Mastering the Hard Stuff: The History of College Concrete-Canoe Races and the Growth of Engineering Competition Culture

Amy Bix, Iowa State University
abix@iastate.edu

Abstract: This article details the history of college engineering competitions, originating with student concrete-canoe racing in the 1970s, through today’s multi-million-dollar international multiplicity of challenges. Despite initial differences between engineering educators and industry supporters over the ultimate purpose of undergraduate competitions, these events thrived because they evolved to suit many needs of students, professors, schools, corporations, professional associations, and the engineering profession itself. The twenty-first-century proliferation of university-level competitions in turn encouraged a trickling-down of technical contests to elementary-age children and high schools, fostering the institutionalization of what might be called a competition culture in engineering.

Keywords: engineering competitions education concrete canoe

Historians have documented the shifting balances of engineering education, between hands-on and theoretical instruction, narrowly-focused versus multidisciplinary. Twentieth-century engineering training came to encompass many components beyond classrooms and studying. National Engineers’ Week, campus technical societies, engineering-student magazines, St. Patrick’s celebrations, and other activities all helped establish undergraduates’ sense of a unique disciplinary identity. Over the last five decades, a new expression of campus engineering culture surged, in which colleges and universities organized teams to enter a multiplying number of regional, national, and international technical contests.

Emergence of what might be called today’s engineering-student “competition culture”
can be traced through the evolution of college concrete-canoe racing, which originated in the 1970s as a small inter-college rivalry, developed by professors as hands-on lessons to help students absorb practice-oriented technical detail by engaging their sense of enjoyment. The American Concrete Institute, American Society of Civil Engineers, and the concrete industry all valued canoe-races as means to promote their institutional interests. Concrete-canoe competitions thrived, while evolving into increasingly-formalized year-round commitments that commanded university investment, business support, and popular attention. That success fostered a proliferation of similar high-profile challenges across engineering disciplines, reinforced by a national agenda in which politicians, educators, corporations, and non-profit groups all valorized STEM education as the twenty-first-century essential. Organized collegiate challenges spilled down to the K-12 levels, where slick messaging touted competitions as the magic solution to make STEM cool for generations to come.

**College Concrete-Canoe Racing’s Origins**

The American Concrete Institute (ACI), an industry and engineering association, played a key role in catalyzing the start of this competition culture in the form of college concrete-canoe competitions. ACI originated in 1904 as the National Association of Cement Users, aiming to promote studies of concrete-block and cement products in order to improve methods, quality, and applications. The organization supervised early materials-testing, issued standards, hosted conferences, and published journals. That knowledge proved useful during World War I, when steel and lumber shortages complicated the drive to build up America’s navy. Knowing that Norway had launched an ocean-worthy concrete ship in 1917, the U.S. Emergency Fleet Corporation planned to construct a “stone fleet” of twenty-four ships with reinforced-concrete hulls. The Concrete Ship Program completed only a few prototypes, too late for action, but
advanced research on lightweight aggregates and improved production techniques.¹

Between the wars, ACI continued promoting both theoretical and practical analysis of materials, practices, equipment, and design. As Amy Slaton details, engineers became increasingly intrigued, as manufacturers developed more affordable, higher-quality cement. Specialists published standards, testing procedures, and inspection methods, mastery of which defined a new professional culture geared toward serving industry. Academics embedded this knowledge-base in courses that promised to transform students into a modern industrial-science elite. “Among university engineering instructors, mathematical formulas, theories, practical experimentation, instruments, and laboratory reports were all invoked… as appropriate means of conveying skills to students,” Slaton writes.² Working with organizations such as the American Society of Civil Engineers (ASCE), concrete specialists established authority to govern testing, a gatekeeping mechanism that in return promised safety and efficiency through quality control.

World War II revived interest in concrete’s naval applications; five shipyards built over one hundred concrete barges and ocean vessels. After war’s end, ACI membership grew to ten thousand, forming seventy technical committees. The group expanded initiatives to address new construction issues, such as nuclear-reactor shield design. Members and staff revised building codes, researched lightweight aggregates and prestressed concrete, and generated more handbooks, monographs, and specialized publications. By 1970, ACI also devoted more attention to education, producing college-curriculum guidelines, complete with textbooks and teaching aids.³

This intersection of concrete expertise, college outreach, and publication proved a perfect opportunity for ACI engineer Mary Krumboltz Hurd to play a key role in mediating the growth

of concrete-canoe racing. Enrolling at Iowa State College during World War II, when
government and industry encouraged female students to advance the war effort by developing
technical skills, Krumboltz joined a small but growing number of women studying engineering.
As a junior, Krumboltz became the first woman elected to edit the engineering school magazine.
In 1946, Krumboltz became the second female student at Iowa State to earn a Woman’s Badge
from engineering honor society Tau Beta Pi, which barred women from full membership. The
Des Moines Register ran a feature on Krumboltz, underscoring the novelty of female success in a
field that most Americans still assumed was “men’s work.”

After Krumboltz graduated in 1947 with a Bachelor of Science degree in civil
engineering, ACI hired her as an engineering assistant to help write, edit, and produce its
publications. She recalled, “Engineers are notoriously not good at written communication, and I
had a lot of writing skills as well as the engineering skills. It was perfect, EXCEPT they didn’t
want a woman,” until a professor intervened to recommend her. Her experience fit the postwar
pattern Margaret Rossiter describes, when chemical and engineering companies channeled young
women with science and engineering degrees into “traditional female ghettos” of technical
journalism, library services, and patent-searching. Lower-pay, subordinate-status desk jobs
reflected and reinforced stereotypes of women as attentive to detail, adept at communication, and
ready “to personify the service ideal,” offering their technical expertise to assist male
researchers.

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1 Wilde, ACI. Robert Eberhardt, “Concrete Shipbuilding in San Diego,” Journal of San Diego
History, 41:2 (spring, 1995).
2 Amy Bix, Girls Coming to Tech: A History of American Engineering Education for Women
3 “Ms. M.K. Hurd, The Reigning Queen of Concrete,” March 8, 2010,
4 Margaret Rossiter, Women Scientists in America: Before Affirmative Action, 1940-1972
(Baltimore:Johns Hopkins, 1995).
After marrying, Mary Krumboltz Hurd took graduate courses at the University of Chicago, University of Michigan, and University of Illinois between 1950 and 1954. From 1956 to 1958, Hurd served as associate editor of the ACI Journal. After that, she set up a private practice preparing engineering reports, industrial articles, and other technical publications. Her 1963 work *Formwork for Concrete* became the standard reference on practice, theory, and safety-issues involved in designing and building wooden and steel frames to support newly-laid concrete during hardening. The title page read “M.K. Hurd,” since she “didn’t want people to not buy the book because it was written by a woman.” Her book, known as the industry “bible,” went into seven editions, selling over 125,000 copies by 2006.

In 1966, Hurd returned to ACI as associate editor, coordinating special publications. From 1967 to 1976, she served as an ACI staff engineer, working with technical committees to compile and review standards and codes. Hurd regularly authored pieces for the *ACI Journal* and other technical publications, covering concrete’s uses in homes, bridges, and landmark structures.

In a 1969 *ACI Journal* article, Hurd reported that the Institute had recently received a “steady flow of questions” about the feasibility of making concrete pleasure-boats or fishing vessels. To satisfy members’ curiosity, her piece described the reinforced-cement boats that French inventor Joseph Louis Lambot displayed at the 1855 Paris exposition, then used on his estate for years. As Hurd detailed, architectural engineer Pier Luigi Nervi built large reinforced-cement ships for the Italian navy during World War II, and his own concrete sailboat. Hurd reported on recent waves of Australian and New Zealand interest in the potential of boats made from ferro-cement, mortar strengthened by multiple layers of wire mesh. Her article praised concrete’s “strength, durability, waterproofness, and economy” as ideally suited for boat-making.

