

This column addresses aspects of lifelong learning for current students, alumni, and faculty. Examples of student and faculty activities that involve industrial practice and engagement as well as continuing education are welcome. These topics may not always lend themselves to the traditional scholarly format with formal assessment and extensive literature review but may be more editorial in nature. Submit papers through journals.flvc.org/cee, include lifelong learning in the title, and specify lifelong learning as the article type.

ALTERNATIVES TO THE TENURE TRACK

TARYN MELKUS BAYLES

University of Pittsburgh • Pittsburgh, PA 15261

Between 2010 and 2017, the number of annually awarded PhDs in chemical engineering grew by 12% from 905^[1] to 1013.^[2] However, during this same time period the total number of *tenure-track* chemical engineering faculty positions has increased by only 5.5%, from 1989^[1] to 2098.^[2] Eighty percent of students who enter their PhD program express interest in an academic career, but this interest declines to 55% later in their PhD program.^[3] It is also reported that 43% of engineering doctoral recipients are without employment commitments at the time of graduation.^[4] Given these statistics, it has been suggested^[5] that the motivation for pursuing a doctoral degree should be for your own intellectual development and not for the hope of landing your dream job of a tenure-track position in academia.^[6] However, I would like to suggest that there are other alternatives to a tenure-track position that I have found very rewarding – let me begin with my story.

MY STORY

As one of few female undergraduate chemical engineering students in my class in the late 1970s, I aspired to do it all – to have a rewarding career in both industry and academia, and also to be a stay-at-home mom. As an undergraduate, I had summer internships in a government lab, a refinery and a chemical plant. These experiences made me quickly realize that I enjoyed classes in which the faculty member incorporated their industrial experience – it helped me understand the practical applications of the theory that I was presented. With that in mind, I set out on a path to first gain industrial experience before embarking upon an academic career. My first job after graduation was an applications engineering position with Exxon at the Benicia refinery in the San Francisco Bay area. This was not the typical starting position as a process engineer; I was immediately responsible for writing computer control programs to optimize process conditions for the production of jet fuel and gasoline. The position allowed me to work with all of the process units of

the plant – and during turnaround, I was a crucial part of the team in charge of shutdown and startup. The learning curve was exhilarating, and it was a great opportunity to practice traditional chemical engineering. Within the first six months I developed a program that optimized the waste CO from the catalytic cracker to the pipe-still and vacuum-still furnaces and minimized the fuel gas consumption. This program resulted in annual savings of over \$1 million (which was a significant amount of money in the '70s). Soon I was promoted to a management position as the energy/oil loss coordinator. However, I found that I missed doing technical engineering work, and so I decided it was time to attend graduate school.

After completing my PhD at the University of Pittsburgh and a short postdoc research position in a government lab, I accepted a tenure-track academic position at the University of Nevada, Reno. During the first few years, I set up my research lab and the undergraduate unit operations lab, and incorporated my industrial experience into the core courses that I taught. I found that I truly *loved* teaching and working with students. Our chemical engineering enrollments were very low, so one of my first funded grants was to teach a summer workshop for high school students and their science teachers to help them learn about chemical engineering.

Taryn Bayles is a Professor, Teaching Track and Vice Chair of Undergraduate Education in the Chemical & Petroleum Engineering department at the University of Pittsburgh. She has spent part of her career working in process engineering, computer modeling & control, process design & testing and engineering management with Exxon, Westinghouse, Phillips Petroleum, Sandia National Labs and PETC. She has also spent over 20 years teaching Chemical Engineering at the UNR, Pitt, UMCP and UMBC. Her research focuses on Engineering Education and Outreach and she has received over \$6.7M of NSF funding; the goal of this research is to increase awareness of and interest in pursuing engineering as a career, as well as to understand what factors help students be successful once they have chosen engineering as a major.



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This was an incredibly rewarding experience, and although I did not realize it at the time, it would lay the foundation for many workshops and education-related NSF grants to come.

