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Undergraduate Research in Chemical Engineering: Benefits and Barriers for Faculty

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Introduction

Not too long ago, including undergraduate students in faculty research projects was uncommon and often limited to students in small honors programs. Then, in 1998, the Boyer Commission report offered recommendations on rethinking undergraduate education with a focus on inquiry-based learning.[1] Because of its positive effects on recruitment and retention of students, undergraduate research is now considered a High Impact Practice (HIP).[2] Undergraduate research benefits to students are well reported and include: research skills, the ability to think and work like a scientist, enhanced preparation for careers and graduate school, and personal and professional gains.[3-6] For university and society benefits, undergraduate research has also been linked to continuation in STEM and graduate programs with particular benefits for students under-represented in those fields.[7-12]

While the benefits of undergraduate research for students, university, and society have been documented, the benefits of undergraduate research for the mentors (graduate students, post-docs, and faculty) are less well-demonstrated and documented. Similarly, barriers for faculty to engage in undergraduate research practices are still being evaluated. Work by Hayward et al. examined researchers' motivation and outcomes by career stage for undergraduate research mentors.[13] Although their work was only at one institution with 30 participants and included mostly graduate students (who benefited from help in the laboratory), they were able to break down motivation into intrinsic (done in the absence of external reward) and instrumental categories (done as a means to an end). Jones and Davis looked at faculty perspectives on undergraduate research at a liberal arts school and an R1 school.[14] Faculty at both institutions listed time and funding resources as barriers; the liberal arts faculty also listed the lack of scholarly (research) culture; and the R1 faculty listed not receiving teaching credit for the work as a barrier. Morales et al. investigated a larger sample of 13 research institutions to study enabling and constraining factors for faculty to support undergraduate research.[15] They did not focus on motivations, but they did recommend actions for institutions to promote undergraduate research by providing training for research skills (it is unclear if this is for faculty or for the students) and transforming the reward system. In more recent and more focused work, Morrison et al. surveyed three institutions (private R3, public masters, and private liberal arts) looking at faculty perspectives on undergraduate research.[16] In this work they found faculty report limited knowledge of how to include undergraduates in research and lack of credit in personnel actions (barriers) and also caring about and enjoying students as motivation (benefits). Similarly, Davis et al., using data from the same institutions, concluded that the single statistically significant motivator for faculty to participate in undergraduate research was perceived institutional support.[17]

To build on the above work, there is a desire to learn more about why faculty participate as mentors in the undergraduate research process. As undergraduate research also grows in importance and participation in academia, it is also important to better understand what barriers that faculty perceive to be in their way to participating in the process. Since there is not likely to

be a sudden influx of new hires just to support undergraduate research, administrators will be looking for approaches to more completely and effectively involve existing, non-participatory faculty in the process. Further, while the previous work outlined above considered criteria such as a variety of institutions (private R3, public masters, private liberal arts, and R1), it looked broadly across the campus at these institutions. This broad approach was not discipline-focused and may not have found benefits and barriers or motivations that are specific to a discipline.

In contrast, in this work, we focus on a single discipline: chemical engineering. Within this discipline, we have surveyed faculty on their perceived benefits to participating in the undergraduate research process along with their perceived barriers. This survey also involves responses from across the spectrum of institutional categories (R1, R2, other doctoral, master's, and baccalaureate). In this way, the goal is to make a more systemic investigation of the benefits and barriers for faculty to participate in undergraduate research in this specific discipline.

Methods

A survey was sent to chemical engineering department chairs with the request that they distribute it to their faculty. The survey was based on an instrument developed by Jones and Davis and modified to suit our interests in the perspective of chemical engineering faculty specifically and to inquire about their practices. [14] Our survey questions are included as an appendix. The survey and its distribution were approved by the Institutional Review Board at the University of South Alabama. A total of 110 responses were received.

Results

Respondents

Before addressing the perceptions that chemical engineering faculty reported, it is helpful to know something about them. More than half were from Carnegie-classified R1 institutions, with R2 institutions the next most common. The distribution is shown in Figure 1. Tenured or tenure-track faculty made up 95% of the respondents (Figure 2). Faculty were also asked to classify the nature of their research. Shown in Figure 3, the majority of respondents run programs that include physical laboratory experiments, but significant numbers also engage in modeling and data analysis. Approximately half chose more than one description. Figure 4 shows how long the respondents have been faculty members, with about a quarter in the first six years and another quarter in the next six. Only eight of the 110 responses stated that they were not currently involving undergraduates, but even those indicated an interest in doing so.

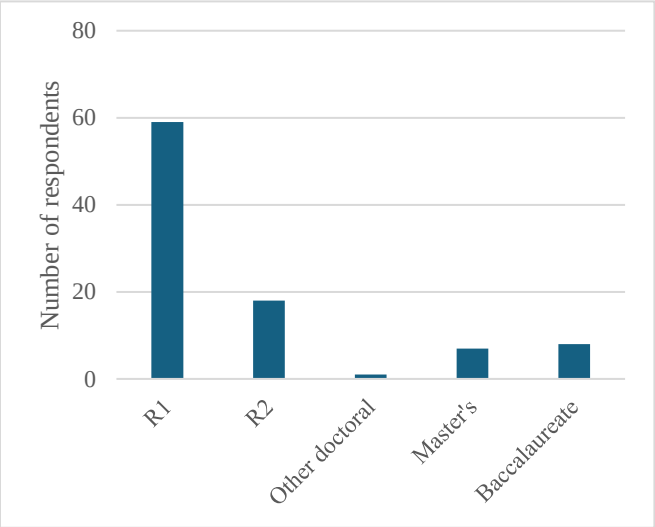

Figure 1. Institutional classifications of survey respondents.

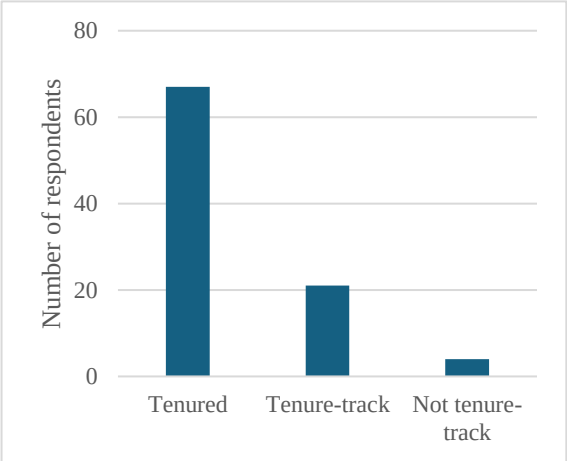

Figure 2. Faculty roles of survey respondents.