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7 Kari Moosmann, “What’s in a Name?” *Concrete Producer*, March 30, 2007,
To encourage interest, ACI offered readers a one-dollar bibliographic list of more than eighty references to concrete boatbuilding and ferro-cement information.\(^8\)

Not coincidentally, this idea was soon picked up by Clyde Kesler, recent ACI president. Kesler taught engineering at the University of Illinois, which had played a leading role in instruction on applied uses of materials since the late 1800s and maintained cutting-edge laboratories to promote advanced research on concrete.\(^9\) To familiarize students with concrete’s behavior as a structural substance, civil-engineering courses often included experimental projects in designing, mixing, molding, pouring, casting, testing, and evaluating concrete cylinders and beams. Seeking more exciting forms of practical exercises, Kesler had his spring 1970 civil-engineering class construct a canoe out of cement, sand, chicken wire, and reinforcing bars. The *ACI Journal* reported that Kesler considered this canoe “easy to build; from what the group learned[,] they could make another one in a very short time, possibly less than one day.” A photograph of students paddling the canoe seemed to validate Kesler’s assessment that it was “much stronger than necessary and highly seaworthy.” One undergraduate recalled it required the entire class’s musclepower to wrestle the heavy vessel into the lake. Covering Kesler’s results, the *ACI Journal* urged readers to build their own ferro-cement boats, again encouraging them to request guidelines by mail.\(^10\)

Within months, Purdue engineers heard of Illinois’ venture, probably via the head of their school of civil engineering John McLaughlin, chair of ACI’s Technical Activities Committee. As the extracurricular part of a senior design class, Purdue’s ASCE chapter made its own ferro-cement canoe. Their design incorporated technical innovations; Illinois students built their canoe

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\(^2\) Slaton, *Reinforced Concrete and the Modernization of American Building*.
without using any forms, but Purdue shaped its vessel by making a mold based on a standard racing canoe. Purdue also used lightweight mortar, applied epoxy-resin coating, and added polystyrene-foam blocks to gain buoyancy.¹¹

On May 16, 1971, the two campus groups converged at a lake near Champaign, Illinois, for a head-to-head match-up. Purdue’s 125-pound craft appeared far sleeker than Illinois’s 370-pound behemoth. Purdue students believed their lighter design offered “just enough durability to last long enough to win the race.” But Illinois students had prepared by practicing on their home course. With better paddling control, Illinois racers captured three out of five quarter-mile-long heats. After Purdue’s boat capsized in the final push, Illinois claimed the concrete trophy it had created for the contest. Purdue settled for second prize: a heavy concrete life-preserver.¹²

Purdue’s publicity department found the 1971 race a source of amusement, describing the event as “collegiate hijinks at its traditional best.”¹³ But Hurd, who served as race judge, told both the ACI and ASCE that this college project deserved encouragement. Purdue’s ASCE chapter seized the initiative, recruiting fellow Midwestern student chapters to compete in the following year. Invitations read, “We would like to introduce to you the great new sport of concrete canoe racing. Due to the false notion that concrete sinks, this sport has had a slow start.” A single paragraph of simple building rules specified canoes should cost less than fifty dollars, be no longer than fourteen feet, and made of “concrete with reinforcing steel as necessary,” with “foam plastic or similar materials … for flotation purposes only.”¹⁴

The challenge of building concrete canoes and the fun of racing soon grabbed

¹³ Purdue University, press release, May 11, 1971; Mary Krumboltz Hurd papers, MS275, Special Collections and University Archives, Iowa State University Library (hereinafter Hurd papers, ISU).
undergraduates’ and professors’ attention at Michigan State, Ohio State, Northwestern, Michigan, Missouri, Notre Dame, Wisconsin-Madison, and other large universities, as well as smaller Valparaiso and Tri-State College. Concrete companies offered construction advice to several teams. At April’s 1972 race in Indianapolis, an estimated one thousand spectators watched through four hours of rain, as Purdue beat sixteen other Midwestern crews in what Purdue publicity agents dubbed “the World Series for Concrete Canoes.” ACI offered the winners complimentary memberships, while ASCE contributed a fancier trophy. Regional concrete companies donated a second trophy, for a new race where faculty paddled the student-built canoes (also won by Purdue). Industry representatives and ACI members (including both Hurd and Kesler) officiated. The *ACI Journal* again publicized the race and encouraged engineering faculty to request information about concrete boat-building to start their own campus projects. Reporting on races gave Hurd a good opportunity to praise concrete’s versatility; she told ACI readers that after competitors rammed Purdue’s canoe, students were able to patch the hole almost instantly.¹⁵

**Successes and Tensions in Concrete-Canoeing’s Growth**

Within three years after the first Illinois-Purdue race, concrete-canoe interest spread nationwide. April 1973’s Indianapolis race attracted twenty-seven schools. Hurd reported that University of Michigan naval-architecture majors “dominated,” thanks to “good workmanship and accomplished paddling.” Purdue reclaimed the concrete life-preserver, rebranded as a tribute to the most-frequently capsized entrant. Canoe design varied widely, with weights ranging from 115 to over five hundred pounds. Students invested new effort in giving their entries popular appeal. Teams decorated vessels with elaborate paint schemes, such as Valparaiso’s teeth-baring

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¹ Joseph Retzner and Bruce Cotterman to ASCE chapters, December 20, 1971; Hurd papers, ISU.

shark, or coined catchy names, including Indiana Institute of Technology’s “Concreeke” and Notre Dame’s “Floating Irish.”

On the same day as Indianapolis’s race, West Coast schools held their second annual race, as part of Cal Poly’s yearly festival celebrating technical skill. Stanford construction-engineering majors beat six other schools to claim victory. Spectators particularly relished the anything-goes heat, when Fresno State piled a crew of ten into its 750-pound colossus; other teams attached sails to their concrete canoes.\(^{17}\) That same weekend, East Coast schools held their own championship in Pennsylvania, judged by local ASCE representatives. Lehigh beat six other schools, aided by a student paddler who was a national sailing champion. Three Philadelphia television stations covered the event, which drew crowds of about five hundred. Three local newspapers also reported on the race, though breaking Watergate news pushed it off the late-edition front page. The \textit{Washington Post} picked up a lighthearted story featuring Drexel’s construction technique of mixing concrete with three carloads of crushed whisky bottles. Though they lost badly, one student commented, “what the hell? It was fun emptying the bottles.” Later that spring, Oklahoma and Oklahoma State teams faced off.\(^{18}\)

Kesler, Hurd, and other fans pushed ACI to promote college concrete-canoe racing more energetically. ACI’s member-services department suggested that a five-hundred-dollar investment to support publicity, staff attendance, and prizes could yield “greatly increased student awareness of ACI.” Advocates also warned that if ACI did not formally sponsor canoe-racing, competing associations (possibly referring to ASCE) might “fill the void.”\(^{19}\) Making that

\(^{17}\) California Polytechnic press release, May 16, 1973; Hurd papers, ISU.
\(^{19}\) Howard McFarland to William Maples, May 30, 1973; Hurd papers, ISU.
commitment, ACI created an Ad Hoc Committee on Concrete Canoe Races in mid-1973, assigned “to provide assistance and guidance for student concrete projects, which are of wide interest and provide educational experience in concrete.” Members included engineering faculty at Illinois, Purdue, Pennsylvania, Berkeley, and West Virginia University, as well as executives at Cleveland’s Master Builders, Toledo’s Kuhlman Corporation, and Illinois’s Superior Concrete Accessories. Herbert Cook, representing Master Builders, told committee chair Kesler, “[T]here is a potential of some worthwhile improvements in concrete as a material and in its promotion, in addition to the fun.”

Cook’s comment revealed an important fact, that while concrete-canoe racing captured the imagination of both academics and businesses, those parties valued it for different reasons and envisioned it heading in different directions. Concrete-company representatives like Cook hailed inter-university competitions as ways to stimulate technological progress. University of Toronto students won one 1973 race with a vessel that employed their professors’ secret patent-pending techniques to bond cement to a steel and glass mesh. But while industry representatives hoped racing might drive innovation, most professors appreciated racing more as a means to give undergraduates vital hands-on education and excite them about engineering. They worried that starting an arms-race in advances could privilege wealthier schools and discourage novice teams.

Given that disagreement, whether racing should emphasize innovation or wide participation, ACI had to resolve questions that quickly emerged about rules governing canoe design. Faculty members on ACI’s committee wanted to ensure “fair play,” by banning polymer

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20 Ad-Hoc Committee, minutes, October 19, 1973; Hurd papers, ISU.
21 M.K. Hurd, ACI memo, May 1, 1973; Roster, ACI Ad-Hoc Committee on Concrete Canoe Races, no date [ca. fall 1973]; Herbert Cook to Clyde Kesler, August 31, 1973; Hurd papers, ISU.
concrete and other “exotic materials and technology that are not readily available” to all. West Virginia’s David Anderson declared, “[T]he canoe should reflect the efforts of the students and not some professor’s research activity or contact with a materials supplier.” ACI’s Hurd seconded the idea of setting “sensible cost limitations which will keep the canoe races a real, fun, undergraduate project, not a playground for sophisticated research.”