I had met the love of my life, a fellow PhD chemical engineer, while in graduate school. When we decided to get married, there were limited industrial positions where I was teaching, so I elected to pursue a position in industry again. Based on my prior experience, I knew that I wanted a position in process engineering/design. With a PhD in chemical engineering, it was a real challenge to convince potential employers to interview me for process engineering/design positions rather than research and development positions. However, I was persistent (and even offered to resend my resume without listing my PhD to be considered for an interview!) During my interview, my eventual boss' boss apologized for his reluctance to interview me and offered me a process engineering/design position on the spot as a senior engineer at Westinghouse. I developed and implemented engineering models used to simulate and design waste-to-energy (WTE) processes. It was rewarding to have a technical position in industry again. I was also involved with compliance testing and served as a translator/consultant during plant construction and start-up. Upon the arrival of our daughter, I wanted to be a stay-at-home mom and was allowed to work part time – entirely from home (long before telecommuting became so popular) – doing design, translations and consulting. After several years, I had the opportunity to teach an evening class in thermodynamics at a local community college. The following semester, Westinghouse asked me to prepare and deliver a professional development course for their engineers in applied thermodynamics and process control. Shortly thereafter, I was offered a local part-time position (as a Visiting Assistant Professor) to teach chemical engineering. After two and a half years in this academic position, my husband was relocated, and we were blessed with the arrival of our son. I spent another few years as a stay-at-home mom and cherished this time with our two young children.

When our son started preschool, I wanted to teach part time again. I set up appointments at three local universities (basically I invited myself to meet with chemical engineering department chairs who were not advertising any openings). I introduced myself, gave them a list of courses that I had taught (every core chemical engineering class except for kinetics), and provided my previous teaching evaluations. My pitch was that I was available to teach a wide variety of classes, on a part time basis, and fill in for any faculty member who was on sabbatical or maternity leave or fill in during hiring transitions. Within weeks, I had offers from all three universities. What began as a part-time position to teach graduate transport at the University of Maryland Baltimore County while a faculty member was on maternity leave turned into a full-time position over the next sixteen

years. During this period, my job title varied from Visiting Lecturer to Professor of the Practice. I continued to teach a wide variety of courses, from freshman engineering design to senior capstone design to graduate transport and most everything in between. I strove to incorporate my industrial experience into each of the courses that I taught. I was the PI or co-PI on over \$6.3 million of NSF grants that focused on undergraduate education and K-12 curriculum development. In addition, I developed and led over 100 workshops with over 5000 participants to introduce K-12 students and their teachers to engineering, as well as summer bridge programs for prospective engineering students.

Our children are now grown – our daughter is a postdoctoral chemical engineer at ETH Zürich (no diversity in the gene pool!), and our son is a computer/software engineer at Manhattan Associates. Recently I had the opportunity to receive a teaching-focused position at the University of Pittsburgh. Former dean Gerald Holder has provided his perspective of how this position is valued in the Swanson School of Engineering:

The use of full time NTS (non-tenure stream) teaching faculty at Research I universities has been expanding in recent years. From my perspective much of this has been because of burgeoning enrollments and the need to meet teaching needs that are rapidly expanding. However, NTS faculty are less and less “temporary” and more and more permanent in their role. As such we have defined the role of NTS faculty differently. They of course often bring rich industrial experience that can be absent in the TTS (tenure-track stream) faculty and they can focus much more fully on teaching and mentoring students. I have found that NTS faculty can also contribute to course creating, curriculum revision, and educational innovation. They can also bring in substantial funding if they participate in educational research programs. Because of this, the creation of career tracks for full time NTS faculty is important in order to recognize these special contributions and to distinguish levels of contribution among them. We have done this at Pitt and while there are a few kinks to work out, I think that career paths are hugely beneficial to both faculty and the institution.

Gerald Holder
Distinguished Service Professor Emeritus
Dean of Engineering Emeritus
University of Pittsburgh

CHEMICAL ENGINEERING FACULTY BY THE NUMBERS

In order to *estimate* the breakdown of chemical engineering tenure/tenure-track (T/TT), administrators, and teaching-focused faculty members in the US, 154 department websites were accessed in Fall 2017 and are reported in Figures 1-3. It is important to note that the numbers of teaching-focused faculty reported here likely represent an underestimate of the actual numbers, as department websites may not have been updated. Many departments do not include the teaching-focused faculty on their faculty websites (however, if these faculty/instructors were listed under Staff, they have been included in the numbers provided). Also, the numbers reported do not include non-tenure track research-focused faculty.

