Pre and Post Tenure: Perceptions of Requirements and Impediments for Chemical Engineering Faculty

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Abstract

The tenure process has been both applauded and criticized since its inception in 1915. While some institutions have chosen to move away from the tenure process, it is still prevalent in the US higher education system. The title of tenured professor is a sought after prize by untenured faculty, and those in chemical engineering are no exception. Anecdotally, faculty know that the tenure process can be variable among institutions, at times unclear, and sometimes perceived as unachievable. The aims of this paper are to shed light on the perceptions of early career faculty (untenured or recently tenured) regarding the tenure process. Specifically, we aim to: (1) classify the variability in perceptions of tenure requirements among assistant and associate professors in chemical engineering programs and (2) identify their perceived impediments towards obtaining tenure. Faculty from ABET accredited programs in tenure-track positions were identified through an online search, and were provided with an online survey to complete. Faculty responses were categorized by rank and according to the Carnegie Classification of Institutions of Higher education that classifies institutions according to their research activity. We hope that this paper will spark conversations regarding clarity of requirements, and concerns about work-life balance for tenure-track faculty.

Introduction and Background

Since first being adopted at Johns Hopkins in 1915, tenure has been a contentious topic [1]. Some believe it can lead to apathy and decreased productivity post-tenure [2]; others argue that it affords invaluable protection against institutional politics [3] and is an “integral part” of higher education [4]. While non-tenure track positions are becoming increasingly more common [5-7], tenure remains a pillar of employment in higher education.

A tenured position in academia comes with a level of job security not commonly found in the modern economy. The reward for what is often stressful years spent demonstrating individual worth as a scholar, teacher, and community member is what may be the epitome of academic freedom. While receiving tenure is the (near-) guarantee of future employment, tenure itself can feel, and be, elusive. In one longitudinal study on faculty retention in science and engineering, only 64.2% of assistant professors were promoted (and presumably tenured) to associate professor at their institution [8].

Academic positions are known to be competitive. The number of PhDs earned from U.S. institutions has been steadily rising since the National Science Foundation first began recording this data in 1958 [9]. Data on Chemical Engineering PhDs granted has been collected every five years since 1988 and follows the same trend. In 2018, 981 Chemical Engineering doctorates were awarded in the U.S [10]. Of those 981 PhDs, 188 went on to postdoctoral positions and a mere 18 to academic positions [11]. The NSF does not provide specific details on the types of academic positions, it is thus presumable that these include tenure-track and non-tenure track positions.

While these numbers do not account for non-US earned doctorates, they do illustrate the relative rarity of a tenure-track position. In human nature, what is rare is often also prized, and the tenure-track position is no exception. Newly hired tenure-track faculty may find that with the prize of the position also comes isolation, as they are likely the only new hire in their department. They may also experience impediments from hidden responsibilities, lack of clarity in expectations, and simple oversights if their department does not hire new faculty regularly.

Methodology

Data was collected in a nationwide survey distributed through the Qualtrics online survey software. Participants were emailed a link to the survey along with an explanation of the purpose of the study. After approximately two weeks, a reminder was sent to non-respondents. Respondents could choose to skip survey questions as desired. All study methods were first approved by the institutional review board before survey dissemination.

A total of 1229 participants were identified from different U.S. universities/colleges. The sample population of tenured and tenure-track faculty in chemical engineering programs was identified through an online search. Chemical Engineering faculty were defined as the faculty belonging to ABET accredited programs. In total 176 different programs were identified for chemical engineering [12].

Contact information of faculty members with the rank of Assistant or Associate Professor was compiled from an internet search of the various department/school websites. The departments/schools were further identified and categorized according to the 2018 Carnegie Classification of Institutions [13] they belonged to as follows:

- R1: Doctoral Universities – Very high research activity,
- R2: Doctoral Universities – High research activity,
- D/PU: Doctoral/Professional Universities,
- M1: Master's Colleges and Universities – Larger programs,
- M2: Master's Colleges and Universities – Medium programs,
- M3: Master's Colleges and Universities – Smaller programs, and
- Baccalaureate Colleges: Arts & Science Focus or Engineering Focus.

