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An Entrepreneurial Mindset-Based Early-Curriculum Exposure to Undergraduate Research

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An Entrepreneurial Mindset-Based Early-Curriculum Exposure to Undergraduate Research

Abstract

Numerous studies have shown that research experience is beneficial to undergraduate students. However, faculty often face challenges identifying potential student researchers and navigating the short duration of student participation. Research opportunities frequently depend on individual faculty recruitment efforts and word of mouth, which means many students are unaware of the possibility of joining a research team until late in their undergraduate career. This late awareness leaves little time for a deep and meaningful research experience.

Through collaboration across five universities, the research team has developed an Early Student Exposure to research program that employs entrepreneurially minded learning at the freshman and sophomore levels to introduce students to the concept of research and inspire them to engage in undergraduate research. A series of videos and designed exercises inform students about research opportunities and the role that research plays in the development of technologies that benefit society. These exercises have been employed at the five universities, which range from primarily undergraduate institutions to large research universities. Post-surveys and one-year follow-up surveys have been employed to evaluate the effects that the program has had on the students' understanding of research, as well as their motivation and inclination to become involved in research themselves. In this paper, the authors describe the videos and activities and present the results of the surveys to evaluate the effectiveness of the Early Student Exposure to research program. Initial results indicate that students who engaged with the full set of Early Student Exposure to research materials, including videos and activities, showed a high motivation to pursue undergraduate research and a greater gain in their ability to explain the research process and the impact of research in society.

Background and Motivation

Undergraduate research (UGR) is a high-impact practice in undergraduate education, with some of the benefits of UGR include helping students to understand their career options in science and engineering, including gaining a greater understanding of the many roles needed in the sciences [1], developing a professional identity within those roles [1]–[3], understanding the balance between independent work and collaboration [4], and helping students to set their own career goals [5]. With respect to furthering their education, UGR has been shown to help students gain resilience to persist through failure [3], [6], improve their research practices and conceptual understanding in the sciences [3], and increase their expectation of pursuing a Ph.D [7].

While the benefits of UGR are evident, it is not a trivial matter for faculty to engage with UGR in their research groups. Some faculty hesitate to host UGR due to the perception that they do not have the time to train and mentor undergraduate students, and that there is not much professional incentive for them to do so [8], [9]. Faculty also may be unaware of which of their

students are interested in UGR; confounding this challenge, many undergraduate students do not know that UGR is even an option, especially during their first year or two of college [4].

An opportunity exists for UGR to transform undergraduate curricula if institutions would publicize these opportunities to first- and second-year students. Some colleges and universities have explored various means of getting early-curriculum students involved in UGR. For example, one program sought to leverage the benefits of UGR to help freshman students who are academically at-risk, but showed mixed results [10], as did another program that sought to create undergraduate research experiences at scale by targeting a single freshman biology course [11]. These studies each highlight approaches used in a single university. In this paper, the authors describe an Early Student Exposure (ESE) to UGR that has been developed by a consortium of engineering faculty members from five universities, supported by the work of the Kern Entrepreneurial Engineering Network (KEEN). Member institutions of KEEN work to develop content that uses the emergent Entrepreneurial Mindset Learning (EML) pedagogy, whereby instructors train engineering students to develop an entrepreneurial mindset by looking for opportunities to make impacts–using Curiosity to make Connections between different bodies of knowledge and Create Value through innovative implementation of engineering design [12], [13]. Through KEEN, this collaboration was formed so that a diverse set of institutions could develop ESE materials that satisfy the cultures of diverse institutions (public/private, large/small) so that the ESE content can be consumed, modified, and disseminated by faculty at a similar diversity of institutions.

Collaboration across the five universities

The overall goal of this project was to develop an effective program for the diverse range of campuses represented by the project team. This approach ensures that the curriculum materials will be applicable to future institutions interested in adopting the ESE modules and allows the program to reach a broad range of undergraduate engineering students.