Seeking to foster “fair play,” Anderson complained that teams had not always been penalized for violating design specifications. Kansas State faculty joined him in calling for more consistent enforcement of building rules. When construction guidelines issued to teams were ambiguous, ACI had to arbitrate. 1973’s West Coast meet raised controversy, since as several schools pointed out, “[e]veryone except Stanford interpreted the rules to require standard sand aggregate, and so there was a great deal of self-interested opposition to allowing the fiberglass filled canoe they [Stanford] entered… [E]very school but Stanford felt that fiberglass filled mortars should not be allowed since they are not used in large sailboat construction.” 1973’s race organizers chose not to disqualify Stanford, reasoning that “it was hard enough getting people to participate in the first place.” Fielding the event’s lightest canoe at 181 pounds, Stanford beat all other contenders, including the 480-pound boat of reigning champions Cal State-San Jose. Not surprisingly, Cal State students sought revenge in 1974’s race by adopting fiberglass themselves. As justification, the team declared, “we should liberalize… so as not to restrict innovation and use of new materials.” Cal State added that East Coast schools were already building canoes with fiberglass aggregates, so “[i]f we are at all interested in a competitive National Championship, we may have to use it [too].” But three other West Coast schools objected, insisting that fiberglass aggregates should remain banned.

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23 David Anderson to Mary Hurd, August 1, 1973; M.K. Hurd to Alan Kolba, August 30, 1973; Hurd papers, ISU.
24 David Hunt to ASCE student chapters, no date [ca. November/December, 1973]; Dave Hunt to Howard McFarland, no date [ca. November/December, 1973]; Hurd papers, ISU.
Adjudicating similar construction disputes among East Coast schools, ACI suggested that new guidelines should indeed allow fiberglass reinforcement, provided that cement remained a canoe’s dominant substance. ACI then stepped into the role of referee. Hurd advised Ohio State’s ASCE chapter in 1973 that the material sample it sent for inspection contained too little concrete and too much fiberglass, which needed to be embedded or mixed into the cement, rather than separate layers. Hurd admitted that existing regulations did not say “specifically that the canoes must be made of concrete;… I felt that would go without saying. Perhaps it should have been made more explicit.” Hurd sought to satisfy both industry sponsors and professors involved with canoe-racing. Her approach aimed to keep the playing field reasonably level between different schools, while leaving room to encourage technical experimentation and design creativity. She concluded that rules should “assure some uniformity of material and yet not tie all contestants down to working with Type I Portland Cement.”

As advisors to campus teams, engineering professors continued to emphasize its educational nature. As the man who originated college concrete-canoe building, Kesler remained among its biggest boosters. Canoe-racing offered uniquely “enthusiastic and stimulating experiences for the students,” Kesler wrote. “I have tried to come up with other possibilities for stimulating student interest in concrete, but nothing comes close.” Like his undergraduates, Kesler competed eagerly and savored victory. After his Illinois team beat Purdue in their initial match-up, he enjoyed teasing colleagues from Indiana by donning a custom-made t-shirt proclaiming Illinois the “1971 world champs.” Kesler and Hurd judged races for years, both repeatedly touting the value of this expanding program. Kesler remarked, “I believe the ultimate concrete canoe race would be to place the crews on a sandy beach with a sack of cement, a roll of chicken wire, and some tools and see who could get to the other side of the lake quickest.… A

25 M.K. Hurd to Peter Grazier, December 4, 1973; Hurd papers, ISU.
trained crew might do this in one hour’s time!”

Michigan State University’s Frank Hatfield similarly maintained a learning-focused ethic of racing. Hatfield emphasized that to gain “maximum participation,” he tried “to have a new set of volunteers making the canoe each year,” though it meant losing the experience advantage of veterans. Hatfield also expressed “mock disgust” upon hearing that Michigan’s team got special coaching from an Olympics canoe-racing bronze-medalist. In actuality, that graduate-student/coach reported he had trouble just showing undergraduates how “to go straight,” given the way concrete’s weight complicated steering.

While Hatfield’s censure of Michigan came in jest, faculty began worrying by 1973 that healthy cross-college rivalry had crossed the line into undesirable aggression. Anderson complained that racing had devolved into a “demolition derby,” reporting that another team coaxed his students to gang up against the favorite, Purdue, with a “‘sink the other guy’ philosophy.” Anderson recommended that ACI redefine competitions, shifting “emphasis [away] from paddling ability to design and construction.” Instead of all-out-speed races, he said, ACI should offer prizes for “most original design, the best engineered, the lightest, the best display of sportsmanship.” Illinois’s Kesler was less wary of competitiveness. Offering tactical advice to fellow professors starting new teams, he recommended that “though you should make every effort to make a lightweight smooth canoe… the real secret is in having a trained crew… start your training program – like right now!... and let them work together.”

ACI’s committee decided to intervene on the side of fairness, announcing that any schools caught deliberately

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27 Michigan State University, press release, April 10, 1973; Hurd papers, ISU.
28 William Clark, “A Concrete Idea in Canoes,” April 1973; Hurd papers, ISU.
29 David Anderson to Mary Hurd, August 1, 1973; M.K. Hurd to Alan Kolba, August 30, 1973; Stuart Swartz to Mary Hurd, May 1, 1973; Hurd papers, ISU.
damaging or overturning rivals would be punished with disqualification. Weighing matters of liability, ACI began requiring paddlers to wear flotation equipment. To keep the event centered around engineering education and deter hyper-competitive teams from importing sports stars to power their side to victory, new regulations mandated that all paddlers in a race “must have contributed to the construction.” Committee members initially stipulated that no varsity athletes could be eligible to compete, but after protests that it would be ridiculous to ban an engineering student who was a table-tennis champion, new rules excluded only varsity-crew members.\(^{31}\)

On balance, ACI’s committee moved to add intellectual discipline to canoe-building, while keeping the fun of racing to motivate undergraduates. ACI formalized judging procedures and regularized technical standards in the competition rulebook. ACI created new awards to recognize top workmanship, which required students to document their construction processes and produce posters explaining design and materials selection.\(^{32}\)

Faculty members’ insistence that canoe competitions should serve the needs of students more than industry reflected a crucial point amid rising concern about ways that classroom engineering had shifted toward the fundamental sciences. Following World War II, curriculum changes had de-emphasized practical techniques, such as surveying, drafting, and machine-shop exercises, in order to include more mathematics, physics, and theory. As Bruce Seely notes, by the 1960s, some employers, professional engineers, and faculty worried that the shift had gone too far, stripping undergraduate training of real-world relevance.\(^{33}\)

Given that context of a push-back against engineering-sciences, it is not surprising that Kesler and other advisors viewed canoe-building as an important corrective to what they

\(^{30}\) Clyde Kesler to Blake Forbes, February 12, 1973; Hurd papers, ISU.
\(^{31}\) Ad-Hoc Committee minutes, October 19, 1973; Jerome Raphael to Howard McFarland, November 1, 1972; Hurd papers, ISU.
\(^{32}\) “ACI’s Concrete Canoe Construction Award,” April, 1975; Hurd papers, ISU.
considered an imbalance in engineering education. Classroom over-emphasis on theoretical concepts, they feared, meant that many graduates lacked any foundation of hands-on building experience. Making canoes drove students to master a range of practical techniques: learning to form molds, choose and prepare concrete mix, shape mesh frames, and build up layers of material. Michigan State’s Hatfield commented, “[W]e can give students all the theory in the world, but until they get their hands dirty – they haven’t really grasped all of what we’re trying to [teach] them.” He argued that previous generations of “[e]ngineering students typically came from a blue collar background” and grew up using tools, but many newer undergraduates from well-off suburban families “never had a trowel in their hands” before.\(^\text{34}\)

First-generation canoes could be literally rough; one Illinois student recalled that jagged rims on their early 1970s vessel lacerated paddlers’ hands, teaching the importance of leaving time to sand edges smooth.\(^\text{35}\) Rookie canoe-builders confronted a steep learning curve. The first face-off between the University of New Mexico and New Mexico State in 1974 ended in a draw, after NMSU’s entry was disqualified for breaking construction specifications, and UNM’s canoe sank.\(^\text{36}\) In 1975’s California race, Berkeley students derided competitors’ “totally unsophisticated ‘tubs,’” adding that “the term ‘first-year canoe’ has come to mean something somewhat humorous.” Berkeley particularly poke fun at the University of the Pacific’s eight-hundred-pound monstrosity with two-inch-thick walls, but praised the novices for taking “all the ribbing good-naturedly” and letting “liquid refreshment” appease any sting from their “speedy elimination.” Berkeley’s team admitted their own vessel was eclipsed by victorious CalPoly’s kayak-like design, “the apex of concrete canoe construction on the West Coast so far.” Berkeley engineers declared that studying CalPoly’s “sleek, aesthetically-pleasing craft” would inspire

