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Assessing the effectiveness of entrepreneurial mindset training materials for undergraduate researchers

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Abstract:
Undergraduate research is a high-impact practice. Studies consistently show that it improves students' engagement in learning and their retention in college. In addition, leveraging undergraduate researchers as professional scholars who are part of the research lab ecosystem can increase the productivity of the lab and help prepare future graduate students. Despite these benefits, many labs have difficulty implementing undergraduate research (UGR) programs. To support undergraduate students as productive researchers, we offer a framework that emphasizes curiosity, connection, and value creation in research activities to foster an entrepreneurial mindset (EM) in undergraduate research. The goal is to make research training more efficient, increase overall lab productivity, boost undergraduate research effectiveness, and improve student intrinsic motivation and satisfaction.

Our team developed a series of faculty-led workshops for undergraduate researchers focusing on research skill development, with an emphasis on the integration of EM in the research process. In this paper, we will discuss the implementation and assessment of our workshops across five partner universities. To assess the impact of our workshop-based interventions on student research productivity and attitudes toward research, we developed a retrospective, post-experience survey and a one-year follow-up survey for students participating in the workshops. We collected survey data from our workshop participants, along with a baseline cohort of students who participated in undergraduate research but did not complete the EM-focused workshops. Our initial results indicate that students who participated in our research training workshops showed increased gains in areas such as setting goals in their research, documenting their work for future researchers, and understanding the needs of stakeholders in their research. Students who participated in the workshops also indicated feeling a greater degree of control over their research. Understanding the impact of training materials on student skills and motivation in UGR can aid in the design of improved workshops and courses for UG researchers, as well as provide direction for individual faculty who are interested in leveraging EM in their mentorship of UG students.

Introduction:

Undergraduate research (UGR) is widely recognized as a high-impact practice that enhances students' academic productivity. The engagement in learning, retention in college, and career preparedness of students can be positively affected by participating in UGR. Studies show that UGR helps students clarify career goals [1], foster a sense of identity as scientists or engineers [2], and build resilience [3]. Additionally, UGR serves as a valuable ecosystem for preparing future graduate students and enhancing research lab productivity. However, despite its benefits, many labs face challenges implementing effective UGR programs due to time constraints for faculty, lack of mentorship resources, and varying levels of institutional support [4].

To address these challenges, our team developed a scalable framework for undergraduate research training [5], [6] to foster an entrepreneurial mindset (EM) [7]. Entrepreneurial mindset, as described in The Kern Entrepreneurial Engineering Network's framework, focuses on the integration of curiosity [8], connections [9], and value creation [10]. The undergraduate research

training framework enhances students' intrinsic motivation, improves research productivity, and equips them with skills to navigate research environments effectively. A series of faculty-led workshops was designed to provide efficient training while minimizing faculty workload. These workshops, which can be implemented in-person or online, cover topics such as framing research questions with EM, building resilience, setting goals in research, developing effective communication strategies, and maximizing research impact. They also create opportunities for students to build community, share experiences, and support one another throughout their research journeys. The workshops were implemented across five partner universities, including primarily undergraduate institutions, mid-sized universities, and R1 research institutes, to adapt to diverse institutional needs.

The integration of EM into UGR aligns seamlessly with entrepreneurially minded learning (EML), a pedagogy that emphasizes discovery, opportunity identification, and value creation. EML leverages real-world experiences, information literacy, and expert-to-novice mentoring, enabling students to address unmet needs, set meaningful goals, and understand the societal impact of their work [11], [12]. By adopting EML principles, UGR becomes a platform for fostering entrepreneurial skills alongside technical and research proficiencies.

Entrepreneurship has traditionally been associated with business education, but its inclusion in STEM and interdisciplinary programs is gaining traction due to its alignment with real-world demands. By fostering skills such as creativity, leadership, and communication, engineering students gain tools to create personal, economic, and societal value [13]. The overlap between STEM outcomes and entrepreneurial skills enhances the relevance and impact of UGR programs, equipping students to thrive in dynamic, interdisciplinary environments.

Continued development and refinement of training materials tailored to diverse institutional contexts will further enhance UGR experiences. Leveraging partnerships with communities like the Kern Entrepreneurial Engineering Network (KEEN), our approach underscores the value of fostering an entrepreneurial mindset in undergraduate research. This approach not only enriches student learning outcomes but also equips them to contribute meaningfully to the broader research and innovation ecosystem.

Project goals:
In our previous work, we demonstrated how these materials were developed and provided the rationale behind each component [5]. In this study, we focus on sharing data from the assessment of the dissemination of these materials across institutions. Our multi-university team's strength lies in its diversity (Table 1), with faculty from large research universities collaborating with faculty from smaller institutions where the emphasis is primarily on undergraduate learning. We implemented a variety of approaches to improve undergraduate research experiences and assessed these approaches to:

1. Understand the impact of the workshops on students' entrepreneurial mindset,
2. Evaluate students' ability to develop core research skills, research communication, and planning, and
3. Measure improvements in students' intrinsic motivation.

This paper describes how our workshops were tailored to students already participating in undergraduate research to provide guidance on leveraging an entrepreneurial mindset in their research projects. Addressing previously identified gaps, these workshops are designed to be flexibly implemented in diverse settings. They can be offered as stand-alone workshops, facilitated either in person or online, or integrated into research-focused courses.