General faculty perception on undergraduate research

Responses to some general questions on faculty perspectives on undergraduate research mentorship are shown in Figure 5. Chemical engineering faculty largely reported confidence in their knowledge and skills in effectively engaging undergraduates in their research. Almost all respondents believe that an undergraduate can contribute to their research, but almost 20% reported that they had not received useful products. Only one response agreed that undergraduate students could not contribute to their research. Those results may indicate an

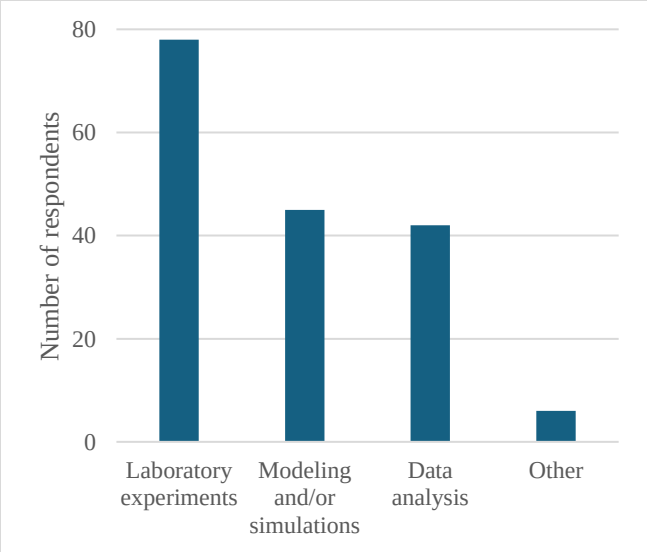

Figure 3. Research program descriptions of survey respondents.

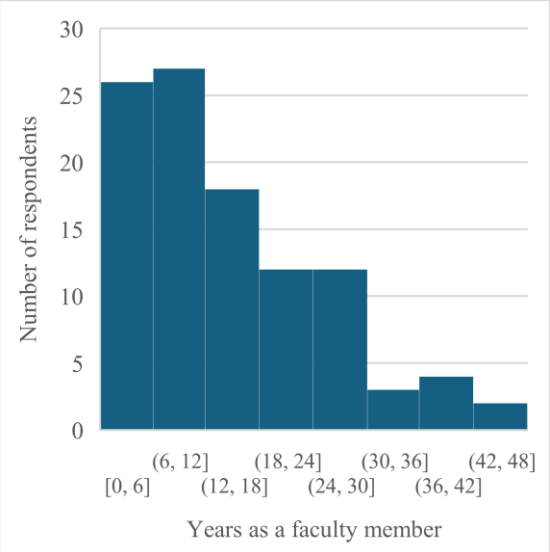

Figure 4. Faculty career length for survey respondents.

opportunity for professional development to strengthen faculty skills in yielding valuable products with undergraduate researchers. On the other hand, approximately 70% of respondents reported useful research products.

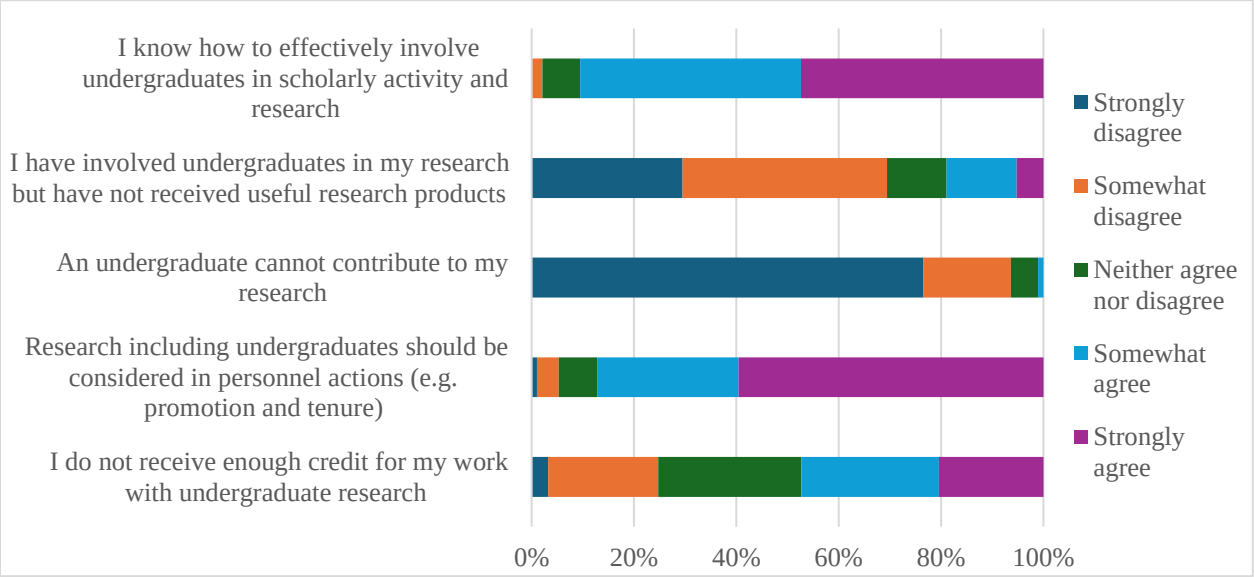

Figure 5. General faculty perceptions on engaging undergraduate researchers.

The responses showed strong consensus that engaging undergraduates in research endeavors should be valued in promotion and tenure decisions. It is notable that almost half of the faculty responding do not feel that they themselves receive adequate credit for their work with undergraduate research, and only a quarter of them do report feeling recognized at some level. Department and institutional cultures regarding such credit and rewards will be discussed in more detail below.

Institutional culture

Questions posed on college or institutional culture with respect to undergraduate research addressed faculty incentives, student opportunities, and institutional messaging. Responses to general questions are shown in Figure 6. While all responses are positive, the two questions regarding faculty incentives related to career advancement, namely tenure and promotion decisions and funding applications, are notable less positive than those addressing internal and external messaging on undergraduate research opportunities.

