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# A Student Research Manual: Helping Students Help Themselves Identifying and Addressing Challenges Facing Prospective Undergraduate Researchers

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Identifying and Addressing Challenges Facing Prospective Undergraduate Researchers

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**ABSTRACT**
Undergraduate research does not only help equip STEM majors to be better researchers and employees but increases retention of students to graduate school in needed scientific fields. However, while resources are being produced for undergraduates like Undergraduate Research Experiences (UREs), Centers for Undergraduate Research and Scholarship (CURS), and Course-based Undergraduate Research Experiences (CUREs), undergraduate involvement and awareness about these resources, and the value of undergraduate research in general, does not seem to be improving. Therefore, it would be valuable to figure out why undergraduates aren't autonomously seeking out undergraduate research during their studies. To investigate why, a two-part survey was developed using the experience of a single undergraduate who, after complications, was able to participate in undergraduate research via a summer research fellowship. The survey asks undergraduates to rate their ability to perform certain aptitudes that are important for research as well as skills that aren't important to research but undergraduates still consider valuable. They were then asked to rate the importance of these skills for acquiring and undergraduate research position. The same survey was administered to faculty. The goal is to determine where faculty and undergraduates are and aren't aligned in terms of both undergraduates' skill level and the importance of each skill. With this data we hope to communicate both to faculty and undergraduates the misconceptions facing each party and to bridge the gap between researchers and undergraduates. In doing so, increasing communication and fostering a climate that will enable more undergraduates to participate in undergraduate research.

**INTRODUCTION**
It is not news that the demand for qualified and experienced researchers is growing day by day; however, “the demand for talented researchers is quickly outpacing the supply” (Hunter, 2007). Why is this? To begin, it’s worth noting that someone can’t learn how to research simply by talking about it—instead students learn how to perform research by doing it. For example, the scientific method is not new. In fact, it is a well-established, reliable, primary method for carrying out experimentation and investigations in a wide variety of disciplines. However, simply learning about the scientific method does not create an outstanding researcher. Elementary aged students are taught the scientific method which is wonderful as it helps capture potential researchers who have had an interest since childhood (Russell 2007). But again, a fourth grader equipped with the scientific model can’t carry out excellent research. Instead, an individual needs not only the prerequisite knowledge, but also a variety of competencies, which are not limited to the abilities to effectively and comfortably identify, question, plan, conduct, analyze, conclude, and communicate. These competencies are described by “Advancing Competencies in Experimentation-Biology (ACE-Bio) Network” (Pelaez et al., 2017) and can serve as a groundwork for basic understanding of the needs of excellent researchers. Developing such capacities clearly requires more than just instruction. It requires the act of practice so that a student can carry out the activities that would indicate competence in communicating, planning, and questioning, for example. Providing opportunities for students to achieve these competencies is challenging in a traditional classroom lecture setting and is best achieved through hands on

research experiences or something close to them, especially for undergraduate students who need these transformative experiences to plan and achieve their future career goals. Cecelia Knight, director of the undergraduate school in the Faculty of Biological Sciences at Leeds University, UK states, "…for research, you need an individual experience, and that's enormously time and resource expensive'" (Hunter, 2007). Both for students undergoing rigorous classwork, and researchers, who are already fully encumbered with their work, undergraduate research is difficult, time consuming, and expensive; especially if there is no funding for either party involved. However, there are some alternatives to this model, such as first-year seminars that include authentic research experiences (FYS) (Wienhold, 2018) and Course-Based Undergraduate Research Experiences (CUREs) (Auchincloss, 2014) which both produce similar, positive outcomes in students. So, it seems there are new, developing methods for producing more experienced undergraduate researchers at high volumes; however, students still don't seem to understand the importance and value of undergraduate research experiences.

While a plethora of literature documents the growing demand for undergraduate research, its benefits, the problems facing it, and how to improve it; little has been done on behalf of students *for* students. Many resources propose vague steps to becoming involved in research but leave undergraduates with questions, confusion, and no clear path. Some colleges have begun to understand that undergraduates desire more guidance in this area and have developed "'centers' and provide part-time faculty directors" (Moran III, 2015) like Bowling Green State University's (BGSU) Center for Undergraduate Research and Scholarship (CURS). The problem with resources like these, and others, is students either aren't aware of them, don't see the value in interacting with them, or don't believe themselves to be fit for pursuing undergraduate research. Nonetheless, such campus wide resources for students show promising results as "one university identified a 400% increase in *reported* undergraduate research over two years … due solely to educating the faculty about the broad nature of undergraduate research, scholarship, and creative activity" (Moran III, 2015). So, helping faculty can clearly impact students, but little, if anything, is being done for students to help themselves autonomously engage in research.

We believe there is no "one stop shop" that directs and answers the questions of an aspiring undergraduate researcher. Therefore, the goal of this research project is to produce an Undergraduate Student Research Manual which explains what students should and shouldn't be doing and focusing on, what resources are already available to them, and how to pursue a meaningful, worthwhile undergraduate research experience.

**What's the Problem?**

Unfortunately, there is no single, glaring problem that is preventing undergraduates from engaging in research--the problems are many and complicated. To begin, consider the most integral part of undergraduate research--the mentor (the faculty member). After all, without mentors, who can lead undergraduates through the research process? So, what is being done to support or encourage faculty members to take undergraduate research? Not enough. In fact, "unless there are formal procedures for rewarding [undergraduate research] in [faculty]

promotion, tenure, and renewal or strong evidence that faculty benefit in the form of increased scholarly productivity from mentoring, some form of compensation will be necessary for continued faculty enthusiasm for" undergraduate mentoring" (Free, 2015). In short, unless something is done to support and promote faculty involvement in undergraduate research, which is remarkably time and energy intensive without being instrumental to their work, we shouldn't expect faculty involvement or enthusiasm for undergraduate research to grow.

In addition, it appears undergraduate research just isn't talked about enough among faculty or students. For example, as stated earlier, "one university identified a 400% increase in *reported* undergraduate research over two years … due solely to educating the faculty about the broad nature of undergraduate research, scholarship, and creative activity" (Moran III, 2015). By better educating the faculty about the need for and methods to engage undergraduates in research this university saw an explosion in undergraduate research! Having resources for faculty and students are great; however, engaging both parties in discussions that reshape how they view undergraduate research is almost certainly necessary for creating not just opportunities but a culture of research.

Perhaps the most troubling problem is addressing implementation of undergraduate research at the university level. How can an institution push or even mandate undergraduates to be involved in research? some universities mandate a certain number of co-ops as a graduation requirement; so, why can't something similar be done for research? Such a requirement could certainly be made but what faculty members would lead the research? What counts as undergraduate research? What counts as successful undergraduate research? How can universities accommodate non-traditional students? Unlike completing a co-op, which is debatably aimed at resume building and job acquisition, research experiences are aimed at skill development and graduate school retention. It seems a university wide demand for undergraduate research may cause more problems than developed researchers.

Perhaps the simplest yet important problem is connecting faculty members with undergraduates. Many students come to college aiming to complete coursework and develop a resume. Unless students are incredibly self-motivated and curious about research, there is no reason for them to seek out research **until** someone else has told them that they should. If the university isn't requiring that students complete a research experience and faculty members aren't approaching, or at least engaging with undergraduates concerning research opportunities, how can we ever expect students to be involved? In a university where research opportunities are limited, waiting for the best and/or most self-motivated may be a good way for offering the limited research positions to a large body of students. However, if the goal is to engage more students in undergraduate research, something must be done to connect faculty members and their research with undergraduate students. Moreover, undergraduate students need to learn the true value of research experiences. Some universities are taking the first step to bridging this gap by implementing "first-year 'Research and Mentoring' [courses]" (Moran III, 2015).

Other problems confront undergraduates, faculty members, and universities as a whole; however, despite the number and complexity of problems, undergraduates can be better engaged in research experiences. While solutions will vary from institution to institution, the goal of this

manual is to discuss general solutions that can implemented widely. Hopefully, once the first steps are taken, each university can better identify their unique problems and develop unique solutions—not unlike research!

### What's the Benefit?

It seems that overcoming the barriers to undergraduate research may be remarkably difficult; so, is it worth it? In an article titled "Lessons from my undergraduate researcher students" Paul Craig writes the following, "[undergraduates] experienced success and failure in the laboratory. they explored the literature. They contacted other scientists-in fact, one time [a student] called the director of the Structural Genomics Initiative" on their own and "had a great conversation" (Craig, 2018). From this alone we can see that undergraduates develop autonomy regarding their research, engage with the scientific community, and become literate in research. In another article, the authors provide a long list of undergraduate publications which have impacted the complex organometallic community and states, "The research featured in this [publication] is a testament to the high-level work that can be performed with undergraduates" (Bradley, 2018). Again, we see the that undergraduate research experiences are developing undergraduates who are active and involved in their field. Moreover, they are producing meaningful research! Whether they continue to higher education or not they are supporting the scientific community. This shows the undergraduates can quickly learn how to engage with and carry out quality research.

Simply put, undergraduate research experiences equip students to become effective and needed researchers not only in the future, but in the present. It engages them in the scientific community, helps them become literate in the research process and scientific writing, and increases the likelihood of graduate school retention (Hunter, 2007).