The survey was designed to collect participants' perceptions of tenure requirements and impediments. Demographic and institutional data were also collected, including the name of institution the faculty is serving, their title, position, and time in current position.

Participants were asked to identify whether they had been given specific guidelines about the requirements to earn tenure. If they were, the survey asked them to provide both the guideline distributions and actual distributions (as percentages) for their time spent on Research/Teaching/Service/Other activities. Participants who reported not receiving any formal guidelines were asked about their perceptions only.

Specific items capturing participants' distribution of Research/Teaching/Service/Other activities included measures of "Teaching Work Load," "Teaching Evaluation Metrics," "Research Dollar

Amount," "Number of Peer Reviewed Journal Articles," "Participation in Conference Proceedings," and any other guidelines.

Participants were also asked to assess whether they believed their requirements are "Attainable" for faculty members in their discipline and their academic unit, "Comparable" to faculty in their academic unit but not in their discipline, and "Comparable" to faculty in other departments in their College.

Finally, participants were asked to rate the following possible impediments on their likelihood of influencing the tenure process:

- Teaching load requirements,
- Expectation of peer-reviewed journal publications,
- Service expectations,
- Availability of funds for research in their fields
- Appreciation for area of research by tenure review committee(s)
- Competition within department for funds,
- Availability of Teaching Assistants (TA) to assist with grading,
- Availability of students to employ as researchers,
- Quality of students to employ as researchers,
- Availability of faculty mentoring,
- Quality of faculty mentoring,
- Interdepartmental politics, and
- Managing work-life balance

Results were tabulated by institution Carnegie classification and position type (tenure-track versus tenured). Statistical analysis identifying the means and quartiles was performed for quantitative data (the percent distribution of time spent by each faculty).

Results and Discussion

Of the 1229 invited participants, 183 provided valid responses to the survey (14.89% response rate). Responses included participants from 46 states, and represented faculty from 111 different institutions. The distribution of responses per state is shown in Figure 1.

One hundred and four (104) of the responders were Assistant Professors (Tenure-Track, designated "TT"), while 79 were tenured faculty members. The distribution of the responses according to institution type and tenure characterization is provided in Table 1.