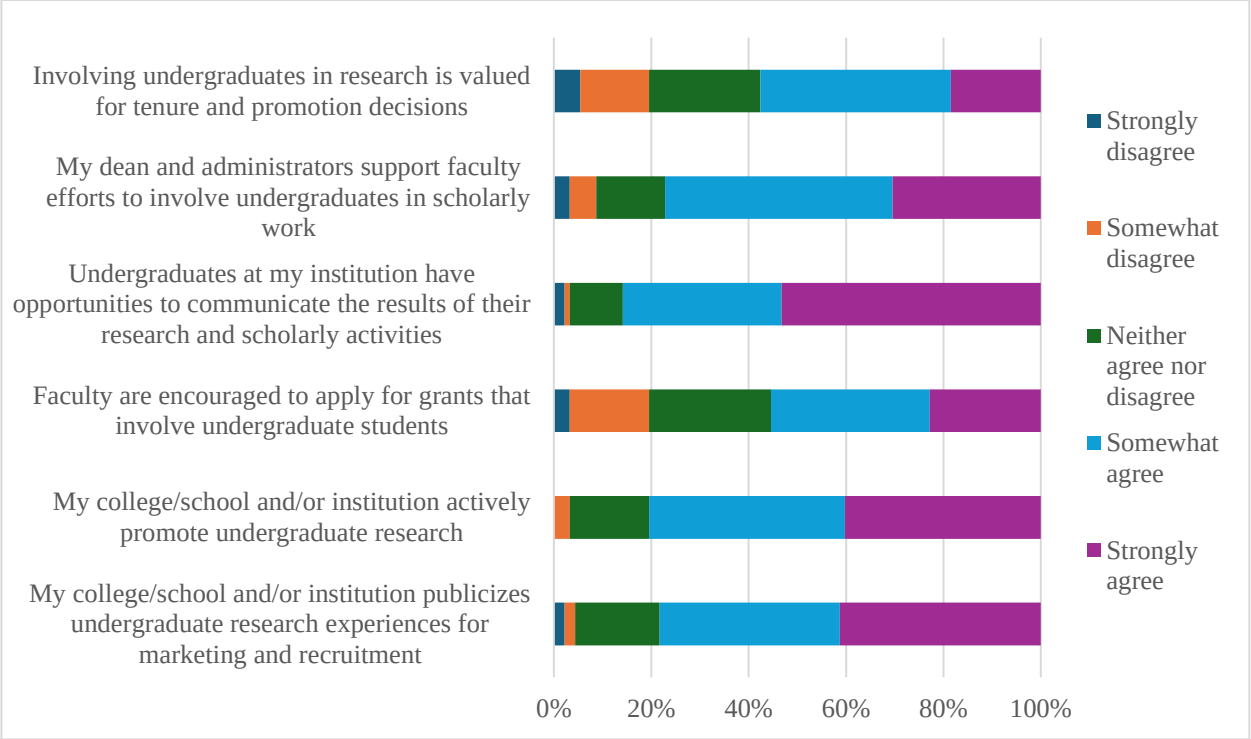

Figure 6. Faculty perceptions of how the culture at their institutions regards efforts in undergraduate research mentorship.

Other questions probed deeper into what faculty incentives were in place at the institutional level to promote involvement in mentoring undergraduates in research. Percentages of respondents reporting that particular incentives were offered at their institutions are shown in Table 1. All of the "Other" responses stated that they were referring to internal student funding opportunities. A

Table 1. Institutional incentives to faculty for mentoring undergraduate research.

Incentive	% reporting
Faculty awards for undergraduate research mentorship	42%
Faculty funding/stipends to mentor undergraduate researchers	43%
Formal credit toward teaching load for mentoring undergraduate researchers	11%
Promotion and tenure criteria include undergraduate research mentorship	28%
Other	9%
None known of	27%

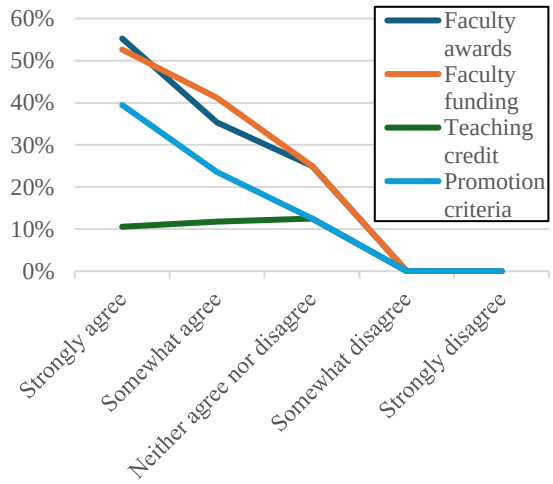

Figure 7. Correlation between institutional external messaging on undergraduate research and offering faculty incentives to engage in it.

deeper analysis of the results confirmed a positive correlation between offering faculty incentives and using undergraduate research opportunities for institutional marketing and recruitment, shown in Figure 7. The horizontal axis in that figure shows agreement with the statement "My college/school and/or institution publicizes undergraduate research for marketing and recruitment," and the vertical axis is respondent agreement that the given incentive exists at their institution. Taking faculty awards as an example, 55% of those who strongly agreed that UGR was used for marketing and recruitment reported that their institutions had faculty awards related to UGR mentorship.

Questions were posed about whether undergraduate research mentorship was specifically mentioned in faculty job descriptions and promotion and tenure criteria. Results are shown in Table 2, including breakdowns of the responses based on the institutional classification. As might be expected, the more research-intensive the environment, the less likely that undergraduate research mentorship is an explicit expectation in faculty job performance.

Table 2. Specific documentation of undergraduate research mentorship in personnel expectations.

	Is UGR mentorship specifically mentioned in your job description?				
	All	R1	R2	Master's	Baccalaureate
Yes	16%	5%	28%	50%	50%
No	57%	66%	39%	33%	38%
Not sure	27%	29%	33%	17%	13%
	Is UGR mentorship specifically mentioned in promotion and tenure expectations?				
	All	R1	R2	Master's	Baccalaureate
Yes	24%	15%	33%	33%	63%
No	51%	54%	50%	50%	25%
Not sure	25%	31%	17%	17%	13%

Departmental culture

The culture and practices surrounding undergraduate research at the chemical engineering departmental level were also explored. Responses to general questions on the departmental culture were exceedingly positive, as shown in Figure 8. The only item with a less than 50% positive response is on whether the department actively promotes UGR, but based on the other responses, the undergraduate research engagement is strong regardless. The other item that stands out as less positive regards faculty willingness to engage undergraduate researchers.

