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Examining Equity in Accessibility to Undergraduate Scientific Research

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Introduction

Research can be defined as the methodical study or analysis of a question in order to gain a better understanding and derive new conclusions. Conducting research, therefore, is the backbone of science and drives advancement in all disciplines. Because of this, a scientist's career is often defined by the research they do and how they are able to better humanity's understanding of the world around us. Just as research can advance a scientist's career, for those undergraduate students wishing to become scientists, figuring out how to access research opportunities early on in a college education can help to introduce the individual to the scientific community at an earlier stage than their peers.

For science students, access to undergraduate research has a direct and significant impact on a student's education. In terms of academic success, "results from a series of multiple regression analyses demonstrate that research involvement is associated with higher undergraduate GPA" (Sell, Naginey, & Stanton, 2018, p.19). Additionally, research has shown that students also benefit in the form of "the growth of self-confidence, independence of work and thought, and a sense of accomplishment" (Lopatto, 2010, p.27). The results of a national survey conducted by Landrum & Nelson (2002) found that generally, the benefits of undergraduate research for students falls into two major categories: interpersonal benefits and increases in overall technical skills. Interpersonal benefits include "teamwork, leadership and time-management skills, self-confidence, and interpersonal communication skills" while technical skills included a variety of discipline-specific "skills [that are] important for graduate school preparedness" (Landrum & Nelson, 2002, p. 16). Another study found that students also reported "increased career clarification [and a] better understanding of whether or not they wished to pursue a research career or attend graduate school" (Laursen, Seymour, & Hunter, 2012, p. 34). For students, these benefits are highly influential and have the ability to change the trajectory of their academic careers and resultingly, their lives.

The influential undergraduate research experience would be impossible without the key role of the research advisor. In fact, the research advisor often determines whether or not a student will gain access to research in the first place and can additionally act as a mentor for a student. Unfortunately, however, the

priorities of the research university and the scientific community in general can negatively impact the research advisor/student relationship. It is important to note that research universities have historically prioritized the production of knowledge; the first U.S. universities that required faculty members to take part in research arose in the aftermath of the Civil War and were modeled after German research universities once they were seen to benefit Germany's industry (Atkinson & Blanpied, 2008). The prioritization of the production of knowledge still pervades today as research professors are often required to publish scholarship and issues like tenure and research funding are often based on the relevancy of research to industry or university prestige (Atkinson & Blanpied, 2008). Additionally, strong communication skills are often valued by the scientific community due to the interdisciplinary nature of science and scientific writing. In her book *The Forgotten Tribe: Scientists as Writers,* Lisa Emerson (2016) argues that scientists are some of the most flexible communicators because unlike some disciplines, science requires collaboration and communication with a wide range of audiences, including industry, scientific peers from a variety of fields, and an assortment of different public audiences.

We can see the manifestation of these priorities and their effects on the research advisor-student relationship when examining how faculty regards research. One study found that for faculty, there are a variety of costs and benefits associated with undergraduate research that can be seen in Figure 1. Most benefits were emotional, including satisfaction and pride in student success, while some of the costs were more tangible including "inexperience and turnover of student lab workers" as well as "undergraduates' slow pace and variable output sometimes compromis[ing] their productivity" (Laursen et al., 2012, p.35). Faculty also reported situational stresses associated with student research, specifically concerning institutional policies that make research a requirement for graduation. Faculty reported that they "felt pressured to accept 'weaker' students" when research was required (Laursen et al., 2012, p.36). This suggests that professors and students have strikingly different views about student research: for students, research is the key to success; for professors, research is, at best, emotionally rewarding and at worst a burden. This sets up a polarizing power dynamic that influences how students and professors engage in discourse and poses some challenges for the scientific community as to what conducting student research should look like.

