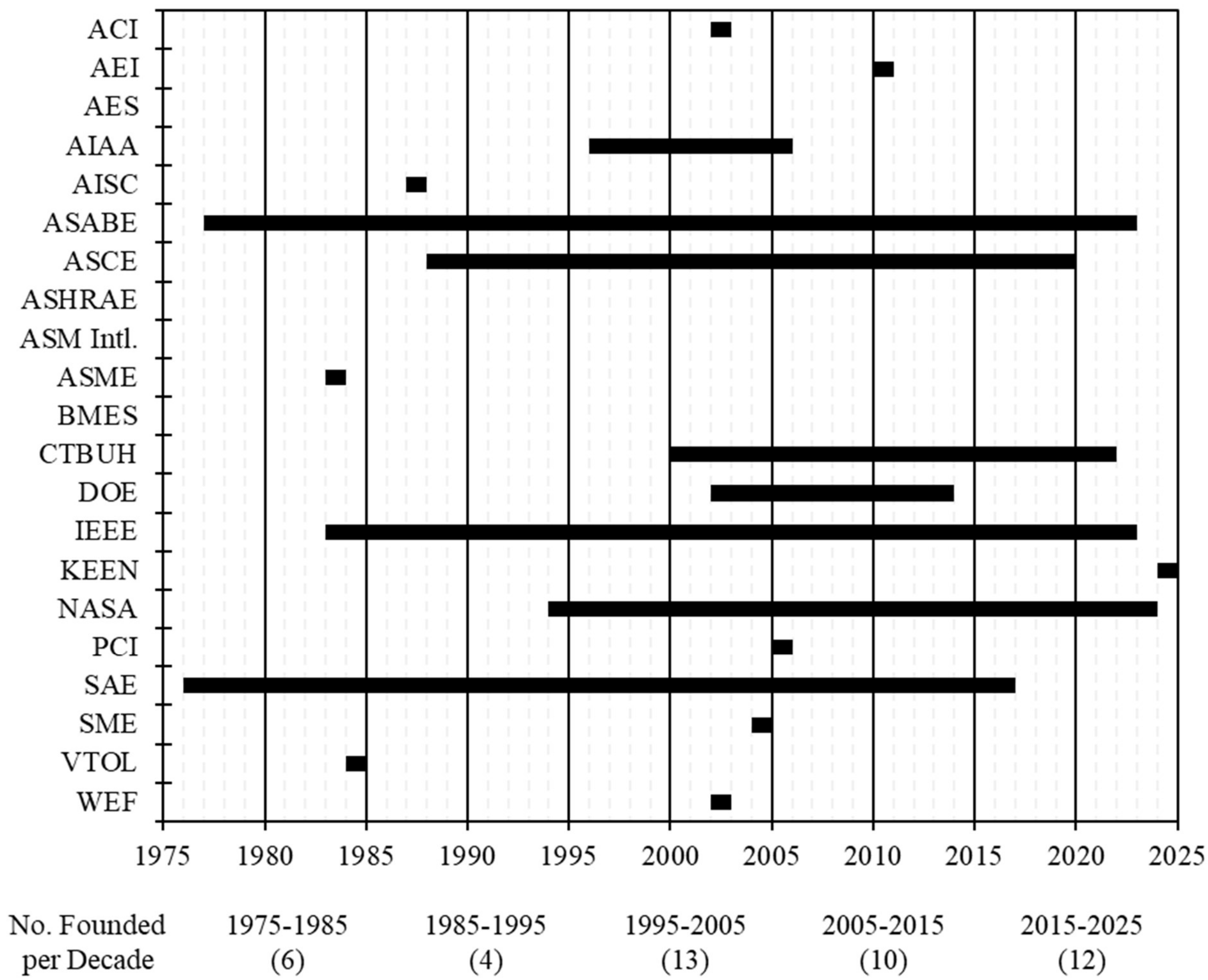

Figure 1—Range of dates when university-level student competitions were created by each sponsor.

The overall range of when CE competitions were created is from 1988-2020, which matches the ranges of other prominent competitions/sponsors. The competitions that have been founded after 2020 are sponsored by ASABE, CTBUH, IEEE, KEEN, and NASA.