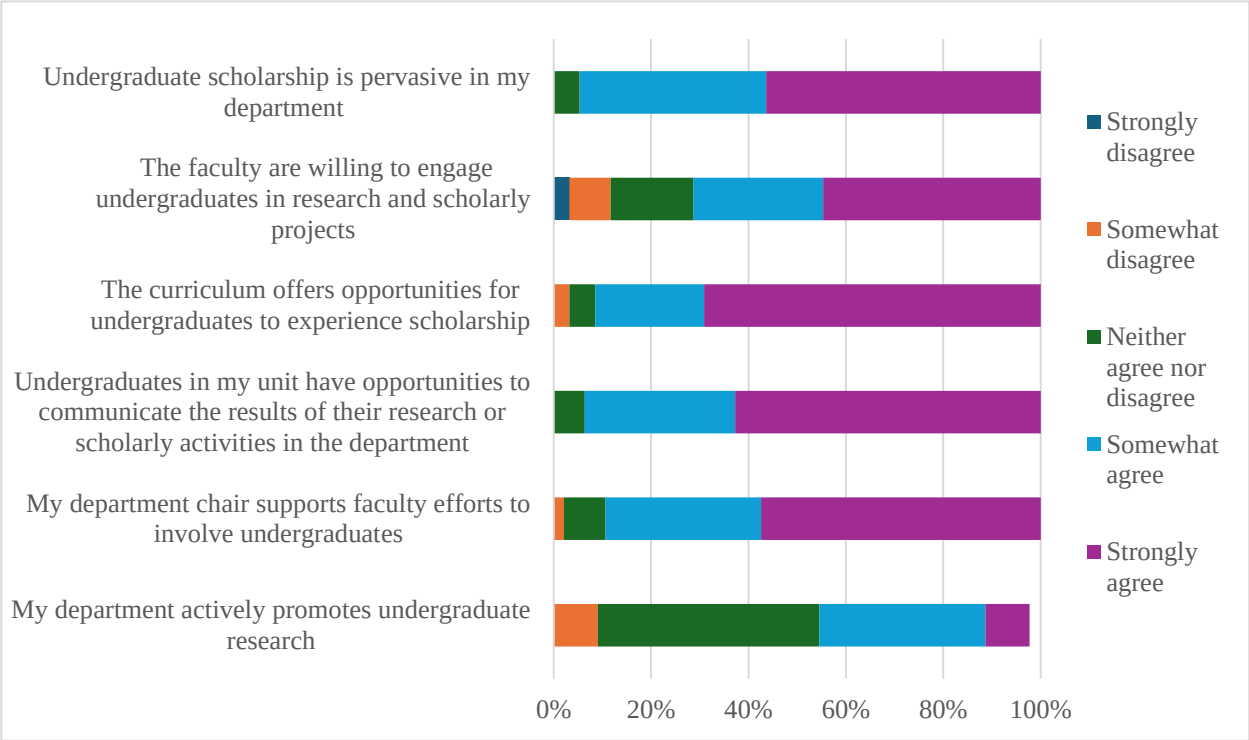

Figure 8. Faculty perceptions of their departmental climate surrounding undergraduate research.

In addition to the questions on the culture in their departments, faculty responded on both formal practices in recruiting undergraduates to engage in research and on any orientation programs for research (Table 3). Formal processes described for recruitment included posting opportunities on departmental websites, offering information on research opportunities in classes (mostly first- and second-year), and presenting on research in student organization meetings. Utilizing university undergraduate research offices, university-sponsored undergraduate research funding opportunities, and research fairs or symposia to publicize opportunities were also noted in several responses. Seven faculty reported that their departments have courses or modules of courses on research methods to prepare students for research experiences. Most of the responses reporting formal onboarding practices were only laboratory safety training. It appears that most student preparation must take place on an individual basis, which means that the faculty mentor must be responsible for it.

Table 3. Departmental practices for introducing undergraduates to research.

	Recruitment	Onboarding
Has formal process	34%	22%
No formal process	60%	72%
Don't know	5%	5%

Based on the responses to questions on research credit in the curriculum, most programs have formal offerings that can count toward a chemical engineering degree, most commonly fulfilling requirements either for chemical engineering electives or technical electives (Table 4). For most of those, the maximum degree credit is either three or six hours, but for a few programs it exceeds that, as shown in Figure 9.

Table 4. Options available for counting research credits toward chemical engineering degree.

Required research course	11%
CHE elective	70%
Tech elective	65%
General elective	27%
No degree credit	2%

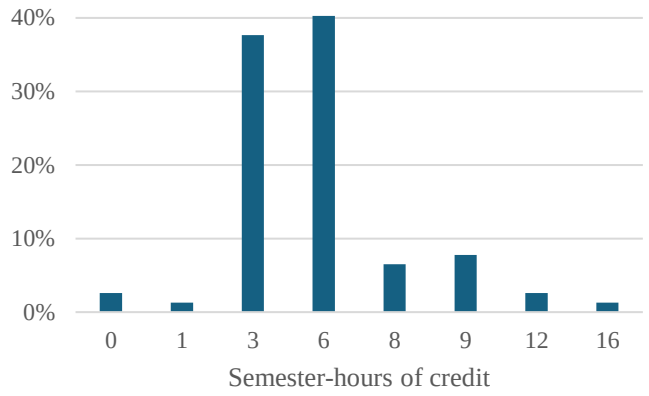

Figure 9. Credit-hours of research experience that can be counted for credit toward undergraduate chemical engineering degree.

Personal motivations of faculty to engage in undergraduate research mentorship

Responses to questions on the significance of motivating factors for faculty to include undergraduates in their research endeavors are shown in Figure 10. As faculty from R1 institutions comprised a majority of the respondents, lack of access to graduate students was not a significant factor for most. Consistent with responses to the general opening questions, chemical engineering faculty do find that undergraduate students are helpful in advancing their research programs. Still, the most positive responses on faculty motivations were on benefits to the undergraduate students themselves, with personal enjoyment the next most positive response. There is also a clear recognition that undergraduate research plays a valuable role in advancing scholarship in the future.