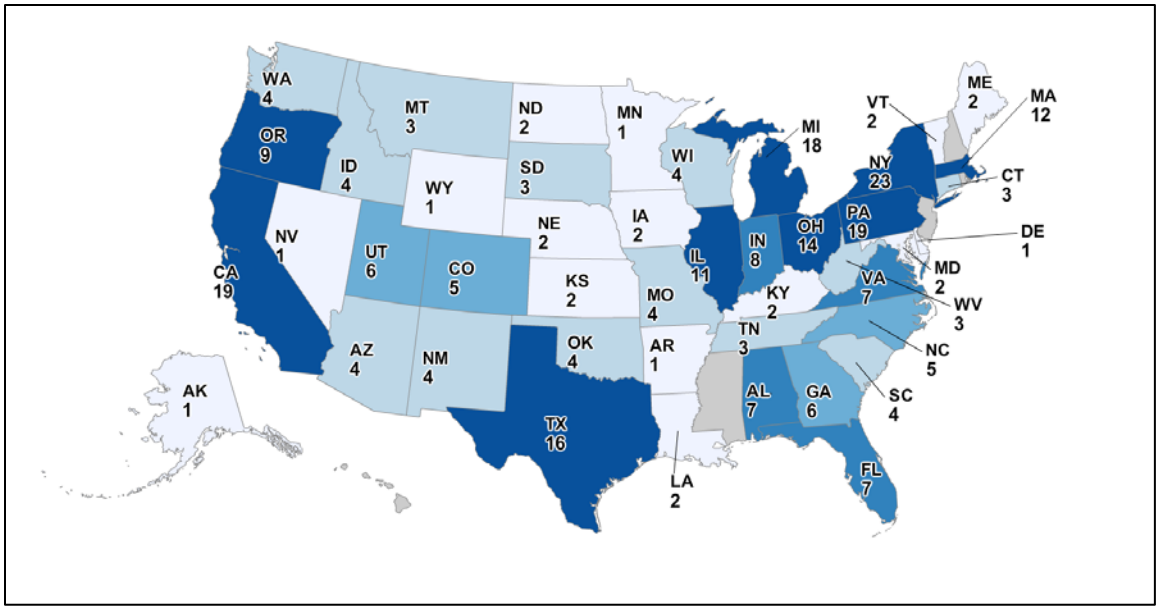

Figure 1: Distribution of Responses

Table 1: Distribution of Responses per Institution Category and Tenure

Institution Category	TT	Tenured	Total
R1	74	42	116
R2	20	25	45
D/PU	1	0	1
M1	2	4	6
M2	1	3	4
M3	1	1	2
B	5	4	9
Total	104	79	183

Participants were further classified according to their sub-discipline within Chemical Engineering. A distribution of the various disciplines is provided in Table 2. Participants could select more than one sub-discipline from the provided list, as well as declare a discipline not listed. In the "Other Category, participants responded with a range of sub-disciplines that included: Agricultural Engineering, Bioenergy, Biomedical Engineering, Catalysis, Colloidal & Interfacial Phenomena, Combustion, Computational Materials Science, Engineering Education, Electrochemistry, Energy, Fluid Mechanics and Experimentation, Molecular Modeling/simulation, Nanomaterials Engineering, Particle Technology, Particulate Processing, Polymer Engineering, Process Systems Engineering, Separations, Soft Matter, Systems Biology, Thermodynamics, and Transport Phenomena.

Table 2: Distribution of Sub-disciplines

Sub-discipline	Frequency
Environmental	37
Bioengineering/Biological	83
Genetic	10
Materials Science	85
Nuclear Engineering	2
Process Safety	1
Process Control	4
Process Design	11
Reaction Engineering	28
Other	41

As summarized in Table 3, less than half of the tenure-track faculty were provided with specific guidelines for the tenure processes (45.1%). For tenured faculty, more than half reported having received guidelines (64.1%). It is important to note that not all 183 respondents answered every question, as they had the option to skip any question they wished.

Table 3: Provision of Guidelines

Rank	Guidelines	R1	R2	D/PU	M1	M2	M3	B	Sum	% per Rank
TT	**Provided**	32	9	0	1	1	1	2	46	45.1%
	Not Provided	40	11	1	1	0	0	3	56	54.9%
Tenured	**Provided**	28	14	0	3	3	0	2	50	64.1%
	Not Provided	13	11	0	1	0	1	2	28	35.9%
	Sum	113	45	1	6	4	2	9	180	

Participants described their requirements for tenure per both the guidelines (when available) and their own perceptions in the categories of teaching, research, and service.

Teaching Expectations

Table 4 summarizes participants' teaching load in terms of number of courses. The data is categorized by institution type and faculty rank, and represents the frequency of response for each subset of number of courses. Because of the low number of responses from Masters and Baccalaureate institutions, their responses have been combined.

Table 4: Annual Teaching Load (Courses Taught/Year)

Type	Rank	Annual Teaching Load (# of responses)			
		1-2 courses	3-4 courses	5-6 courses	7+ courses
R1	TT	43	18	2	-
	Tenured	18	7	1	-
R2	TT	5	12	1	1
	Tenured	2	19	1	-
D/PU+M+B	TT	-	2	4	2
	Tenured	-	4	3	4

The number of courses taught is typically lower for faculty at higher research activity institution, with a few exceptions. This is well-aligned with the convention that higher research activity institutions require their faculty to devote a larger percentage of their time to research activities, and consequently less time to teaching. There appears to be no notable difference in distribution of number of courses taught between tenured and tenure track faculty.