Table 1. Project team

Institution	Region	Type	Size
Rose-Hulman Institute of Technology	Midwest	Private University	Small
University of Illinois Urbana-Champaign	Midwest	Public Research University	Large
Lawrence Technological University	Midwest	Private University	Small
Georgia Tech	Southeast	Public Research University	Large
Baylor University	South	Private Research University	Medium

Methods:

Our team developed and implemented a series of faculty-led workshops, referred to as the "intervention" in this paper, emphasizing six areas important to supporting undergraduate students in their research efforts [5]. These workshops, which we have previously described and published, covered the following topics:

1. Framing Your Research Questions
2. Thriving in a Research Environment
3. Building Your Resilience in Research
4. Pitching Your Research
5. Visualizing Your Data
6. Maximizing the Impact of Your Research

Each workshop is approximately 60 minutes in length and includes an introductory video, instructor guide, workshop slides, and structured activities and handouts for students. Full workshop materials are available for download on Engineering Unleashed through KEEN card #3619 [14]. The learning objectives for each topic spotlight the active practice focus of the workshops to allow students to reflect, craft, practice, and set themselves up for success in their research (Table 2).

The workshop topics were determined through reflection of the diverse project team members and conversations with undergraduate research-heavy constituents to identify key areas where students typically struggle and where there are common, degree-agnostic training opportunities, as well as following undergraduate research mentoring best practice guidelines [15], [16], [17]. The goal was to create expectations and structure for the undergraduate research experience, to explain that research is iterative across time, investigators, projects, and tests. The aim was also to enable students to develop an entrepreneurial mindset to apply to their research and their lives, such as skills for self-advocacy and persisting through failure. This collection of workshops is also designed to be highly interactive to not only improve students' learning of the workshop content but also to foster community within and across researchers to create shared experiences for general support, continued practice of the skills learned, and a sense of belonging.

Table 2. Learning objectives for undergraduate student research training workshops, from [5].

Workshop	Learning Objectives
1. Framing Your Research Question	● Describe, at a high level, how the framework of the Entrepreneurial Mindset can be applied to research, emphasizing the connections between research opportunities, research plans, and research impact. ● Use the technique of connecting broad statements to specific claims to help formulate a research question. ● Use concept mapping to help identify open questions in your research project and collect information needed to understand your research opportunity. ● Identify key stakeholders for your research project and describe the interests of those stakeholders.
2. Thriving in a Research Environment	● Describe the importance of using SMART goals to be able to answer your research question and make connections between your research and the interests of stakeholders. ● Practice writing SMART goals for next steps in your research. ● Prepare a goal-setting plan that includes frequency of reflection and a plan for accountability.
3. Building Your Resilience Research	● Explain your tendencies for how you respond to engaging with others during stressful situations: passive, aggressive, or assertive. ● Describe empathic listening and its importance for achieving your goals and building relationships for maximum impact. ● Through role-play, practice being assertive and using empathic listening skills.
4. Pitching Your Research	● Create a connection to start interest in research. ● Stimulate curiosity by developing interest in the audience. ● Capitalize on opportunities. ● Create a lasting connection with the audience.
5. Visualizing Your Data	● Understand the importance of identifying opportunities relevant to research and business goals from data collected and analyzed throughout the research process. ● Evaluate the effectiveness of different types of data visualizations. ● Learn key data visualization principles and techniques behind creating effective and meaningful visualizations. ● Demonstrate the ability to communicate insights from data visualization to stakeholders and use those insights to drive informed decisions. ● Recognize ethical considerations relevant to data gathering and data visualization.
6. Maximizing the Impact of Your Research	● Describe the impact level of your research, including listing key results and identifying the groups most interested in those results. ● List a variety of options for sharing undergraduate research, including both traditional academic venues (conferences, journal articles) as well as venues for reaching audiences outside of the academic context. ● Identify the venues that might be most appropriate for sharing your work. ● Prepare a dissemination plan for your research, including information on the intended audience and the message to be shared with each audience.

These six workshops were delivered at five institutions (Table 1) where students were encouraged, but not required, to participate. The workshops were facilitated by faculty members and were delivered in a variety of ways depending on the university's preference:

- A series of 60-minute sessions spread out over a summer, or summer and a term, or
- Three longer combined sessions throughout a summer or academic year, or
- An intensive, two-day "boot camp" at the beginning of a research project period.

Regardless of the delivery mode, students engaged with similar content, consisting of an introductory video, discussion and instruction, and practice opportunities. During each workshop, students translate the skills being taught directly to their own research. The workshop materials include a slide deck for facilitators to display during the workshop, a slide deck for students to catalog a research portfolio if desired; an instructor guide with a detailed schedule with additional resources, handouts for students for the workshop activities, and a short, professionally-prepared, introductory video to draw in participants.

The workshop focus is to allow students to leave with a set of new tools that they have practiced and applied to their specific research projects. Students may need to practice the tools further once they leave the session, but the desire is for students to practice the skills and obtain feedback and additional examples from other students so that they can extend and implement the skills in their work beyond the workshop.

Study Design

Retrospective self-assessment surveys were developed to understand students' perception of their research skills, motivation, integration of EM into their research, as well as their actual research outcomes. Two surveys were developed and implemented. The first (post-survey) was designed to be implemented immediately following the set of interventions (e.g., after a summer or semester series, or after a "boot camp" event). The second (follow-up survey) was designed to be implemented one year after the post-survey to quantify realized research activities and changed professional goals [5]. Responsible procedures were followed according to our exempt human subject research protocol. The full text of the survey questions can be found in the Appendix.