In order to develop content that could be used widely by engineering programs of various sizes and cultures, a diversity of institutions collaborated in this effort. The University of Illinois Urbana-Champaign is a large public midwestern R1 institution, and the venues for participation in this project were all held in the Mechanical Engineering and Engineering Mechanics programs. Content was delivered to a freshman survey course and a sophomore-level seminar course, reaching a total of about 350 students per year, as well as a faculty that over the years of this project exceeded 60 different individuals. The research conducted in this institution tends to emphasize engineering science more so than entrepreneurial innovations. Georgia Institute of Technology is a large R1 institution in the southern United States. Students had access to research materials through two primary venues: a sophomore-level core Biomedical Engineering course and a cohort-based certificate program [14, 15]. Each semester, approximately 150 students enroll in the sophomore core class, where they engage with all five modules of early

exposure to research throughout the semester. The cohort-based program, designed to support the students without prior research experience, is conducted in collaboration with the Office of Undergraduate Education. From a pool of over 150 applicants, 40 students are selected based on their backgrounds. Baylor University is a private mid-size R1 institution also located in the southern United States. Students in the School of Engineering and Computer Science at this institution participated in the program through first-year survey courses in engineering and data science, reaching a total of approximately 290 students. Lawrence Technological University is a small private primarily undergraduate institution located in the Midwest. Students from the College of Engineering also participated in the implementation of these modules through first-year engineering courses, reaching a total of approximately 335 students. Rose-Hulman Institute of Technology is a private primarily undergraduate institution in the Midwest. Content from these modules was introduced in a multidisciplinary introduction to research course and in an introductory survey course within one engineering department, reaching approximately 135 students total.

Because undergraduate research is a high-impact practice, positively impacting student outcomes and increasing rates of retention in undergraduate and graduate STEM programs [1], [7], the team developed the ESE modules to fit into existing courses for first and second-year students. The team hoped to encourage a positive student *mindset* towards research and increase student *motivation* to engage in research. The team expected that early exposure to these ideas (within the first two years of an undergraduate program), would have the greatest impact on student success by engaging students early enough for them to participate in meaningful research experiences. The results from the pilot study showed that early exposure to the research process improved student perception of and interest in research experiences [13].

Previous work by the current authors outlined the initial development of five modules addressing fundamental questions about research engagement: "What Is Research?," "Why Should I Get Involved in Research?," "What Is the Entrepreneurial Mindset?," "How Does Research Get Done?," and "How Can I Get Involved in Research?" [13]. These modules included professionally-produced videos that were kept brief (5–10 minutes) to maintain student engagement while conveying key concepts about the research process and its connection to EM. Each video module was paired with targeted active learning activities which ranged from reflection exercises and researcher interviews to grant exploration activities and a "Research Opportunity Bingo." This modular design enabled flexible integration into existing first-year engineering courses, with individual institutions able to customize implementation based on their specific needs and curricular constraints. These resources were made available online through a website where instructional materials, including links to the previously discussed videos, are hosted [16], [17].

Assessment

The team implemented a 22-item survey to evaluate the impact of the videos and activities on student engagement and motivation. The survey was taken by undergraduate students after they have completed a course with the developed modules embedded. To evaluate the long-term impacts of the new curricular materials, the team also implemented a follow-up survey which was sent out to the same students one year after completing the course. The survey adapts the retrospective gains model used by the Undergraduate Research Student Self-Assessment (URSSA) [18]. It evaluates the student's perceived gains in areas related to research knowledge, motivation, and engagement, as well as entrepreneurial mindset.

Implementation of survey

The team delivered the post-survey, taken immediately after the course or workshop utilizing the ESE modules, to the AY22–23 cohort (hereafter "partial intervention cohort;" $n = 118$ responses; 18% response rate) in which students participated in activities and homework assignments for some workshops, and the AY23–24 / 24–25 cohorts (hereafter "full intervention cohort;" $n = 266$ responses; 27% response rate) in which students received the full implementation of the complete set of modules, including videos. If the ESE modules were effective, the team expected to see self-reported gains in students' understanding of research and motivation to conduct future research across both cohorts. If the videos were successful in increasing student engagement or interest in the workshops relative to the activities alone, the team expected to see increased effects in the full intervention cohort compared to the partial intervention cohort.

The research team used Mann-Whitney U tests to determine whether the two cohorts differed in their responses to Likert-type questions. The team opted for non-parametric *t*-tests because responses to Likert-type questions are ordinal and responses deviated significantly from normality (Shapiro-Wilk test, all $p < 0.05$) [19]. The team adjusted *p*-values using the Holm-Bonferroni correction for multiple comparisons, which offers strong control of the family-wise error rate and greater power than the Bonferroni correction [20]. The team applied the correction separately to each family of sub-questions (sub-questions from the same family are presented in the same table/figure).