Although the number of teaching-focused faculty is small compared to T/TT faculty, hiring of full-time teaching-focused engineering faculty members has increased in recent years. In 2006 there were 2143 non-tenure track (NTT) teaching faculty in Engineering and Engineering Technology colleges, and these numbers almost doubled to 3907 by 2015.^[7] At my own institution, the number of engineering T/TT faculty grew from 86 in 1997 to 132 in 2017. During that same time period, the number of full time teaching-focused positions grew from 11 to 42. There are a wide variety of reasons for this trend – most recently the consensus has been that it is due to the failure of states to provide adequate funding to hire enough T/TT faculty to meet the needs of rising enrollments.^[5-8] It is also important to point out that hiring practices have

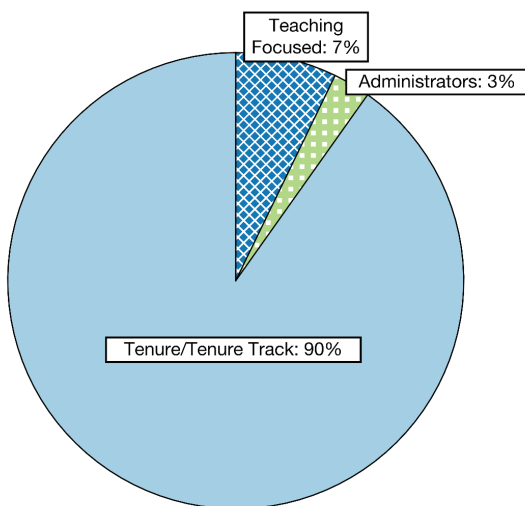


Figure 1: US Chemical Engineering Faculty Member Percentages (by Category – Tenure/Tenure Track, Administrators and Teaching Focused Faculty) as Reported on 154 Department Websites, Fall 2017.

changed in recent years; hiring decisions for teaching-focused faculty have moved to the departments (i.e., made at the department level rather than the school/college/institution level). Teaching-focused appointments are not tracked as closely as T/TT appointments, and there has been a diminished focus on strategic planning related to hiring.^[9]

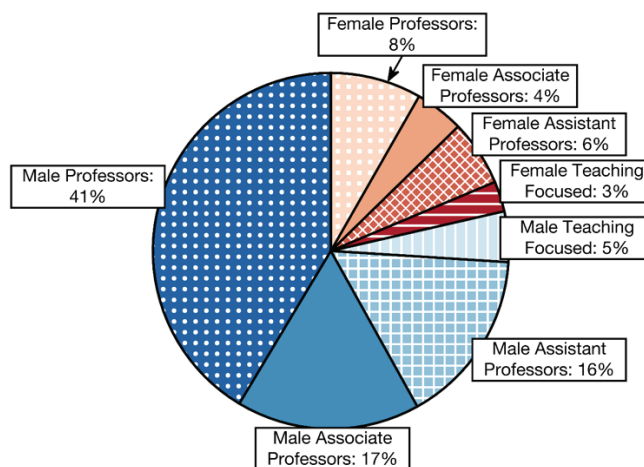


Figure 2: US Chemical Engineering Faculty Member Percentages (by Title and Gender) as Reported on 154 Department Websites, Fall 2017.

However, hiring of teaching-focused engineering faculty has been a long standing practice to recruit engineers with industrial experience.^[10,11] These faculty typically have a deep understanding and appreciation of best practices as applied to real world operations and to enrich the students' experience, as noted by Dean Holder. They are well suited to teach practical courses such as capstone design and laboratory courses,^[10] which are often writing intensive. Since their appointments are primarily teaching, they often have more time and expertise to devote to students in terms of mentoring and career development. They are also an excellent fit for large, hands-on freshman engineering design courses because of the career perspective that they can provide. Teaching-focused faculty are able to devote more of their time and energy^[12] on larger numbers of undergraduate students, whereas T/TT faculty tend to focus on graduate students since their own reputations depend on how successfully they place their PhD students.^[8] Teaching-focused faculty are often able to bring expertise in serving as advisors on design projects and/or project teams and can provide guidance in entrepreneurial activities. At my institution, a teaching-focused position is an intentional *career path* (as noted by Dean Holder) where faculty have two areas of responsibility (one primary and one secondary; for example, teaching and service or teaching and research), while T/TT faculty have three areas of responsibility (teaching, research and service).