Building on our earlier work to establish a baseline, we surveyed 500 students across five universities in the AY22–23 cohort (hereafter 'baseline cohort'), who did not participate in our research training intervention and therefore provide a baseline for student growth in the absence of our workshops. The students were conducting research in STEM fields, with the vast majority in engineering disciplines. Responses were excluded from analysis if the student reported that they did not yet have any research experience at the time they completed the survey. We had a total of $n = 55$ responses (11% response rate; Baylor – 5, Georgia Tech – 39, LTU – 2, RHIT – 6, UIUC – 3) where the students reported having research experience and at least partially completed the survey. Response rates for individual questions on the survey ranged from $n = 37$ to $n = 54$. The follow-up survey was likewise distributed to the same group of students with $n = 8$ responses (1.6% response rate).

We then surveyed 145 students across five universities in the AY23–24 and AY24–25 cohorts (hereafter 'intervention cohort'), who participated in our workshops and STEM research experiences, again with the majority in engineering. Responses were excluded from analysis if

the student reported that they did not yet have any research experience at the time they completed the survey. We had a total of $n = 25$ responses (17% response rate; Georgia Tech – 8, LTU – 2, RHIT – 15) where the students reported having research experience and at least partially completed the survey. Response rates for individual questions on the survey ranged from $n = 22$ to $n = 25$. The 105 students in the AY23–24 cohort also received the 1-year follow-up survey (total responses: n=5, 4.8% response rate).

Assessment

The questions on both surveys were inspired by the Undergraduate Research Student Self-Assessment (URSSA) [18] and Intrinsic Motivation Inventory (IMI) [19]. Our assessment instrument included questions from these sources in addition to questions developed by our team to assess student growth related to intrinsic motivation and entrepreneurial mindset, as previously reported [5]. Guiding questions for development of the surveys were related to considering if students were more engaged in their work, shared their work more broadly, increased their ability to leverage EM, increased their identity as an engineer, scientist, or mathematician, improved confidence, and demonstrated increased motivation towards their research (Table 3 and Appendix).

Table 3. Key questions our group aimed to explore through student self-assessment surveys, mapped to specific survey questions. The full survey questions and question numbers can be found in the Appendix.

Question	Post-survey	Follow-up survey
Do students participating in training workshops during their research experience…		
Stay involved in undergraduate research longer and/or spend more hours doing research?		**X**
Disseminate their research results more widely or frequently?	**X**	**X**
Incorporate aspects of EM into their motivation for research and future plans?	**X**	**X**
Show increased ability to relate the 3C's to research?	**X**	
Show increased gains in thinking and working like a scientist or engineer?	**X**	
Show increased confidence and personal gains related to research?	**X**	
Show positive changes in attitudes or behaviors related to research?	**X**	
Find value in the workshop material?	**X**	

Results and discussion:
We compared survey responses from our baseline and intervention cohorts across several areas, including questions focusing on aspects of entrepreneurial mindset and questions drawn from the URSSA focusing on research communication, planning, and analysis.

In terms of development of skills and abilities correlated with entrepreneurially minded learning (Figure 1), students in the intervention cohort were more likely than the baseline cohort to report great gains in their ability to (i) explore knowledge gaps (baseline: 33%; intervention: 57%), (ii) gather data to support and refute ideas (baseline: 35%; intervention: 52%), and (iii) describe how a discovery could be scaled or sustained (baseline: 21%; intervention: 50%). These trends suggest that our workshops on "Framing your Research Question" and "Maximizing the Impact of your Research" are both impactful.

