

In-Class Workshops to Teach Introductory Biology Students about Undergraduate Research

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Abstract

Decades of evidence support the premise that undergraduate research experiences are valuable endeavors for science students; however, a lack of knowledge about research and how to get involved can preclude equitable participation. We developed two in-class workshops to teach introductory biology students about undergraduate research experiences. In the first workshop, students are introduced to various types of undergraduate research, including faculty-mentored research, Course Based Undergraduate Research Experiences (CUREs), summer research experiences and research-related jobs and internships. Students hear first-hand accounts about research from undergraduates actively performing research and learn about the benefits and challenges associated with participating. In the second workshop, students learn how to effectively identify and secure research opportunities and engage in an exercise that teaches them how to write a professional email to potential research advisors. Students also work together to develop strategies for building resilience if faced with rejection from a faculty member or internship/job opportunity. The workshops utilize student speakers, think-pair-share activities, and class discussions to engage and inform students. By the end of the workshops, all students are familiar with undergraduate research and have the knowledge and skills needed to identify and secure a research opportunity. The workshops were designed for introductory biology students but can be adapted for students in related majors or at different stages of the academic journey.

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Learning Goals

Students will:

- ◊ increase their awareness and understanding of undergraduate research experiences.
- ◊ recognize some of the benefits of performing undergraduate research.
- ◊ understand how to secure a research experience.
- ◊ effectively communicate with potential research advisors.

Learning Objectives

Students will be able to:

- ◊ describe various undergraduate research opportunities.
- ◊ explain the benefits and challenges often associated with participating in undergraduate research.
- ◊ use resources to identify research opportunities both on and off their campus.
- ◊ formulate a professional email to faculty or staff inquiring about undergraduate research opportunities.

INTRODUCTION

There are various ways students can participate in undergraduate research, including traditional faculty-mentored research during the academic year, summer research experiences, and on- or off-campus internships. Many institutions have also integrated Course-based Undergraduate Research Experiences (CUREs) into laboratory curricula to provide additional research opportunities for students, often benefiting those who may not have the time or resources to perform research outside of class (1). These various research experiences can provide students with a range of benefits (2, 3), including clarification or confirmation of career plans (4–6), improved critical thinking skills (7), and perhaps most importantly, a greater likelihood of graduating with a STEM degree (4, 8). Additionally, when students from historically

marginalized groups do gain these experiences, the benefits they receive are often amplified (4, 9, 10). UREs can shape students' educational and career trajectories, with participants being more likely to develop an interest in and be prepared for graduate STEM programs, while also increasing their chances of being accepted into a degree program (6, 9, 11, 12).

While the benefits are widely lauded, the barriers to obtaining an undergraduate research position are greater for some students than others, which results in inequities that can have short and long-term impacts. One factor contributing to a student's ability to find and secure a research experience is their scientific research cultural capital (SRCC), which is the awareness, understanding, and knowledge about the research enterprise that can help them obtain a research position (11). Thus, students who possess less SRCC may be at a disadvantage

and less likely to participate. To make UREs more equitable, students need to be taught about undergraduate research early in their college careers so they can make informed decisions about participating, understand how they can get involved, and be more competitive in the selection process.

Universities may try to address inequitable research participation with targeted advertising through research or student success centers, peer mentoring programs, and partnerships between community colleges and universities. Here we describe another strategy to broaden research participation by addressing disparities in students' SRCC. We outline two in-class workshops that teach students about UREs, including what undergraduate research is, the benefits versus the challenges of participating, and strategies for finding and securing research experiences. The workshops engage students in think-pair-share activities and whole class discussions and include current and/or former undergraduate researchers who provide first-hand perspectives about research. These easy-to-implement sessions provide students with the necessary information and resources to successfully navigate the process of finding and securing a research experience.

Intended Audience

The workshops were designed for students enrolled in an introductory biology course at either a four-year institution or community college and who intend to major in a Science, Technology, Engineering, or Mathematics (STEM) discipline, such as biology or chemistry, in which research is fundamental. The workshops could be applicable to other disciplines (e.g., engineering or environmental studies), but may require modifications. While the workshops could be beneficial for students at any point during their academic training, having the workshops in introductory-level courses may allow for a more diverse group of students to learn about research experiences and provide them with ample time to apply the information they learn. Furthermore, the majority of STEM students who leave their majors do so in their first or second years, many citing lecture-heavy pedagogical practices that are dry and disengaging (14). We hope that exposing early career students to the potential to engage in authentic research in an area of their interest will motivate more to persist.