## METHODS

### A Case Study

To help explain why this manual was created, and to give it context, I would like to offer to you my experience in becoming involved in undergraduate research. Please note the following experience was the lens through which the questions, needs, and goals of this manual were created. It is unlikely that my experience fully encapsulates the experiences of other students; however, I do believe there will be similarities strong enough to help students in general.

To begin, you should know I am a Type-1 diabetic. I began my search for research involvement as a senior in high-school when I wanted to learn more about Type-1 diabetes and couldn't find free access to diabetes research (this isn't to say free publications weren't available but that I was unable to access them if they were). I then asked my endocrinologist--someone who had access to the research--what to do. She told me free publications were hard to come by but if I reached out to a research organization, they may give me access to their literature if I got lucky.

Unfortunately, I didn't get lucky; however, I did gain a contact! At first, I asked the Juvenile Diabetes Research Foundation (JDRF) if they had any research I could access. They pointed me to their publicly available articles that were informative about diabetes but were not the current research publications with citations to other current works, methodologies, data, and conclusions; that I was looking for. However, the JDRF did make me aware of Glu. Glu is a Type-1 diabetes community that has a type of social media platform tailored to diabetics and news relevant to them. I joined, found some other interesting articles, and finally a few old publications! However, at the time I couldn't make sense of what I was reading. So, I reached out to the Glu support team and a researcher reached out to me to answer all of my questions regarding the research, where to look for new research, what major to choose in college, what classes to take, where the research was headed, etc. I knew I wanted to be involved in research well before college and was dying to get a chance to get in a lab!

Then I went to college, declared the major my contact had advised (Biochemistry), and started course work. At first, I was just trying to adapt to college and to earn good grades. By the end of my Spring semester of Freshman year I had reached out to a few chemistry professors about undergraduates working in their lab. Sadly, not one of my emails was returned. I don't know if it was because I was just a freshman or if it was because I used a personal email rather than my college provided email. Nonetheless, I felt defeated. However, during the final weeks of that semester Dr. X (pseudonyms are being used throughout this document excluding my name (Landon Rohrer) and Dr. Karen Sirum) reached out to me! He was leaving the university but felt he could still help me become involved in research. He spoke to me about how to approach faculty members, told me that I could learn more about faculty members' research through research pages or descriptions hosted on their listing on the university website, and even helped me draft new emails to each faculty member! He also told me to be sure to use my college provided email. I sent out the emails to professors at BGSU and The University of Toledo (UT). A single professor from UT responded. We met, discussed her research, and talked about college paths; however, she was unable to offer me a research position. She needed a graduate student, not a freshman undergraduate.

At this point I didn't know where to turn but was still determined to seek out a research experience. Dr. X mentioned applying for a paid fellowship through the BGSU Chemistry Department, that I was unaware of, called the Summer Undergraduate Research Fellowship (SURF). He also mentioned applying for a Research Experience for Undergraduates (REU) which is a paid summer research program through the National Science Foundation (NSF). The beauty of both options is that both were paid and over the summer which meant I could put in some serious lab hours. Since it was too late to apply for a summer research program, I applied for a job at the BGSU Chemistry Stockroom and was hired! This wasn't research but was a way to be in the Chemistry community, to meet faculty and graduate researchers, and to develop basic lab skills. It was another step in the right direction for carrying out research.

During the Fall semester of my Sophomore year I was involved in a Course-Based Undergraduate Research Experience (CURE) through the lab portion of my Biology 2050 course known as the Science Education Alliance-Phage Hunters Advancing Genomics and Evolutionary

Science, or SEA-PHAGES for short, program. In the SEA-PHAGES lab I was conducting inquiry based, experiential research that would be used to further an already growing pool of data regarding bacteriophages. Between the stockroom job and this research experience my desire to do real, novel research was growing ever stronger. While in the SEA-PHAGES lab I was taking Organic Chemistry with Dr. A and loved it! I received great grades and loved the class even more second semester. Using what I'd learned from Dr. X, and what I knew about Dr. A from seeing him and his graduate students in the stockroom, I approached him about his research. He shared with me what he was doing, and I understood maybe a tenth of what he said—but was *fascinated*! So, I asked him if he'd help me write the grant proposal for the SURF fellowship. He agreed.

Now the only item standing between me and carrying out ten, 28-hour weeks of paid research was a single grant proposal. However, like most undergraduates, I'd never written a grant proposal. Dr. A showed me his grant proposal for the project which was approved by the NSF which was at least twenty pages of terminology, data, images, and other research I hadn't read yet. He asked me to reduce this to around three pages and he'd revise it with me. I tried my hardest but ultimately was unsuccessful. Thankfully, Dr. A, and the graduate student in charge of this project, worked with me to draft a proposal for the SURF fellowship. Even better is when I received the SURF fellowship!

I share with you this story to make a couple of points. First, I was exceptionally self-motivated to pursue research. Not to build my resume or make it into graduate school, but simply because I wanted to. Second, I did this from a relatively early point in my college career. Third, it took the help of faculty member to figure out how I could learn about faculty research and how to speak to faculty about their research. Fourth, despite persistent effort, a job performing chemistry lab skills, and good grades, finding a research opportunity was exceptionally difficult. I was trying hard and was reasonably well prepared to engage in research but was failing to find a position. More importantly, I didn't know where to go, what to do, or who to speak to about engaging in research.

Therefore, I decided to develop this manual based on my experiences and on data I collected from surveys of students and faculty, to help overcome some of these obstacles to entering an undergraduate research experience. Not all undergraduate students are as self-motivated and determined to seek out a research experience as I was (although I'm certain some are equally self-motivated and some are even more so), but since research experiences are vital to developing future researchers and retaining STEM students in graduate school, helping more students with research opportunities is important.

In this work, I address the question, "How can we help undergraduate students understand the value of undergraduate research experiences, help them understand what is required, and help them better engage in research?" To this end, we are interested in finding out if there is a disconnect between student expectations, requirements, and procedures for obtaining a research position and faculty expectations, to begin to identify potential discrepancies and solutions.

**A Mirrored Survey**

In order to better understand what faculty and undergraduates think about undergraduates' skill levels and the value of their skills, a mirrored survey was developed and administered to 9 current BGSU faculty members and one Emeritus Professor in a variety of STEM fields, as well as to 92 students in an entry level Majors Biology lecture. Background questions were asked in order to capture information about the students, such as academic standing and grade point average, and about the faculty, like their field of research and involvement with undergraduate research.

Faculty survey participants were asked, on a Likert-Type scale of 1 to 5, with one being strongly disagree, 3 being neither agree nor disagree, and 5 being strongly agree; to rank statements about the level of skills undergraduate have in a variety of competencies. This list of skills was developed from my research experience and from the Advancing Competencies in Experimentation-Biology (ACE-Bio) Network (Pelaez et al., 2017). Faculty were also asked to rank, according to the same scale, the importance of each of those skills for acquiring an undergraduate research position. Students were given nearly an identical survey with the only changes being to wording and relevant background questions at the beginning of the survey. It is worth noting that statements were worded as both positive and negative statements as a check to ensure participants were reflecting on the questions.

While, some survey questions were composed by using statements from the ACE-Bio Network's list of basic competencies for research (Pelaez et al., 2017), others were developed by Dr. Sirum and myself to ask broader questions that were more relevant to individuals who hadn't conducted research. This section was composed questions about skills that didn't neatly fit into the ACE-Bio Network's competencies lists *or* were skills I felt were necessary not for doing research but for acquiring a research position like, "ability to ask researchers about their research" or "ability to locate information about local professors' research." Note, the ACE-Bio competencies were developed to assess the success of a research experience; however, in this instance they were used to determine students' self-perceptions of their ability to perform these skills and faculty's perception of student skills. These competencies included Identify, Question, Plan, Conduct, Analyze, Conclude, and Communicate.

Here are examples of the types of scales used in the surveys:

- Undergraduates Self Evaluation: "On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability".
- Undergraduate Skill Importance: "On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important".
- Faculty Evaluation of Most Undergraduate Science Majors: "On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree

or disagree with the following statements concerning most undergraduate science majors".

- Faculty Skill Importance: "On a scale of 1-5, with 1 being not at all important and 5 being very important, how important is it that an undergraduate possesses the following skill before being accepted into a research group?".

Also, to encourage students to complete the survey, they were given the chance to win a $50 Amazon gift card—one random respondent was awarded the gift card. While this was done to increase response rate, we are aware that the possibility exists that it may have encouraged some students to simply complete the survey without responding carefully and honestly. While the data doesn't support this potential, it is worth keeping in mind as the analysis of survey data is presented below.

The surveys were administered to a class of 135 enrolled students in an introductory biology class and 92 student responses were obtained. The surveys for students were administered digitally when the professor of the class (Dr. Karen Sirum) invited her students to take the survey digitally on their personal devices with ~10 minutes at the beginning of a lecture period. The link to the Faculty survey was sent to the Biology Dept. email list by Dr. Sirum, to 6 faculty members of the Chemistry Dept via ersonal emails from myself., and to the Physics Dept. faculty email list. There were 10 faculty respondents. Note, during the faculty survey responses, one respondent seems to have stopped part way through the survey, at which point sample size goes from (N=10) to (N=9). Whenever this happens percentages in the results section reflect the sample of respondents who *did* answer.