Perceived student discipline

The perceived discipline of students who would primarily be involved in each competition was categorized; the disciplines were labeled as perceived because any student could likely be a part of any competition, but linking the competitions with the students who would primarily compete was sought. For example, robotics competitions may often require mechanical engineering, electrical engineering, and computer science students, while competitions associated with building scaled houses may require architectural, civil, and construction management students. In the case of multidisciplinary involvement, each of the relevant disciplines was counted. Data in Figure 2 show that many of the student disciplines identified in this study have relatively few exclusive competitions sponsored by a professional society or affiliated industry. The four disciplines with the highest number of student competitions are CE, computer science, EE, and ME; however, the ME and EE disciplines have significantly more student competitions that are primarily sponsored by ASME/SAE and IEEE, respectively.

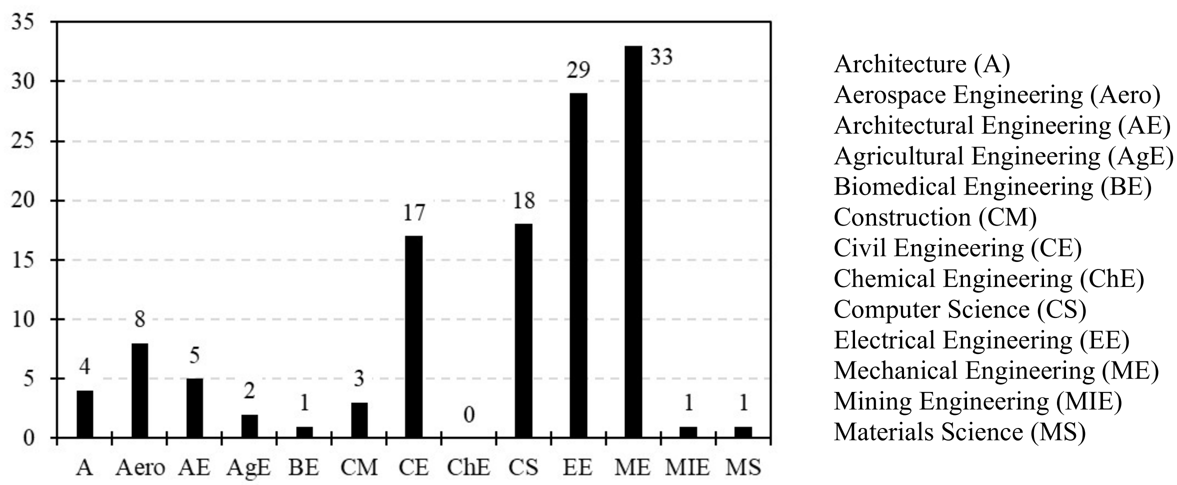

Figure 2—Number of university-level competitions in each perceived student discipline.

CE students have access to a high number of student competitions compared to the other disciplines in this study. A deeper investigation of the data indicated that only 6 of the 17 (35%) CE competitions may be cross-disciplinary. However, mechanical and electrical engineering have 22 of 33 (67%) and 19 of 29 (66%) competitions that are cross-disciplinary, respectively. When compared to CE, mechanical and electrical engineering have over twice as many competitions that involve numerous engineering disciplines.

Mode, recurrence, cost types

The mode in which the student competitions are completed was investigated. For this study, the categories included in-person at the competition site (IP), initial judging of an online submission (IO), asynchronous online submission/judging (O), synchronous virtual competitions (V), and competitions that require local testing (L) of a component or element. Furthermore, most student competitions require a combination of these elements. For example, data in Figure 3 show that the most common mode of student competitions is the combination of an online submission that is judged prior to an event where the teams compete in-person (IO, IP). The next most common type of event is those that only require an asynchronous online submission that is judged (O); these types of competitions typically involve submission of a paper, report, video, or final design document that is judged without an in-person event. The least common types of competition mode were those that require local testing of a component or element (L) or those in which the students fully participate synchronously in a virtual environment (V).