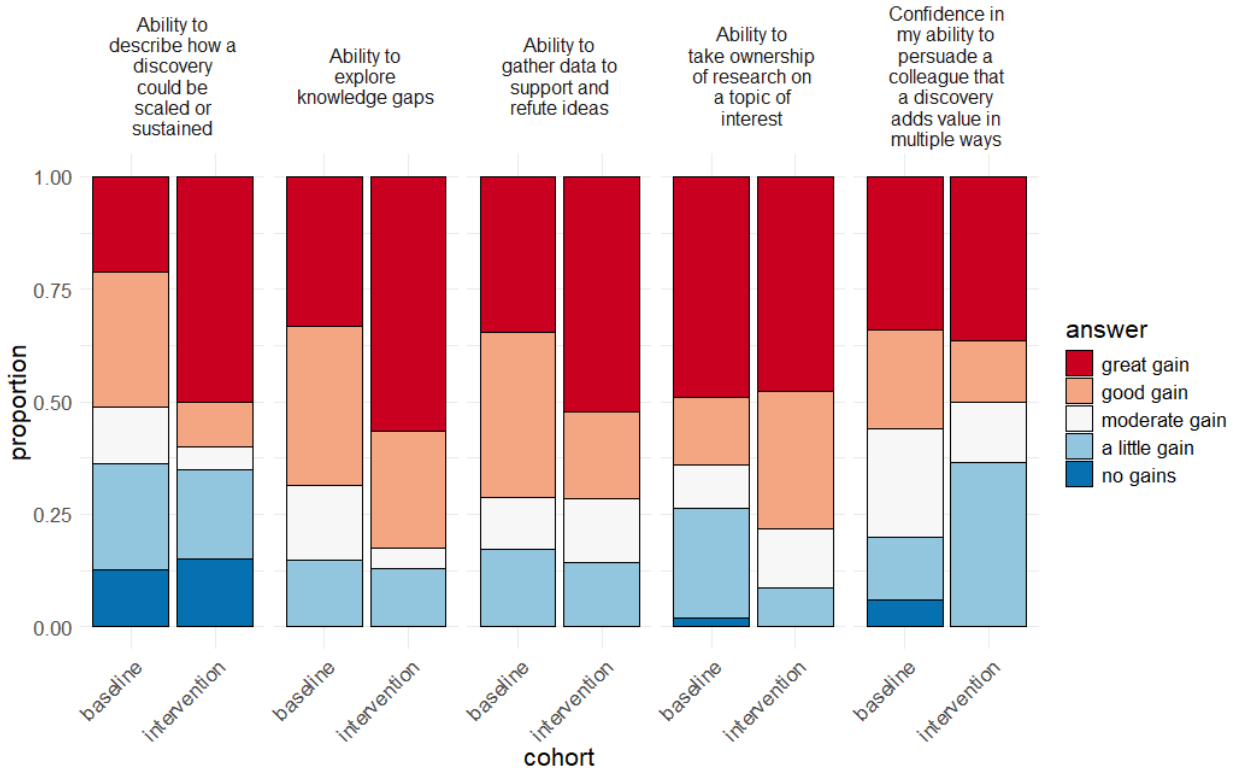

Figure 1. Student responses to the self-assessment survey question "How much did you gain in the following areas as a result of participating in undergraduate research?"

Students in the intervention cohort also showed improvement in several areas related to research communication and planning (Figure 2), including their ability to (i) set goals to make research progress (baseline: 9%; intervention: 36%) (ii) document their work for future researchers (baseline: 16%; intervention: 40%), and (iii) defend an argument (baseline: 8%; intervention: 35%). These trends suggest a positive impact of our workshops focused on developing a research pitch and setting SMART goals. However, only a small percentage of students reported a great gain in their ability to make oral presentations, indicating additional workshop content or practice related to presentation skills might be valuable.

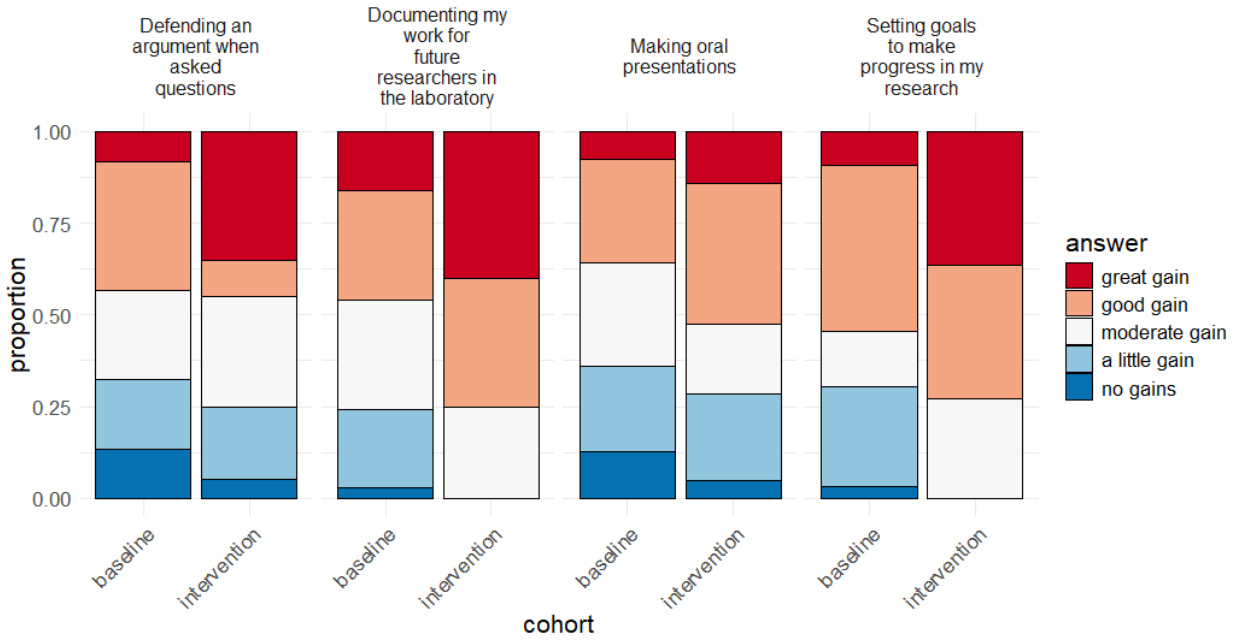

Figure 2. Student responses to the self-assessment survey question: "How much did you gain in the following areas as a result of your most recent research experience?", with sub-questions focused on communication and planning.

In terms of skills related to core research work (formulating research questions, understanding day-to-day research, and analyzing data), the number of students indicating that their research experience led to 'great gains' in a particular skill was similar in many areas between the baseline and intervention cohort (Figure 3). Many of these skills, such as analyzing data for patterns, may be learned primarily through students' discussions with their direct mentors in the field of their research. However, it was notable that a higher proportion of the students in the intervention cohort indicated a great gain in (i) their ability to formulate a research question (baseline: 29%; intervention: 45%) and (ii) their understanding of the theory and concepts guiding their research (baseline: 39%; intervention: 59%). These topics are addressed in our workshop on "Framing your Research Question." However, we could potentially strengthen later workshop content focusing on the theme of connections to help augment gains in areas like understanding the relevance of the research to coursework or the connections between different disciplines.