A copy of each of the surveys can be found in the Appendix section.

## RESULTS

### Survey Data

It is the goal of this project to identify major trends and potential alignments and misalignments between faculty and student responses, so here only the most similar, dissimilar, or interesting data are reported and discussed. Potential future work might involve getting more faculty and students to complete the survey, and further comparisons and analyses.

*Table 1. Student Demographics*

| Year in College | Number of Responses | Percent of Total Responses |
|---|---|---|
| Freshmen | 61 | 66.30% |
| Sophomore | 20 | 21.74% |
| Juniors | 6 | 6.52% |
| Seniors | 5 | 5.43% |

Given the above information found in Table 1, this sample set is useful for determining how undergraduates, especially young undergraduates who could benefit the most from undergraduate research, responded to the self-ranking and skill importance questions.

*Table 2. Student Desire to Pursue Undergraduate Research*

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| Yes | 44 | 47.83% |
| No | 48 | 52.17% |

Table 2 indicates that student respondents are split about their desire to pursue undergraduate research, so this data should reflect both types of students well.

*Table 3a. Undergraduate Minimum GPA Expectations*

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| 3.5 - 4.0 | 32 | 52.46% |
| 3.0 - 3.49 | 41 | 67.21% |
| 2.5 - 3.0 | 11 | 18.03% |
| I believe GPA is not an important criterion for acquiring an undergraduate research position. | 8 | 13.11% |

*Table 3b. Faculty Minimum GPA Expectations*

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| 3.5 - 4.0 | 0 | 0% |
| 3.0 - 3.49 | 5 | 50% |
| 2.5 - 3.0 | 1 | 10% |
| 2.0 - 2.49 | 1 | 10% |
| I believe GPA is irrelevant to acquiring an undergraduate research position. | 3 | 30% |

The data in Tables 3a and b indicate that students believe undergraduate research is meant to be for the most academically high achieving students. However, it appears researchers are willing to accept lowering achieving students as not a single respondent expected a 3.5+ GPA. This should be expressed to both faculty and students so realistic, general expectations can be set and communicated.

*Table 4a Students Taking on Research Without Compensation During the Academic Year.*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3).

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| Yes | 47 | 51.09% |
| No | 45 | 48.91% |

*Table 4b Faculty Taking on Research Without Compensation During the Academic Year*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3).

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| Yes | 10 | 100% |
| No | 0 | 0% |

The data in Table 4a and b indicate that faculty seem to fully expect students to engage in undergraduate research without financial compensation; however, nearly half our student respondents (48.91%) indicate that doing so would be unreasonable.

*Table 5a. Student Expectations of Time Commitment for an Undergraduate Research Project*

| Hours of research per week | Number of Responses | Percent of Total Responses |
|---|---|---|
| 0-5 | 13 | 14.13% |
| 6-10 | 36 | 39.13% |
| 10-20 | 22 | 23.91% |
| 20-30 | 12 | 13.04% |
| 30-40 | 6 | 6.52% |
| Over 40 (50 hours...) | 1 | 1.09% |
| Unsure | 2 | 2.17% |

*Table 5b. Faculty Expectations of Time Commitment for an Undergraduate Research Project*

| Hours of research per week | Number of Responses | Percent of Total Responses |
|---|---|---|
| 0-5 | 1 | 10% |
| 5-10 | 7 | 70% |
| As Many as Possible | 1 | 10% |
| Too Broad a Question | 1 | 10% |

A variety of answers were given by faculty and students in response to the question about the hours per week expected for research (Tables 5a and b). Since respondents were asked to type an answer, values from individual numbers to ranges were given by respondent. The data was sorted into these hour ranges given in the Tables 5a and b to best capture what respondents answered. For example, if a respondent answered 5 hours or less, their value was placed in 0-5. However, if they answered 5-8 hours, since they seem to mean some value greater than 5, their value was placed in the 5-10 category. This was less of a problem for the undergraduate data and more prevalent in the faculty data. However, undergraduates had values and ranges over a much greater range. Given that more than 10 hours a week is likely to be somewhat unrealistic with a full course load, all values and ranges of 10+ weren't sorted into smaller categories.

Upon first inspection it may seem students didn't know how to respond to this question. After all, one student responded with 50 hours a week. However, this may indicate that students simply have no generalized idea of how many hours per week an undergraduate research project could demand of them. For faculty, it seems most expect between 5-10 hours which seems reasonable given that at BGSU, every credit one earns for research the expectation is a 3-hour commitment. Therefore, a 3-credit hour research project would expect a total of ~9 hours per week. This isn't unlike normal teaching lab expectation, which is 2-3 hours of student time in the lab per credit hour.

*Response to Ability and Potential Obstacles when Considering Giving 6 Hours a Week to an Undergraduate Research Project*

**The question:**

- Students: "Given your current schedule, could you conduct 6 hours of unpaid research?"
- Faculty: "Which of the following are obstacles you believe prevent undergraduates from pursuing a research experience"

*Table 6a. Student Response to Potential Obstacles to Committing 6 Hours a Week to an Undergraduate Research Project*

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| Yes | 28 | 30.43% |
| No, I would need to work another job to earn money | 33 | 35.87% |
| No, my class schedule is challenging and I need those 6 ours for schoolwork | 31 | 33.70% |
| No, that much time would interfere with extra curriculars (clubs sports, volunteering, etc.) | 15 | 16.3% |
| Possibly | 3 | 3.26% |

*Table 6b. Faculty Response to Potential Obstacles to Committing 6 Hours a Week to an Undergraduate Research Project*

| Response | Number of Responses | Percent of Total Responses |
|---|---|---|
| There are no obstacles preventing most undergraduates from doing research | 1 | 10% |
| Require pay for their time to pay for basic needs / bills | 6 | 60% |
| Demanding Class Schedule | 9 | 90% |
| Already involved in other projects like clubs, sports, or volunteering | 7 | 70% |
| Lack of interest or no understanding the vale, laziness | 1 | 10% |
| Occasionally, non-traditional students will have family obligations they have to work around | 1 | 10% |

In Tables 6a and b, some respondents answered with multiple obstacles. If a respondent selected more than one choice both were counted. Nonetheless, each response count and percent of total responses reveals how many, of the total set, selected that choice. Therefore, the number of responses will exceed the set size (N) and the percent values will sum to more than 100%.

However, Tables 6a and b show that ~30% of students are currently prepared to engage in 6 hours of unpaid research; however, ~35% would need financial support and ~33% find their class scheduling too demanding to engage in further projects. However, only 10% of faculty members think students simply can jump into research. The remainder think students require funding (60%), are already too involved in other activities (70%), or have a demanding class schedule (90%). Unfortunately, the wording of this questions may be misleading. It appears students are responding to what *is* actually preventing them while faculty are responding to what *could* prevent them. Nonetheless, faculty appear to believe there are many obstacles facing undergraduates, but they may only be able to influence one of them (compensation).

In a different question ("If you were to take on an undergraduate, would you need additional sources of funding to pay for materials/supplies, etc., needed for their work?) faculty members responded 50% Yes and 50% No. So, the problem of students requiring compensation may be more difficult to address than simply providing student stipends.

*Table 7a. Evaluation of Students' Ability to Understand Scientific Literature (Articles, Journals, Reviews, etc.)*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3).

| Respondent | Yes | No | Neutral |
|---|---|---|---|
| Students | 45.65% | 14.13% | 40.22% |
| Faculty | 20% | 40% | 40% |

Table 7a shows that students rate their ability to understand scientific literature higher than faculty members do. This is clearer when we consider only 14% of students responded with No while 40% of faculty members did.

*Table 7b. Importance of a Students' Ability to Understand Scientific Literature (Articles, Journals, Reviews, etc.)*

Important is agree (4) or strongly agree (5), Not Important is disagree (2) or strongly disagree (1), and Neither is neither agree nor disagree (3).

| Respondent | Important | Not Important | Neither |
|---|---|---|---|
| Students | 80.43% | 5.43% | 14.13% |
| Faculty | 30% | 40% | 30% |

Tables 7a and b show that even though students seem to rate themselves more highly than their faculty members do, this may not be a problem as only 30% of faculty members deemed this skill important. However, 80% of undergraduates deemed the skill as important. This is a large **misalignment** and should be communicated to both faculty and students.

*Table 8a. Evaluation of Students' Familiarity with BGSU CURS Center*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3) where Yes indicates familiarity and No indicates lack of familiarity.

| Respondent | Yes | No | Neutral |
|---|---|---|---|
| Students | 11.96% | 72.83% | 14.13% |
| Faculty | 10% | 40% | 50% |

*Table 8b. Importance of a Students' Familiarity with BGSU CURS Center*

Important is agree (4) or strongly agree (5), Not Important is disagree (2) or strongly disagree (1), and Neither is neither agree nor disagree (3).

| Respondent | Important | Not Important | Neither |
|---|---|---|---|
| Students | 45.65% | 20.65% | 31.52% |
| Faculty | 0% | 90% | 10% |

Tables 8a and b show remarkable data. The Center for Undergraduate Research and Scholarship (CURS) is only familiar to ~12% of students yet deemed important by ~45% of them! This is a huge difference. Moreover, 90% of the faculty we surveyed responded to being familiar with the CURS as not important! If the goal is to increase involvement in undergraduate research, then students and faculty should be asked what they feel they need from the CURS so it can be seen for the true value it is worth.