Required Learning Time

The workshops are designed to take place within two separate class sessions, spaced several weeks apart. Workshop #1 is designed to be 30–35 minutes long and workshop #2 is designed to be 20–25 minutes long.

While it is possible to fit both workshops into a single 50-minute class period, having two distinct workshops may give students time to reflect on the material and promote more interest. Additionally, spacing the workshops out could allow students the opportunity to ask questions during the second session that might have come up after the first workshop.

Prerequisite Student Knowledge

None.

Prerequisite Teacher Knowledge

The facilitator(s) must be familiar with the various types of undergraduate research experiences discussed (*i.e.*, faculty-mentored research, CUREs, summer research experiences,

research-related jobs or internships) and know the opportunities available at their institutions and/or in their communities. To enhance their understanding of UREs, facilitators may wish to read select publications (15–17). Furthermore, they can explore resources like [CUREnet](#), a platform that allows instructors to network and share information about CUREs and CURE resources. The facilitator(s) should also know about any specific, institutional norms about research (e.g., common procedures for finding or securing a research experience at their school, opportunity for student pay or course credit for research) and institutional resources available that can aid students trying to secure a research experience (e.g., campus or departmental programs, institutional research centers, career centers). A better understanding of institutional norms and how students can access research experiences may also be gained by speaking with other instructors or employees at institutional centers.

SCIENTIFIC TEACHING THEMES

Active Learning

Opportunities for peer and group discussions have been shown to help students better understand presented concepts and ideas (18). As a result, we incorporated multiple opportunities for think-pair-share activities (19) and whole group discussions into the workshops. The specific activities are described within the lesson plan.

Assessment

The think-pair-share activities and group discussions serve as formative assessments that allow facilitator(s) to gauge students' comprehension during the workshops. Facilitators can also incorporate quick-write activities throughout the workshops or as a summative assessment to gauge students' learning. In a quick-write, students are typically given 2–5 minutes to respond to a prompt without worrying about grammar or sentence structure. Several SLO-guided quick-write prompts include:

1. Describe a specific research project or opportunity you find intriguing and explain why it caught your interest.
2. Are there specific benefits or skills that you believe you could personally gain from a research experience?
3. What challenges might you encounter as an undergraduate researcher?
4. Imagine you are starting your research journey today. Write down specific steps you would take to find research opportunities, both on and off campus.
5. Imagine that you just found a research lab on campus that you would like to join. Draft an introductory email that you could send to the research professor.

Inclusive Teaching

Think-pair-share activities and group discussions have been identified as practices that foster an inclusive and engaging learning environment for students (20, 21). By incorporating these activities into the workshops, students work together and can benefit from each other's diverse perspectives.

Numerous studies have demonstrated the need for undergraduate students, especially STEM students, to see role models within their field who are successful and share their gender and racial identities (22–24). Within the workshops,

undergraduate speakers can be selected to represent the gender and racial identities of the class as well as possible. The interactions between the speakers and class may help students from historically marginalized groups better engage with the material and envision themselves participating in undergraduate research.

The content of the workshops explicitly addresses a common barrier students face when trying to get involved in research: a lack of knowledge about research (1). The workshops aim to build students' awareness, understanding and knowledge (scientific research cultural capital) about the research enterprise that can help them obtain a research experience. By teaching all students about UREs, research acquisition can be made more equitable.

LESSON PLAN

This lesson plan describes two in-class workshops designed to teach students about undergraduate research (Table 1). The first workshop introduces students to various types of undergraduate research experiences and explores the potential benefits of participating in research. The second workshop addresses how students can best find and secure the research experiences introduced in the first workshop.