Research Expectations

Research expectations, as measured by research funding dollars, are summarized in Table 5. Data represents the number of respondents for each range of dollar amounts and is categorized by institution, faculty rank, and whether guidelines provided.

Table 5: Research Funding Expectations

Type	Rank	Guidelines Provided	$ Amount of Research Funding Secured by Tenure Application				
			<$500k	> $500k - $1mill	> $1mill - $1.5 mill	>$1.5 mill	NA or Unspecified
R1	TT	Yes	1	5	3	-	15
	Tenured		-	4	1	-	16
	TT	No	4	16	1	-	15
	Tenured		1	3	1	-	7
R2	TT	Yes	2	-	-	-	6
	Tenured		5	3	-	-	4
	TT	No	2	3	-	-	5
	Tenured		3	1	1	-	4
D/PU+M+B	TT	Yes	3	-	-	-	2
	Tenured		4	-	-	-	4
	TT	No	4	-	-	-	-
	Tenured		3	-	-	-	-

Among faculty reporting research funding expectations, the responses show a general trend of greater dollar amounts expected from higher research activity institutions. Again, this is well-aligned with these institutions requiring more research, as research funding is one mechanism for catalyzing productivity.

Comments provided by faculty in this section suggest that funding requirements are not quite clear. Respondents note that certain levels of funding were “implied” or that vague terms such “sufficient” or “sustained” were used.

Journal Publication Expectations

The number of journal publications expected by the time a candidate applies for tenure is summarized in Table 6. Once again, the data represents the number of faculty who responded for each range of publication numbers, and is sorted by institution type, faculty rank, and whether guidelines were provided.

Table 6: Journal Publication Expectations

Type	Rank	Guidelines Provided	Number of Journal Publications by Tenure Application				
			1-4	5 - 9	10 - 14	15+	NA or Unspecified
R1	TT	Yes	-	2	13	1	15
	Tenured		1	2	7	3	10
	TT	No	-	5	18	7	5
	Tenured		-	-	4	5	5
R2	TT	Yes	1	5	2	-	1
	Tenured		1	4	4	2	2
	TT	No	1	4	2	1	2
	Tenured		-	4	2	1	2
D/PU+M+B	TT	Yes	-	3	1	-	1
	Tenured		3	3	-	-	2
	TT	No	2	-	-	-	2
	Tenured		-	2	-	-	1

Once again, the higher research expectations of higher research activity institutions is evident in the faculty responses. It is notable that for R1 institutions, a greater proportion of tenure-track faculty reported that 15+ publications were required in the group that did not receive tenure guidelines. This may be driven by a desire to exceed expectations as a form of security in achieving tenure, as journal publications are a widely accepted measure of research productivity. Such a hypothesis has some support from a study on the turnover rates among corporate Chief Executive Officers where it was found that CEOs were more likely to be retained when the company performance exceeded expectations under their purview [14].

Comments again suggested that many of what the faculty perceive as the requirements noted here have been “implied” and that there was an expectation of a “ramp up” in publication as they approach tenure. Some noted that the requirements were “similar” to what has been achieved by recently tenured faculty. Notably, one respondent openly stated that the recently tenured faculty at their institution were working to increase the requirements for journal publications.

Attainability of Tenure and Comparability of Tenure Requirements

Faculty that were given guidelines for tenure requirements were asked to rate whether they believed these guidelines to be a true representation of what is required by a faculty in their department. Table 7 summarizes these responses by institution type and faculty rank. The majority of faculty reported neutral (the guidelines may or may not be a true representation) to affirmative (they definitely are) perceptions. While we predicted that tenured faculty may be

more likely to respond in the affirmative, as they have achieved these requirements, the responses are largely similar between faculty ranks.