*Table 9a. Evaluation of Students' Inability to Write Scientifically*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3) where Yes indicates inability and No indicates ability since this question was asked as a negative statement.

| Respondent | Yes | No | Neutral |
|---|---|---|---|
| Students | 18.48% | 53.26% | 28.26% |
| Faculty | 30% | 20% | 50% |

*Table 9b. Importance of a Students' Inability to Write Scientifically*

Important is agree (4) or strongly agree (5), Not Important is disagree (2) or strongly disagree (1), and Neither is neither agree nor disagree (3).

| Respondent | Important | Not Important | Neither |
|---|---|---|---|
| Students | 70.62% | 3.26% | 22.83% |
| Faculty | 30% | 10% | 50% |

Tables 9a and b show that in terms of inability to write scientifically, only 18% of students this they are unable while 53% think they are able. However, 30% of faculty think students are unable while only 20% think they are able. Here, students seem to be ranking themselves higher than their skills are perceived to be. By contrast, 70% of students deem this to be an important skill while only 30% of faculty do. While it may seem that students should improve their scientific writing ability, this skill doesn't appear to be vital for achieving an undergraduate research position. This may be another perceived obstacle standing in the way of students confidently pursuing research opportunities, if they feel they do not have the requisite skills.

*Table 10a. Evaluation of Students' Ability to Perform Core Lab Techniques (like measuring mass or volume, recording data, or preparing standards/samples)*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3).

| Respondent | Yes | No | Neutral |
|---|---|---|---|
| Students | 66.30% | 9.78% | 23.91% |
| Faculty | 70% | 0% | 30% |

*Table 10b. Importance of a Students' Ability to Perform Core Lab Techniques (like measuring mass or volume, recording data, or preparing standards/samples)*

Important is agree (4) or strongly agree (5), Not Important is disagree (2) or strongly disagree (1), and Neither is neither agree nor disagree (3).

| Respondent | Important | Not Important | Neither |
|---|---|---|---|
| Students | 79.35% | 3.26% | 14.13% |
| Faculty | 77% | 0% | 22% |

Tables 10a and b show that students and faculty rate student ability to perform key lab techniques, the kinds taught in Lab Classes STEM majors are expected to take, similarly. Faculty and students also seem to rate this ability importance similarly.

*Table 11a. Evaluation of Students' Ability to Perform Lab Techniques Taught to Undergraduates in Research Specific Settings*

| Respondent | Yes | No | Neutral |
|---|---|---|---|
| Students | 75% | 5.43% | 19.57% |
| Faculty | 77% | 0% | 22% |

*Table 11b. Importance of a Students' Ability to Perform Lab Techniques Taught to Undergraduates in Research Specific Settings*

Important is agree (4) or strongly agree (5), Not Important is disagree (2) or strongly disagree (1), and Neither is neither agree nor disagree (3).

| Respondent | Important | Not Important | Neither |
|---|---|---|---|
| Students | 80.43% | 2.17% | 14.13% |
| Faculty | 100% | 0% | 0% |

Like Tables 11a and b, Tables 10a and b show that students and faculty rate student ability to carry out techniques that are taught to them *during* research similarly. However, all faculty respondents rated this skill as highly important while only 80% of students rated it the same. This seems to be a key ability that students should be aware of and potentially use when applying for a research position.

*Table 12a. Evaluation of Students' Ability to Display Data/Results Visually*

Yes is agree (4) or strongly agree (5), no is disagree (2) or strongly disagree (1), and neutral is neither agree nor disagree (3).

| Respondent | Yes | No | Neutral |
|---|---|---|---|
| Students | 75% | 3.26% | 20.65% |
| Faculty | 30% | 20% | 50% |

*Table 12b. Importance of a Students' Ability to Display Data/Results Visually*

Important is agree (4) or strongly agree (5), Not Important is disagree (2) or strongly disagree (1), and Neither is neither agree nor disagree (3).

| Respondent | Important | Not Important | Neither |
|---|---|---|---|
| Students | 81.52% | 2.17% | 13.04% |
| Faculty | 60% | 0% | 30% |

Tables 12a and b show that both undergraduates and faculty agree that the ability to display results visually are important. In fact, no faculty member rated this as unimportant, their response was either very important, important, or neither important nor unimportant, but *no* faculty members deemed the skill as unimportant. However, the students' self-evaluation of this skill is higher than the faculty members deemed their skill. 75% of students think they can display data visually while only 30% of faculty agreed. Moreover, only ~3% of students said they were unable to display data visually while 20% of faculty said they were unable. Also, 30% of the faculty said neither in Table 12b. This deserves attention in follow-up work as it is unclear how, and especially why, faculty would respond with neither rather than yes.

## CONCLUSIONS AND FUTURE WORK

Before any firm conclusions can be drawn, we must remember that conclusions are limited by the data set: 92 undergraduate students from BGSU in an introductory Biology course and only 9 current faculty members and one professor emeritus from a variety of STEM fields were our respondents to the administered surveys. To better understand how students and faculty think about student skills, skill importance, and undergraduate research as a whole; this survey needs to be administered on a much larger scale. Also, additional demographic factors need to be considered, such as institution wealth, student demographic, and the level of research each university or college conducts compared to others. While below I will provide *some* resources to help students begin their path towards engaging with faculty members about their research and working their way into a research position, a more compressive list of resources that can help students (understand scientific literate, write scientifically, locate grant and scholarship opportunities, direct them to faculty research, etc.) should be made publicly available and *familiar* to undergraduate students. This will function as a springboard to pique curiosity, start conversations, and bridge the gap between students and faculty.

Nonetheless, this preliminary data set may show that there are a variety of alignments and misalignments among undergraduate students and faculty at BGSU concerning undergraduate research. Each alignment and misalignment may be used to guide students, faculty, and the college institution in engaging more undergraduates in undergraduate research experiences. Unfortunately, due to time constraints, the data collected could not be fully analyzed. I had planned to break each competency, as described by the ACE-Bio Network, into a category and determine if entire competencies are in alignment or not. This should be conducted for future work. Moreover, the surveys developed can be modified and used to better understand where students and faculty seem to have the same ideas concerning undergraduate research. By improving these surveys, they can be distributed at other institutions to help increase the culture of undergraduate research in secondary education throughout the U.S., if not on a global scale.

### First Steps for Undergraduates

Perhaps the first thing undergraduates need to know is value of an undergraduate research experience. These are the experiences that develop the mind of a scientist. It is through hands on research, asking interesting questions, and failure, that a mind capable of carrying out valuable, novel research is born. Students need more opportunities to see or hear about research and engage with those carrying out the research (whether in a one-on-one setting or public form setting). They need to hear about it from their professors and advisors. Hopefully, they can discuss it with nearby graduate students so they can see and hear about what they could be doing. Overall, the conversation simply needs to start soon and take place more often.

Next, students should know that while faculty members naturally want the best and brightest among the undergraduate classes, they truly want students who are curious and excited to work. Earning high grades is important not just for earning a job, making it into graduate school, or

becoming involved in research; but for increasing a student's wealth of knowledge and for fostering a mind that notices small details and asks curious questions.

Next, while this returns to the earlier point about speaking about research more frequently, students need better understand what research "looks like". By this I mean students should know they generally will not be compensated and are expected to work something like 6-9 hours per week on average. However, this number can change based on student availability and interest level. Moreover, students should know that there are ways to earn money while researching by engaging with undergraduate research centers like the CURS at BGSU. The CURS awards scholarships for undergraduate research that covers project expenses, which may be valuable when asking a researcher to work in their lab, and awards a stipend. While the stipend is modest, it is surely better than working for no compensation at all. Even if a stipend can't be awarded students may have the wrong idea about research as it's not a "job" in the typical sense. Yes, students are expected to show up, carry out work, and be responsible for completing certain tasks; however, this is true in lab settings for which they aren't compensated either! The point here is that research can count as credit-hours for many students in the same way labs do. However, if a student truly needs financial assistance, engagement with organizations like CURS and applying for undergraduate scholarships is a great place to start. Afterall, I was only able to begin undergraduate research because I was awarded the SURF as described in the **A Case Study** section.

To follow the concerns regarding finances, students need to know that most professors are aware of their hard course load, busy schedule, and involvement with other activities. They will work with you if you truly desire to engage in research; however, like any commitment, it should be made with confidence. If research is a goal, then undergraduates need to make it a priority like they would any other engagement. It is worth pausing here to restate just how valuable research experience is for retaining undergraduates to graduate school and strong of a resume-builder the it can be. If graduate school is a goal for any undergraduate student, the ability to carry out research is far more valuable than high grades.

Perhaps the most subtle benefits of undergraduate research are learning how to become scientifically literate. Any research project requires one to locate, read, understand, and produce scientific literature. Data from the surveys suggests that students aren't as good as they are at these things while they are deemed valuable by faculty members. While these are skills worth developing, they come with time—they come with research.