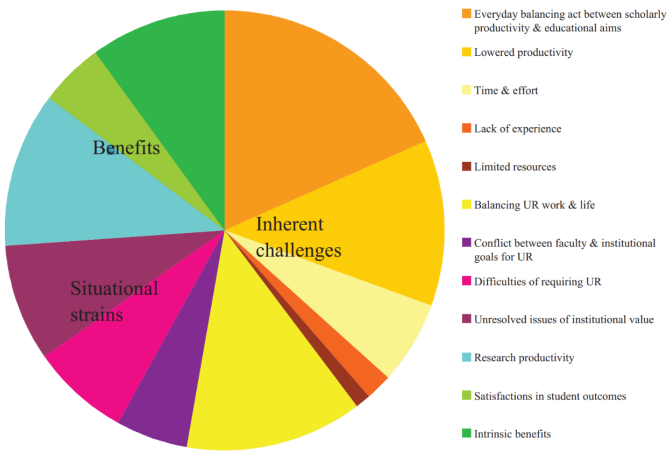

Figure 1: Cost and Benefits to Faculty of Conducting Research with Undergraduates (Laursen, Seymour, & Hunter, 2012).

The priorities of the research university and this polarizing power dynamic unfortunately has the potential to affect the equity of student access to undergraduate research. *Equity* can be defined as equality of opportunity and is recognized by the Association of American Colleges and Universities (AAC&U) as one of the core principles of what the organization calls “Inclusive Excellence.” It was my belief that despite this emphasis on equity and inclusiveness, access to undergraduate research at my university (a member of the AAC&U) had the potential to be inequitable. Because the research advisor has to worry about issues of research funding, publication quotas, and how their research could impact their standing within the university, it is likely that research advisors actively search for students who could help them achieve these goals (e.g. “stronger” students). This could be detrimental to students who are reliant on the research advisor to allow them access into the research space because what counts as “strength” is likely influenced by the research advisor’s implicit bias.

While there are many studies looking at the benefits of student research for both faculty and students (e.g. Landrum & Nelson, Laursen et. al., Lopatto & Sell et. al.,), there is a gap in literature in regard to equity in accessibility to undergraduate scientific research opportunities (accessibility in this context being the opportunity to partake in undergraduate scientific research). With the understanding that student research is a valuable experience for students and a gateway into the scientific community and the context of what the research university values, I will be looking at how my university, as a school that advertises an emphasis on undergraduate research, influences how students can access research and how professors provide opportunities for student research.

Context

My university is located in New England and is an independent, private, coeducational university with over 5,000 students and 480 educational staff. At my university, biology research is not a requirement for graduating with a biology degree while chemistry research is a requirement for graduating with a chemistry degree.

Methods

This IRB-approved research study focused on the following questions in regard to undergraduate research at my university:

- "What information is advertised and made available to students about research and how is this information presented?"
- "What does the process of accessing undergraduate research look like?"

I explored these questions in the spring of 2020 by completing a textual analysis of the information made available to students online at the time and by interviewing student research assistants.

I narrowed the scope of this study after examining the research opportunities provided by the university that fell under the natural sciences. The majority of research performed on campus by natural science majors fell under research in chemistry and research in biology. For this reason, I examined the biology and chemistry majors. The requirements regarding research for both the chemistry and biology majors are on the university website while the research course descriptions for "CHEM 450- Research in the Chemical Sciences" and "BIO 450- Research in the Biological Sciences" are on the website used for student course sign-up. I compared the chemistry and biology department sites, also on the university website, in order to look at how the university advertised research opportunities at the time. Comparing both departments, I analyzed the omission and organization of information regarding how to become a research assistant.

In order to look more closely at access to research at my university and gain insight into the selection process of students, I conducted interviews with student research assistants (RAs). Participants included a RA working on a joint marine biology/chemistry research project and, as a RA working on chemistry research, I also recounted my own experience becoming a RA; I also supplemented this data with emails. The other student RA and I were sophomores at the time of interview who had been at the university for the same amount of time for ease of comparison. Both of our experiences accessing research occurred during pre-COVID times. In order to understand how effectively the university and professors communicate about student research and to gain perspective from a student who does not have access to undergraduate research, I interviewed a

student who is not a RA. This student was also a sophomore for ease of comparison. All students were majors in a chemistry and/or biology discipline.