\(^\text{34}\) William Clark, “A Concrete Idea in Canoes,” April 1973; Hurd papers, ISU.
\(^\text{35}\) “Forty Years of Concrete Canoe,” \emph{op. cit.}
\(^\text{36}\) \textit{New Mexico Society of Professional Engineers} newsletter, April 1975: 8.
them to think more creatively in planning their next entry.\textsuperscript{37} Overly-ambitious design experiments could backfire, as in one canoe featuring an inverted prow with a high point. Illinois rivals remembered, “I think they had the idea that it would work as a battering ram. It worked fine until they started paddling hard, at which time the taper caused the front end to dive, and it sank.”\textsuperscript{38}

Despite their disagreements about whether competitions should prioritize wide educational access or cutting-edge innovation, both engineering faculty and concrete-industry boosters were elated by what Hurd described as “the fantastic mushrooming of interest” in canoe-racing. Sudden popularity caused problems. By late 1973, multiple universities were vying to host future races. Though ACI had no authority to block any site from staging a race, the organization sought to regularize expansion by organizing regional divisions and offering awards only for selected events.\textsuperscript{39} Regional differences temporarily precluded prospects for holding national championships; West Coast design rules let schools construct four-person canoes up to eighteen feet long, while Midwest racers built shorter two-person vessels.\textsuperscript{40}

Within the small world of engineering schools, canoe competitions fed faculty and administrators’ institutional pride. Missouri’s civil-engineering chair told ACI that he set up a trophy display and collected photographs to document students’ successes.\textsuperscript{41} Berkeley’s civil-engineering department kept its 1975 canoe on exhibit.\textsuperscript{42} Iowa State engineers entered their concrete boat to race against conventional canoes at the big campus festival.\textsuperscript{43} Especially when faculty and administrators at different places knew each other well, schools took satisfaction not


\textsuperscript{38} “Forty Years of Concrete Canoe,” \textit{op. cit.}

\textsuperscript{39} M.K. Hurd to Charles Scholer, October 31, 1973; Hurd papers, ISU.

\textsuperscript{40} Jerome Raphael to Howard McFarland, November 1, 1972; Hurd papers, ISU.

\textsuperscript{41} John Cassidy to M.K. Hurd, November 15, 1973; Hurd papers, ISU.

\textsuperscript{42} Alden, “A Classic???” \textit{op. cit.}
just in student victories, but in friendly rivalries where faculty raced the undergraduate-built canoes. In 1975, the University of New Mexico and New Mexico State University set up a head-to-head challenge between the two deans of engineering, each co-piloted by his civil-engineering department chair.44

The wider university community also began to treat concrete canoes more seriously. Purdue’s early publicity portrayed racing as a droll diversion. Amidst the era’s campus unrest, antiwar protests, hippie counterculture, and civil rights activism, concrete-canoe building seemed a strange but innocent pastime. By 1973, Purdue’s tone shifted toward respect. Official press releases stressed, “The event is not all ‘fun and games,’ although the races emerge as collegiate hijinks at its traditional best. The contest is a logical extension of laboratory experiments in uses of different cements, aggregates and strength of materials – all academic – and the natural penchant for collegians to turn serious subjects into fun when possible.”45

College racing attracted increasing coverage not just by local media and technical publications such as the ACI Journal, but also in national media. Articles typically drew readers’ attention by underlining the seeming-ridiculousness of concrete canoes. A 1985 New York Times piece about a West Point race quoted one mother asking her son, “Are you a nut?... How are you going to stay afloat?”46 The Times proceeded to explain why floating concrete—an apparent contraction in terms—actually made perfect technical sense, given principles of buoyancy and proper choice of aggregates, admixtures, and design. Kesler, like other faculty and ACI race supporters, welcomed mass-media attention as promoting appreciation for engineering skill. He declared, “Some of the public comes to see the races because they do not believe [concrete can

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45 New Mexico Society of Professional Engineers newsletter, April 1975: 8.
44 Purdue University, press release, April 24, 1973; Hurd papers, ISU.
The races do show the versatility of concrete and provide an educational experience.”

Engineers and industry especially appreciated the chance to stress favorable impressions of concrete, given the substance’s often-negative connotations. The 1950s to 1970s represented the heyday of Brutalist architecture. Designs such as Le Corbusier’s 1952 Marseille apartment complex Unite d’Habitation aimed to represent rugged functionality, stripping away meaningless ornamentation. Fans promoted “raw concrete” as tangible authenticity, lending striking muscularity to buildings. Architecture writer Leonard Koren praised Brutalism as “three-dimensional poetry” that sculpted dramatic angles, intersecting spaces, and variegated textures.

Thanks to concrete’s affordability and speed of construction, American, British, and European governments, universities, and other project commissioners embraced Brutalist style for housing blocks, garages, industrial sites, and bureaucratic buildings. Such grim applications reinforced many people’s distaste for Brutalism as claustrophobic, dystopian, and ugly, especially when marred by leaking, crumbling, and rust-stains. Brutalism’s most high-profile detractor, Prince Charles, condemned plans for London’s National Gallery expansion as a “monstrous carbuncle,” compared the British Library to “an academy for secret police,” and sarcastically hailed the Royal National Theatre as “a clever way of building a nuclear power station in the middle of London without anyone objecting.”

According to architectural historian Adrian Forty, hatred for Brutalism made concrete “a material with an image problem” and a “bad name,” reaching the point where “unpopularity”

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47 Clyde Kesler to the Ad-Hoc Committee, August 27, 1973; Hurd papers, ISU.
might be considered a “structural feature of concrete.”51 While advocates promoted concrete’s bare aesthetic as representing honesty, the dignity of hand labor, and urban modernism, critics saw it as alienating, even totalitarian.52 Physical roughness emphasized concrete’s unfriendly side; one user of Yale’s 1963 Art and Architecture building complained, “It’s difficult to be in a building where if you stumble into a wall, you may end up going to the hospital with skin abrasions.”53

Company representatives and engineers admired concrete’s usefulness and efficiency, but knew it struck others as depressing, absent the warmth of wood, tradition of stone and brick, glitter of glass, sleekness of aluminum, and wild color of plastics. Gazing at office blocks and bunker-like factories, one thing many thought they knew about concrete was that it was heavy. To learn that such hefty material could make good racing boats inevitably intrigued people. For boosters, canoe-racing promised to re-brand concrete as high-tech, versatile, and interesting.

Not coincidentally, Mary Hurd, who promoted concrete-canoe racing within ACI and fed its publicity, also led ACI’s efforts to rehabilitate popular feelings about concrete. In 1985, Hurd organized the ACI Committee on Concrete Aesthetics, which she chaired until 1991. ACI distributed “Concrete is Beautiful” bumper-stickers, published illustrated volumes on bridge-design aesthetics, and congratulated Texas’s Highway Department for producing attractive concrete railings. Hurd’s speeches and articles extolled what she called concrete’s “offbeat recreational, agricultural and artistic applications… [f]rom the playground to… the drawing room.” She promoted do-it-yourself projects, encouraging Americans to build concrete rowboats,

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bookends, and lawn furniture. Hurd wrote, “Beautiful concrete gives people a positive attitude about its quality, usefulness, and the extension of its applications.”

Expansion of Concrete-Canoe Competition

In 1975, University of Maine students challenged other New England ASCE chapters to the first whitewater concrete-canoe race. Eighteen schools entered twenty-five canoes, of which only six managed to complete the course. The University of New Hampshire’s winner, the sole vessel to make it without being perforated, finished the ten-mile course half-an-hour ahead of the runner-up. The rapids destroyed many vessels; one 1980 competitor remembered that she and her teammate “put our knees on towels over the holes that appeared until we ran out of knees, and we finally sank well ahead of the finish line.”