ENGINEERING EDUCATION RESEARCH

It was *my* experience (and many of my counterpart colleagues) that teaching-focused faculty are encouraged to pursue external funding (educational, research or industry), as these research expenditures increase the department's total research expenditures and the average research expenditures per full-time T/TT faculty – both of which were used by the *U.S. News and World Report Best Engineering Schools Rankings*.^[13] In the average research expenditures per faculty member calculation, the funding secured by teaching-focused faculty is added in the department numerator, but these faculty members are not included in the denominator since they are not considered as “full time equivalent T/TT faculty”, thereby increasing the average research expenditure per faculty member for the department.

The focus of most teaching-focused faculty is undergraduate students, and as such these faculty tend to bring in much needed educational research grants that benefit the student body more broadly than the T/TT faculty who focus more on experimental and computational research and graduate student development. There are several current NSF funding opportunities that are well suited for teaching-focused faculty, and are provided in Table 1.

The student-focused grants often provide minimal overhead and summer salary for faculty, but they provide substantial opportunities (scholarships, mentoring, undergraduate research experiences, etc.) for the students who are selected to participate in the programs. There are also other programs for department/curricular/research reform that are particularly well suited for teaching-focused faculty who are interested in studying the impact of new teaching, learning, and educational research in their classrooms. For teaching-focused faculty who are interested in K-12 outreach, there are additional programs that provide excellent opportunities. Although securing education-related research funding was not a formal part of my teaching-focused position (which required teaching and service), I wrote grant proposals in several of the programs listed in Table 1. The result of this funding was two-fold; my

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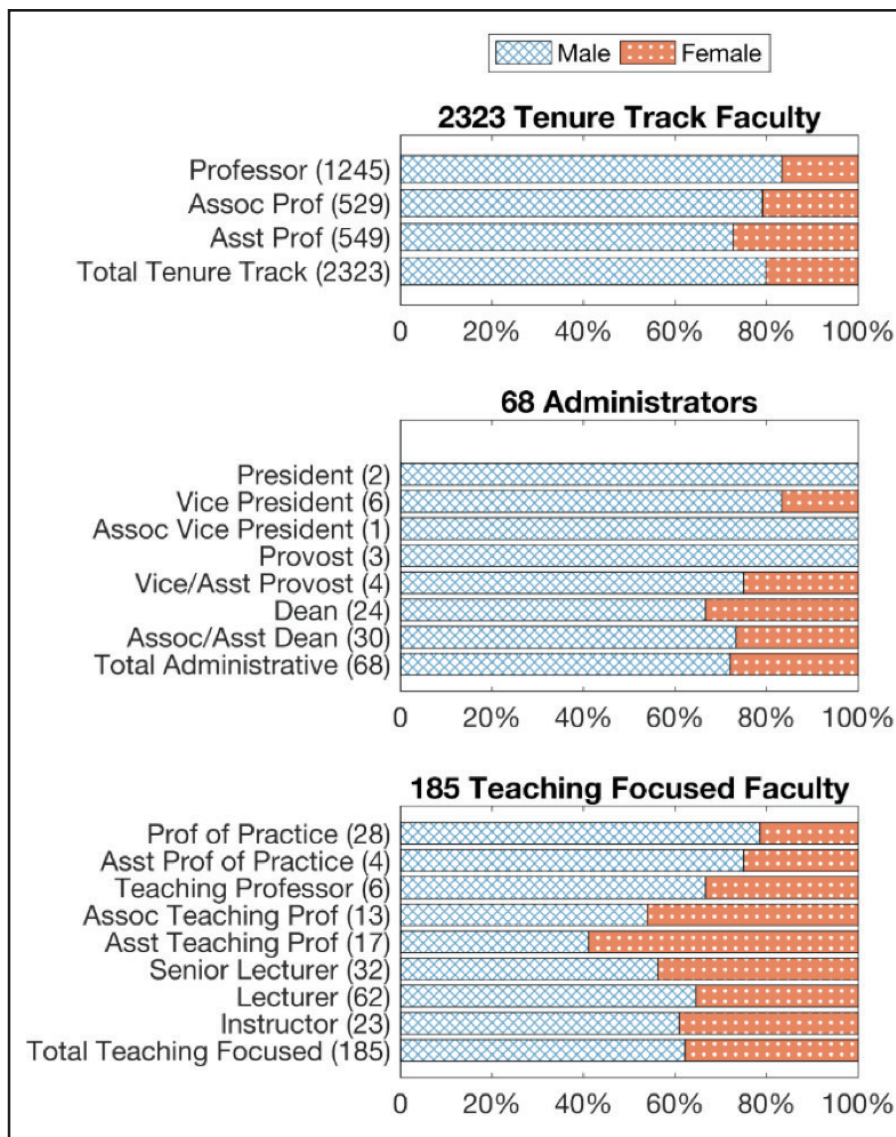