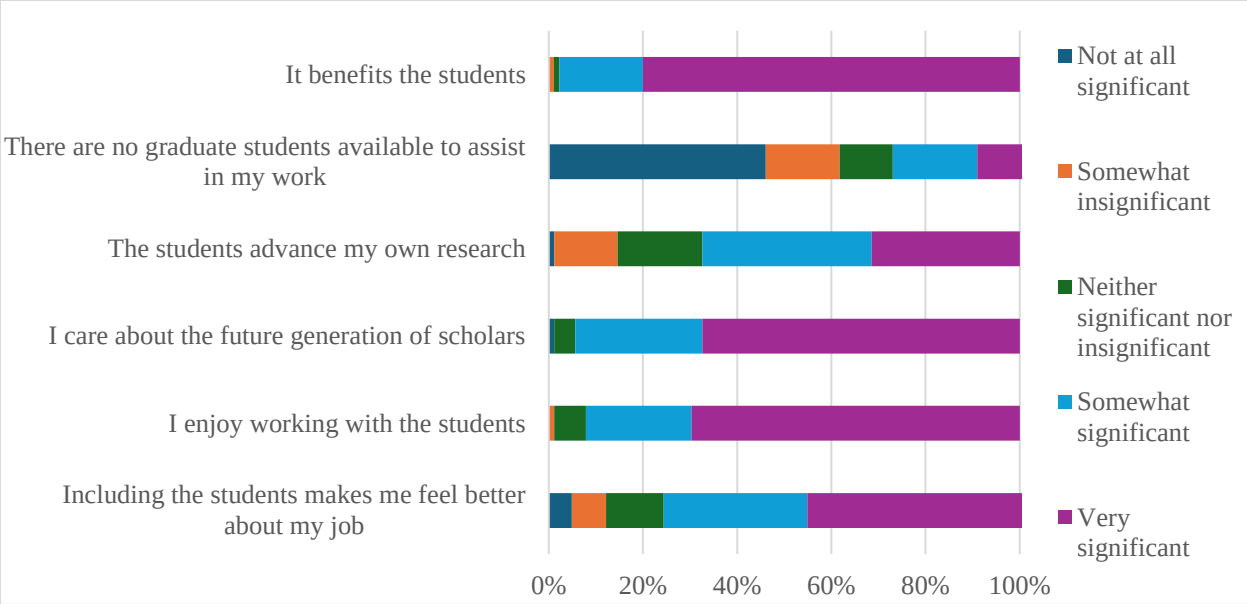

Figure 10. Faculty's motivations for mentoring undergraduate researchers.

Perceived barriers to engaging undergraduates in research

In response to questions on barriers to engaging undergraduates in research, lack of resources, both time and money, stand out as the most significant challenges, as indicated in Figure 11. Lack of student preparation for research is also significant, which is probably related to the time it takes to prepare them. More faculty indicate that lack of credit on promotion and tenure is

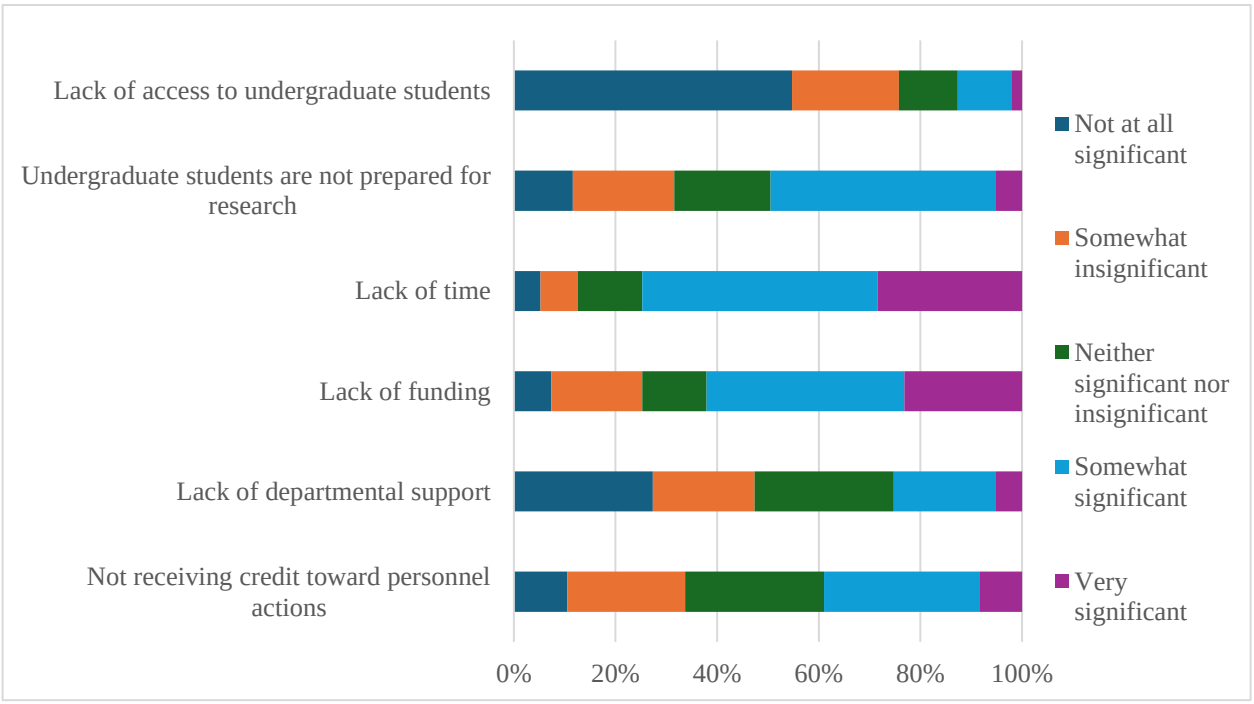

Figure 11. Barriers to faculty mentorship of undergraduate researchers.

significant than report that it is not significant. For a large majority, lack of access to undergraduates to work on research is not a concern.

Related to the time constraints, faculty were asked to provide their ideal distribution of their time between teaching, research, and service, and also to report how their time is actually spent. The results, shown in Figure 12, indicate that on average, respondents are content with their time spent teaching, and that they would prefer to spend less time on service to allow more time for research, which would presumably include undergraduate mentorship.