College concrete-canoe events continued to multiply. During one month alone in spring 1976, the ACI and ASCE together sponsored fourteen races at schools across the United States. By 1980, Australia’s Concrete Institute instituted racing there, with other events in Belgium, Britain, Canada, and the Netherlands. In 1982, the Swedish Concrete Institute hosted what it called the world’s first international competition, alongside a congress of the International Organization for Concrete Design, Construction, and Development. Contestants came from Australia, the United Kingdom, and five European countries, with entries from the University of Sydney, Sweden’s Chalmers University of Technology, Technical University of Denmark, the Norwegian Institute of Technology, Germany’s Karlsruhe Institute, Delft University of Technology, and Eindhoven University of Technology. Other entries were non-academic productions, filed by building contractors, the Swedish Cement and Concrete Research Institute, and Britain’s Atomic Energy Authority. Delegates watched ten heats in the heart of

Mary Hurd, “Bathtubs, Boats and Brontosauruses,” and Mary Hurd to John Hanson, July 25, 1990; Hurd papers, ISU.

Stockholm, while enjoying a pleasant lunch with jazz accompaniment. Medals were awarded over dinner in Stockholm’s landmark City Hall, the site of Nobel Prize banquets. Students from the Technical University of Denmark won, after the Australian favorites made paddling errors in a key turn.57

University of Sydney students did capture Stockholm’s prize for design innovation. Their “Aurora Australis” had a hull just one millimeter thick and weighed only twenty-five kilograms. Australia’s team transported the canoe to Sweden rolled up in a small container, thanks to an origami-inspired innovation devised by two Sydney professors. Their method created concrete sheets so fine that after being cast flat, they could be curved into shape without cracking. “Folding the flat sheets of concrete was like folding pieces of cardboard,” wrote two students, and yielded a canoe “with tremendous straight line speed, marginal turning ability, and next to no stability.” Durability also suffered; trying to avert a capsize during another race, a Sydney paddler put his heel through the hull, but finished the heat by plugging the hole with his foot. Instability and poor turning ability cost Sydney first place in Stockholm’s final, but students remained proud of creating what they proclaimed to be the world’s lightest two-person concrete canoe. The following year, Sydney’s team further slashed their canoe’s weight by more than half, down to just eleven kilograms, with a hull 0.6 millimeters thick. The design used fiberglass flyscreen as reinforcement, since the concrete layer was too thin to protect the usual steel mesh from corrosion.58

Back in the United States, in 1987, the ASCE took over management of college concrete-canoe competitions from ACI. The next year, the ASCE instituted a national championship

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57 “1st FIP International Concrete Canoe Race in Stockholm, Sweden on June 8, 1982,” https://www.youtube.com/watch?v=Ia2gHzUmtPw.
sponsored by Master Builders, an Ohio firm specializing in analysis of cement technology and innovations in concrete construction methods. In 1989, ASCE held twenty regional races, whittling down a field of almost two hundred entries before two-day finals held at Texas Tech, where UC-Berkeley successfully defended its national title. More than forty students had invested three thousand hours of work preparing Berkeley’s championship vessel, which had a hull just three millimeters thick. Senior Donald Sandstrom, head of UC’s construction unit, told ASCE, “It’s tough getting [canoe walls] thin enough without breaking – we’re constantly trying to push that edge.” Berkeley’s paddlers had practiced racing almost daily and held three gym workouts per week, but the competition had evolved to prioritize technical depth over athletic strength. Rules emphasized academic seriousness; race performance counted for only forty percent of total points, with the remaining sixty percent judged on teams’ written design reports and oral poster-presentations. As reward for demanding greater formal effort, ASCE upped the payoff; Berkeley’s triumph earned $5000 in scholarships, with $2,500 for second-place Michigan State and $1,500 for third-place University of New Hampshire.59 Michigan State seized the national title in 1990, dropping Berkeley to third, despite the handicap that East Lansing students couldn’t practice paddling until their icy lake broke up in late spring.60

In key ways, the ASCE represented a more comfortable home than ACI for work with students. ASCE’s long-established chapters on campuses across the country served as natural vehicles to recruit rosters of undergraduate canoe-builders, secure faculty advisors, arrange institutional support, and communicate with national organizers. Yet at ACI, college-racing’s original parent, some regretted losing this link, especially with its publicity spotlight for the glories of concrete. In 1991, Atlantic magazine praised European and Japanese innovations in

concrete, while disparaging American researchers for neglecting the material. That article failed to mention the ACI, while offering ASCE lukewarm praise for backing college racing and thus “the organization that comes closest to treating concrete in an academic fashion.” Writing to the editor to protest the “painful” omission of ACI, Hurd touted ACI’s commitment to research, training, and publication. Retorting that he was “surprised to be taken to task… for not mentioning” ACI, Atlantic’s author maintained, “I had not intended my comments about the academic value of the… canoe race to be taken too strictly, but I’m still not persuaded that the ACI does much more than the ASCE to teach concrete as an academic subject.” Labeling that “glib” comment “inane,” ACI member Peter Courtois scolded Atlantic’s fact-checkers for missing the truth “that it was the American Concrete Institute that founded and originated concrete canoe races… [and] established rules for the construction of the canoes and rules for safety considerations.” For Courtois, who had judged 1971’s first-ever Illinois-Purdue race alongside Kessler and Hurd, failure to credit ACI’s patronage of early concrete-canoeing rankled.

From the 1990s onward, the “America’s Cup of Civil Engineering” (as concrete-canoe racing was nicknamed) became more elaborate, demanding more time, resources, and investment from students, universities, and industry. Rulebooks ballooned to hundreds of pages, evolving to cover more and more technical options and design contingencies. Twenty-first-century canoes grew increasingly complex, incorporating Kevlar carbon fibers, pre-tensioned carbon-fiber ribbons, microballoons, microscopic ceramic beads, and other high-tech options. While earlier student teams had just started building or relied on simple molds and paper models, twenty-first-century designs drew on advanced computer programs for structural analysis. Canada’s Laval University team declared in 2012 that its build had consumed over nine thousand work-hours.

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man-hours, with approximately a $55,000 budget. Contest expectations kept rising; by 2018, concrete-canoe scoring placed equal weight on students’ oral-presentation, design papers, vessels’ appearance, and race-results. After previously losing in regionals, Michigan Tech’s 2010 team raised its game by focusing on eye-catching aesthetics; its new canoe featured intricate layers of design, including shadow-effect inlaid nameplates. A display stand shaped like the Mackinac bridge showed off the “Upper Peninsula”-themed vessel, lavishly decorated with images of brilliantly-colored maple leaves, outdoor activities, and UP landmarks, including mining and logging sites, state parks, and skiing facilities.

Formalizing and expanding competition requirements did not obliterate concrete-canoeing’s amusing side. Teams still christened vessels with humorous names, as in Michigan State’s “Rowing Stone.” Marking racing’s fortieth anniversary, Illinois’s “Boneyard Yacht Club” (named after a campus creek) created “The Cementery,” with graveyard-themed decorations, including a light-up skull at the prow. In 2015, 215 teams entered ASCE’s concrete-canoe competitions.

Expansion of Competition Culture Across Engineering Disciplines

Concrete-canoeing’s popularity quickly generated spinoff contests; starting in 1973, enthusiasts in northern states and Canada held a sister challenge, building and racing concrete toboggans. As concrete-canoe competitions multiplied, students and faculty extended the appeal by adding novel side-challenges: concrete-ski racing, concrete frisbee, concrete bowling,

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65 Peter Courtois to William Whitworth, August 16, 1991; Hurd papers, ISU.
70 David Nauheimer and Jacob Thede, “Canoe Team 2nd at Regionals, Off to Nationals,” CEE, University of Illinois, summer, 2011:20.
concrete bocce, concrete horseshoes, concrete skeeball, baseball with concrete bats, and even concrete ‘Ulu Maika (traditional Hawaiian lawn-bowling).  

Highly-visible growth of ACI/ASCE concrete-canoe competitions set the stage for fellow engineering societies to subsequently nurture their own ambitious contests across disciplines. The Society of Automobile Engineers (SAE) built an empire of college-competitions. Creating SAE’s Mini Baja contest in 1976, University of South Carolina professors brought together ten teams that designed all-terrain vehicles around a stock engine from sponsor Briggs and Stratton, which supplied judges. In 1981, University of Texas students and faculty approached SAE to create Formula SAE, small-racecar design and testing competitions. In 2003, Dartmouth planned to enter a hybrid racer; after learning that rules precluded that option, Dartmouth secured SAE approval to start a new Formula Hybrid contest in 2007, which in turn spawned Formula Electric (2012). SAE created numerous other competitions during this period, including SAE’s Supermileage challenge (1980), Aero Design (1986) for radio-controlled aircraft, and AutoDrive unmanned-vehicle challenge (2018).