Table 7: Provided Guidelines as a True Representation of Requirements

Rank	Type	Def. Yes	Prob. Yes	Might/Might Not	Prob. Not	Def. Not
TT	R1	3	11	7	1	0
	R2	3	6	2	0	1
	D/PU	0	0	0	0	0
	M1	1	1	1	0	0
	M2	1	2	0	0	0
	M3	0	0	0	0	0
	B	0	1	0	0	1
Tenured	R1	2	14	4	2	2
	R2	1	2	4	1	1
	D/PU	0	0	0	0	0
	M1	0	1	0	0	0
	M2	1	0	0	0	0
	M3	0	1	0	0	0
	B	1	1	0	0	0

In dichotomous forced-choice yes/no questions, the participants were asked if they believed the tenure requirements (provided or perceived) are “Attainable” for faculty members in their discipline and academic unit. They were also asked to respond if they thought the requirements, perceived or otherwise, were comparable to other members of the faculty not within their discipline, and comparable to other faculty within their college. These responses are summarized in Table 8.

Table 8: Attainability and Comparability of Requirements

Type	Rank	Attainable		Comparable within Department		Comparable to other Departments in the College	
		Yes	No	Yes	No	Yes	No
R1	TT	92.5%	7.5%	85.1%	14.9%	71.7%	28.3%
	Tenured	90.6%	9.4%	80.0%	20.0%	68.8%	31.3%
R2	TT	88.2%	11.8%	72.2%	27.8%	82.4%	17.6%
	Tenured	95.0%	5.0%	88.9%	11.1%	78.9%	21.1%
M1	TT	100.0%	0.0%	50.0%	50.0%	100.0%	0.0%
	Tenured	66.7%	33.3%	75.0%	25.0%	50.0%	50.0%
M2	TT	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%
	Tenured	66.7%	33.3%	100.0%	0.0%	66.7%	33.3%
M3	TT	100.0%	0.0%			0.0%	100.0%
	Tenured			100.0%	0.0%	100.0%	0.0%
B	TT	80.0%	20.0%	0.0%	100.0%	33.3%	66.7%
	Tenured	100.0%	0.0%	100.0%	0.0%	0.0%	100.0%

No statistically significant relationships were observed in the analysis of faculty perceptions on attainability and comparability of their tenure process. Overall, we see that the vast majority of research university faculty believe their requirements are both attainable and comparable, as do most faculty at master's granting institutions. The Baccalaureate-only institutions are the only case where the majority of tenure track faculty do not think their requirements are comparable within their department or with other departments in the college, and the majority of tenured faculty do not think they are comparable to other departments in the college specifically. It is important to note that the masters and baccalaureate institution categories each have a sample size of less than 10 when considering these results.

While the majority of faculty report that they believe their requirements are attainable and comparable, their included comments paint a somewhat conflicting picture. Tenured and tenure-track faculty at all institutions name a number of challenges, particularly a lack of resources, in achieving tenure. Many note the challenge of securing funding, and the variable nature of the funding climate. Several comment on faculty and staff shortages creating added difficulty, or having inconsistent or imbalanced expectations (e.g., research expectation too high for teaching load). While still viewing tenure as attainable, these respondents cite that it takes "hard work" or "makes pre-tenure life very stressful." Some faculty credit vague or lack of guideline as a strength of the tenure process – that it adds flexibility to the process that can account for different funding landscapes and timescales for scholarship. Others believe these vague and missing guidelines create opportunity for discrepancies in reviewing tenure cases. A couple of tenured faculty note that they do not believe the requirements at their institution are attainable anymore, in some cases citing perceived increase in requirements and in others not elaborating. One respondent notes that their institution has formal pre-tenure mentoring that includes meeting with your mentor 1-2X annually to specifically discuss your progress to tenure, citing that this has been "extremely valuable."