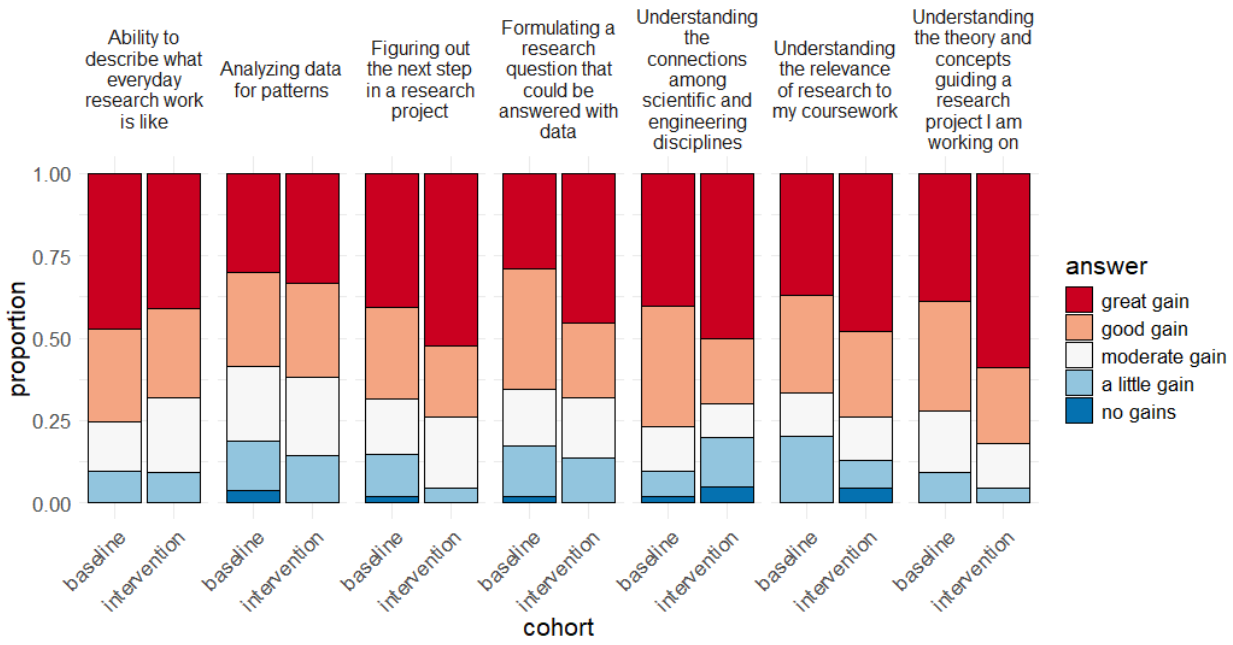

Figure 3. Student responses to the self-assessment survey question "How much did you gain in the following areas as a result of your most recent research experience?", with sub-questions focused on the theory and analysis.

In addition to skill development, we sought to examine whether the training had any impact on students' intrinsic motivation for research by including selected questions from the Intrinsic Motivation Inventory on our survey. The framework of entrepreneurial mindset emphasizes consideration of the impact of doing research and helping students draw connections between their day-to-day tasks and the larger problem they would like to solve. We hypothesized that strengthening these connections to real-world problems could help increase students' motivation to continue research, even as they might experience challenges in their work.

We found that in our intervention cohort, the number of students marking the statement 'I did not put much energy into research' as true or very true declined (baseline: 25%; intervention: 5%, Figure 4). Students in the intervention cohort were also less likely to report feeling tense while doing research (baseline: 36%; intervention: 23%) or like they did not really have any control over their project (baseline: 22%; intervention: 14%). These results indicate a possible role for our workshops in helping students feel like they have ownership of their project, reducing tension around trying to find the "right" answer, and providing motivation to devote time and energy to research.