As seen, concrete-canoe competitions attracted rising interest, despite the fact that no commercial concrete-canoe market existed; engineering competitions gained still more big-money sponsorship when tied to actual consumer products, as well as immediate political issues. Take, for instance, the “inaugural clean snowmobile challenge” held near Yellowstone in 2000. For years, soaring snowmobile-tourism in Yellowstone National Park had brought clouds of smelly smoke, high carbon-monoxide and hydrocarbon levels, and jet-level noise that stressed wildlife. Duelling lawsuits over access-rules pitted environmentalists against snowmobiling-enthusiasts, manufacturers, and local outfitters. To placate all sides, Wyoming county

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69 Howard McFarland memo, ACI, November 15, 1973; Hurd papers, ISU.
commissioners and SAE pursued technological solutions to increase snowmobiles’ acceptability. This led to the contest in 2000, in which seven universities fielded machines retooled for low-noise, low-pollution targets; the University at Buffalo won the $17,000 prize. In 2003, SAE’s Clean Snowmobile Challenge moved to Michigan Tech, illustrating a historical pattern of schools’ gaining specialized depth in one specific contest, frequently winning and/or hosting. Such specialization typically reflected an area’s geographic or economic strengths; in Michigan Tech’s case, its dependably-deep snow, good snowmobiling-trails, and snowmobile-manufacturers’ experience using the school’s 900-acre facility for winter vehicle-testing. Staging the week-long competition cost roughly $200,000 annually, covered largely via sponsorship from the International Snowmobile Manufacturer’s Association, major snowmobile companies, and local businesses. SAE’s competition promised that student innovation could ensure “an environmentally-sustainable future for the sport,” but market realities proved complex. Recreational riders preferred high-performance snowmobiles, giving firms little incentive to produce “green” models. But in 2006, climate-change concerns helped SAE justify creating a sub-competition for zero-emissions snowmobiles, promising to help polar researchers reach remote sites without having ice samples and atmospheric data contaminated by emissions. To encourage universities to invest effort in assembling new zero-emissions-teams, the National Science Foundation funded competitors’ travel costs and had winning students bring their snowmobile to Greenland for field-trials.72

As histories of concrete-canoe and SAE competitions show, university faculty often formulated new contests and convinced engineering organizations to lend support. In other

instances, societies themselves seized the outreach initiative, adding to post-1980 competition growth. The Vertical Flight Society initiated student contests in 1984. In 1987, ASCE chapters from three Michigan campuses entered a steel-bridge contest created by Robert Shaw, associate director of education at the American Institute of Steel Construction, which started funding national competitions in 1992. The American Institute of Aeronautics and Astronautics opened “Design/Build/Fly” competitions in 1997. The American Society of Agricultural and Biological Engineers began quarter-scale-tractor design contests in 1998, “Fountain Wars” contests in 2003, and agricultural-robotics competitions in 2007. University of Michigan professor Scott Fogler worked with the American Institute of Chemical Engineers to start its ChemE-Car competition in 1999. ASME offered the Human Powered Vehicle Challenge as well as various design contests built around specialized problems. IEEE’s Student Activities Committee created the IEEEEXtreme Programming Competition in 2006. That same year, Queen’s University in Canada held an autonomous-sailboat design, racing, and navigation contest that grew into the annual Robotic Sailing Regatta (SailBot), alongside similar competitions such as Roboboat. Publicity represented a primary drive; ASME advised organizers, “Make it hard for reporters and spectators alike to tear themselves away from the contest by keeping it moving and interesting at all times.” The society added that venues should conspicuously position ASME’s logo in “as many video or photographic shots as possible!”

As Gary Downey and Juan Lucena note, engineering faculty reoriented education, especially post-1990, to emphasize design exercises and cultivate students’ applied resourcefulness. Fitting that pattern, universities increasingly incorporated contests into

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curricula, letting students count team-activity toward required design classes, or forming capstone courses around specific competitions. Grand Valley State had first-year CAD/CAM classes prepare for ASME’s design competition, as did Rice’s electrical and mechanical-engineering majors. Energy Technology seniors at Montana entered ASME’s Human-Powered Vehicle Challenge or Shell’s EcoMarathon Challenge. Oklahoma State University, among others, incorporated Chem-E-Car challenges into chemical-engineering classes.

Internal competitions also became increasingly-common elements of engineering classes over these decades. MIT prided itself on pioneering that trend; around 1970, mechanical-engineering professor Woodie Flowers created an “Introduction to Design and Manufacturing” class that emphasized project-oriented training. Challenges initially involved solving mechanical puzzles, then evolved into annual robotics competitions with elaborate themes, including Paul Revere’s ride, Star Wars, Willy Wonka, and Apollo 11, and with major sponsors such as GM, Ford, Shell, and ExxonMobil. Winners earned bragging-rights but no extra-credit; even so, MIT had to discourage students from obsessing over the heated contest, which drew cheering audiences of five hundred or more.76 Ohio State University divided first-year engineering-majors into teams to design roller-coasters; after 2012, the competition shifted to alternative-energy vehicles. Iowa State, like many other universities, asked its two hundred “Introduction to Aeronautical Engineering” students to design lighter-than-air vehicles and steer them through obstacle courses.

Twenty-first-century competition varieties kept multiplying: catapult-building, app-development, cyberdefense, seismic design, solar-car racing, green-energy-house design, and more. The history of concrete-canoe races is typical in showing how competitions’ dollar-value

rose as deep-pocket corporations paced each other in underwriting outreach. In 1991, General Motors facilities hosted Formula SAE; Ford did the same in 1992, Chrysler in 1993, and a joint Big Three consortium provided 1994’s sponsorship. Smaller companies also valued contests for providing publicity as well as access to potential interns and future employees. For example, at 2018’s SAE, component-maker MacLean-Fogg delivered a specialized workshop to several dozen students and held a separate sub-contest, the “MacLean-Fogg Fastening Challenge,” where Graz University’s team won a thousand dollars by explaining how their vehicle used fasteners to facilitate switching drivers mid-race.77

Leading universities and engineering departments felt pressure to keep up with each other, fielding teams across the range of top-level competitions. Major US-based contests attracted two hundred or more teams, drawing competitors from major European universities as well as Canada, South and Central America, Asia, and the Mideast. International SAE affiliates staged official and unofficial contests in India, China, Europe, Brazil, Australasia, and numerous other countries. By 2015-2016, more than five hundred universities worldwide had entered SAE events as competition culture pervaded global engineering education. Chennai Institute of Technology boasted that its “competition based learning” involved students in thirty-seven technical contests and hackathons.78

As contests multiplied, student involvement added up, with striking impact at smaller tech-centric schools and for world-class competitions. Missouri University of Science and Technology reportedly had over 1,300 students (out of a total 8,900) working with twenty

78 http://www.chennaiinstituteoftechnology.com/competition-based-learning/
different design teams. Approximately 120 students belonged to Iowa State’s solar-car team; Michigan and Georgia Tech’s teams comprised about seventy students each. Solar-car teams were elaborate interdisciplinary affairs; mechanical-engineering students designed and fabricated vehicles, with sub-teams for frame, suspension, aerodynamics, and steering. Chemical and electrical engineers worked on fuel and power systems, while computer and software engineering majors handled hardware, programming, data, and communication systems. Other undergraduates handled publicity, social media, branding, and fundraising.

SAE teams and other large competition-projects needed to raise thirty to forty thousand dollars annually, but at elite schools, alumni and institutional connections opened doors to top-flight patronage. Berkeley’s 2018 solar-car team secured backing from Ford, GM, 3M, Rockwell Collins, Lockheed Martin, and more than eighty other corporate sponsors; Stanford had Hyundai, Chevron, Siemens, and SpaceX. A Ford executive declared that collaborating with University of Michigan students building a million-dollar solar-car gave the business “access to cutting-edge research that … helps us learn as we develop our own products… Technology that the team works with – the lithium-ion batteries, how you manage thermal energy – is hardwired into our electrification strategy going forward.”

In addition to sponsoring SAE teams at nationals, Goodyear organized regional invitation-only competitions, opportunities to recruit interns and promote its racing tires. Joining school teams thus offered career-minded undergraduates not just coveted resume credit, but also chances to impress faculty, mentors, and potential employers by spinning team involvement as initiative, dedication, and leadership experience. As Amy Slaton details, early twentieth-century

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79 Missouri S&T, “Student Design and Experiential Learning Center,” [https://design.mst.edu/designteams/index.html](https://design.mst.edu/designteams/index.html)
educators wielded claims of sterling character to convey special status for engineering graduates. Twenty-first-century leaders similarly touted technical contests as cultivating essential virtues, such as discipline, teamwork, and communication ability. Competitions rhetorically served engineering educators’ campaigns to nurture such “soft skills,” as Atsushi Akera describes in tracing ABET accreditation criteria.