The team also delivered the follow-up surveys one year after the completion of the modules, but saw a low response rate for follow-up. For the AY22–23 cohort (partial intervention), there were four responses and for the AY23–24 cohort (full intervention) there were five responses.

Results and discussion

The survey included several questions to assess student *knowledge* of research (research process and types of research), as well as their *mindset* toward approaching research (recognition of

connections to coursework and society, willingness to contact a faculty member about research). The majority of students reported a ‘good gain’ or ‘great gain’ in knowledge or skills within the

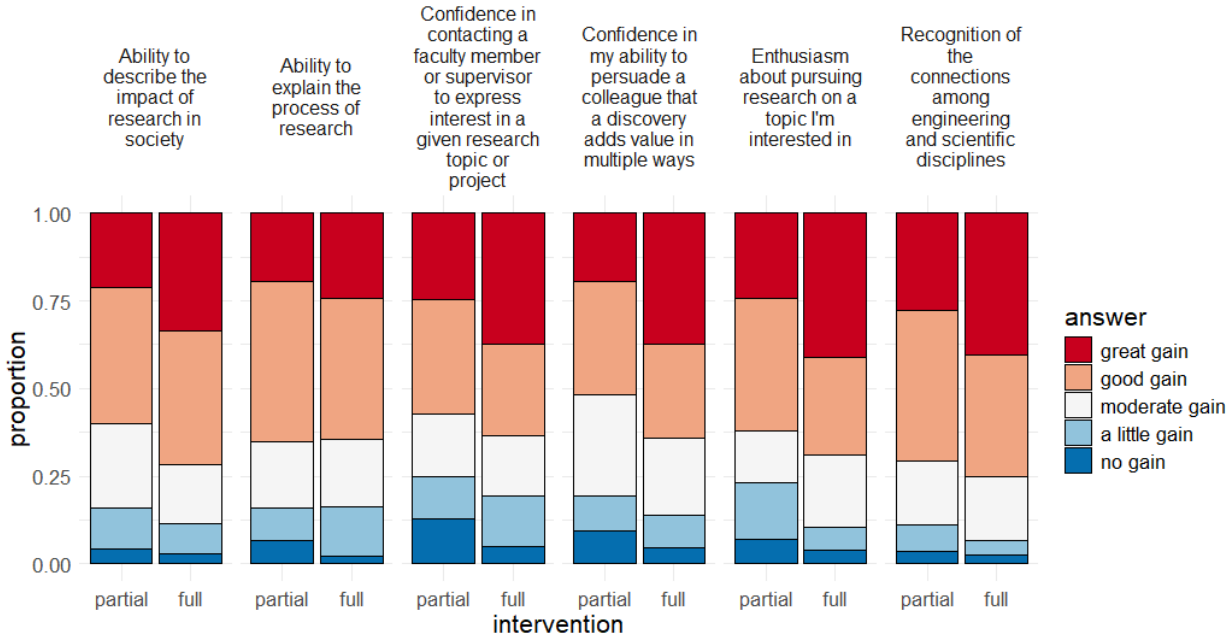

Figure 1. Student responses to the self-assessment question: “How much did you gain in the following areas as a result of participating in the activities in this course?”

areas surveyed after completing the ESE activities within their class. Additionally, students from the full intervention cohort reported a greater impact in most areas that the survey assessed; for six out of eight questions, students in the full intervention cohort showed a statistically significant increase in gains, scored on a Likert scale, related to their research knowledge and mindset. These results are summarized in Figure 1, with full data sets and statistical analysis included in Appendix A.