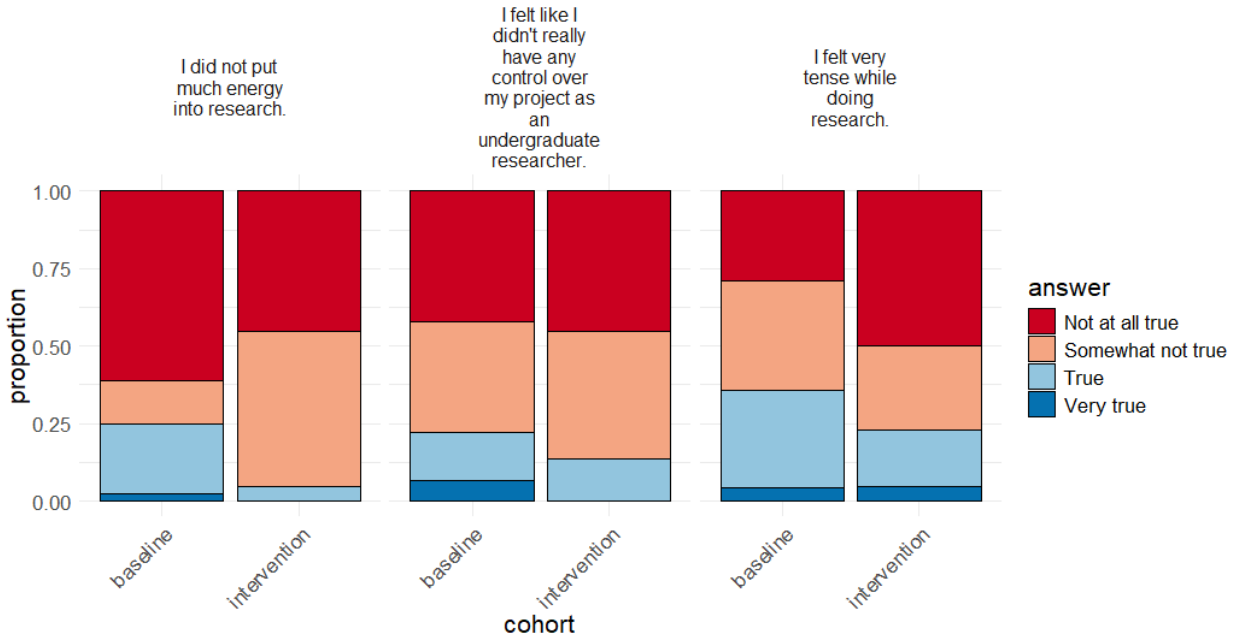

Figure 4. Student responses to the self-assessment survey question: "For each of the following statements, please indicate how true it is for you using the following scale".

In addition to our post-survey, distributed immediately after completion of a term or research experience that included our workshops, we emailed a 1-year follow-up survey to all students in the baseline and intervention cohorts. In the follow-up survey, we asked students about their continued research experience, if any, and the products of their research, such as publications. The response rate for the follow-up survey was low due to a combination of factors, including graduation of student researchers and lack of ongoing interaction with the instructor who sent the survey. Among the baseline group (n=8 responses), 5 students continued undergraduate research after 1 year, but 3 did not, while for the intervention group (n=5 responses), 3 students continued undergraduate research after 1 year, but 2 did not. Among the students who continued research, outputs included internal reports, external poster presentations or talks, and authorship of a conference paper. In both groups, one student reported receiving a scholarship or award based on research.

Given the small sample size for the follow-up, we did not try to make comparisons between the two groups. However, it was positive to see that the majority of the students who responded to the follow-up survey continued their research, and those who did generated outputs that were valuable to their own development, such as scholarships or awards, as well as the professional development of their mentors, such as conference papers.

Conclusions and future work:

Research experiences support student skill development in a wide variety of areas, from research planning to data analysis to communication. However, mentors have limited time to spend with undergraduate mentees, and targeted training workshops have the potential to enhance student skill development and self-efficacy during research experiences. By comparing an intervention cohort, who completed our series of workshops building entrepreneurial mindset in research,

with a baseline cohort, who completed a research experience without this additional support, we hoped to explore the impacts of this added training during research. Our initial work indicates that our workshops have the potential to enhance student learning in several areas. As expected, some of the largest gains relative to the baseline cohort were seen in areas closely linked to entrepreneurial mindset, like identifying knowledge gaps and communicating findings.

While the trends are promising, the limited sample size and high level of variation in the data precluded formal statistics. We plan to expand the sample size for our intervention cohort as we collect additional data in AY24–25 and continue the work in AY25–26. We are also looking for collaborators in other departments within our group of universities who may be willing to collect baseline data before implementing our workshops within their research programs.

Some limitations of our work include the modest response rate for our surveys, as well as possible self-selection among workshop participants and survey respondents. We have seen that response rates are lower for the surveys when there is a gap between the workshop delivery and receipt of the survey (for example, while students are completing research or the gap before the follow-up survey). We have encouraged workshop facilitators, when possible, to schedule a final workshop around the time the survey will be delivered and offer time in the workshop for survey completion. Future inclusion of incentives for survey completion could also increase response rates. For this study design, approved as exempt from full human subjects research review across all five universities, we are relying on anonymous self-reported data from all students. However, considering the limitations of response rate on the follow-up survey, a future study design could incorporate collection of linked student data at each institution, such as retention or career placement data, to understand longer-term student impacts. Mentor lists of publications or presentations could also be linked with student data collected in this manner.

Self-selection among workshop participants could have an additional impact on the trends in the data set. As discussed, the delivery of the workshops varied among collaborating universities. The summer workshops were often strongly encouraged as part of a research experience, while the “bootcamp” style workshops were voluntary. We focused our baseline data collection in the research programs that would use the workshops in future years and among the student groups most likely to enroll in the bootcamp workshops. However, it is still possible that the voluntary workshops select for a group of more motivated students, and as we collect additional data, we could explore trends by workshop delivery mode in the future.