When coupled with the Likert-scale response that tenure is perceived as attainable, the qualitative responses suggest faculty acceptance that the road to tenure is difficult and stressful.

Time Spent Teaching and Research

Table 10 and Figure 2 both summarize the responses for how much of their time faculty spend on research and teaching. Responses are categorized by institution type and official versus actual time spent in Table 10. In Figure 2, contractual and actual (percent) time spent on teaching and research is compared in box plots representing the data categorized by both institution type and faculty rank.

Table 9: Percentage of Time Spent in Research & Teaching

	Type		Minimum %	Q1 %	Median %	Q3 %	Maximum %
Contractual Expectations	R1	Research	20	40	45	60	70
		Teaching	15	30	40	45	75
	R2	Research	8.33	40	45	53.75	65
		Teaching	20	30	40	45	83.34
	D/PU+M+B	Research	0	18.75	34	40	50
		Teaching	34	40	50	62.5	80
Actual Time Spent	R1	Research	10	40	50	60	90
		Teaching	0	20	30	44.25	80
	R2	Research	10	30	40	55	75
		Teaching	15	30	35	45	80
	D/PU+M+B	Research	0	15	20	29.5	65
		Teaching	20	50	60	70	80

Figure 2: Percentage of Faculty Time Spent in Research (top) and Teaching (bottom)

Contractually, faculty of all rank at R1s and R2s, and tenured faculty at Masters/Baccalaureate institutions report similar percentage of time obligations for research. Actual percent time spent on research is more variable, with tenure-track faculty at R2s reporting the highest percentage, and their tenured counterparts reporting the lowest. This may suggest that these faculty are most affected by the anecdotal "post-tenure slump" in productivity that may come from being worn out during the process.

Tenure-track faculty at Masters/Baccalaureate institutions report both the highest contractual and actual percentage of time spent teaching. This is well-aligned with expectations, as these institutions are known (and report) higher teaching loads than research intensive institutions.

Overall, faculty at all institution types report working on average 50-55 hours a week for tenured faculty and 55-60 hours per week for tenure-track. Seventy-five percent of all faculty report working 50+ hours per week, with the maximum time reported going as high as 90 hours/week.

Impediments

Faculty members were asked to rate the likelihood of several potential impediments affecting their tenure process. That information is shown in Table 10 (following page). Highlighted are the observations where at least 50% of responses were either likely or unlikely to affect the faculty tenure process.

Notable observations from these responses include that both tenure-track and tenured faculty at research institutions perceive the expectation of peer-reviewed journal publications as having a positive impact on their quest to achieve tenure. This may be an effect of journal publication requirements serving as a motivator for faculty in these roles. Tenured faculty at research institutions also report greater confidence in their review committee's appreciation of their research. Having successfully gone through the review process, they may see more evidence that their research is valued by their peers compared to tenure-track faculty.

The majority of respondents in all categories cited that competition for academic funds in units had neither positive nor negative impact. Surprising to the study team, tenured faculty and tenure-track non-PhD granting institution faculty rated availability of student researchers most positive, though the majority of faculty in most categories (except tenure-track, masters/baccalaureate and tenured R1) noted that the quality of students had a negative impact on their tenure process.

In general, tenure-track faculty reported more positive impact from the availability of faculty mentoring, particularly at R2 and masters or baccalaureate institutions. As R1 institutions are typically larger than others, these faculty may find greater challenges in building community and mentoring relationships than their R2 or non-PhD granting peers.