The interviews with the RAs included questions aimed to discover how they heard about the research position they hold, their recount of the process of becoming a RA, and what being a RA looks like now.

The following questions were asked:

1. How was the information about this research position communicated to you?
2. How did you become a research assistant?
3. In what ways are you compensated for research, if you are?
4. What is your role in your research project?

This article only addresses questions 1 and 2. The interview with the student who was not working on research at the university included questions aimed to determine what they have heard about student research opportunities both from professors and the university, and how this information was presented.

The following questions were asked:

1. What, if anything, have you heard about student research opportunities on campus?
2. How was this information communicated?
3. Do/Would you want to become a research assistant? Why or why not?
4. Do you know how students are compensated for research?

Again, this article only addresses questions 1 and 2.

In order to analyze this data, I used the theory of Critical Discourse Analysis or CDA described by Thomas Huckin, Jennifer Andrus, and Jennifer Clary-Lemon (2012) in their paper “Critical Discourse Analysis and Rhetoric and Composition” as “. . . an interdisciplinary approach to textual study that aims to explicate abuses of power promoted by those texts, by analyzing linguistic/semiotic details in light of the larger social and political contexts in which those texts circulate” (p.107). CDA is based on the principles that “discourse analysis is interpretive and explanatory” and, with the understanding that discourse itself is historical and inherently social, works to analyze linguistic details quantitatively and qualitatively (Huckin, Andrus, & Clary-Lemon, 2012, p.108). By analyzing the policies and actions surrounding research at my university within the context of the research university environment, I implement CDA as my tool in order to show how the tension elucidated above between advisor and student plays out in policy language and behavior.

Results

My first method was to examine the language concerning research opportunities in biology and chemistry. The B.S. biology degree page found on the university website had both a section titled “Research Opportunities” as well as a featured section titled “Meaningful Research.” The section titled “Research Opportunities” says “Undergraduate research is integrated into the biology curriculum, with opportunities for students to earn academic credit for doing research” (*Biology*, 2020). It is important to note that biology research is not a requirement for graduating with a biology degree. The section titled “Meaningful Research” on the other hand, outlined in detail the specific research one biology major alumnus completed when they were a student. In this way, the organization of the page calls attention to the biology research that is available, but not guaranteed, at my university and provides examples of what this research could look like for potential students if they chose to do this optional research. As the intended audience is prospective students, the university essentially uses the possibility of access to research in order to attract biology students. In other words, the biology major site encourages research-centered discourse by highlighting the benefits for students.

Unlike the B.S. biology degree page, the B.S. chemistry degree page does not have a section devoted to research. Instead, chemistry research is only mentioned in the description of the major saying “Students can collaborate with faculty on research as early as their first year, presenting their research at chemistry meetings across the U.S.” (*Chemistry*, 2020). Unlike the biology major which does not call attention to the role the research professor plays in the process of becoming involved in research, the relationship between the student and the research professor is described as a “collaboration” for chemistry, making the position of research assistant seem equal to that of research professor. This can be misleading and set up false expectations for students as the level of collaboration between the student and research advisor is highly dependent on the research advisor. When considering the importance of collaboration in the scientific community, advertising the student/research advisor relationship as a collaboration is particularly significant and shows exactly how highly the social aspect of research is valued. Instead of focusing on the work that would be done while performing research, this particular description skips straight to how completed research would allow the student to engage in scientific discourse with esteemed fellow scientists and make a name for themselves in the community by “presenting their research at chemistry meetings across the U.S.” (*Chemistry*, 2020). This description places a significance on communicative and collaborative skills from the beginning, something that the scientific community values. It is important to note, however, that the description implies that research “can” be a possibility when the chemistry major at my university actually requires research to graduate with this degree. This

description can be misleading for chemistry students who may believe research is optional and could subconsciously discourage students from actively seeking out research.