Not surprisingly, faculty reported that students can carry out lab techniques taught to them during their lab classes *and* taught to them during research projects. They also rated both skills highly important—and so did students. The main take away here is that students need to be able to perform *practical* laboratory skills. Depending on who a student is trying to work with, the ability to already perform certain techniques may make them a far more valuable candidate for a research position than other students. Again, this is something that will also be learned with time and isn't something students can work on improving or developing in their free time.

Given these findings it appears that students need to talk about and hear about research more. To get their feet in the door students should start by investigating faculty members' research. Students can learn more about research by looking at current faculty research web pages, by asking their professor questions about their research, where data is coming from, and how the research is being done, either before or after a lecture or during office hours. Students should also be striving to be more scientifically literate. By learning to read and understand scientific articles, students will gain a better understanding of what it is they are expected to communicate. Unfortunately, the only way some students will learn how to do this if they are made to by their professors through class assignments. Finally, students need to become aware of the resources made available to them, such as research presentations, facilities like BGSU's CURS, general library resources and helpdesks, along with undergraduate grants and scholarships, to name a few. These are the places and resources that are designed for undergraduates to help them engage in research. This is undoubtedly where undergraduates should start. Or, by working with a trusted faculty member like I did with Dr. X.
(Please see Appendix C for a preliminary list of resources for students.)

**First Steps for Faculty (Mentors/Researchers)**

If faculty are going to be involved with undergraduate research, and the number of undergraduates performing research is to grow, then faculty will need support. The most important barrier for overcome to help faculty members facilitate undergraduate research is to provide them with incentive. Whether it financial, as an alternative to teaching (in the traditional sense), or as consideration for promotion or tenure (Free, 2015).

There are two other major roles faculty members can play in increasing undergraduate research. First, they can discuss research more in traditional classroom settings and make students engage with literature. By providing them with the research literature, or asking them to find some on their own, students will be more able to engage with the research community and participate.

Second, faculty can just talk about research more. Be it their own, research within their department or the university, or more generally; by talking about research and what it looks like students will be more exposed. Greater exposure will help undergraduates engage with and consider research.

A more challenging but still important role faculty members can play would be securing funding for undergraduates. It is up to students to manage their schedules and make research a priority in their undergraduate career if it aligns with their goals; however, to keep research from being limited to those with markedly high work capacities or those with better financial standing, faculty could help undergraduates secure funding for performing the research. Now, if the research earns a student academic credit, there isn't a compelling argument that a student deserves financial support, as no other classes earn a student money (in fact they cost money!). However, in deserving cases, or for students seeking to perform research without earning credit, financial aid may be a huge factor and potential motivator for getting students into the lab, and therefore, readily accessible information about how to obtain this financial aid is essential.

Finally, there needs to be more communication and information for students to understand faculty expectations of students when beginning research. More students are candidates for research, but their beliefs about their skills and their misconceptions about faculty expectations may be holding them back from seeking out research experiences.

**First Steps for The College Institution**

The college institution will be the most powerful influencer in determining what changes make it to undergraduates. However, the goal of this manual was to develop a list of actions or resource so students could autonomously help themselves. In the end, it seems some of these resources require development or assistance from the college.

For example, if a college (for example the College of Arts and Sciences at BGSU) made it a part of the undergraduate requirements to sit in on a meeting about undergraduate research, students would be made aware of the opportunities and resources available to them. Students would also be more aware of the value and need for undergraduate research. Similarly, some of the issues and discrepancies about expectations could be addressed during Department and Program faculty meetings, developing a better pipeline from college resources to faculty, and from college resources and faculty to students.

This cooperation wouldn't just benefit students either. For example, project funding from CURS would pay for the undergraduate's work in the lab. This means the faculty member's research is being, in part, part for by CURS. In addition, faculty and resources like CURS could work together to build better resources for students like a link to "Faculty Current Research" pages, giving students a direct path to finding out more about the research their faculty members are doing at their university. These pages could also include resources faculty have found to further help undergraduate research students, for example, how to find and read research papers in their fields.

The other most important benefit the college institution could indirectly offer to students is developing a consistent and generalized set of definitions, implementations, and expectations among faculty members for undergraduate research. In doing so, faculty would know what they are expected to provide and communicate to undergraduates, undergraduates would know what's expected of them and what the research would like, and communication between all parties would simply be easier and more effective. For example, consider the benefits of establishing a minimum set of requirements for what constitutes a research experience. By making this, faculty would know what is expected of them, be able to develop it, and importantly, be better able to communicate to students what undergraduate research at their institution generally looks like.

The institution can also consider implementing more undergraduate research on a large scale by mandating inquiry-based research experiences in the form of a CURE. See the section titled **A Case Study** and look at the "SEA-PHAGES" class for an example. While these large-scale implementations may be less impactful since students are still following a prescribed procedure and research protocol rather than developing one themselves in conjunction with faculty

members, they are an easy way to reach many students in lieu of available research space in faculty labs and research stations.

Overall, college expectations can play a large role in developing not only the research opportunities, but the culture of research. By making undergraduate research a required a part of the undergraduate experience and providing adequate support to faculty members supervising undergraduates conducting research, involvement in undergraduate research will surely see a similar increase as seen in (Moran III, 2015). This will require the college to promote undergraduate research among students and faculty by generally involving an increase in the exposure of research to undergraduates, for example, in the form of research meetings, research presentations, including research as part of course work, and potentially course requirements like co-ops in engineering majors. Faculty incentives may include compensation, workload considerations, as well as increasing the value of mentoring undergraduate researchers for merit, promotion, and tenure evaluation.

## References Cited

Auchincloss, L.C.; Laursen, S.L.; Branchaw, J.L.; et al. Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report. *CBE-Life Sciences Education.* **2014,** *Vol. 13,* 29-40.

A thorough examination of Course-Based Undergraduate Research Experiments (CUREs) as a growing method for involving students in meaningful research experiences. While not a research internship, CUREs may reap many of the same results found in, and some not found in, a research internship (see Table 1). The five goals of CUREs (30-31) may be useful for evaluating current research experiences and for modeling the survey (Table 2). Some of the skills evaluations on pages 33-34 may also be useful for the survey. The outcomes in figure 1 (35) may inform student expectations and teacher designs and methods.

Bradley, C.A.; Nataro, C. Undergraduate Research: Contributions to Organometallic Chemistry. *Organometallics*, **2018,** *37,* 1813-1816.

Overall, this article highlights a variety of scientific reports published by undergraduates from Primarily Undergraduate Institutions (PUIs). Notes some of the problems facing PUIs, the reasons for them, and the support they are currently receiving.

A great example of how undergraduate research is not only a "natural incubator for next generation" researchers, but can produce valuable, timely research too. This will be strong evidence to support that undergraduate research is producing high quality scientists thus explaining the growing need for undergraduate research or similar programs.

Craig, P.A. Lessons from My Undergraduate Research Students. *Journal of Biological Chemistry.* **2018,** *293 (27),* 10447-10452.

This is an account of a professor who implemented a variety of methods to "help students become scientists". He lists 5 lessons he learned from undergraduates about research and insists that discovery-based research become the norm but points out it is challenging in time, effort, money, and resources.

More examples for the need of Undergraduate Research (UR) and evidence of its value. Possible outline for how it should be done before and at the "Future Plans" heading. This can potentially be used in conjunction with the ACE-Bio basic competencies for developing survey questions and setting guidelines for successful undergraduate research experiences.

Dolan, E.L. Undergraduate Research as Curriculum. *Biochemistry and Molecular Biology Education.* **2017,** *Vol. 45 (4),* 296-298.

Gives great purpose for CUREs and research in general and lists many of the outcomes a URO can provide. Notes that one-on-one research experiences are limited and is a reason CUREs need to be developed. ***Maybe I can argue that CUREs are needed one, because they offer unique experiences, and two, because spots in one-on-one are simply so limited.*** Finally

provides some benefits to CUREs over normal lab procedures thus raising the bare minimum of lab experiences.

Free, R.; Griffith, S.; Spellman, B. Faculty Workload Issues Connected to Undergraduate Research. *New Directions for Higher Education.* **2015,** *Spring no. 169,* 51-60.

The Council of Public Liberal Arts Colleges (COPLAC) identifies faculty workload issues concerning undergraduate research. It seems many teachers, in this group but perhaps more broadly too, are asked to take on mentoring undergraduate research (UR) but aren't compensated for it financially or in terms of time. A distance learning pilot was conducted and investigated not only the program's effectiveness, but the impacts of "credit-bearing courses, the shape of faculty work in an increasingly constrained fiscal environment, and the larger faculty rewards system" (53). It went on to investigate faculty involvement in undergraduate research, the number of students involved, the models of the undergraduate research, and the timing. While the data is small and only truly represents these COPLAC schools, it may be indicative of problems facing faculty at most schools. In short, it seems that "unless there are formal procedures for rewarding UR in promotion, tenure, and renewal or strong evidence that faculty benefit in the form of increased scholarly productivity from mentoring, some form of compensation will be necessary for continued faculty enthusiasm" in undergraduate research (55). Overall, this is evidence that UR problems don't stem just from the students but from faculty and the systems within which they work. If UR is going to become an integral part of the college education, resources don't only need to be made available to students but to faculty as well.