The team also surveyed students regarding their *future plans and motivation* after the course, with an emphasis on activities related to research and entrepreneurship (Figure 2). In both cohorts, students reported an increased likelihood of contacting a professor about undergraduate research or applying for a summer position focused on research after completing ESE activities in their course. Notably, a greater share of students in the full intervention cohort, which included videos, described themselves as being somewhat or extremely more likely to (i) apply to an industry internship or position focused on research (partial: 54%; full: 75%, Figure 2), (ii) contact a professor about an advertised undergraduate research opportunity (partial: 52%; full: 69%), or (iii) apply to a summer undergraduate research program (partial: 48%; full: 69%). A goal of the video content was to demystify the process of research, making it and the faculty conducting research more approachable to students. The significant increase in the percentage of students interested in contacting a professor about undergraduate research in the full intervention cohort (+17%) indicates that beyond the workshop content, the videos may play an important

role in making research seem more accessible to students. Relative to the partial intervention without the videos, students in the full intervention cohort showed a statistically significant

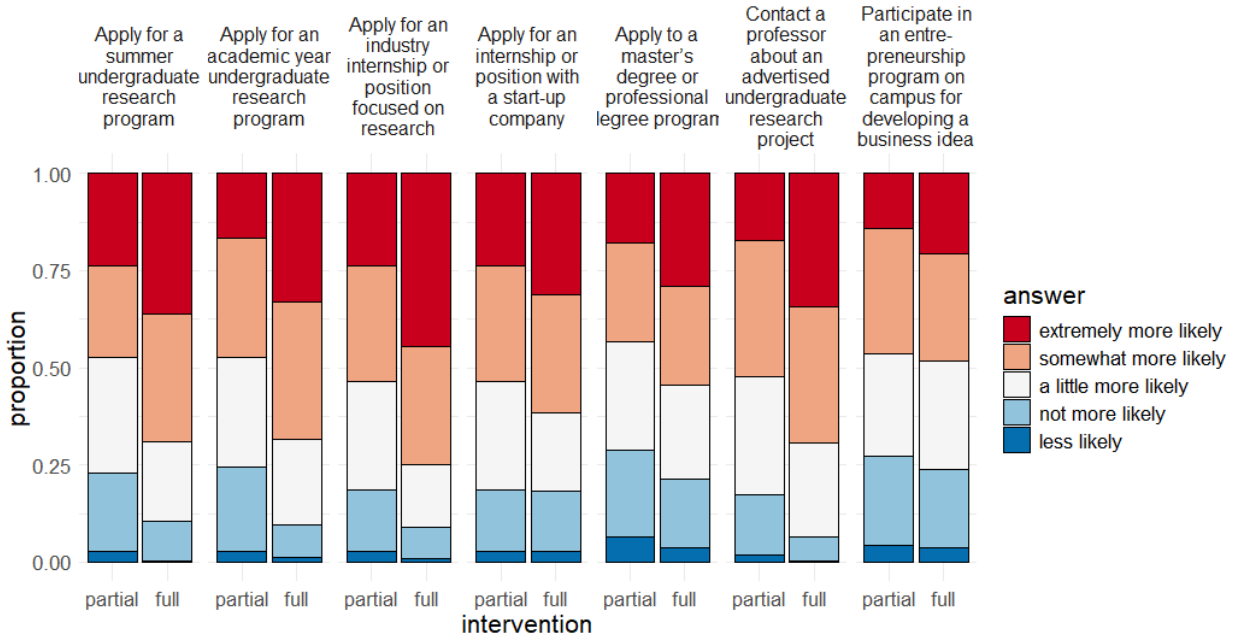

Figure 2. Student responses to the self-assessment survey question "Compared to your intentions before taking this course, how likely are you now to:"

increase in gains, scored on a Likert scale, for seven out of nine areas related to their future plans and motivation for research.

Qualitative data were also collected as part of the survey deployment and ESE module implementation. Data included quotations from students as well as testimonials from instructors who implemented ESE modules. Representative quotes from the qualitative data are included in Table 1. The team had heard overwhelmingly positive feedback from instructors and some noteworthy feedback from students. Several students at the University of Illinois Urbana-Champaign followed up with the instructor to indicate that they were hired as undergraduate researchers during their freshman year after completing the course where these modules were implemented.

The one-year follow-up survey of students had a low response rate, so the research team was not able to accurately estimate if students followed up on their plans to contact faculty members regarding research. Of the five students who responded to the follow-up survey from the full intervention cohort, two reported conducting undergraduate research with a faculty member. One future area for follow-up at each institution could be collaboration with offices for undergraduate research or institutional assessment to evaluate how many students from the courses where the

ESE materials were implemented enrolled in tracked UGR experiences, such as summer programs or UGR conducted for course credit.