It is also important to recognize that while this description does paint chemistry research in a positive light, this was only one sentence, which directly contrasts the way research is discussed and featured for the biology major. The page also does not make the fact that research is required for the major readily obvious; in order to find this information, you have to open up another link that details the major requirements. In this way, the chemistry major page does not encourage research centered discourse; at most it implies that research is a possibility. Despite the emphasis placed on communicative skills in this description, there is actually very little information communicated to the student about research even though research is a requirement for the major, so research must consequently be guaranteed to chemistry majors. In this way, the language downplays chemistry research by making it seem less accessible in comparison to biology. This could potentially act to discourage, or at least not actively encourage, chemistry majors from seeking out assumedly guaranteed research opportunities.

As the chemistry and biology departments play a role in determining the requirements for their majors and are instrumental to student research on campus, I looked at their pages on the university website as well. On the Department of Chemistry and Physics page and on the Department of Biology, Marine Biology, and Environmental Science page, there are links entitled “Learn More About Research Opportunities” (*Research in Chemistry*, 2020 & *Research Opportunities*, 2020). Both departments initiate conversation about research and seem to actively inform students about opportunities. The information provided on the two pages, however, is drastically different. The link for chemistry leads to a list of student presentations and theses from past years. There is no information about how to become involved in research; instead, the page explains that B.S. Chemistry majors are required to do research. Only displaying student presentations once again emphasizes the importance placed on communicating completed research without communicating *how* to get the opportunity to engage in research in the first place. The link for biology leads to a page that has a list of ways to get involved in undergraduate research as well as links to more information and applications. This shows that not only is chemistry research downplayed, but the information of how to get involved is completely omitted.

Despite the welcoming language on the biology site, the policies surrounding both biology and chemistry research are still exclusionary in that there is a somewhat informal and selective recruitment and application process, as determined by the information found on the biology site in regard to applying for positions and as determined through interviews with RAs. In order to get an understanding of how effectively the university communicates about research

opportunities, I interviewed a biology student on campus who is not involved with research. They said:

> I've seen a couple of emails that have gone out about research but I've never really looked into them . . . none of my teachers really said they were doing any research at all. I could probably ask them… Nothing has really stood out. I have some friends who do research, or they're helping teachers with research.

When asked if they knew how their friends got their research position they said, "I believe that they asked the teacher about research and they had to go through some hoops to get on their research team." This indicates that students have to be the ones to initiate conversation about research. Since communication skills are highly valued within the scientific community, waiting for students who communicate first allows research professors to ensure their research assistants already come with these valued skills, at least to some degree. This becomes especially obvious when considering that professors can feel "pressured to accept 'weaker' students" (Laursen et al., 2012, p.36) when research is required.

At my university, usually students engaging in research are either paid for their time or complete a major-specific research course. When looking at the research courses for chemistry and biology, CHEM 450, "Research in the Chemical Sciences," is a required course for the B.S. in Chemistry major while the BIO 450, "Research in the Biological Sciences," course is offered but not required for the B.S. in Biology major. The course descriptions are below:

> BIO 450 Rsch in Biological Sci (1 to 4 Credits) Original independent research in biology or marine biology. Project chosen in consultation with a research advisor" (*Course catalog – BIO 450*, 2020).
>
> CHEM 450 Rsrch in Chem Science (1 to 3 Credits) Prerequisite: Only open to qualified students with consent of a research advisor Research and directed readings. Project chosen in consultation with the research advisor" (*Course catalog – CHEM 450*, 2020).