Hunter, P. Undergraduate Research: Winning the Battle for Students' Hearts and Minds. *EMBO Reports.* **2007,** *8(8).* 717-719.

There is a growing demand for talented researchers but the resources for capturing them and training them are sparse at best. Teaching is a direct impediment on research and training undergraduates. Funding for undergraduates is hard to come by. A real, individual experience is key, and this is time intensive as well. Nonetheless, active research directly correlates to increased retention in PhD programs. The third column of page 718 explains some of the reasons Germany *may* be producing better and more researchers.

There is a serious value in and need for undergraduate research, but the time and money are hard to come by. Unlike what Craig, P.A., said in the above article, this one notes publishing for undergraduates in incredibly hard; however, this doesn't disvalue the importance of UR. This reveals some of the problems facing UR—namely that experience is hard to come by and that the actual experience doesn't produce tangible results. Therefore, their value may be underrated. If students were more published, or had some form of completion, UR would set them apart from other graduate candidates hopefully improving both interest and enthusiasm for UR.

Use as evidence for problems facing UR and benefits of UR.

Moran III, J. D.; Wells, M. J.; Smith-Aumen, A. Making Undergraduate Research a Central Strategy in High-Impact Practice Reform: The PASSHE Journey. *New Directions for Higher Education.* **2015,** *Spring no. 169,* 61-71.

This article investigates how to make UR a core component of education in the Pennsylvania State System of Higher Education (PASSHE). This system makes up 14 schools, only two of which can offer PhD programs, but are otherwise incredibly homogenous. It affirms that UR advocacy isn't a new concept (62) but notes that the demand is rising and asks why. It suggests that the desire and need for post-secondary and declining state funding and enrollments has made students involved in UR more valuable than ever. It also notes that academic preparation may not alone be teach critical thinking skills which are crucial for employment—further driving up the need for UR. The PASSHE faculty pooled together and aimed to increase performance funding, increase opportunities for students and increase graduation rates to assist in producing better graduates and improve UR experiences. This was done in part by revising curricula to include more access to high impact learning practices like UR. Consequently, this demanded increasing funding and developing scholarships to enable students to take on UR. Questions like, "what counts as UR" arose which lead to the inclusion UR as a performance indicator of universities. Some campuses were also troubled with developing UR experiences when most of their lab spaces were designed for instructional use only. Moreover, overcoming these obstacles is difficult when faculty have no "evaluation for merit, tenure, or promotion" (67). Faculty recognized that increased funding and changes in culture would be needed to reform UR. However, the impact is undeniable as producing a CUR workshop increased reported UR by 400% over two years at a single university. Perhaps the problem is that students and faculty just aren't aware of resources at their disposal.

It goes on to recommend more meetings and discussions about UR, developing it into curricula, and defining useful ways to track UR success and requirements as each college sees fit.

Russell, S.H.; Hancock, M.P.; McCullough, J. Benefits of Undergraduate Research Experiences. *AAAS, Science.* **2007,** *Vol. 316,* 548-549.

While slightly dated (2003-2005 survey published in 2007), this short report finds that Undergraduate Research Opportunities (UROs) are needed and breaks them down. Most involved are "mainly juniors and seniors" and among those in STEM, developed a pursuit of research during "childhood" (548). Also found the experience in and of itself was important and that the activities (reports) or season of experience (summer, fall, or spring) were largely irrelevant. Notes many students report "more effective faculty guidance" as a desired improvement but may actually be evidence of the "complexity of the mentor's role rather than its unimportance". Also found no real difference among gender or race and found that diverse mentors were somewhat superior but ultimately race and gender or mentor played no *major* role in outcomes.

Pelaez, Nancy; Anderson, Trevor; Gardner, Stephanie M; Yin, Yue; Abraham, Joel K.; Bartlett, Edward; Gormally, Cara; Hill, Jeffrey P; Hoover, Mildred; Hurney, Carol; Long, Tammy; Newman, Dina L.; Sirum, Karen; Stevens, Michael. "The Basic Competencies of Biological Experimentation: Concept-Skill Statements" (2017). PIBERG Instructional Innovation Materials. Paper 4. http://docs.lib.purdue.edu/pibergiim/4

This is a compilation of the seven competencies needed for, in this case, biological experimentation, but more broadly speaking for research according to the ACE-Bio network. Each section discusses the key concepts and associated skills for the corresponding competency. This is incredibly useful for assessing UR outcomes as this provides clear sets of skills and general concepts an undergraduate student should develop throughout the experience.
This resource was developed by a large, reputable source and has been reviewed and is currently in use for developing better Biology curriculums and is therefore of remarkably high credence.

Purugganan, M.; Hewitt, J. How to Read a Scientific Article. *Cain Project in Engineering and Professional Communication, Rice University.* **2004,** 1-6.

This article explains how to approach reading scientific literature. It explains what components make most scientific articles and what information is contained in each component. Moreover, it offers a few strategies for successful understanding and retention of new information. It suggests first reading the abstract to understand the general goals, outcomes, and then deciding if the article is of interest. If it is, consider reading the introduction to discover the question(s) being asked. It then lists some key words and phrases to look for upon primary readings. Finally, it recommends taking notes during this process but ending with asking questions and searching for answers, or the lack thereof, to better understand the article and retain information.

Wienhold, C.J.; Branchaw, J. Exploring Biology: A Vision and change Disciplinary First-Year Seminar Improves Academic Performance in Introductory Biology. *CBE-Life Sciences Education.* **2018**, *17:AR22.*1-11

Many students in biology aren't remaining in the major and or don't know how to become involved in the scientific community. Thus, a first-year seminar (FYS) biology course was developed to help integrate students into college and biology specifically. The course reveals that the FYS improves grades, retention, and *involvement and awareness* in research. This may also support the idea that individual UR is not necessary and alternative experiences like FYS may be just as valuable for undergraduate students—especially early on.

This may be a first step for helping students to become aware and engaged in research. See data tables with relevant research statistics.

Appendices

Appendix A: Copy of Undergraduate Survey

Appendix B: Copy of Faculty Survey

Appendix C: Preliminary list of resources to help students.

# Undergraduate Research Survey

A brief survey to aid in Landon Rohrer's development of an undergraduate student research manual for his Honors Project.
This is an anonymous survey which means no personal information will be associated with any of your answers.

NEXT

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# Undergraduate Research Survey

## Background

What field do you teach and/or do research in?

Your answer

I am a

- ○ Faculty Member
- ○ Graduate Student
- ○ Other: _____

Are undergraduate researchers typically accepted into your lab?

- ○ Yes
- ○ No

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# Undergraduate Research Survey

## Section 1

1) What minimum GPA do you feel an undergraduate should have to be able to acquire an undergraduate research position?

- ○ 3.5 - 4.0
- ○ 3.0 - 3.49
- ○ 2.5 - 3.0
- ○ 2.0 - 2.49
- ○ I believe GPA is irrelevant to acquiring an undergraduate research position.

2) How valuable would you consider undergraduate research compared to an internship for undergraduates?

- ○ Internships are always more valuable than undergraduate research
- ○ Internships are never more valuable than undergraduate research
- ○ Internships and undergraduate research is always of the same value
- ○ It depends on the research/internship and student goals

3) When deciding to accept an undergraduate into your research group, is it important that they be planning to attend graduate school?

- ○ Yes
- ○ No

4) Do you feel that it is feasible for undergraduates to take on undergraduate research without compensation during the school year?

- ○ Yes
- ○ No

5) Do you feel that it is feasible for undergraduates to take on undergraduate research without compensation during a break from school? (Summer or Winter break for example)

- ○ Yes
- ○ No

6) How many hours per week (during the school year) do you think the typical undergraduate researcher should perform undergraduate research?

Your answer

7) Which of the following are obstacles you believe prevent undergraduates from pursing a research experience

- [ ] Require pay for their time to pay for basic needs / bills?
- [ ] Demanding class schedule
- [ ] Already involved in other projects like clubs, sports, or volunteering
- [ ] There are no obstacles preventing most undergraduates from engaging in research
- [ ] Other: _____

8) Is previous research experience expected of undergraduate researchers entering your lab?

- ○ Yes
- ○ No

9) If you said yes to question 8, please explain what types of previous research experience(s) are most valuable and least valuable when considering accepting an undergraduate (for example, high school projects and experiences, course-based research, other lab work, etc.)

Your answer

10) Do you expect undergraduate researchers to have previously kept a Lab Notebook or Lab Diary?

- ○ Yes
- ○ No

11) Briefly explain the purpose of a Lab Notebook in your field

Your answer

12) How frequently are you contacted by undergraduates about your research? (In person, over email, etc.)

- ○ Never
- ○ By one student per year
- ○ By one student per semester
- ○ By 2-3 students per semester
- ○ By 4-5 students per semester
- ○ By 5+ students a semester

13) Do you seek out undergraduate researchers for work in your lab?

- ○ Yes
- ○ No

14) If you were to take on an undergraduate, would you need additional sources of funding to pay for materials/supplies, etc., needed for their work?