Workshop #1: Introduction to Undergraduate Research

Pre-Workshop Planning

The first workshop involves undergraduates and/or recent graduates, who have participated in undergraduate research, discussing their experiences with the class. Prior to the workshop, the student researchers need to be identified and briefed about their roles. We highly recommend seeking a group of student researchers who represent the diversity of the student population and the types of research experiences covered in the workshop. A sample recruitment email and the instructions we provided to our student speakers are outlined in Supporting File S1. If possible, we suggest compensating the speakers for their time with a small gift or monetary incentive. If you have access to students who conduct research and also work for the institution as student assistants or peer leaders, you may be able to negotiate compensation through their regular paychecks. If financial compensation is not possible, consider other incentives, such as a letter of gratitude/reference that they can use as evidence of their participation (e.g., for employment, scholarships, and other applications).

In-Class Workshop

The workshop follows lecture PowerPoint slides (Supporting File S2) which guide the facilitator through the content, think-pair-share activity, and student speaker portions. The workshop starts by providing context for why the workshops are being conducted to encourage student buy-in and engagement. We mention that at our institution, many students do not participate in research because they are hindered by a lack of awareness and knowledge about available research opportunities. We also make it clear that the goal of the workshop is not to convince students that they need to participate in research, but rather to provide information, so they can make informed decisions and understand how to proceed if they are interested.

We define undergraduate research and describe the broad scope of topics and fields studied. Students participate in a think-pair-share activity where they address the questions "Why do students participate in research?" and "What do students get out of undergraduate research?" We found that students tend to provide answers like "to gain new skills" or "to learn new concepts." We elaborate on what students have shared by showing a list of skills that employers are looking for in college graduates (obtained from our institution's Career Center) and describing how undergraduate research can help students gain and/or improve upon those desired skills.

We then breakdown and discuss various types of research experiences open to students. We specifically address faculty-mentored research, Course-based Undergraduate Research Experiences (CUREs), summer research experiences and research-related jobs/internships. We separate these experiences into two categories: on-campus research (faculty-mentored research and CUREs) and off-campus research (summer research and research-related jobs/internships). We describe each type of research experience and explain the general activities performed as part of that experience. We also discuss what requirements (if any) are needed to participate. After outlining a specific type of research experience, a student speaker who has participated in that type of research is introduced and given two to three minutes to describe their experiences. This description of a research opportunity followed by a student speaker sharing their experiences and insights is repeated for the four types of UREs addressed in the workshop.

The workshop ends by emphasizing that anyone can do research. We also mention that while research is an excellent way to gain experience and learn new concepts and skills, it is not the only activity students can do to gain valuable skills. We emphasize these points to alleviate stress students may have if they believe research is needed to be successful.

Workshop #2: Finding and Securing a Research Experience

In-Class Workshop

The workshop follows lecture PowerPoint slides (Supporting File S3) which guide students through the content, think-pair-share activity, and class discussion. This workshop outlines some of the best practices for finding and securing each type of research experience discussed in the first workshop. This workshop starts with a quick review of the previous workshop to remind students of the various types of UREs.

Students participate in a think-pair-share activity where they are asked "If you decide to participate in faculty-mentored research, how would you go about it? How would you get started?" We have found that students tend to provide very general ideas that we can elaborate on. For example, students often mention that they would find a faculty member who conducts research. We build on that response by sharing how students can discover which faculty at our institution conduct research and what they study. If not mentioned by students, we also suggest that students try to strike up conversations about research with faculty members who they are comfortable with, visit the campus' research center, or send an email to a professor with whom they would like to work.

Next, students participate in an email writing activity where they evaluate (in groups of three to four) example emails addressed to a potential research advisor. Students are provided with both a poorly written and well written email and asked to critique them. We then have a class discussion about the strengths and weaknesses of each email and brainstorm ways to improve them. We then discuss what a good email should include, like some personal background/information and enough information to demonstrate that the student has investigated what the instructor studies. After discussing the email, we provide students with general tips for being prepared to meet with a potential research advisor in person. The tips include having answers to commonly asked questions (e.g., What are your academic and career goals?) and having questions to ask the potential advisor (e.g., What are your expectations for an undergraduate starting in your lab?). We emphasize that students should think of the meeting as a way for them to interview the faculty member, in addition to being interviewed, as they also want to determine if this person would be a strong mentor for them. This also tends to alleviate anxiety and empowers the students to look out for their best interests as well.