Table 1. Representative quotations from qualitative assessment. Student quotations were gathered from open-answer sections of the survey. Instructor quotations were gathered from informal feedback given to team members.

Institution & role	Quotation
Baylor University, Instructor	"When the [modules were] originally talked about for ENGR 1301 I was skeptical. How boring was a talk about research going to be? … But when I first viewed the videos, indeed it was a point of pride. The were expertly produced… And they included Baylor engineering faculty alongside faculty from other institutions and that shined a positive and prominent light on Baylor… showing students that student-research opportunities exist right here at Baylor"
Baylor University, Student	"I liked the videos we watched… It was a good way to ask questions about things we found interesting."
Georgia Institute of Technology, Instructor	"70% of students at our school participate in official undergraduate research by registering for credit. The modules created by your team have a very high quality. If the modules can be implemented asynchronously, the academic office can ask students to take them as a prerequisite or corequisite with their research credits."
Lawrence Technological University, Student	"The Research Opportunity Bingo was the most enjoyable engineering research assignment to me because it helped me get out of my comfort zone and actually go out there and talk to researchers; this unironically will end up putting me at a good spot if I ever decide to do research in the future."
Rose-Hulman Institute of Technology, Student	"Exploring research articles was the most fun to me, as it allowed me to explore my field of interest more."

Summary and conclusions

The Early Student Exposure modules addressed two critical challenges in undergraduate research: the need to engage students earlier in their academic careers and the importance of developing an entrepreneurial mindset as a part of the larger research mindset. Through implementation across five diverse institutions, the assessment data showed that students who engaged with the full intervention, including both videos and activities, showed markedly increased interest in pursuing research opportunities and greater confidence in their ability to engage with the research process. Of particular note was the 73% (17% higher than the partial cohort) of students reporting a good or great gain in their confidence in contacting a faculty

member or supervisor to express interest in a given research topic or project, suggesting that the multimedia approach reduced barriers to entry for undergraduate research. Student testimonials highlighted the value of hands-on activities like Research Opportunity Bingo in making research more approachable.

The impact of the program extended beyond just increasing research participation interest, with students reporting significant gains in their ability to connect research to broader societal impact and recognize connections across engineering disciplines. The incorporation of Entrepreneurial Mindset Learning appeared particularly effective, with students in the full intervention cohort showing increased interest in both traditional academic research paths and industry- or startup-focused research opportunities. This balanced approach helps prepare students for diverse career paths while maintaining strong connections to fundamental research principles.

One limitation of the current work is the low response rate for the one-year follow up surveys, which makes it difficult to track if students actually engaged in undergraduate research after completing the workshops. In the future, the team could consider incentives for survey completion to increase response rates or alternative study designs. The current study design, approved across all five universities, relied on anonymous self-reported data from all students. However, a future study design could incorporate linked student data at each institution to track enrollment in undergraduate research courses or programs and also provide an idea of whether the workshops might help increase the participation of underrepresented groups in undergraduate research.

The modular nature of the program, demonstrated through successful implementation across varied institutional contexts, suggests strong potential for broader adoption. Faculty feedback indicated that the materials were both high quality and flexible enough to fit within existing curricular structures. While these materials were primarily targeted towards first year engineering experiences (FYEE) there are also many potential opportunities to use these materials for the recruitment and onboarding of undergraduates into research programs or individual projects. For example, these materials could be used as introductory material during summer research programs, REUs, research expositions, or even STEM outreach events.

As institutions continue to seek ways to enhance undergraduate research participation and outcomes, this framework provides a tested approach for early engagement that benefits students, faculty, and institutions while fostering the development of entrepreneurially-minded undergraduate researchers. The evidence from the survey results strongly indicates that such interventions are effective at getting students past the barrier of seeing opportunities to get involved in research and then closing the gap towards taking such opportunities.

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Appendix A: Tabular Data, Complete Figures, and Statistical Analysis

Table A1. Student responses to the self-assessment question: "How much did you gain in the following areas as a result of participating in the activities in this course?" Responses are reported as a percent of total responses. Areas where the full intervention cohort showed statistically significant increases in student gains relative to the partial intervention cohort are noted in bold.