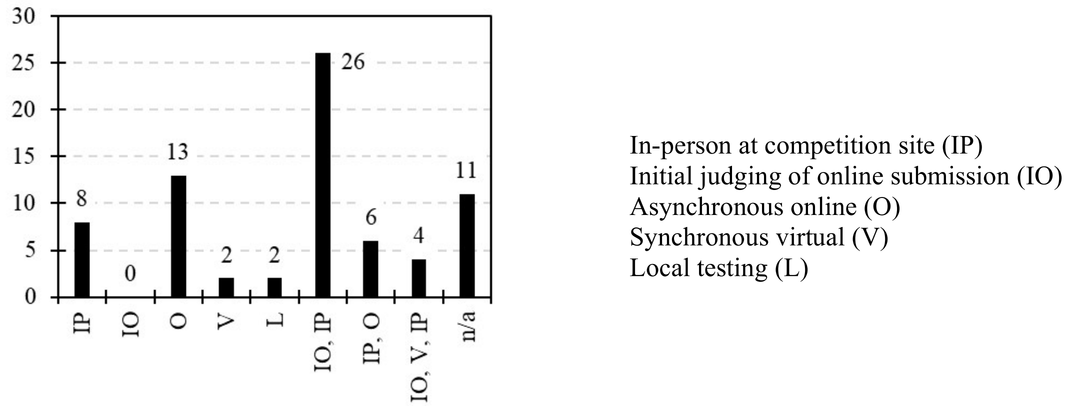

Figure 3—Mode of university-level competitions investigated in this study.

Overall, most student competitions recur on an annual basis (71%). Approximately 4% of the student competitions investigated in this study are sponsored on a biennial basis (every-other-year), and 5% of competitions occur once every three years. However, of the 75 student competitions investigated, it was not evident what the recurrence interval was for 15 of the 75 events (20%).

Many student competitions require financial, space, and equipment resources that were grouped into the materials (M) category in this study. Furthermore, other frequent costs that students may incur during a competition are those associated with travel (T) to or registration (R) for a professional conference where the competition occurs. When collecting data in this study, it was assumed that material costs would be incurred if student teams are required to fabricate any type of specimen (even though those costs may be offset by donations or industry sponsorship) and travel to/registering for a conference to compete in-person (even though some or all of those costs may be covered by the university or sponsoring agency). Data in Figure 4 indicate that the most common type of cost is the combination of materials, travel, and registration. However, approximately 37% of competitions did not distinctly report all the costs that student groups might incur or the rules/registrations were blocked to the public and only accessible to registered student teams.

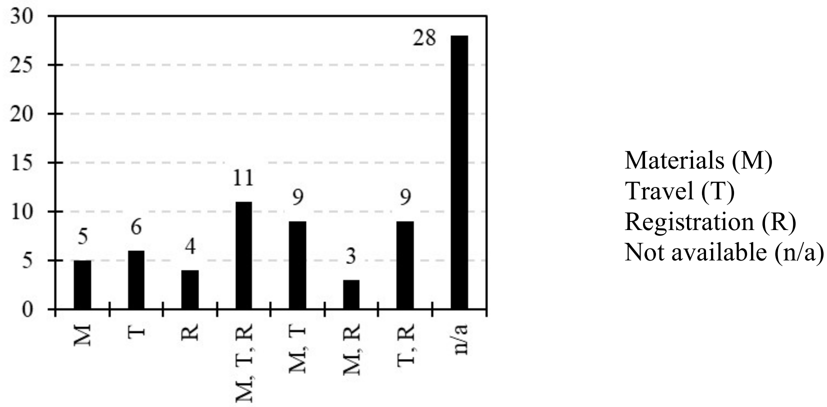

Figure 4—Cost types of university-level competitions investigated in this study.

<u>Team and participant data</u>

Considering all the student competitions, the most common number of teams that can be entered by any single university was either 1 or an unlimited number, as shown in Figure 5. Furthermore, the number of individuals allowed on any single team in the student competitions varied, but the most common requirements were 1 person (e.g., essay, poster, video, etc.), 10 people, or no limit on the team size, as shown in Figure 6. Publicity from some of the competitions noted how many teams recently participated and the rules/regulations sometimes noted the maximum number of teams allowed to participate in the university-level student competitions; data in Figure 7 show that the number of teams participating ranged widely, from 6 to 10 teams up to approximately 450 teams. Furthermore, competitions often only specified that there was no maximum limit on the number of teams that could participate—the IEEEXtreme competition stated that there were over 8700 teams participating in 2024, which was omitted from Figure 7 for clarity. Finally, considering the rules/regulations of each competition, data in Figure 8 indicate that the most common team composition can include a mix of both undergraduate and graduate students (UG, G), which is applicable to approximately 50% of the competitions; the next most common team composition is only undergraduate students, which is applicable to approximately 30% of the competitions.