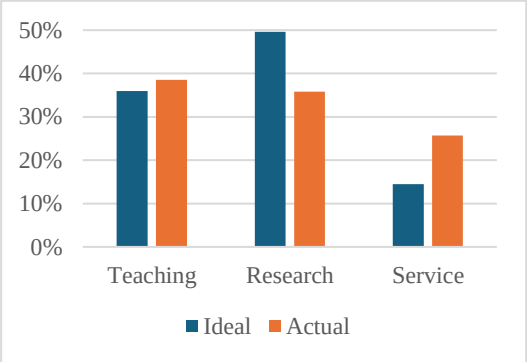

Figure 12. Faculty time distribution.

Discussion

Overall, chemical engineering faculty have extremely positive perceptions and attitudes regarding undergraduate research mentorship. Their institutions and departments appear to have embraced it as a high-impact practice that is promoted to students. Faculty are widely encouraged to engage undergraduates in their research programs, though formal credit for doing so is lacking. As such, motivations to participate as a mentor are more intrinsic than extrinsic/instrumental. Faculty feel that those who engage in undergraduate research should be more highly rewarded for the efforts to benefit the students.

Climate

Faculty overwhelmingly agree that their universities promote undergraduate research and encourage faculty to engage students in undergraduate research, but the focus of that promotion is the benefit to the students. Undergraduate research is widely publicized for marketing and for recruitment of new students, and students are given ample opportunities to showcase their achievements. Numerous responses mentioned internal programs that fund student stipends to work on research. But while faculty efforts are supported and encouraged by administrators, they are not commonly rewarded in ways that foster career advancement. It is rare for undergraduate research mentorship to be mentioned in job descriptions or specifically noted in promotion and tenure criteria. Thus, the mentorship efforts, while sometimes recognized but not formally part of the job expectation, are essentially extra work (service?) for the benefit of students. Part of most faculty job expectations include external funding, but encouraging pursuit of funding to include undergraduates in research appears as a lower priority.

While some departments have formal processes in place to assist with recruiting undergraduate researchers or preparing them to do the research, most of that work is left to the faculty mentors themselves. Even for those faculty who did report processes in place, the comments revealed that the processes were not systematic, just that opportunities existed to post positions or present to a class. The most commonly mentioned formal process in research preparation was fulfillment of required safety training; that stipulation addresses university liability more than faculty support. Training of students is largely left to individual faculty members. While that

does allow them to address specific techniques that the students need for their particular research, more general research skills could be addressed more efficiently at the departmental level and thus reduce the individual faculty load.

Incentives

As noted above, faculty efforts in mentorship are crucial to institutional initiatives to promote it as an available high-impact educational opportunity. The data indicate that an institution that publicizes UGR is more likely to have mechanisms to recognize faculty for excellence in mentorship, such as awards. Still, occasional individual recognition does not likely incentivize a time-intensive effort that is not required to advance one's career.

Circling back to a focus on student benefits, mechanisms to offer degree credit for research are widespread in chemical engineering curricula. However, formal credit in the teaching load to faculty for the efforts that undergraduate research mentorship entails is quite rare. Recognizing that time commitment by offering teaching credit for it, perhaps as a course replacement, would offer an additional incentive for excellence in mentorship.

Of course, the ultimate incentive for a faculty member is credit toward tenure and promotion and in performance evaluations. It is notable that slightly more than half of the responses indicate that UGR mentorship is valued for tenure and promotion decisions, only about a quarter state that is specifically mentioned in the criteria, and only 16% that is part of their job descriptions. The more research-intensive the institution, the less likely that undergraduate research direction is expected. The more stringent research productivity expectations are, the less incentivized the faculty are to include undergraduates.

In summary, while universities and departments promote and value undergraduate research as an educational practice, incentives for faculty to participate are not significant.

Motivations

When examining faculty motivations for mentoring undergraduate research students, (Figure 10), the faculty were broadly altruistic in their responses. The faculty reported 90+% of somewhat and very significant that undergraduate research benefits the students, that they care about future generation of students, and that they enjoy working with students. These responses are consistent with Morrison et al. who also reported that caring about and enjoying students was a strong motivation factor.[18] All of these responses outpaced (by 20%) the response that students advance their research which demonstrates that benefit to the faculty is less than the benefits to the students. Still, most reported that they had yielded valuable research products through engaging undergraduate researchers (Figure 5).

Barriers

There are some disconnects in the data. When looking at faculty perceptions (Figure 8), 90+% of respondents stated that undergraduate scholarship was pervasive, but only ~70% of respondents reported that they were willing to engage undergraduate researchers. This also is

different from Figure 5, where 90+% of respondents agreed that students could contribute to their research. Perhaps as expected, the largest reported barrier to mentorship of undergraduate researchers was lack of time (70+% reported somewhat or very significant). While this concern can never be removed, there is growing scholarship reporting on multiple methods for group mentoring students into research.[19, 20] Better student preparation and the corresponding reduction of basic mentoring by the individual faculty may reduce the time commitment per student. After lack of time, lack of funding was the second largest barrier. This again contrasts with Figure 6 reporting 80% of units actively promote undergraduate research and 75% report their dean and administrators support faculty efforts to involve undergraduates. This may indicate that while some support is available, the financial support is not quite as developed. Lastly, not receiving credit toward personnel actions is only the fourth largest concern in Figure 9 (just under 40%). Again, compared to Figure 5 with 50% reporting not receiving enough credit and 85% stating that undergraduate research should be considered in personnel actions, there is an inconsistency in the reported perceptions. While it is not clear where this disconnect occurs, the vast majority of respondents to this survey were tenured faculty. Thus, credit towards personnel actions was possibly less important to them individually, but they were able to look back retrospectively and see that it should be considered.

Comparing and contrasting this work with Jones et al.[14], who look more broadly across campus at two institutions (R1 and liberal arts) not just on chemical engineering as we have focused, there is some consistency in results. Similar to our results, time, inconsistent valuing of efforts, limited funding sources, student characteristics, and need for institution level support were barriers that were reported. Our results did not reveal a lack of student availability (not unexpected at mostly larger R1 and R2 institutions that house chemical engineering programs) but that some (40%) felt that students were somewhat unprepared. Similar to Jones et al., our results also showed limited funding resources as a barrier, but in contrast to their work, respondents felt that the work was supported (encouraged to apply for funding, actively promote it, and publicizes research experiences).