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Appendix: Full Text of Student Survey Questions

Post-survey for Student Research Training Workshops

This post-survey was administered immediately after completion of the research experience or term that included the student research training workshops.
* = optional question

Research experience

1. Including this term, how many semesters (or quarters, if applicable for your university) have you been involved in undergraduate research during the academic year? *(Response options: 0, 1 semester, 2 semesters, 3 or more semesters, 1 quarter, 2 quarters, 3 quarters, 4 or more quarters)*

2. Including this term, how many times have you participated in summer undergraduate research? *(Response options: 0, 1 summer, 2 summers, 3 or more summers)*

3. *Including this term, what was the duration of your longest research experience working with a single research group? *(Free response)*

4. *Approximately how many hours per week did you work at research-related activities in your research experiences? *(Free response)*

Gains in attitudes or mindsets related to research

5. How much did you GAIN in the following areas as a result of your most recent research experience?
   Question source: URSSA "Thinking and working like a scientist" and "Personal gains related to research"
   Response options: Slider of 0-4 with the following text: No gains (0), a little gain (1), moderate gain (2), good gain (3), great gain (4), not applicable
   a. Analyzing data for patterns
   b. Figuring out the next step in a research project
   c. Formulating a research question that could be answered with data
   d. Understanding the theory and concepts guiding a research project I am working on
   e. Understanding the connections among scientific and engineering disciplines
   f. Understanding the relevance of research to my coursework
   g. Comfort in working collaboratively with others.
   h. Ability to work independently
   i. Ability to describe what everyday research work is like

6. How much did you GAIN in the following areas as a result of participating in undergraduate research?
   Question source: Team's review of EM-related metrics from KEEN

Response options: Slider of 0-4 with the following text: No gains (0), a little gain (1), moderate gain (2), good gain (3), great gain (4), not applicable

a. Ability to explore knowledge gaps
b. Ability to gather data to support and refute ideas
c. Ability to take ownership of research on a topic of interest
d. Ability to evaluate sources of information
e. Confidence in my ability to persuade a colleague that a discovery adds value in multiple ways (value could be technological, societal, financial, environmental, etc.)
f. Ability to modify an idea, experiment, or product based on feedback
g. Ability to describe how a discovery could be scaled or sustained, using elements such as revenue streams, key partners, costs, and key resources
h. Ability to explain the needs or motivations of various stakeholders

7. During your research experience HOW MUCH did you:
   Question source: URSSA "Changes in attitudes or behaviors"
   Response options: None, a little, some, a fair amount, a great deal, not applicable
   a. Think creatively about your project
   b. Try out new ideas or procedures on your own
   c. Feel responsible for your project
   d. Work extra hours because you were excited about the research
   e. Interact with researchers from outside your school
   f. Feel a part of the scientific and engineering community

Gains in skills related to research

8. How much did you GAIN in the following areas as a result of your most recent research experience?
   Question source: URSSA "Skills" list edited to focus on skills most relevant to EML
   Response options: Slider of 0-4 with the following text: No gains (0), a little gain (1), moderate gain (2), good gain (3), great gain (4), not applicable
   a. Making oral presentations
   b. Conveying my findings visually in graphics, posters, or presentation slides
   c. Writing scientific reports or papers
   d. Defending an argument when asked questions
   e. Explaining my project to people outside my field
   f. Documenting my work for future researchers in the laboratory
   g. Setting goals to make progress in my research

Motivation, overall research experience, and future plans

9. *Please rate the following:
   Question source: URSSA
   Response options: Poor, fair, good, excellent, not applicable
   a. My working relationship with my research mentor

b. My working relationship with research group members or other students on this project
c. The research experience overall

10. *Rate how much you agree with the following statements:
Question source: URSSA
Response options: Strongly disagree, disagree, agree, strongly agree
    a. Doing research confirmed my interest in my field of study
    b. Doing research clarified for me which field of study I want to pursue
    c. My research experience has prepared me for graduate school
    d. My research experience has prepared me for a job
    e. My research experience has prepared me for entrepreneurial activities

11. What motivated you to do research? I WANTED TO DO RESEARCH TO: (rank your top three motivations)
Question source: URSSA, reframed from yes/no to top three choices for motivation
Response options: rank top three + free response if Other
    a. Explore my interest in science / engineering
    b. Gain hands-on experience in research
    c. Clarify which field I wanted to study
    d. Clarify whether I wanted to pursue a career in research
    e. Have a good intellectual challenge
    f. Work with a particular faculty member
    g. Participate in a program with a strong reputation
    h. Get good letters of recommendation
    i. Enhance my resume
    j. Make an impact on the world
    k. Other *(free response)*

12. For each of the following statements, please indicate how true it is for you using the following scale
Question source: Intrinsic Motivation Inventory
Response options: 0 = not at all true to 4 = very true
    a. I enjoyed undergraduate research.
    b. I think I did well at research, compared to other students.
    c. I did not put much energy into research.
    d. I am satisfied with my performance as an undergraduate researcher.
    e. I felt very tense while doing research.
    f. I felt like I didn't really have any control over my project as an undergraduate researcher.
    g. I felt like I could really trust my immediate mentor.
    h. I would be willing to do undergraduate research again because it has some value to me.

13. Compared to your intentions BEFORE doing research, HOW LIKELY ARE YOU NOW to:

Question source: Expanded version of URSSA future plans question
Response options: less likely, not more likely, a little more likely, somewhat more likely, extremely more likely, not applicable

a. Contact a professor with an idea for a new research project
b. Apply for an industry internship or position focused on research
c. Participate in entrepreneurship programs on campus for developing a business idea
d. Apply for an internship or position with a start-up company
e. Apply to a master's degree or professional degree program
f. Apply to a PhD program