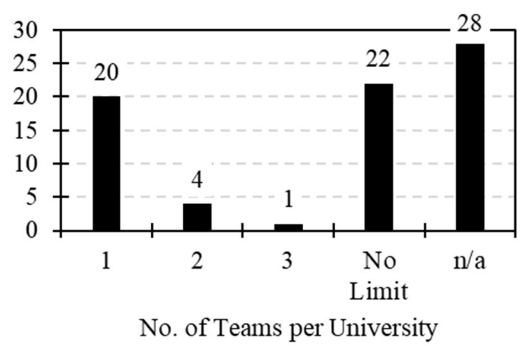

Figure 5—Number of teams per institution allowed in the university-level student competitions.

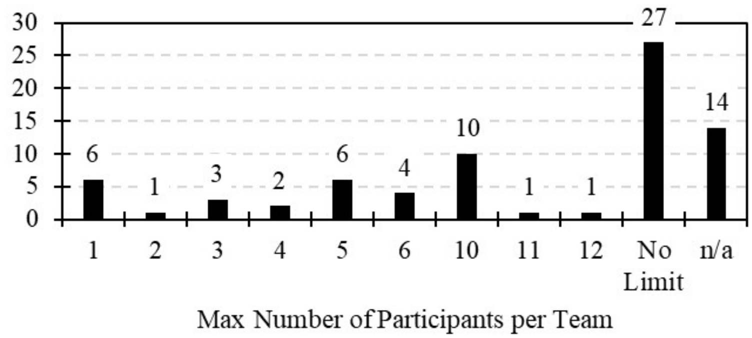

Figure 6—Maximum number of participants per team allowed in the university-level student competitions.

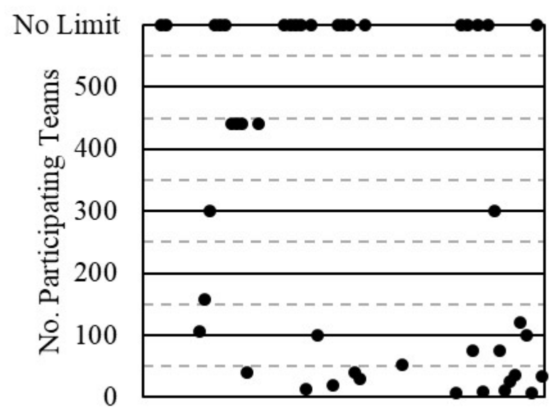

Figure 7—Recent or maximum number of teams participating in the university-level student competitions.

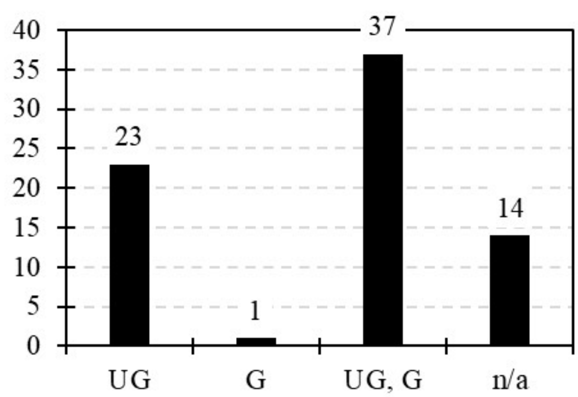

Figure 8—Enrollment level of students allowed to participate on teams in the university-level student competitions. UG = undergraduate, G = graduate.

<u>Prizes and notoriety</u>

The two most common prizes are a monetary award and a physical award that can be displayed at the university (e.g., certificate, plaque, trophy, etc.). The monetary awards are often awarded as a single lump sum (ranging from approximately $1,000 to $50,000) and can be divided among the student team members; the monetary awards are typically highest for the first-place team and can be awarded to many teams (e.g., up to 20 teams total or for the top 3 or top 5 teams).

While collecting data for this study, three types of notoriety were considered:

1. Online (e.g., sponsor website)
2. Conference (e.g., recognition at annual sponsor conference)
3. Mass media/news outlets (e.g., newspapers, television news, magazines)

Overall, the type of notoriety most observed in this study was recognition of the winning team or top set of winning teams (i.e., top 3 or top 5 teams) on the sponsor's website. The second most common type of notoriety for winning teams is the ability to travel and showcase/present at the conference affiliated with the sponsoring organization. By far, the least observed type of notoriety associated with university-level student competitions was recognition in mass media/news outlets.