Conclusions and Recommendations

Overall, the data to date demonstrate the need for additional training of both faculty and students. The faculty indicate that training would be desirable to help them more effectively mentor the students and to also obtain research products from the undergraduate students. Best practices for effective mentoring of undergraduate researchers can be found in the literature by Shanahan et al. [21]. This topic might be suitable for a department meeting, a department retreat, or from the institution's teaching/learning center. A representative from the institution's undergraduate research center may be available to lead the discussion. Best practices in undergraduate research also suggest tools such as contracts as means to obtain useful research products from these students.[22] To help the students transition quickly into research, and respond to the faculty concern that students are not adequately prepared for research, structured mentorship for the students can be provided through dedicated coursework.[19, 20] This group mentoring can reduce the time load for the subsequent faculty member mentoring the research. Lastly, many faculty are still looking for undergraduate research to be more valued in their personnel decisions (i.e., tenure and/or promotion). This indicates a need for departments and colleges to consider

revisions in their P&T guidelines to provide clear and appropriate value to undergraduate research mentors.

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Appendix: Survey

Faculty Perceptions on Undergraduate Research in Chemical Engineering

The first set of questions regards your own experience in academic research.

How many years have you been a faculty member?

How would you characterize your research activities?

- Laboratory experiments
- Modeling and/or simulations
- Data analysis
- Other (please specify)
- I have not been active in research.

Broadly describe your research area in ten words or less.

In your opinion, how would you prefer to distribute your time between the following three professional areas? Please enter numbers between 0 and 100, totaling 100%.

- Teaching
- Research and scholarly activities
- University or professional service

How is your time actually distributed? Please enter numbers between 0 and 100, totaling 100%.

- Teaching
- Research and scholarly activities
- University or professional service

How many peer-reviewed journal articles have you published?

The next questions concern your general perspectives regarding the inclusion of undergraduates in research and scholarly activities.

Based on your personal experience with undergraduate students, what do you think about the following statements? [Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly disagree, Not applicable]

- I know how to effectively involve undergraduates in scholarly activity and research
- I have involved undergraduates in my research but have not received useful research products
- An undergraduate cannot contribute to my research
- Research including undergraduates should be considered in personnel actions (e.g. promotion and tenure)
- I do not receive enough credit for my work with undergraduate research

The following have been identified as obstacles to involving undergraduates in research and scholarly activity. From your perspective, how significant are the following obstacles? [Very significant, Somewhat significant, Neither significant nor insignificant, Somewhat insignificant, Not at all significant]

- Lack of access to undergraduate students
- Undergraduate students are not prepared for research
- Lack of time
- Lack of funding
- Lack of departmental support
- Not receiving credit toward personnel actions

The next questions regard departmental and program structures and culture for undergraduate research.

Related to your academic department, what do you think about the following statements? [Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree]

- Undergraduate scholarship is pervasive in my department
- The faculty are willing to engage undergraduates in research and scholarly projects
- The curriculum offers opportunities for undergraduates to experience scholarship
- Undergraduates who are involved in research are better prepared for their career goal and/or advanced study
- Undergraduates in my unit have opportunities to communicate the results of their research or scholarly activities in the department
- My department chair supports faculty efforts to involve undergraduates
- My department actively promotes undergraduate research

How can students receive credit towards their chemical engineering degree in your program? Check all that apply.

- As a required research course
- As a chemical engineering elective
- As a technical elective
- As a general elective
- They cannot receive credit towards their degree for research

What is the maximum number of research credit hours that can count towards the chemical engineering degree?

What calendar system does your institution employ?

- Semesters
- Quarters
- Trimesters

Is a research thesis an option for your undergraduate students? Check all that apply.

- Yes, a thesis is required for all chemical engineering students
- Yes, students can choose to write a thesis for elective credit
- Yes, a thesis is required for honors students
- No, a thesis is not an option for undergraduates

Does your department have an established process for recruiting undergraduates for research? If yes, please describe.

- Yes
- No
- Not sure

Does your department have an established process for training undergraduates for research? If yes, please describe.

- Yes
- No
- Not sure

The following section addresses institutional practices surrounding undergraduate research.

Is undergraduate research mentorship specifically mentioned in your job description?

- Yes
- No
- Not sure

Is undergraduate research mentorship specifically mentioned in the promotion and tenure expectations at your institution?

- Yes
- No
- Not sure

Related to your college or school, what do you think of the following statements? [Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly disagree]

- Involving undergraduates in research is valued for tenure and promotion decisions
- My dean and administrators support faculty efforts to involve undergraduates in scholarly work
- Undergraduates at my institution have opportunities to communicate the results of their research and scholarly activities to our community
- Faculty are encouraged to apply for grants that involve undergraduate students
- My college/school and/or institution actively promote undergraduate research
- My college/school and/or institution publicizes undergraduate research experiences for marketing and recruitment

What incentives are available at your institution to promote faculty engagement in undergraduate research? Please check all that apply.

- Faculty awards for undergraduate research mentorship
- Faculty funding/stipends to mentor undergraduate researchers
- Formal credit toward teaching load for mentoring undergraduate researchers
- Promotion and tenure criteria include undergraduate research mentorship
- Other (please specify)
- None that I know of

How is your institution classified?

- R1
- R2
- Other doctoral-level institution
- Master's-level institution
- Baccalaureate institution

Do you involve undergraduate students in your research and scholarly activity?

- Yes, I currently do so
- No, I am not interested in involving undergraduate students
- I haven't, but I would like to involve undergraduate students
- No longer, but I would consider involving undergraduates again
- No longer, but I did when I was active in research
- Not applicable; I have not been active in research

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

How many undergraduates do you usually mentor in research per academic term?

- Three or more on average
- One or more on average
- Less than one on average

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I did when I was active in research

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

How many total undergraduate students have you mentored in research?

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? != Not applicable; I have not been active in research

How many graduate students have you mentored in research?

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I did when I was active in research

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

Or Do you involve undergraduate students in your research and scholarly activity? = I haven't, but I would like to involve undergraduate students

The following questions regard your individual motivation, experience and practices with including undergraduates in your research and scholarly activities.

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I did when I was active in research

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

Or Do you involve undergraduate students in your research and scholarly activity? = I haven't, but I would like to involve undergraduate students

What is (or was) the significance of each of the following factors in your motivation to engage undergraduates in your research and scholarly activities?