Table 10: Impacts of Possible Impediments

		TT			Tenured		
Impediment	**Impact**	R1	R2	M+B	R1	R2	M+B
My teaching load	**Positive**	23.0%	35.0%	66.7%	37.8%	55.0%	27.3%
	Neither	36.1%	25.0%	11.1%	24.3%	20.0%	27.3%
	Negative	41.0%	40.0%	22.2%	37.8%	25.0%	45.5%
Expect. of peer-reviewed journal publications	**Positive**	61.0%	60.0%	44.4%	72.2%	75.0%	27.3%
	Neither	25.4%	25.0%	44.4%	16.7%	20.0%	45.5%
	Negative	13.6%	15.0%	11.1%	11.1%	5.0%	27.3%
My service expectations	**Positive**	36.1%	30.0%	55.6%	40.5%	52.6%	36.4%
	Neither	37.7%	35.0%	33.3%	29.7%	15.8%	36.4%
	Negative	26.2%	35.0%	11.1%	29.7%	31.6%	27.3%
Availability of funds for research in my field	**Positive**	47.5%	31.6%	37.5%	40.5%	45.0%	10.0%
	Neither	16.9%	36.8%	25.0%	18.9%	25.0%	40.0%
	Negative	35.6%	31.6%	37.5%	40.5%	30.0%	50.0%
Apprec. for my area of research by review commit.	**Positive**	34.0%	38.9%	33.3%	56.8%	55.0%	20.0%
	Neither	45.3%	33.3%	33.3%	24.3%	25.0%	60.0%
	Negative	20.8%	27.8%	33.3%	18.9%	20.0%	20.0%
Competition within academic unit for funds	**Positive**	14.6%	27.8%	28.6%	13.3%	17.6%	12.5%
	Neither	60.4%	61.1%	71.4%	70.0%	64.7%	62.5%
	Negative	25.0%	11.1%	0.0%	16.7%	17.6%	25.0%
Availability of TA for grading	**Positive**	30.4%	25.0%	33.3%	51.5%	36.8%	0.0%
	Neither	28.6%	40.0%	50.0%	21.2%	26.3%	20.0%
	Negative	41.1%	35.0%	16.7%	27.3%	36.8%	80.0%
Availability of students to employ as researchers.	**Positive**	36.7%	45.0%	62.5%	51.4%	50.0%	30.0%
	Neither	15.0%	10.0%	37.5%	11.4%	10.0%	10.0%
	Negative	48.3%	45.0%	0.0%	37.1%	40.0%	60.0%
Quality of students to employ as researchers	**Positive**	36.2%	30.0%	44.4%	47.2%	45.0%	11.1%
	Neither	17.2%	25.0%	44.4%	16.7%	0.0%	33.3%
	Negative	46.6%	45.0%	11.1%	36.1%	55.0%	55.6%
Availability of faculty mentoring	**Positive**	42.6%	72.2%	87.5%	43.2%	40.0%	11.1%
	Neither	16.4%	11.1%	12.5%	29.7%	15.0%	22.2%
	Negative	41.0%	16.7%	0.0%	27.0%	45.0%	66.7%
Quality of faculty mentoring	**Positive**	45.9%	80.0%	100.0%	40.0%	54.5%	16.7%
	Neither	27.0%	10.0%	0.0%	40.0%	18.2%	33.3%
	Negative	27.0%	10.0%	0.0%	20.0%	27.3%	50.0%
Interdepartmental politics	**Positive**	29.8%	42.1%	22.2%	21.2%	23.5%	20.0%
	Neither	43.9%	31.6%	44.4%	48.5%	41.2%	30.0%
	Negative	26.3%	26.3%	33.3%	30.3%	35.3%	50.0%
Managing work-life balance	**Positive**	21.0%	35.0%	11.1%	19.4%	15.0%	25.0%
	Neither	25.8%	30.0%	55.6%	38.9%	30.0%	25.0%
	Negative	53.2%	35.0%	33.3%	41.7%	55.0%	50.0%

Observations and Conclusions

The study sample of 183 assistant and associate chemical engineering faculty was heterogeneous in being recruited from 46 different states and 111 institutions, and therefore, our findings may be generalized to faculty for Chemical Engineering across the U.S. However, the findings presented in this paper should not be generalized to faculty in other disciplines or countries.