Sub-question	Cohort	No gains	A little gain	Moderate gain	Good gain	Great gain
Ability to explain the process of research	Partial	7%	9%	19%	46%	19%
	Full	**2%**	**14%**	**19%**	**40%**	**24%**
Ability to describe the impact of research in society	Partial	4%	12%	24%	39%	21%
	Full	**3%**	**8%**	**18%**	**38%**	**34%**
Ability to make connections between research topics and my coursework	Partial	3%	8%	19%	46%	24%
	Full	2%	8%	21%	38%	31%
Confidence in contacting a faculty member or supervisor to express interest in a given research topic or project.	Partial	13%	12%	18%	32%	25%
	Full	**5%**	**15%**	**17%**	**26%**	**37%**
Recognition of the connections among engineering and scientific disciplines	Partial	3%	8%	18%	43%	28%
	Full	**3%**	**4%**	**18%**	**35%**	**41%**
Insight into the types of research going on at my university	Partial	5%	14%	23%	30%	28%
	Full	3%	11%	23%	28%	35%
Enthusiasm about pursuing research on a topic I'm interested in.	Partial	7%	16%	15%	38%	24%
	Full	**4%**	**7%**	**20%**	**28%**	**41%**
Confidence in my ability to persuade a colleague that a discovery adds value in multiple ways	Partial	9%	10%	29%	32%	19%
	Full	**5%**	**9%**	**22%**	**27%**	**37%**