- ○ Yes, I lack the funds to allow an undergraduate to start a new project or work on an ongoing one.
- ○ No, I (my research group) possess the necessary funds to have an undergraduate work in my (our) lab

# Undergraduate Research Survey

## Section 2

On a scale of 1 to 5, with 1 being very easy, 2 being easy, 3 being neither easy nor difficult, 4 being somewhat difficult, and 5 being very difficult:

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| How challenging do you think it is for students to acquire an undergraduate research position | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 3

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are able to understand scientific literature (journals, articles, reviews, etc.) | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to work independently | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are generally unorganized | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are comfortable in a lab setting | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are familiar with BGSU's CURS center | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to locate information about local professors' research | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are comfortable asking a researcher about their research | ○ | ○ | ○ | ○ | ○ |
| I feel an undergraduate research experience is only useful if it is related to an undergraduate's major | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| I feel an undergraduate research experience is only useful if it is related to an undergraduate's career interests | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are unable to write a useful resume for acquiring an undergraduate research position | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are aware of campus resources which are helpful for writing a useful resume | ○ | ○ | ○ | ○ | ○ |
| Grades in classes relevant to the research determine an undergraduate's suitability to be accepted into my lab (group) | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to learn from their failures | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

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# Undergraduate Research Survey

## Section 4

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are able to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a resource other than a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to determine what specific articles, of they ones they have found in a literature search, are relevant to the specific research topic | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to roughly understand the main idea of a scientific journal article | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Section 5

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are able to develop research questions based on observations | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are unable to interpret diagrams, models, or other types of visual explanations | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to make predictions | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to ask questions when unsure of what to do | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Section 6

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are unable to create a timeline for projects | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to design experimental controls | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to plan what data/variable they should be measuring/observing | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to plan how to measure relevant data | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

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# Undergraduate Research Survey

## Section 7

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are able to perform core techniques taught in relevant lab classes like measuring mass or volume, recording data, or preparing samples | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to replicate a lab technique that was taught to them | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 8

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are able to detect and describe patterns in data | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able identify sources of error | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are unable to perform basic statistics on data | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to organize and display data/results visually | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Section 9

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are able to generalize their findings | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to describe trends in data with words | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to describe trends in data with visual representations | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to propose follow up experiments | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Section 10

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements concerning most undergraduate science majors.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Most undergraduates are unable to write scientifically | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to create and use posters to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to create and use Powerpoints to communicate their findings to others | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to develop and use a speech (oral presentation) to communicate their findings to others | ○ | ○ | ○ | ○ | ○ |
| Most undergraduates are able to communicate their findings appropriately based on an audience's understanding of their research project (consider their ability to explain the same research to a professor, a family member, and an elementary student) | ○ | ○ | ○ | ○ | ○ |

# Undergraduate Research Survey

## Half Way

You will now be asked to rank the same statements in regards to how important they are to acquiring an undergraduate research position.
So, now please consider the following statement when ranking:
On a scale of 1-5, with 1 being not at all important and 5 being very important, how important is it that an undergraduate possesses each of the following skill before being accepted into a research group?

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# Undergraduate Research Survey

## Section 13

On a scale of 1-5, with 1 being not at all important and 5 being very important, how important is it that an undergraduate possesses each of the following skill before being accepted into a research group?

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to understand scientific literature (journals, articles, reviews, etc.) | ○ | ○ | ○ | ○ | ○ |
| The ability to work independently | ○ | ○ | ○ | ○ | ○ |
| Being generally organized | ○ | ○ | ○ | ○ | ○ |
| Being comfortable in a lab setting | ○ | ○ | ○ | ○ | ○ |
| Being familiar with BGSU's CURS center | ○ | ○ | ○ | ○ | ○ |
| The ability to locate information about local professors' research | ○ | ○ | ○ | ○ | ○ |
| Being comfortable asking a researcher about their research | ○ | ○ | ○ | ○ | ○ |
| The ability to write a useful resume for acquiring an undergraduate research position | ○ | ○ | ○ | ○ | ○ |
| Being aware of campus resources which are helpful for writing a useful resume | ○ | ○ | ○ | ○ | ○ |
| The ability to learn from their failures | ○ | ○ | ○ | ○ | ○ |

# Undergraduate Research Survey

## Section 14

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| The ability to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a resource other than a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| The ability to determine what specific articles, of they ones they have found in a literature search, are relevant to the specific research topic | ○ | ○ | ○ | ○ | ○ |
| The ability to roughly understand the main idea of a scientific journal article | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 15

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to develop research questions based on observations | ○ | ○ | ○ | ○ | ○ |
| The ability to interpret diagrams, models, or other types of visual explanations | ○ | ○ | ○ | ○ | ○ |
| The ability to make predictions | ○ | ○ | ○ | ○ | ○ |
| The ability to ask questions when unsure of what to do | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 16

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to create a timeline for projects | ○ | ○ | ○ | ○ | ○ |
| The ability to design experimental controls | ○ | ○ | ○ | ○ | ○ |
| The ability to plan what data/variable should be measured/observed | ○ | ○ | ○ | ○ | ○ |
| The ability to plan how to measure relevant data | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 17

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to perform core techniques taught in relevant lab classes like measuring mass or volume, recording data, or preparing samples | ○ | ○ | ○ | ○ | ○ |
| The ability to replicate a lab technique that was taught to them | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 18

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to detect and describe patterns in data | ○ | ○ | ○ | ○ | ○ |
| The ability to identify sources of error | ○ | ○ | ○ | ○ | ○ |
| The ability to perform basic statistics on data | ○ | ○ | ○ | ○ | ○ |
| The ability to organize and display data/results visually | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

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# Undergraduate Research Survey

## Section 19

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to generalize their findings | ○ | ○ | ○ | ○ | ○ |
| The ability to describe trends in data with words | ○ | ○ | ○ | ○ | ○ |
| The ability to describe trends in data with visual representations | ○ | ○ | ○ | ○ | ○ |
| The ability to propose follow up experiments | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

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# Undergraduate Research Survey

## Section 20

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements .

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to write scientifically | ○ | ○ | ○ | ○ | ○ |
| The ability to create and use posters to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| The ability to create and use Powerpoints to communicate findings to others | ○ | ○ | ○ | ○ | ○ |
| The ability to develop and use a speech (oral presentation) to communicate findings to others | ○ | ○ | ○ | ○ | ○ |
| The ability to communicate findings appropriately based on an audience's understanding of the research project | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Thank You!

BACK SUBMIT

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# Undergraduate Research Survey

A brief survey to aid in Landon Rohrer's development of an undergraduate student research manual for his Honors Project.
This is an confidential survey which means no personal information will be associated with any of your answers.

NEXT

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# Undergraduate Research Survey

## Amazon Gift Card

At the end of this survey you will be able to enter your BGSU email for a chance to win a $50 Amazon gift card! Your email will not be tied to your answers. You do not have to enter your email if you would prefer not to.

BACK NEXT

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# Undergraduate Research Survey

## Background

What is your Major (if you have a specialization please include that too).

Your answer

What year of college are in you right now

- ○ Freshman
- ○ Sophomore
- ○ Junior
- ○ Senior
- ○ Other:

What is your GPA?

- ○ 4.0
- ○ 3.5 - 3.99
- ○ 3.0 - 3.49
- ○ 2.5 - 3.0
- ○ 2.0 - 2.49
- ○ Less than 2.0

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# Undergraduate Research Survey

## Section 1

1) Do you currently wish to engage in undergraduate research before you graduate?

- ○ Yes
- ○ No

2) What minimum GPA do you think you can have and be able to acquire an undergraduate research position?

- ○ 3.5 - 4.0
- ○ 3.0 - 3.49
- ○ 2.5 - 3.0
- ○ 2.0 - 2.49
- ○ I believe GPA is not an important criterion for acquiring an undergraduate research position.

3) How valuable would you consider undergraduate research compared to an internship

- ○ More valuable
- ○ Less valuable
- ○ Of the same value

4) Do you currently wish to pursue graduate school after graduating?

- ○ Yes
- ○ No
- ○ Maybe

5) Would it be reasonable for you to take on undergraduate research without pay during the school year?

- ○ Yes
- ○ No

6) Would it be reasonable for you to take on undergraduate research without pay when university isn't in session?

- ○ Yes
- ○ No

7) How many hours a week do you think the typical undergraduate researcher performs undergraduate research?

Your answer

8) Given your current schedule, could you conduct 6 hours of unpaid research?

- [ ] Yes
- [ ] No, I would need to work another job to earn money
- [ ] No, that much time would interfere with extra Curriculars (clubs, sports, volunterring, etc.)
- [ ] No, my class schedule is challenging and I need those 6 hours for school work
- [ ] Other:

9) Do you have any previous research experience?

- ○ Yes
- ○ No

10) If you answered yes to question 9, please briefly describe your previous research experience.

Your answer

11) Have you ever kept a Lab Notebook or Lab Diary?

- ○ Yes
- ○ No

12) If you answered yes to question 11, please explain the purpose of a Lab Notebook.

Your answer

13) If you answered yes to question 11, please describe what kinds of data you recorded.