	Very significant	Somewhat significant	Neither significant nor insignificant	Somewhat insignificant	Not at all significant
It benefits the students	○	○	○	○	○
There are no graduate students available to assist in my work	○	○	○	○	○
The students advance my own research	○	○	○	○	○
I care about the future generation of scholars	○	○	○	○	○
I enjoy working with the students	○	○	○	○	○
Including the students makes me feel better about my job	○	○	○	○	○

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

How often do you do the following with or for your undergraduate research mentees (on average per mentee)?

	Frequently	Sometimes	Rarely	Never
Give advice on careers and/or graduate school	○	○	○	○
Help choose appropriate models, techniques, or methods for your work	○	○	○	○
Help select a research topic	○	○	○	○
Teach a laboratory technique	○	○	○	○
Plan an experiment	○	○	○	○
Provide a paper to read	○	○	○	○
Make yourself available when needed	○	○	○	○
Encourage him/her/them to communicate thoughts and ask questions	○	○	○	○
Explain concepts	○	○	○	○
Provide support to help him/her/them make progress	○	○	○	○
Communicate clear expectations for your work	○	○	○	○
Provide constructive feedback	○	○	○	○
Assist him/her/them with a difficulty	○	○	○	○

Emphasize strong research ethics	○	○	○	○
Review an abstract, paper, or poster	○	○	○	○
Write a letter of recommendation	○	○	○	○
Offer advice on choosing courses and/or electives	○	○	○	○
Treat him/her/them with respect	○	○	○	○

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I did when I was active in research

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

Please rate the importance of your students' research experiences to the following aspects of their learning.

	Very important	Somewhat important	Neutral	Somewhat unimportant	Not at all important
Understanding current issues in chemical engineering	○	○	○	○	○
Judging the quality of research studies	○	○	○	○	○
Identifying advantages and limitations of different methods of approach to a chemical engineering problem	○	○	○	○	○
Understanding how to contribute to a scholarly or professional conversation	○	○	○	○	○
Understanding the research process in chemical engineering	○	○	○	○	○
Understanding the difference between personal beliefs and evidence in drawing conclusions	○	○	○	○	○
Developing career-related knowledge and skills	○	○	○	○	○

Understanding the relevance of research to topics in chemical engineering courses	○	○	○	○	○
Using chemical engineering terminology	○	○	○	○	○
Matching a scholarly question to appropriate theories and methods	○	○	○	○	○
Understanding the scientific method	○	○	○	○	○
Reading the technical literature	○	○	○	○	○
Searching the technical literature	○	○	○	○	○
Practicing ethical conduct in chemical engineering	○	○	○	○	○
Identifying the appropriate data to collect for a research question	○	○	○	○	○
Designing an experiment	○	○	○	○	○
Dealing with obstacles faced in the research process	○	○	○	○	○
Analyzing data	○	○	○	○	○

Writing clearly and effectively	○	○	○	○	○
Evaluating claims to determine how well they are supported by evidence	○	○	○	○	○
Presenting research results orally	○	○	○	○	○
Articulating the broad implications of a research project	○	○	○	○	○
Creating new ideas or solutions based on research findings	○	○	○	○	○

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

What funding sources have you used to support your work with undergraduate researchers? Check all that apply.

- Internal department-level grant
- Internal college-level grant
- Internal university-level grant
- Federal grant for technical research
- Federal grant for undergraduate research
- Other external grant
- Overhead or discretionary funds
- Other (please specify)
- None

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

How do you identify or recruit undergraduates for research? Check all that apply.

- I find them from my classes
- I advertise the opportunity
- I speak to student organizations about my research
- I ask colleagues for recommendations
- Students find me and ask to do research
- Students are assigned to me for research
- Other (please specify)

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Are you selective in taking on undergraduate students for research? Check all that apply.

- I select based on academic records
- I select based on demonstrated interest in my research
- I select based on schedule compatibility
- I select based on compatibility of expectations
- Other (please specify)
- I give any student the research opportunity

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

How do you establish expectations with your mentees? Check all that apply.

- Informal discussion
- Written contract/compact
- Other (please specify)

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

How often do you meet individually with your mentees during a term?

- Weekly
- Biweekly
- Less than biweekly, but more than monthly
- Monthly
- Less than monthly

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Are your meetings scheduled or just as needed?

- Scheduled
- As needed
- Both

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

[

Where do you meet with your mentees? [Usually, Occasionally, Never]

- In my office
- In the laboratory
- In a classroom, conference room, or other common space

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Do your undergraduate mentees attend your research group meetings?

- Always
- Usually
- Sometimes
- Rarely
- Never

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = Yes, I currently do so

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I did when I was active in research

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

Have you sent undergraduates to present research in conferences?

- Yes
- No

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = No, I am not interested in involving undergraduate students

Or Do you involve undergraduate students in your research and scholarly activity? = I haven't, but I would like to involve undergraduate students

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

We previously listed the following potential obstacles to involving undergraduates in research. Please rank them in order of importance to you personally. Use 1 to indicate the most significant obstacle and 6 the least.

_____ Lack of access to undergraduate students
_____ Students are not prepared for research
_____ Lack of time
_____ Lack of funding
_____ Not receiving credit toward personnel actions
_____ Lack of departmental support

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = No, I am not interested in involving undergraduate students

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

If you previously mentored undergraduate students in scholarly activity or research and then decided to not continue, what prompted this change?

Display This Question:

If Do you involve undergraduate students in your research and scholarly activity? = No, I am not interested in involving undergraduate students

Are there institutional and/or departmental changes that would increase your interest in mentoring undergraduates? If no changes are likely to alter your perspective, then please indicate that.

If Do you involve undergraduate students in your research and scholarly activity? = I haven't, but I would like to involve undergraduate students

Or Do you involve undergraduate students in your research and scholarly activity? = No longer, but I would consider involving undergraduates again

Are there institutional and/or departmental changes that would facilitate your starting to mentor undergraduates? If not, then please indicate that.

This survey concludes with a few questions on your academic position and demographic identity.

Please indicate the status of your academic position.

- Tenured
- Tenure-track
- Not tenure-track
- By term

What is your gender identity?

- Male
- Female
- Non-binary / third gender
- I identify as ___
- Prefer not to say

How do you identify racially/ethnically/culturally?

- White
- Black/African American
- Asian/Asian American
- Hispanic/Latinx
- Native American / Alaska Native
- Native Hawaiian / Pacific Islander
- I identify as ____
- Prefer not to say