Summary, Conclusions, and Future Work

The goal of this study was to assess the current university-level competitions available to engineering students, including those in CE, and compare their attributes. Within this, an initial understanding of how student competitions are being used was sought. Internet searches, advertisements, and personal experience were the main tools used to collect student competition data. The following conclusions were drawn from the data collected in this study:

(1) The ways in which students can get involved in competitions are wide ranging. University-level student competitions are popular and have been created since the decade between 1975-1985. The decade surrounding the year 2000 was when the most student competitions began, and some new competitions continue to be implemented each year.

(2) Competitions that focus on communication are very common—the opportunity for teams of one or more students to author a technical paper, technical presentation, research poster, or research presentation abound. These types of competitions have low barriers to entry, such as not requiring multiple students and often not requiring money to compete (i.e., students are not tasked with obtaining materials, traveling, and the competitions may be virtual or asynchronously online).

(3) In-depth, complex, time-consuming student competitions are prevalent and exist across disciplines. Within these competitions, industry sponsorship, hands-on activities, travel, conference attendance, and prize money are often part of the experience. These characteristics (among others) are likely very attractive to a large subset of university-level students, but they can also serve as significant barriers to entry that the universities, industry, and sponsors must continue to alleviate.

(4) About 50% of the competitions had material costs and about 25% had travel or registration costs. Only about 33% of competitions had no significant costs.

(5) While it is hard to determine exact time commitments, nearly all competitions require extra-curricular time outside of classes. Very few were specifically designed to be used in a classroom setting.

(6) Data indicated that CE has a significant number of competitions based on quantity, but the number still trails the quantity available in mechanical engineering, electrical engineering, and computer science. Thus, students have ample opportunities to get involved. However, mechanical and electrical engineering have over twice as many cross-disciplinary competitions as CE.

(7) The makeup of student competition participants and teams is often such that both undergraduate and graduate students can join a team, and multiple teams can form from one university. However, within CE this is often not the case. Typically, student competition teams are formed by undergraduates and the competitions are limited to one team per school. A push for continued participation from graduate students may inspire undergraduates to persist in the field of CE and eventually join the workforce. Furthermore, integrating or connecting student competitions to senior year capstone-style courses may be a good incentive for institutions to participate, faculty to help, and students to be inspired to continue in the profession.

(8) Incentivizing students through prizes such as money, travel, and national recognition, particularly at conferences, was common. Currently, a very limited number of CE student competitions have prizes beyond regional recognition. To continue growing interest in professions such as CE, notoriety of the outstanding work being completed by student groups should be broadcast more widely and publicly (likely in mass media), with the goal of reaching and inspiring the next generation of students. Prize money in the thousands of dollar range was very common in most other competitions. All competitions investigated in this study lacked wide ranging notoriety of student work, which could be a path on which to focus moving forward.

(9) The most significant differences between the CE competitions and other engineering competitions were the lack of virtual competitions, the exclusion of graduate students from participating (as either participants or in their own division), the lack of outreach requirements as part of the competitions (particularly to local K-12 students), and the requirement that only one team is allowed per school. ASCE has a very well defined set of regional competitions at their symposium, and this structure is not as well developed by other engineering societies on the local or regional levels.

(10) The competitions available in CE need to be attractive such that students are willing to commit their limited time and energy, even when universities are focused on streamlining graduation paths and lowering program credit requirements. Overall, a few goals should exist to improve CE competitions: (i) seek to increase the participation rate with low barriers to entry and highly attractive competitions relevant to modern society and issues that future students are/will face in their careers, (ii) add competitions or realign existing competitions in alignment with the first goal, and (iii) modify existing competitions to encourage cross-disciplinary student participation because the collaboration and communication required to complete this type of project would be reflective of the CE industry and align with how engineers will need to solve future, complex challenges faced by society.

Future work should be conducted to characterize student perceptions of the competitions that they deem the most impactful and inspirational to their education, interests, and the future of society. This could include collecting data from student surveys or focus groups to determine if the competitions available provide an adequate path to inspiration, engagement, and persistence. For example, do students perceive they have a high quantity of student competitions options but lack quality? Do students perceive that the available competitions address the issues they will face in their career or will the newly created competitions lack longevity? Are students excited to participate in competitions that require a hands-on in-person approach or are they satisfied with online and asynchronous opportunities?

Overall, student competitions are abundant, wide ranging, and a common practice across all engineering disciplines. Civil Engineering should continue to place an emphasis on recruiting and inspiring the next generation of engineering students with student competitions and put resources into old and new competitions alike.

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