Figure 3: US Chemical Engineering Faculty Numbers in Tenure/Tenure Track, Administration and Teaching Focused Positions (by Faculty Title) as Reported on 154 Department Websites, Fall 2017.

multi-year contracts were extended and I received *tenure-track* job offers at other institutions.

ACADEMIC SERVICE

Service is another area where teaching-focused faculty can provide significant support to the department. New tenure-track faculty at Research I institutions must often focus on establishing/maintaining their research program and publishing so they often do not have the extra time to focus on recruiting undergraduates. It is well documented that the US still has a large need to increase the number of students who will pursue engineering degrees.^[14] Although increased employment opportunities for chemical engineers are forecast for

TABLE 1
Current NSF funding opportunities focused on engineering education

Student Focused	SSTEM – Scholarships in Science, Technology, Engineering and Mathematics REU – Research Experiences for Undergraduates INCLUDES – Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering Science BPE – Broadening Participation in Engineering
Curricula Reform and Educational Research	RED – Revolutionizing Engineering and Computer Science Departments CREST – Centers of Research Excellence in Science and Technology IUSE – Improving Undergraduate STEM Education
K-12 Outreach	CADRE – Community for Advancing Discovery Research in Education ITEST – Innovative Technology Experiences for Students and Teachers DRK-12 – Discovery Research in K-12

the future^[15], national enrollment in engineering disciplines, coupled with retention, have not kept up with the demand for these graduates.^[16-17] Teaching-focused faculty with a commitment to service often have the time and desire to meet with prospective students and their families, and these one-on-one or small group meetings often provide the personal touch that results in higher enrollments and retention.^[14,18-20]

There is also a large need for “train the teacher” programs so that K-12 teachers can inspire their students to pursue engineering.^[21-28] These programs need the expertise of engineering faculty to provide K-12 teacher professional development to learn about engineering and how to incorporate engineering into their classrooms. This type of effort does not necessarily help a tenure track faculty member with their tenure package; however, for teaching-focused faculty, these are excellent opportunities to provide valuable service for the development of K-12 teachers, which can lead to an increase of engineering students in our programs.

Traditional academic service that is typically provided by teaching-focused faculty include serving as the Undergraduate Program Director, Director of Outreach, Director of Advising, ABET coordinator and curriculum review. In addition, serving as a faculty advisor for student chapters of professional organizations such as AIChE (American Institute of Chemical Engineers), SWE (Society of Women Engineers), NSBE (National Society of Black Engineers) and oSTEM (Out in Science, Technology, Engineering and Mathematics) are rewarding experiences and support the development of our students.

RECOMMENDED BEST PRACTICE

At the 2018 ASEE Annual Conference a leadership roundtable was held to discuss how teaching-focused faculty can be supported. Based on these discussions with teaching-focused faculty, experience and the literature, best practices for those considering teaching-focused faculty positions (or who have recently started in this type of position) include the recommendations in Tables 2 and 3.

As supported by the data provided, over the last twenty years there has been a large increase in the number of teaching-focused positions in public, private and Research I institutions, and it has been my experience that a teaching-focused faculty position involves a multi-year contract – and can also be a career-path orientated position with reviews and promotions. Because the focus on students has allowed me to concentrate on what is most important to me,^[49,51] I have found this position to be very rewarding. I have had the privilege to work closely with students as they have embarked on their chemical engineering careers, and I cannot imagine a better path that I could have chosen. Many others agree with the job satisfaction of a teaching-focused faculty position; when surveyed, 86% of teaching-focused faculty said they would take the same path if they had the chance to do it all over again.^[52] Looking back, I *have* made the most of a wide range of opportunities and have been fortunate to have had many rewarding positions. In the years to come, I hope that many more chemical engineering graduate students and working professionals will decide to reap the same rewards.