We then transition to a short discussion on CURE courses. We focus on the CUREs offered at our institution and the topics our CURE courses investigate. Because CURE courses are often easier for students to participate in than other forms of research, we spend less time on how to “secure” a CURE course and instead outline the CUREs our institution offers. We further emphasize the fact that students should view CUREs as authentic research experiences to put on their resumes and discuss in interviews for faculty-mentored UREs, employment or future academic applications.

We also cover how students can find paid summer research experiences. We discuss specific summer research experiences at our institution but focus primarily on the National Science Foundation’s Research Experiences for Undergraduates (NSF REUs). We provide example research projects and topics that have been conducted through these programs. We also elaborate on the application requirements, which typically include a personal statement and letters of recommendation. We highlight that these opportunities often encourage students from historically marginalized groups, teaching institutions, and community colleges to apply.

We then cover how students can find research-related jobs and internships. We highlight institutional resources that students can use when searching for jobs or internships (i.e., job portals, our career center, major-specific email lists). We also mention several agencies and companies in our area that routinely hire student interns and entry-level technicians. We end this section by mentioning other campus programs, like our campus’ Louis Stokes Alliance for Minority Participation (LSAMP) program and our Center for Science and Math Success, that can assist STEM students on their academic journey and can help them get involved in undergraduate research.

To end the workshop, we facilitate a classroom conversation where we ask the question: “What should you do if you get rejected from a research experience?” We give students several moments to discuss their thoughts in small groups

before having a class discussion on what students could do if and/or when they face rejection. We found that it is very helpful to share a personal story of rejection or share a story of someone you know who faced rejection but was resilient and continued seeking a research position. We also found that this is a great time to bring up common reasons a student may not be able to join a lab right away (i.e., no lab space, student needs to complete certain classes). As a class, we brainstorm things that students can do after facing rejection, like searching for another lab, asking the research mentor to keep their name in mind in the future or inquire about other labs who may be seeking students, and regularly checking in with the research advisor to ask about lab space and/or how they can be a more competitive applicant. The goal of this class discussion is to let students know that rejection is a normal part of finding a research position, but it isn’t a reason to give up and it is not indicative of one’s ability to be a scientist or a researcher. During this time, we also try to dispel misconceptions or alleviate student concerns. For example, we found that some students are concerned about emailing faculty and if or when it is appropriate to send a follow up email. To address these concerns, we tell students that it is okay to email multiple faculty at one time about a position and that if a faculty member doesn’t return their email, it is okay to send a follow-up email or go to their drop-in office hours. This class discussion tends to lead into the question-and-answer time. Immediately after the workshop, we pass out a handout (Supporting File S4), which summarizes the material covered in the workshops.

TEACHING DISCUSSION

Effectiveness

After our first semester of piloting the workshops at our institution, we conducted semi-structured interviews in which we asked students to describe an undergraduate research experience, how they would acquire research experiences, and the benefits they expected to receive from participation. In subsequent iterations of the workshops, including at our university and a nearby community college, a more detailed evaluation of workshop effectiveness was conducted. This included whole class focus groups and pre-post surveys. Here, we describe our findings from our student interviews; results from the surveys and focus groups will be published separately. Our study was conducted under IRB#19-20-289.

When asked to describe an undergraduate research experience, students described it as a valuable, hands-on endeavor with one student stating:

“I would describe an undergraduate research experience as you’re getting ... more hands on knowledge in the research field and getting an idea of what it’s like to be in a professional environment while still in school.”

We asked students if they felt they would personally benefit from an undergraduate research experience and students responded positively. One student responded with:

“Before I even knew what [undergraduate research] was I was like ‘No.’ But now, I think that ‘yeah’ because it’s a good experience, even like for outside of school...”

Students explained that research could help them along their career path or even confirm a career plan. One student said:

"I believe I would personally benefit a whole lot from a research experience because I still don't really know what I want to do, so if I just get a little bit of just what people do, I would be able to see if I actually want to continue pursuing that or if I should just change to something else..."