Once again, the course description language makes chemistry research sound more exclusive by listing a vague prerequisite: being a "qualified" student and having consent from the research advisor. It is through these course descriptions that we first explicitly see the importance of the student "consulting" with a research advisor. Knowing that research professors often feel as if they must choose students they perceive as "weaker" when research is required, discreetly making chemistry research seem less readily available wards off possible students who don't have the communication skills and who may not be able to jump through the hoops set up by this language use (Laursen et al., 2012). By emphasizing biology research but not requiring it, however, the university is able to keep its reputation as a research-focused undergraduate university while still

being able to turn away “weaker” biology students because research opportunities for undergraduates are not guaranteed. The power to grant desirable research positions to students is put into the hands of the research advisor when research advisors may not want research assistants in the first place, reinforcing this polarizing power dynamic.

My own experience becoming a RA continues to emphasize the importance of initiating discourse surrounding research and how easy the process of becoming a chemistry RA can be when a professor deems you “qualified.” I approached my chemistry professor in class after I scored the highest on an exam and asked if they’d be available to talk about research. We then had a meeting where they asked what type of research I’d like to do, and once describing what I wanted to work on, they said they would talk to a chemistry professor who specialized in my interests about their research. I specifically remember my professor pulling up my grades and saying that while I have great grades so far, they would know if I’d be a “strong” chemistry student after I took Organic Chemistry. Afterwards they sent me the following email:

> I mentioned your name to Dr. [Redacted] and Dr. [Redacted] over the last couple of days. They are excited that you are interested in doing some research. Dr. [Redacted] invited you to join a “Master Class” which will be given by the “Distinguished Seminar Speaker” we have scheduled . . . If you can arrange your schedule to attend the lecture, that would be great. Also, you should plan to attend [the speaker’s] seminar on the same day . . . And finally, you are invited to dinner after the seminar to get to know some chemistry majors and to have some relaxed fun time with Dr. [Redacted], Dr. [Redacted] and the guest speaker. Of course, the department picks up the tab. All we ask is that you dress business casual (no jeans, tee shirts etc.). It is an honor to be invited to these events and you should go if you can. If you need me to speak with an instructor if you have a conflicting class, let me know…

Once I initiated a conversation about research and once my professor looked at my grades, I received not only an invitation to a master class but to a private dinner with a distinguished guest speaker and my possible research professor. During the dinner, I spoke with that research advisor about making a meeting about research, and I got the position. By taking the first step, showing initiative, and demonstrating I had the communication and collaboration skills necessary to successfully navigate a highly social group dinner in which I took my first real step into the scientific discourse community, I “earned” myself a research position. While this is fortunate for me, this brings up issues of inequity as not all students may be able to take this initiative or be comfortable advocating for themselves. Additionally, there are a variety of reasons why a student may not have exemplary grades that are not taken into consideration by research professors when selecting RAs. This begs the question: How many other students never received this opportunity—and should?

After interviewing the other student RA, I noticed several similarities. Similar to how I reached out to my chemistry professor, this student RA "went to [their] chemistry professor at the time . . . and he told [them] to talk to another marine biology professor about research opportunities that he thought [they'd] be good for." Once again, the student had to initiate discourse about research opportunities, something that not all students are aware of or may be capable of doing. The professor also actively decided to reach out to other research professors and continue this discourse based on the student's interests. The opinion of this professor and the research professor was also academically based; the student noted:

> I went to the research professor that my chem[istry] professor told me to go to . . . and [he] told me about his project that he thought I'd be good for because I was good at chemistry and marine biology and math. He knew this because I think he talked to my chem[istry] professor, he was my marine bio[logy] professor, and he knew I was a Calc[ulus] 1 tutor. He offered me the position, and I said okay.

I have not conducted interviews with every chemistry and biology research assistant, but through passing conversations with students, this seems to be a common trend.

Discussion

Based on the information available in the spring of 2020, this research shows that while biology research is displayed as more accessible on the university website, it is inequitable in policy as it is not required, while chemistry research was not accessible on the website but more equitable in its policy because it is required. In either case, both disciplines have systemic informal and exclusionary practices of linking advisees and students. In this way, the university prioritizes faculty over students when it comes to undergraduate research by implementing policies that leave students uninformed and subsequently disadvantaged. It is the university's policy language that leads to an apparent reliance on students to initiate discourse about research and reach out to faculty, setting up a system where access to research can be carefully controlled. By heavily advertising biology research that can be gated due to the logistics of high demand, the university is able to keep the prestige brought on by declaring itself a research university while still handpicking student research assistants. Downplaying chemistry research and making it seem inaccessible ultimately leads to an inequity in access to student research. This also fortifies the power structure between student and research advisor who selects students that show the collaboration and communication skills that are valued by the larger scientific community.