In addition to invitationals such as Goodyear’s and official regional/national competitions, many universities also entered “off-season” contests. Kentucky’s “Midnight Mayhem” unofficial Baja SAE event drew more than a hundred entries. Teams also expected members to interact with local schools and join institutional outreach-events such as Engineers’ Week. In 2017, Iowa State students drove their solar car to all ninety-nine state counties, claiming to contact over six hundred thousand citizens. The tour involved “promoting STEM education, showing off the car, and getting communities excited about sustainable transportation,” the team wrote. “Invite us to your next event and be the spark that creates the next Thomas Edison or Elon Musk.” As commitments multiplied, undergraduates without superb time-management skills might pay a steep price. From first-hand observations, Cal Poly SAE advisors cautioned that “adrenaline of competition” easily tempted students to “over-prioritize” contests and neglect classwork.

Given competition-teams’ intense expectations, collegians struggling with financial constraints, jobs, or family obligations might not have flexibility or freedom to join. Emphasis on competitions thus risked widening gaps between students at different institutions, or within the

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85 PrISUm Solar Car, “Outreach,” https://www.prisum.org/outreach
same school. Clarkson promised students that its competition-focused engineering laboratory “gives you the competitive edge for your future career… The skill set cultivated during these exciting projects are [sic] highly sought after by global corporations.”

Even as contests raised the bar for expensive, high-tech entries, smaller schools were still drawn to compete. Cedarville University, with total enrollment just 4200, fielded teams in SAE Aero, SAE Supermileage, Shell Eco-Marathon, and ASEE robotics, for which the Baptist school aimed “to build robots for the glory of God.” Notably, Cedarville captured Solar-Splash’s boat championship eleven times between 2004 and 2018, typically beating a dozen or more schools, including big-names such as Carnegie Mellon. Cedarville benefitted because Solar Splash maintained a relatively-level playing-field; rules barred using expensive space-grade solar-cells, so schools could develop respectable boats for just five thousand dollars. Highlighting those victories for potential students, Cedarville’s website urged, “Check out our teams and compare their results to those of your favorite engineering school --- we think you'll be pleasantly surprised!”

In an era when student-loan debts and precarious employment prospects fostered a careerist mentality, competition-culture conveyed a sense of pitting students (and universities) against each other, continually measuring performance. Wisconsin’s concrete-canoe team promised to make recruits “familiar with aspects of using computer modeling before learning in the classroom [to keep you a] step ahead of the rest!” Clarkson told engineering majors to prepare to “compete against teams that are just as driven — and almost as smart — as you. Want

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87 Wendy Reffoor et. al, “Using the ASME Student Design Competition as the Culminating Design and Build Experience in a Freshman Level CAD-CAM Course,” ASEE conference 2013; Clarkson University, “SPEED,” https://www.clarkson.edu/speed
to win? So does everybody else. Prove it — and you’ll prove yourself, too… Go up against the best … around the world.”

**Expansion of Competition Culture to K-12 Education**

Competition culture became ingrained, not just in colleges, but trickling down to elementary and secondary-levels. For instance, SAE ran high-school versions of its supermileage competition from 2004 through 2008. SAE’s Detroit section offered high-schoolers the chance to win $2000 by designing and racing battery-powered mini-vehicles. Over previous decades, youngsters had participated in science fairs, pinewood derbies, model-airplane and model-car building. The new twist was the ambitious scale and grand mission of K-12 engineering contests. Educators, parents, sponsors, corporations, government, non-profits, and technical associations joined forces to organize enormous competitions that sought to hook new generations on the lure of competitive innovation.

The heavy-hitter was FIRST (“For Inspiration and Recognition of Science and Technology”) founded by inventor/entrepreneur Dean Kamen with support from MIT’s Woodie Flowers. FIRST initiated high-school robotics championships in 1992, followed in 1998 by FIRST LEGO League (also robotics) for grades 4-8, then FIRST LEGO League Junior (2004) for grades K-4, and FIRST Tech Challenge for grades 7-12 (2005). Kamen admired what he regarded as Little League’s success in engaging children, saying, “Sports… has latched onto, and optimized, everything that gets kids passionate… the cheerleader and the mascots,” pep-rallies and webcasts. He wanted to make robotics competitions an “equivalent of the Super Bowl,” nurturing “the next ‘Peyton Mannings’ of STEM.” Publicity heralded FIRST as the “‘Final Four’

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of smarts,” copying basketball-playoffs with play-by-play commentary, judges wearing sports-referee jerseys, and halftime-performances by celebrity-booster will.i.am.92

Kamen’s push to define robotics as a “Varsity Sport for the Mind,” infused with “excitement and adrenaline rush,” extended beyond analogies.93 FIRST encouraged students and parents to lobby schools to recognize robotics as an approved sport. Texas, Minnesota, and Connecticut agreed to offer FIRST teams equivalent privileges, including varsity-lettering, excused absences, and trophies placed in schools’ athletic “hall of fame.” Despite the irony of a “sport” that kept youngsters crouched over computers and workbenches, FIRST believed robotics-champions deserved equal honors, having triumphed over an “opponent and [earned] the strategic moments of glory in every contest.”94 Lego League Jr. was non-competitive, but FIRST expected older children to “compete like crazy.”95 Kamen noted that its name originated in competitiveness, commenting, “Kids don’t run around with their arms in the air yelling that they’re going to be SECOND.”96 Students systematically scouted rivals and reviewed videos of previous competitions, assisting coaches in planning elimination-round strategies.

Kamen’s rationale for pushing robotics as “the ONLY sport where everyone can go pro” rested on assumptions that the future revolved around STEM. He envisioned robotics as preparing youngsters for work “curing cancer and Alzheimer’s, or producing engines that don’t

Recapitulating post-Sputnik alarmism, boosters promoted competitions as solving America’s “STEM crisis.” Formally partnering with Kamen to “inspire the next generation of innovators,” ASME encouraged members to start local FIRST teams by announcing, “The need to excite high school students about math, science, and engineering has never been stronger… FIRST competition … shows youth that no other career compares to one in science and engineering.”

Pre-college competitions skyrocketed during the same decades as college contests. In 2019, over 615,000 students participated in FIRST programs; VEX Robotics claimed to involve over one million students worldwide, and the World Robot Olympiad over seventy thousand. Thousands more youngsters joined RoboCupJunior, Robonation, and other events. In 2007, PBS launched “Design Squad,” a reality-show where teenage teams competed for a $10,000 Intel scholarship by designing improved go-karts, cardboard furniture for IKEA, and remote-controlled pet-rescue boats for New Orleans firefighters. With funding from the NSF, “Design Squad” targeted junior-high viewers, reflecting the conviction that dramatic competitions glamorized engineering and widened its appeal.

Children’s competitions varied substantially; some required teams to use specific robotics platforms and pre-packaged kits. Others remained low-cost, especially locally-staged egg-drop contests, roller-coaster-design challenges, and similar unbranded events. But by 2019, FIRST robotics teams spent five or six thousand dollars just on registration and basic kits; substantial expenses accrued for extra equipment, regulation-style practice-fields, competition fees and

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travel. Given state and local funding disparities in America’s public-education system, there was a wide gulf in support for robotics between privileged and poorer schools. Students in industry-rich areas found it easier to collect money and materials donations, secure technically-expert mentors, and convince self-labeled “robotics moms” to volunteer for bookkeeping. Well-positioned, assertive high-school teams gained major sponsors, such as Bechtel and GE. One frustrated rival vented online, “We run at around 7K budget… [I]t can be depressing for the kids when they compete with teams that have $76K and $100K.” Another commenter responded, “I am the finance director for on[e] of those teams … with the massive budgets, and I will be upfront and say it is not fair.”

High-tech regions financed high-prestige teams, but also intensified competitive obsessions. A high school in Palo Alto, California (home of Stanford University) established a FIRST robotics team in 1996 and fielded three teams by 2019, with over one-hundred students vying for the overcrowded A-team. Palo Alto’s team secured Silicon-Valley sponsorships, including Apple, Google, and Dropbox, and had its own 501(c)3 booster-club formalizing parental involvement. Handbooks specified that during each “build-season,” students were “expected to work at least 100 hours total (15 hours per week). Many team members end up approaching double that number.” Even in autumn’s “off-season,” the rules added, “Everyone is expected to put at least six hours per week of work into robotics.” In summer, to raise money (and build resumes), the team ran junior-high computer camps. Its robotics-lab remained open over vacation, while faculty coaches and student captains scrutinized veterans to judge if each earned the right to return. Administrators sought diversity, concerned that Hispanic students comprised 11.7 percent of the school’s enrollment but under five percent of membership in the

robotics teams. Resulting lawsuits over team-selection charged the school with discriminating against other demographics. Further controversy arose after a new teacher tightened machine-shop access, citing safety risks of inadequate supervision. Students rebelled, accusing the coach of intimidating them, insulting them, and failing “to understand the nature and goals of the robotics team.”