Many of the results are well-aligned with expectations for institutions based on research classification. In general, faculty spend more time teaching and less time on scholarship at lower research level institutions, despite reporting similar contractual obligations on how time is spent among categories. Qualitative responses suggest that faculty perceptions of what is required to achieve tenure lean on implication in many cases more than specific guidelines, with less than half (approximately 45%) of the untenured respondents reporting that they received any guidelines.

While the majority of faculty report that they believe their tenure requirements to be attainable, qualitative responses note a number of challenges conflicting with this response. The language used ("stressful," "difficult," "challenging") suggests that faculty have accepted that the tenure process is strenuous. This is further supported by the fact that 75% of faculty report working 50 or more hours/week, well above the standard 40 hour workweek.

Recommendations

For tenure-track faculty seeking to achieve tenure, the results here suggest that their effort should be distributed among teaching, scholarship, and service as dictated by their institution's Carnegie Classification and advice they receive. Attempts should also be made to receive greater clarity of requirements in the absence of guidelines.

Departments and institutions seeking to hire faculty in tenure-track chemical engineering positions may consider developing guidelines for achieving tenure to support their new hires through the process. Furthermore, exploring best practices such as a "tenure mentoring committee" as mentioned by one respondent may prove extremely valuable. These measures may help alleviate some of the stress inherent to the process.

Future Work

The scope of this work was limited to comparisons across rank and institution type. In future work we will explore demographic relationships (e.g., gender, race/ethnicity) and are also interested in eventually looking at cross-disciplinary comparisons.

References

[1] R. Varma, "The tenure system and engineering institutions," in *Procceedings of the ASEE Annual Conference and Exposition*, Salt Lake City, UT, 2004.

[2] T. Sowell, Inside American Education: The Decline, the Deception, the Dogmas., New York: Free Press, 1993.

[3] R. B. McKenzie, "In defense of academic tenure," *Journal of Institutional and Theoretical Economics* , pp. 325-341, 1996.

[4] M. S. McPherson and G. C. Winston, "The economics of academic tenure: A relational perspective," *Journal of Economic Behavior & Organization*, vol. 4.2, no. 3, pp. 163-184, 1983.

[5] A. Kezar, Embracing non-tenure track faculty: Changing campuses for the new faculty majority., Routledge, 2012.

[6] R. G. Baldwin and J. L. Chronister, Teaching without tenure: Policies and practices for a new era., Baltimore, MD: Johns Hopkins University Press, 2001.

[7] R. G. Ehrenberg and L. Zhang, "Do tenured and tenure-track faculty matter?," *Journal of Human Resources,* vol. 40, no. 3, pp. 647-659, 2005.

[8] D. Kaminski and C. Geisler, "Survival analysis of faculty retention in science and engineering by gender," *Science,* pp. 864-866, 2012.

[9] N. S. Foundation, "Doctorate recipients from U.S. colleges and universities: 1958-2018," [Online]. Available: https://ncses.nsf.gov/pubs/nsf20301/data-tables/.

[10] N. S. Foundation, "Doctorate recipients, by major field of study: Selected years, 1988-2018," [Online]. Available: https://ncses.nsf.gov/pubs/nsf20301/data-tables/.

[11] N. S. Foundation, "Definite postgraduation commitments of doctorate recipients, by citizenship status and major field of study: 2018," [Online]. Available: https://ncses.nsf.gov/pubs/nsf20301/data-tables/.

[12] ABET, "Accredited Programs," [Online]. Available: https://amspub.abet.org/aps/name-search?searchType=institution.

[13] C. F. f. t. A. o. Teaching, "Carnegie Classification of Institutions," [Online]. Available: https://carnegieclassifications.iu.edu/index.php.

[14] K. A. Farrell and D. A. Whidbee, "Impact of firm performance expectations on CEO turnover and replacement decisions," *Journal of Accounting and Economics,* vol. 36, no. 1-3, pp. 165-196, 2003.