The Association of American Colleges and Universities' (AAC&U) guiding principle, Making Excellence Inclusive, works to "help colleges and universities integrate diversity, equity, and educational quality efforts into their missions and institutional operations" (Making Excellence Inclusive, 2019). While my university, a member of AAC&U, has a page on their website dedicated to diversity, equity, and inclusion, there is an inequity in access to research. Because access to research is placed in the hands of research advisors, access is primarily based on student-faculty interactions, and my research indicates faculty prioritize academic merit. When access to opportunities is based on academic merit, in many cases "this merit is inherited [and because] access to higher education is, to varying degrees, competitive, [academic merit] will always privilege those with superior economic, social and cultural resources" (Clancy & Goastellec, 2007). This is especially important because in addition to how beneficial student research can be, positive student-faculty interactions have also proven to be,

> related to numerous positive outcomes, including increased confidence in their abilities as scholars, achievers, and leaders; an enhanced sense of emotional wellbeing; and greater satisfaction with faculty contact and with the campus community. Faculty support is also related to higher degree aspirations and higher rates of bachelor's degree attainment. (Sax et. al., 2005)

If this faculty support is largely given based on merit, this only works to further reward those with inherited merit while limiting opportunities for others.

Even before inequitable student-faculty interactions determine access to research, policy language provides another barrier. While the scope of this research is limited by only looking at the experiences of a small number of students, ultimately, the university sets up discourse surrounding research to be student driven. Even for biology research that is given more attention and for which students are provided with more information, by making these opportunities available only to a select few students, students are driven to actively reach out, start conversation, and prove themselves to research advisors. For chemistry research where research is guaranteed because it is a requirement, research is downplayed and no information is given on how to get involved. The language for the chemistry research course also sets up a barrier by listing being a "qualified" student as a prerequisite. By providing no information and making the process seem more exclusive, the student is driven to reach out to advisors and initiate conversation about how to get involved. This acts a barrier to students as first, they may not even be aware of research opportunities and second, if they are, they may not have the communication skills necessary to talk to the advisor or the confidence to approach an authority figure. Warding off potential students without these skills may even act to disproportionately benefit a subset of students from the same socio-cultural backgrounds as professors because these students may be more confident about knowing how to talk to the advisors in a way that the professor values.

Overall, it makes sense that universities would favor faculty over students based on the understanding that the research led by faculty can often lead to university prestige (Atkinson & Blanpied, 2008). A study looking at the observations of faculty from 4 colleges found that many research advisors noted that undergraduate research often “compromises their productivity” and in some cases, leads to “dozens of lost publications” which can impact a university as well as their faculty (Laursen et al., 2012). It should be noted, however, that my research only spoke to the experiences of students and that faculty may have other reasoning for their selection of student research assistants. Additionally, as this research was performed in 2020 and was not ongoing up until publication, there may be updates or changes to the information provided on the university website that could influence these findings. This research could be expanded by determining whether changes were made to the university websites since 2020, interviewing research professors and more students, and by reaching out to policy makers on campus.

By allowing discursive policies and practices to pervade higher education, diverse perspectives (e.g. historically marginalized perspectives) are likely lost which inevitably weakens the scientific field where different perspectives have led to incredible discoveries that better our understanding of the world. My research demonstrates how my university and other universities more broadly can make access to research more equitable. By fixing issues regarding lack of information given to students, merit-based accessibility, and by working to ensure student/advisor interactions are not student-driven, access to undergraduate research could be made more equitable.

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