Research dissemination and application

14. Which of the following activities did you complete as part of your most recent research experience? (Check all applicable boxes below.)
Question source: URSSA dissemination question with additional options
Response options: Check boxes to select activities, plus text box for Other option if checked
    a. I presented a talk or poster to other students or faculty at my university.
    b. I attended an external conference.
    c. I presented a talk or poster at an external conference.
    d. I wrote a thesis or research report on my work.
    e. I wrote or co-wrote a conference paper.
    f. I wrote or co-wrote a paper that was submitted to an undergraduate research journal.
    g. I wrote or co-wrote a paper that was submitted to a peer-reviewed academic journal.
    h. I won an award or scholarship based on my research.
    i. I participated in an entrepreneurship competition or idea accelerator program related to my research.
    j. I presented my research to the broader community (e.g. museum or K-12 outreach programs).
    k. I trained or mentored other undergraduate researchers.
    l. I collaborated with students or faculty outside of my primary laboratory group as part of my research.
    m. Other (please specify):

Workshop / activity feedback

15. How much did the following workshops support your learning and success in research?
Question source: List of research training workshops created by team
Response options: did not do this activity, not at all, a little, a good amount, a great deal
    a. Framing your research question with entrepreneurial mindset
    b. Thriving in a research environment (setting SMART goals)
    c. Building resilience in research

d. Developing your research pitch
e. Data visualization
f. Maximizing the impact of your research

16. Which aspect of the workshops did you find most helpful? *(Free response)*

17. Please list one suggestion for improving the workshops. *(Free response)*

Demographics

18. What university do you attend? *(Drop down response)*
19. *What is your current class year? *(Response options: 1st year, 2nd year, 3rd year, 4th year or more)*
20. *What is your primary major? *(Drop down response options relevant to each program)*
21. *Is there any aspect of your identity that is important to you as a STEM student? *(free response)*

Follow-up Survey for Student Research Training Workshops

This survey was distributed to the same group of students one year after the post-survey above.
* = optional question

Current research experience

1. Including this term, how many semesters (or quarters, if applicable for your university) have you been involved in undergraduate research during the academic year? *(Response options: 0, 1 semester, 2 semesters, 3 or more semesters, 1 quarter, 2 quarters, 3 quarters, 4 or more quarters)*

2. Including this term, how many times have you participated in summer undergraduate research? *(Response options: 0, 1 summer, 2 summers, 3 or more summers)*

3. *Including this term, what was the duration of your longest research experience working with a single research group? *(Free response)*

4. *Approximately how many hours per week did you work at research-related activities in your research experiences? *(Free response)*

Motivation and future plans

5. Are you currently involved in undergraduate research? *(Response options: yes, no)*

6. If yes to 5, what motivated you to continue to do research? I CONTINUED RESEARCH TO: (rank your top three motivations)
   Question source: URSSA, reframed from yes/no to top three choices for motivation
   Response options: rank top three + free response if Other
   a. Explore my interest in science / engineering
   b. Gain hands-on experience in my field of interest
   c. Clarify which field I wanted to study
   d. Clarify whether I wanted to pursue a career in research
   e. Have a good intellectual challenge
   f. Work with a particular faculty member
   g. Participate in a program with a strong reputation
   h. Get good letters of recommendation
   i. Enhance my resume
   j. Make an impact on the world
   k. Other *(free response)*

7. For each of the following statements, please indicate how true it is for you using the following scale
   Question source: Intrinsic Motivation Inventory
   Response options: 0 = not at all true to 4 = very true
   a. I enjoyed undergraduate research
   b. I think I did well at research, compared to other students

c. I did not put much energy into research
d. I am satisfied with my performance as an undergraduate researcher
e. I felt very tense while doing research
f. I felt like I didn't really have any control over my project as an undergraduate researcher.
g. I felt like I could really trust my immediate mentor.
h. I would be willing to do undergraduate research again because it has some value to me

8. Compared to your intentions BEFORE starting undergraduate research, HOW LIKELY ARE YOU NOW to:
Question source: Expanded version of URSSA future plans question
Response options: less likely, not more likely, a little more likely, somewhat more likely, extremely more likely, not applicable
    a. Contact a professor with an idea for a new research project
    b. Apply for an industry internship or position focused on research
    c. Participate in entrepreneurship programs on campus for developing a business idea
    d. Apply for an internship or position with a start-up company
    e. Apply to a master's degree or professional degree program
    f. Apply to a PhD program

Research dissemination and application

9. Which of the following activities did you complete as part of your most recent research experience? (Check all applicable boxes below.)
Question source: URSSA dissemination question with additional options
Response options: checkboxes to select activities, plus text box for Other option if checked
    a. I presented a talk or poster to other students or faculty at my university
    b. I attended an external conference
    c. I presented a talk or poster at an external conference
    d. I wrote a thesis or research report on my work
    e. I wrote or co-wrote a conference paper
    f. I wrote or co-wrote a paper that was submitted to an undergraduate research journal
    g. I wrote or co-wrote a paper that was submitted to a peer-reviewed academic journal
    h. I won an award or scholarship based on my research
    i. I participated in an entrepreneurship competition or idea accelerator program related to my research
    j. I presented my research to the broader community (e.g. museum or K-12 outreach programs)
    k. I trained or mentored other undergraduate researchers
    l. I collaborated with students or faculty outside of my primary laboratory group as part of my research

m. Other (please specify):

Demographics

10. What university do you attend? *(Drop down response)*
11. *What is your current class year? *(Response options: 1st year, 2nd year, 3rd year, 4th year or more)*
12. *What is your major? *(Drop down response relevant to each program)*
13. *Is there any aspect of your identity that is important to you as a STEM student? *(free response)*