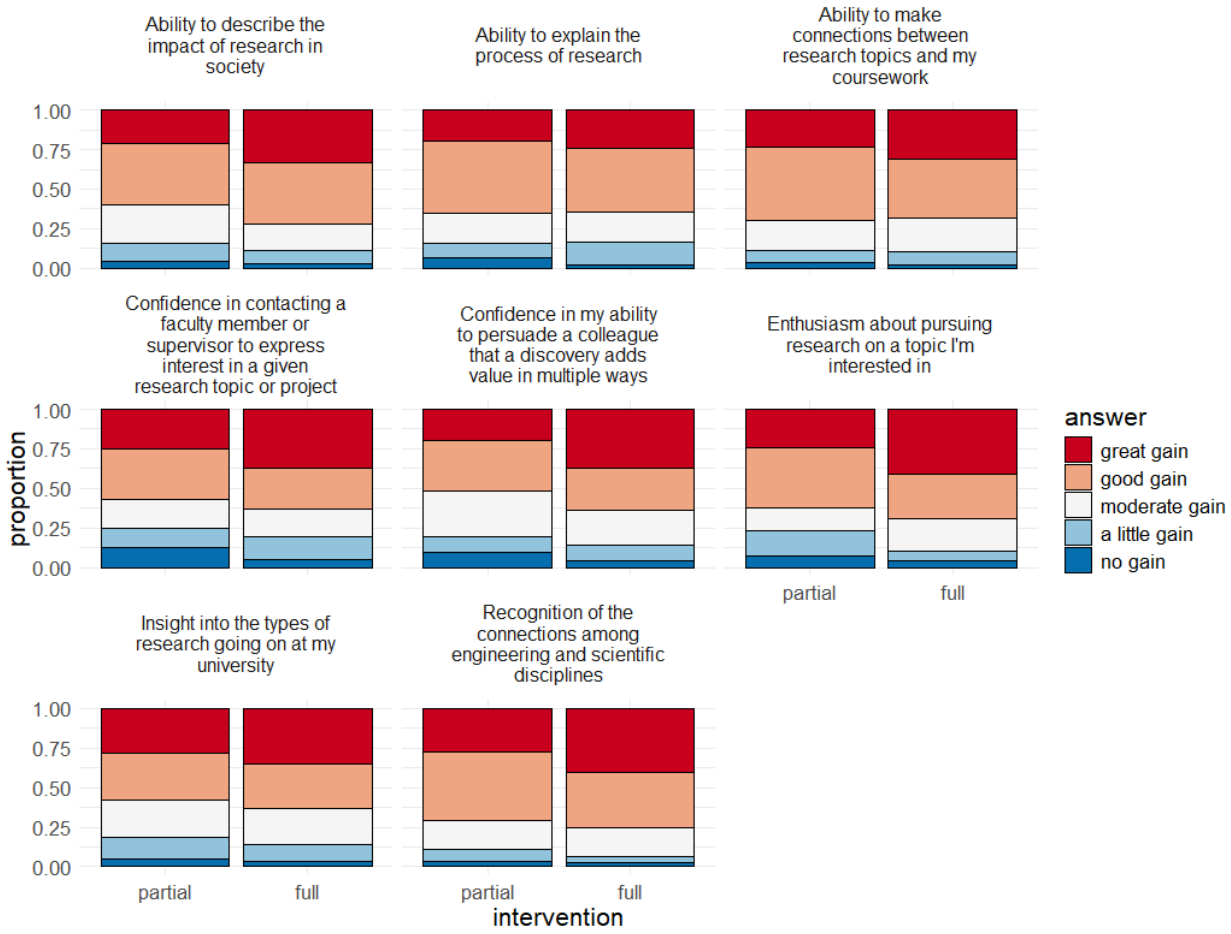

Figure A1. Student responses to the self-assessment question: "How much did you gain in the following areas as a result of participating in the activities in this course?"

Table A2. Results (*W*- and *p*-values) of Mann-Whitney U tests comparing Likert-type responses between the 2022–2023 and 2023–2024 EE cohorts for the question "How much did you gain in the following areas as a result of participating in the activities in this course?" Areas where the full intervention cohort showed statistically significant increases in student gains relative to the partial intervention cohort are noted in bold.

Sub-question	*W*	*p*	Adjusted *p*
Ability to explain the process of research	**9061**	**0.005**	**0.035**
Ability to describe the impact of research in society	**9038**	**0.005**	**0.035**
Ability to make connections between research topics and my coursework	7898	0.3	0.3
Confidence in contacting a faculty member or supervisor to express interest in a given research topic or project	**8809**	**0.016**	**0.048**
Recognition of the connections among engineering and scientific disciplines	**8862**	**0.011**	**0.044**
Insight into the types of research going on at my university	8809	0.046	0.092
Enthusiasm about pursuing research on a topic I'm interested in	**9002**	**0.007**	**0.035**
Confidence in my ability to persuade a colleague that a discovery adds value in multiple ways	**9150**	**0.003**	**0.024**

Table A3. Student responses to the self-assessment survey question: "Compared to your intentions before taking this course, how likely are you now to:" Responses are reported as a percent of total responses. Areas where the full intervention cohort showed statistically significant increases in student gains relative to the partial intervention cohort are noted in bold.

Sub-question	Cohort	Less likely	Not more likely	A little more likely	Somewhat more likely	Extremely more likely
Contact a professor about an advertised undergraduate research project	Partial **Full**	2% **1%**	16% **0%**	30% **31%**	35% **31%**	17% **36%**
Contact a professor with an idea for a new research project	Partial Full	2% 0%	18% 17%	32% 30%	33% 34%	15% 19%
Apply for a summer undergraduate research program	Partial **Full**	3% **0%**	2% **8%**	30% **21%**	24% **39%**	24% **32%**
Apply for an academic year undergraduate research program	Partial **Full**	3% **1%**	22% **9%**	28% **29%**	31% **37%**	17% **32%**
Apply for an industry internship or position focused on research	Partial **Full**	3% **0%**	16% **4%**	28% **14%**	30% **36%**	24% **45%**
Participate in an entrepreneurship program on campus for developing a business idea	Partial **Full**	4% **0%**	23% **20%**	26% **28%**	32% **32%**	14% **19%**
Apply for an internship or position with a start-up company	Partial **Full**	6% **1%**	13% **13%**	25% **17%**	42% **36%**	13% **32%**
Apply to a master's degree or professional degree program	Partial **Full**	6% **7%**	23% **12%**	28% **28%**	25% **27%**	18% **27%**
Apply to a PhD program	Partial Full	7% 10%	37% 26%	29% 29%	16% 22%	11% 14%