TABLE 2
Best practices when considering teaching-focused faculty positions

- Look for opportunities to co-teach a course (beyond serving as a Graduate Teaching Assistant; some universities often have Teaching Fellowships^[29] for their Ph.D. candidates)
- Take courses/workshops and read to learn about teaching pedagogy.^[30-32]
- Make sure to get your contract in writing, specifically your course load and service requirements
 - » Are courses weighted or counted differently if they are large enrollment courses, multiple section courses, or if you are co-teaching a course, etc.?
 - » Is advising a large number of students expected as a service contribution, or is it counted as a 'course'?
 - » Is serving as the Undergraduate Program Director, Director of Advising or Outreach, ABET coordinator, etc. spelled out as a specific service requirement, or is it counted as a 'course'?
- Join (or start) a Teaching and Learning community on your campus^[33] and network with other teaching focused faculty at your institution
- Sit in on classes taught by outstanding teachers; ask them to observe your classes and give you feedback
- Seek mentoring from teaching-focused faculty (which means that you might have to look outside of your department or institution)
- Obtain the department's, school's, college's and university's guidelines for the teaching-focused position as well as guidelines for promotion from Assistant to Associate to Full teaching-focused Professor (these guidelines are extremely important for your professional development – if your school does not have guidelines for teaching-focused positions, the Swanson School of Engineering at the University of Pittsburgh as well as North Carolina State University are happy to share their guidelines as examples)
- Seek mentoring from tenure-track faculty in your department as they will likely be on your promotion and/or contract renewal committee
- Seek mentoring from faculty who are great teachers, regardless of rank and tenure status
- Document time spent^[12] with students on mentoring, career development, recruitment, advising student groups, etc.
- After a few years, get involved in activities, committees, etc. that are outside of your department
- Become an active member of the ASEE Chemical Engineering Division and the AIChE Education Division^[31]
- Apply for the ASEE Educational Research and Methods Division (ERM) Apprentice Faculty Grant^[34], ASEE Chemical Engineering Division Young Faculty / Future Faculty Mentoring and Travel Grant^[35] and AIChE Education Division's Faculty Mentoring Program.^[36]
- As an advocate for your students (often with an open door policy), be aware of your own mental health – take time to recharge between semesters.^[37]
- Remember that **you** will need to be your strongest advocate

TABLE 3**Best practices for department chairs (or the leadership team) looking to support teaching-focused faculty**

- Provide equitable pay, benefits, governance, curriculum design and responsibilities^[38-41]
- Ensure equitable hiring practices^[9,42]
- Articulate how performance will be reviewed and evaluated, and provide guidelines for the position to the teaching-focused faculty
- Clearly outline the teaching-focused position responsibilities – which are requirements, which are encouraged optional activities, and what activities are discouraged
- When teaching faculty are evaluated based on their students' evaluation of teaching scores, be aware of various biases (course level, class size, gender, faculty experience, etc.)^[43]
- Articulate how contract renewals/extensions will be determined
- Advocate for changing the name of the teaching-focused position at your institution (who wants to be associated by what they are 'not'^[44]?)
- Include faculty mentors who are both tenure-track and teaching-focused faculty members in the evaluation process, as most promotion committees are primarily composed of tenured faculty
- Educate the entire faculty on the roles and responsibilities of the teaching-focused faculty position
- Be vigilant to prevent workplace bullying and harassment^[39]
- Provide professional development opportunities^[41-45] (i.e., How to Engineer Engineering Education workshop at Bucknell^[46], National Effective Teaching Institute (NETI I and II)^[47], Chemical Engineering Education Summer School^[48] – the next offering will be summer 2021)
- Provide opportunities for sabbatical^[49] to gain industrial experience^[11], develop new courses, pursue engineering education and Fulbright Scholar opportunities, etc.
- Nominate teaching-focused faculty for campus and professional society awards (many university teaching, mentoring and service awards are limited to T/TT faculty – advocate to have these awards include the consideration of teaching-focused faculty)
- Provide funding to attend conferences (ASEE, AIChE, Wakonse^[50], etc.)

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