We asked students how they would go about acquiring a research experience as an undergraduate, and we noted that students mentioned tips and strategies that were provided in the workshops. Students described that they would reach out to professors and advisors, and several students described how they would perform background searches on professors to find out more about what they study before reaching out to them. Another student added that they would use websites that were described in the workshops to find out-of-state research experiences. One student even revealed that they were currently looking for a research experience and stated:

"Right now, I'm in the researching stage and going on the [department] website and looking into what the professors are doing, but I still haven't gotten to the part where I want to actually go out and email everyone..."

Overall, the workshops were well received and seemed to help students gain a better understanding of what undergraduate research is and how they can start participating.

Adaptations

The workshops are highly adaptable, and information should be added, removed, or elaborated on to reflect the resources and norms of your specific institution. In a pilot semester, we demonstrated the adaptability of the workshops by presenting the information across three workshops, each lasting approximately 25 minutes. These sessions were integrated into the lecture, lab, and activity sections of an introductory biology course to best accommodate time and course constraints. In subsequent semesters, we streamlined the workshops into the two sessions described here. This highlights the flexibility of the workshop structure, as the workshops can be scaled or condensed to better fit different instructional formats and time constraints. However, shorter, more frequent workshops may be best for retention and engagement. We also recommend the workshops be held during class as opposed to an optional or out of the classroom activity. In-class workshops will ensure that all students, regardless of their other commitments, have equal access to the information.

If your institution has alternative ways for students to find research mentors or if there are alternative research opportunities that you believe to be valuable, they should be incorporated into the workshops. We have successfully completed these workshops at a community college that does not currently have faculty-mentored research or CURE courses. We still discussed these types of research experiences but framed them as research experiences students may participate in if they transfer to a four-year institution. We also provided context for why we were discussing faculty-mentored research and CURE courses by stating that transfer students have less time at four-year institutions compared

to non-transfer students, so we want them to know of these opportunities before transferring to give them the best chance of participating. Supporting File S3 contains hidden slides which show how we modified the workshop to better serve community college students. If implementing these workshops at a community college that does not have research opportunities, we recommend trying to implement in courses students often take when close to transferring. This may help student buy-in and prevent students from forgetting too much information before transferring to a four-year institution.

If implementing at a university lacking CUREs, the CURE portion of the workshops could be removed, shortening the length of each workshop by approximately 5–10 minutes. Alternatively, facilitator(s) could spend more time discussing the other types of research experiences, or introduce other valuable research-related opportunities, such as projects conducted in capstone courses.

SUPPORTING MATERIALS

- S1. In-Class Workshops – Speaker Instructions
- S2. In-Class Workshops – Workshop #1 PowerPoint Slides
- S3. In-Class Workshops – Workshop #2 PowerPoint Slides
- S4. In-Class Workshops – Handout

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Table 1. Teaching timeline table for the research workshops.

Activity	Description	Estimated Time	Notes
Preparation for Workshop #1			
Recruit student speakers	Recruit undergraduates or recent graduated who have participated in research to speak to your class.	~ 1 hour	We recommend reaching out to former students, other instructors, research advisors, or your campus' research center to get help finding students.
Workshop #1			
Introduction into research	Define undergraduate research and address potential benefits.	10 minutes	Lecture slides with notes are in Supporting File S2.
Student speakers	Discuss different types of research opportunities with examples (from guest speakers).	15 minutes	Following the lecture slides (Supporting File S2), introduce each type of research experience, giving the student speakers time to discuss their experiences with research. It is important to collaborate with student speakers to keep their sections within the allotted timeframe and/or budget more time for this section.
Question-and-answer	Provide opportunity for students to ask questions about the content from the lecture slides or from the student speakers' stories.	~ 5 minutes	You can ask questions to student speakers to get the ball rolling if the class is shy or if you want to re-address an important point.
Workshop #2			
Finding and securing a research experience	Cover how students can best find and secure the research experiences discussed in the first workshop.	15 minutes	Lecture slides with notes are in Supporting File S3.
Rejection discussion followed by question-and-answer time	Class discussion addressing what students could do if they experience rejection from a research opportunity.	5–10 minutes	We recommend sharing any personal experiences or stories that normalize failure and reaffirm that rejection is common and not reflective of ones' ability to conduct research.

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