Parents jumped in, declaring children no longer felt “emotionally safe in the robotics lab,” leading to the teacher’s resignation. Students complained that team turmoil distracted them during SAT/ACT-exams, a serious charge when adolescents internalized norms equating well-being with elite-college admission. An *Atlantic* article noting that Palo Alto’s high school had suicide rates four to five times above national averages specifically mentioned its robotics team as exemplifying pressures for “success.”103 Nor was Palo Alto’s extreme competitiveness unique. New Hampshire teams, for instance, also informed parents that high-schoolers needed to attend “off-season” cohesion-building sessions, demonstrations for elementary schools and potential sponsors, plus additional “fall mini-competitions” as “training for rookie drive teams and pit crew members.”104

Like colleges, high-schools increasingly centered technical classes around contests, often involving commercialized content. Teachers nationwide implemented Intelitek’s “Robotics Engineering Curriculum” that required students to build competition entries using the VEX

platform, for which a two-semester classroom license cost almost $3300 in 2008. One VEX advisor wrote that buying kits, spare parts, handbooks, “You can easily spend more than $1,000 per pair of students – and even more if you buy curriculum.” Marketing steered classrooms toward branded contests; LEGO’s “Education Academy” offered training to help instructor/coaches “perfectly prepare [students] for competitions.” Creating lessons with “direct ties to the annual FIRST LEGO League Robot Game,” the firm inseparably entangled curriculum, branding, and competitions.

Further monetizing competition culture, pre-college tech-coaching became big business. In Boston, for instance, Einstein’s Workshop, Code Wiz, GreenApple Campus, Kids4Coding, iD Tech, Worcester Polytechnic Institute, and the Berkshire Museum all offered immersive robotics classes and computer summer camps. Empow Studios promised that its weekly workshops helped “your child… start training for [next year’s FIRST] competition… We built our FLL table to match the qualified specifications regulated by FLL, that way future competitors will be well-prepared for the season.” Play-Well TEKnologies marketed LEGO-robotics instruction in twenty-three states. The nationwide franchise Bricks4Kidz promised parents that engineering competitions fostered “sticky learning,” which “could make your child more confident and engaged in school.”

Boosters declared competitions the ideal instructional-method for “enhancing social and emotional learning,” “increasing intrinsic motivation,” “strengthening academic self-concept,”

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“facilitating growth mindsets,” and “building mental toughness.” Competition-based businesses suggested that education must adapt for children raised on ubiquitous videogaming. VEX CEO Tony Norman declared that his company’s contest “strongly appeals to this intensely competitive generation.”¹¹⁰ One New Hampshire teacher announced that he held in-house contests and entered students in VEX, FIRST, mini-FRC, and robot-soccer, so “[w]e have competitions going on all year, with overlapping schedules, so the kids never get bored.”¹¹¹ That perpetual-amusement ethos led some observers to warn about a “bait and switch” trap, where “edutainment” engaged children in playing with open-ended design, only to disappoint them with “fundamentals-first” rigors of college engineering.¹¹²

Critics also worried about structured activities eating up children’s leisure and about competition’s costs versus benefits. Healthy competition promised to incentivize youngsters to try their best, raising self-esteem, but unhealthy pressure meant frustration and discouragement. Undermining assumptions that youngsters naturally relished contests, psychologists have found significant gender differences in attitudes toward competition.¹¹³ Furthermore, almost three-quarters of high-school robotics groups had only male mentors, potentially reinforcing perceptions linking technology with masculinity. Studies suggested that on mixed high-school teams, “responsibilities are typically more [girl/boy] segregated,” perhaps reflecting “greater pressure from peers, parents, mentors, or broader social expectations [for students] to adopt specific gendered roles.”¹¹⁴ Seemingly meritocratic, contests could conceal ways that class

constraints determined how society perceived intelligence, if poorer children were shunted away from extracurriculars by after-school jobs, family chores, or lack of resources. Competitions reinforced differential impacts of social capital, when well-connected parents arranged access to university laboratories or high-tech employers. Indeed, competitions created new paths to keep merit flowing to the favored; by 2019, FIRST promised participants eighty million dollars’ worth of scholarships. Universities such as Rice jockeyed to attract applicants involved with FIRST, offering dedicated scholarships and special information sessions. Boosters repeatedly claimed that by making engineering fun, competitions widened its appeal. FIRST boasted that “[o]ver 75% of FIRST Alumni are in a STEM field as a student or professional,” but skeptics questioned the premise, suggesting that children already predisposed toward STEM interests naturally gravitated toward robotics.¹¹⁵

Conclusion

Across the history of engineering, industries, governments, and private promoters have proffered rewards to induce inventors to pursue prioritized problems. Britain’s 1714 Longitude Act prize spurred John Harrison’s invention of the marine chronometer, Napoleonic France rewarded food-preservation discoveries, and Charles Lindbergh’s 1927 nonstop New York-Paris flight won the $25,000 Orteig Prize.¹¹⁶ The twenty-first-century difference was the sheer dominance of competition-culture paradigms in both K-12 education and college engineering-enculturation.

Starting in 1971 as friendly Illinois-Purdue rivalry, concrete-canoeing spread rapidly, because large-scale competitions suited needs of multiple constituents. Undergraduates appreciated racing’s thrills and career-credentialing, faculty valued hands-on lessons, ACI and concrete businesses sought favorable publicity. Concrete-canoeing’s popularity presaged the

¹¹⁵ FIRST Alumni and Scholarship Program FAQs,
post-1980 multiplication of competitions across engineering disciplines. As Matthew Wisnioski shows, during the 1960s, cultural criticism of perceived technological dangers fostered professional unease among engineers.¹¹⁷ Modern competition-culture re-romanticized engineers as creative change-agents, elevating Elon Musk, Dean Kamen, and other technical entrepreneurs as celebrities.

Underneath innovation-centered imagery, competitions often reflected conservative sides of the engineering/business alliance. When Yellowstone threatened to limit snowmobiling, SAE’s Clean Snowmobile Challenge sought to deflect environmental criticism through technological solutionism. Competitions served the marketplace and channeled effort down certain paths; developing self-driving cars offered more glamour and potential reward than improving public-transport. As Thomas Hughes observes, “The organizational mentality favored incremental rather than abrupt change.”¹¹⁸ By definition, competitions tightly controlled teams’ direction; rule-bound investigation potentially suppressed true “outside-the-box” thinking. Initially forbidden to race hybrid-vehicles, students had to push SAE to set up a new competition. Concrete-canoeing eventually required teams to make green choices, using LEED-approved stains, recycled fibers, and recycled-glass particles, but that commitment to sustainability took years to emerge.

As competition culture became a new engineering-education norm, government enlisted students in high-profile challenges. NASA invited college teams to design ultra-efficient aircraft, monitor aerosols, and create Mars habitats. The Pentagon hosted testing for military robots and autonomous vehicles. DARPA promoted competitions as superior to grants and contracts in encouraging “broad participation,” adding that “the economics are great,” since agencies only

https://www.firstinspires.org/community/scholarships/scholarships-faq
had to pay the winners and many teams invested more than the prizes were worth. Companies and foundations joined in staging million-dollar competitions, including the Netflix Prize to write better algorithms, and multiple X-Prize challenges: building spacecraft, developing “Star-Trek” tricorders, and other bold goals. Competitions harnessed students to high-tech agendas set by elite patrons.

Narratives celebrating the heroism of innovation came to permeate K-12 competition culture, as advocates sought to replace engineers’ dull, nerdy image with sports-style glory. Slickly-packaged K-12 competitions grew into an industry themselves, accommodating the interests of schools, business, and professional engineers and engineering societies. The result also excited many students but did not serve everyone equally well, since some elements of competition culture tended to reinforce inequities already embedded in educational privilege. All in all, fascination with a STEM-centered modernity aligned closely with intellectual, economic, and social interests to foster a culture of competition as the twenty-first-century’s ideal mechanism of engineering education.

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