Your answer

14) Have you ever asked a researcher about their research?

- ◯ Yes
- ◯ No

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# Undergraduate Research Survey

## Section 2

On a scale of 1 to 5, with 1 being very easy, 2 being easy, 3 being neither easy nor difficult, 4 being somewhat difficult, and 5 being very difficult:

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| How challenging do you think it is to acquire an undergraduate research position | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

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# Undergraduate Research Survey

## Section 3

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am able to understand scientific literature (journals, articles, reviews, etc.) | ○ | ○ | ○ | ○ | ○ |
| I am able to work independently | ○ | ○ | ○ | ○ | ○ |
| I am generally organized | ○ | ○ | ○ | ○ | ○ |
| I am generally comfortable in a lab setting | ○ | ○ | ○ | ○ | ○ |
| I am familiar with BGSU's CURS center | ○ | ○ | ○ | ○ | ○ |
| I am able to locate information about local professors' research | ○ | ○ | ○ | ○ | ○ |
| I am comfortable asking a researcher about their research | ○ | ○ | ○ | ○ | ○ |
| I feel an undergraduate research experience is only useful if it is related to my major | ○ | ○ | ○ | ○ | ○ |
| I feel an undergraduate research experience is only useful if it is related to my personal interests | ○ | ○ | ○ | ○ | ○ |
| I am unable to write a useful resume for acquiring an | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| undergraduate research position | | | | | |
| I am aware of campus resources which are helpful for writing a useful resume | ○ | ○ | ○ | ○ | ○ |
| I feel that grades in classes relevant to the research determine my ability to acquire an undergraduate research position | ○ | ○ | ○ | ○ | ○ |
| I am able to learn from my failures | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 4

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am able to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| I am able to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a resource other than a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| I am able to determine what literature (of the ones I've found) are relevant to a my specific topic | ○ | ○ | ○ | ○ | ○ |
| I am able to roughly understand the main idea of a scientific journal, article, review, etc. | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 5

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am able to develop research questions based on observations | ○ | ○ | ○ | ○ | ○ |
| I am unable to interpret diagrams, models, or other types of visual explanations | ○ | ○ | ○ | ○ | ○ |
| I am able to make predictions | ○ | ○ | ○ | ○ | ○ |
| I feel I would be able to ask questions when unsure of what to do while researching | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 6

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I feel I would be unable to create a timeline for projects | ○ | ○ | ○ | ○ | ○ |
| I am able to design experimental controls | ○ | ○ | ○ | ○ | ○ |
| I am able to plan what data to measure | ○ | ○ | ○ | ○ | ○ |
| I am able to plan how to measure relevant data | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 7

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am able to perform core techniques taught in relevant lab classes like measuring mass or volume, recording data, or preparing samples | ○ | ○ | ○ | ○ | ○ |
| I feel I would be able to replicate a lab technique that was taught to me | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 8

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am able to detect and describe patterns in data | ○ | ○ | ○ | ○ | ○ |
| I am able identify sources of error | ○ | ○ | ○ | ○ | ○ |
| I am unable to perform basic statistics on data | ○ | ○ | ○ | ○ | ○ |
| I am able to organize and display data/results visually | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 9

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am able to generalize my findings | ○ | ○ | ○ | ○ | ○ |
| I am able to describe trends in data with words | ○ | ○ | ○ | ○ | ○ |
| I am able to describe trends in data with visual representations | ○ | ○ | ○ | ○ | ○ |
| I am unable to determine whether my data supports my hypothesis | ○ | ○ | ○ | ○ | ○ |
| I am able to propose follow up experiments | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

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# Undergraduate Research Survey

## Section 10

On a scale of 1-5, with 1 being Strongly Disagree and 5 being strongly agree, please rate how strongly you agree or disagree with the following statements based on your current ability.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| I am unable to write scientifically | ○ | ○ | ○ | ○ | ○ |
| I am able to create and use posters to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| I am able to create and use Powerpoints to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| I am able to develop and use a speech (oral presentation) to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| I am able to communicate my findings appropriately based on an audience's understanding of my research project (consider your ability to explain the same research to a professor, a family member, and an elementary student) | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Half Way

You will now be asked to rank the same statements in regards to how important they are to acquiring an undergraduate research position.
So, now please consider the following statement when ranking:
On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

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# Undergraduate Research Survey

## Section 13

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to understand scientific literature (journals, articles, reviews, etc.) | ○ | ○ | ○ | ○ | ○ |
| The ability to work independently | ○ | ○ | ○ | ○ | ○ |
| Being generally organized | ○ | ○ | ○ | ○ | ○ |
| Being comfortable in a lab setting | ○ | ○ | ○ | ○ | ○ |
| Being familiar with BGSU's CURS center | ○ | ○ | ○ | ○ | ○ |
| The ability to locate information about local professors' research | ○ | ○ | ○ | ○ | ○ |
| Being comfortable asking a researcher about their research | ○ | ○ | ○ | ○ | ○ |
| The ability to write a useful resume for acquiring an undergraduate research position | ○ | ○ | ○ | ○ | ○ |
| Being aware of campus resources which are helpful for writing a useful resume | ○ | ○ | ○ | ○ | ○ |
| Being able to learn from my failures | ○ | ○ | ○ | ○ | ○ |

# Undergraduate Research Survey

## Section 14

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| The ability to find scientific literature (journals, articles, reviews, etc.) related to a specific topic using a resource other than a Google Scholar search | ○ | ○ | ○ | ○ | ○ |
| The ability to determine what literature (of the ones I've found) are relevant to a my specific topic | ○ | ○ | ○ | ○ | ○ |
| The ability to roughly understand the main idea of a scientific journal, article, review, etc. | ○ | ○ | ○ | ○ | ○ |

BACK NEXT

# Undergraduate Research Survey

## Section 15

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to develop research questions based on observations | ○ | ○ | ○ | ○ | ○ |
| The ability to interpret diagrams, models, or other types of visual explanations | ○ | ○ | ○ | ○ | ○ |
| The ability to make predictions | ○ | ○ | ○ | ○ | ○ |
| The ability to ask questions when unsure of what to do while researching | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 16

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to create a timeline for projects | ○ | ○ | ○ | ○ | ○ |
| The ability to design experimental controls | ○ | ○ | ○ | ○ | ○ |
| The ability to plan what data to measure | ○ | ○ | ○ | ○ | ○ |
| The ability to plan how to measure relevant data | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 17

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to perform core techniques taught in relevant lab classes like measuring mass or volume, recording data, or preparing samples | ○ | ○ | ○ | ○ | ○ |
| The ability to replicate a lab technique that was taught to me | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 18

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to detect and describe patterns in data | ○ | ○ | ○ | ○ | ○ |
| The ability to identify sources of error | ○ | ○ | ○ | ○ | ○ |
| The ability to perform basic statistics on data | ○ | ○ | ○ | ○ | ○ |
| The ability to organize and display data/results visually | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 19

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to generalize my findings | ○ | ○ | ○ | ○ | ○ |
| The ability to describe trends in data with words | ○ | ○ | ○ | ○ | ○ |
| The ability to describe trends in data with visual representations | ○ | ○ | ○ | ○ | ○ |
| The ability to determine whether my data supports my hypothesis | ○ | ○ | ○ | ○ | ○ |
| The ability to propose follow up experiments | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Section 20

On a scale of 1-5, please rate the importance of each skill in terms of acquiring an undergraduate research position with 1 being not at all important, 3 being neither unimportant or important, and 5 being very important.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| The ability to write scientifically | ○ | ○ | ○ | ○ | ○ |
| The ability to create and use posters to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| The ability to create and use Powerpoints to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| The ability to develop and use a speech (oral presentation) to communicate my findings to others | ○ | ○ | ○ | ○ | ○ |
| The ability to communicate my findings appropriately based on an audience's understanding of my research project (consider your ability to explain the same research to a professor, a family member, and an elementary student) | ○ | ○ | ○ | ○ | ○ |

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# Undergraduate Research Survey

## Amazon Gift Card

To be entered for a chance to win a $50 Amazon gift card please enter your BGSU email below. You do not have to enter your email if you do not wish.

NOTE: your email will in no way be tied to your answers as this is a confidential survey.

### Please enter your BGSU email

Your answer

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# Undergraduate Research Survey

## Thank You!

Please click submit to finish.

BACK SUBMIT

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## Appendix C: Resources for Students

This is simply a first step in developing resources that can be delivered to students to help them help themselves.

1) Understanding Scientific Literature:
   See the references cited entry by Purugganan, M.
2) Scientific Competencies:
   See the references cited entry by Pelaez, N.J.
   This is a list of skills that undergraduates are expected to develop as a result of their research experience. Some of them are valuable for acquiring an undergraduate research position while others aren't expected at all. This was the data was used to frame the survey. Students should consult this when considering what they should expect to gain as a result of performing research.
3) An Undergraduate Research Website:
   Look at the University of South Carolina's Department of Biological Sciences' Research page for some ideas about how a website could be developed. The best feature of this page is how it breaks the research down into categories and links students to faculty and the faculty's research pages seamlessly.

   https://sc.edu/study/colleges_schools/artsandsciences/biological_sciences/research/index.php