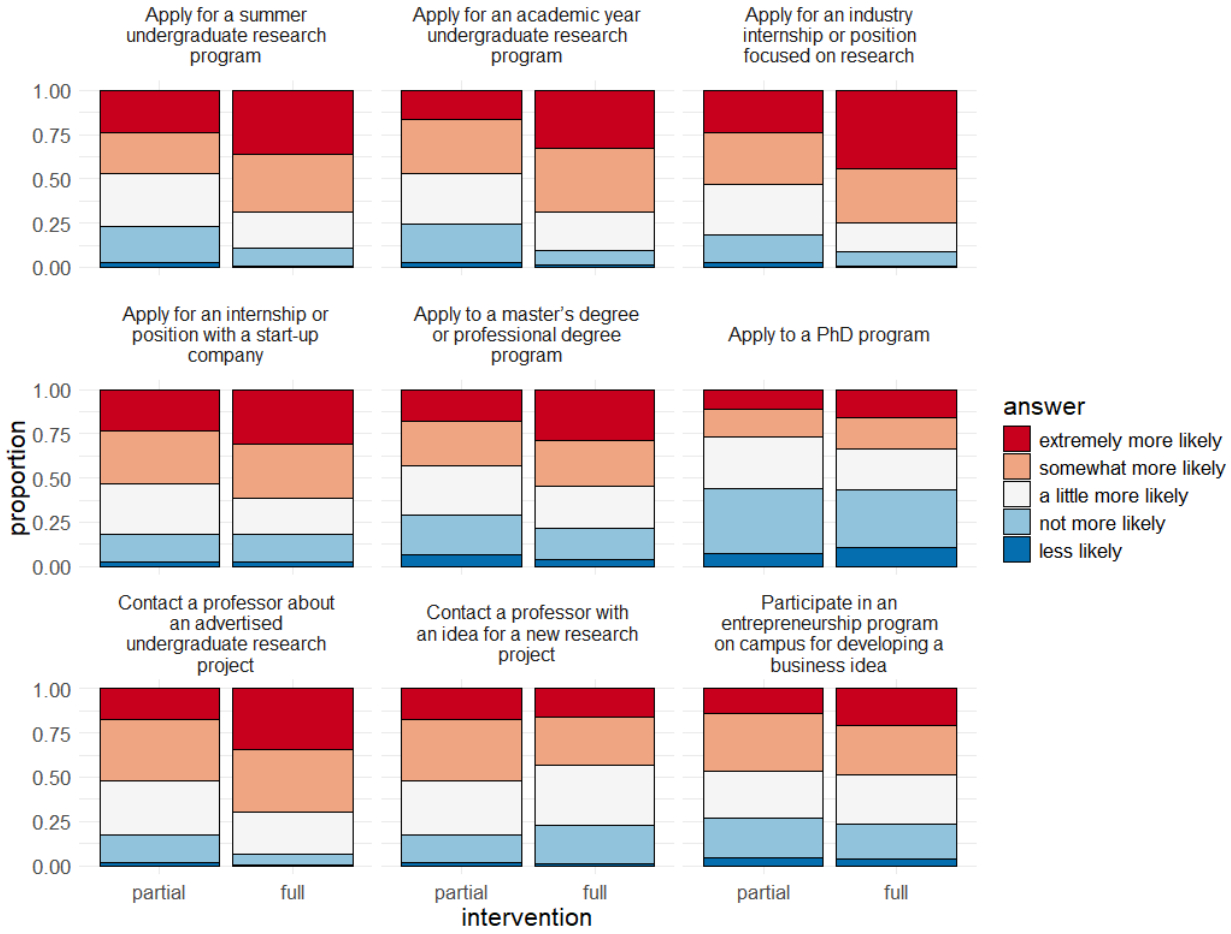

Figure A2. Student responses to the self-assessment survey question "Compared to your intentions before taking this course, how likely are you now to:"

Table A4. Results (*W*- and *p*-values) of Mann-Whitney U tests comparing Likert-type responses between the 2022–2023 and 2023–2024 EE cohorts for the question "Compared to your intentions before taking this course, how likely are you now to:" Areas where the full intervention cohort showed statistically significant increases in student gains relative to the partial intervention cohort are noted in bold.

Sub-question	*W*	*p*	Adjusted *p*
Contact a professor about an advertised undergraduate research project	**8937**	**<0.001**	**0.002**
Contact a professor with an idea for a new research project	6650.5	0.988	0.988
Apply for a summer undergraduate research program	**8818**	**<0.001**	**0.003**
Apply for an academic year undergraduate research program	**9154**	**<0.001**	**0.001**
Apply for an industry internship or position focused on research	**8280**	**0.009**	**0.004**
Participate in an entrepreneurship program on campus for developing a business idea	**8305.5**	**0.009**	**0.004**
Apply for an internship or position with a start-up company	**8905.5**	**<0.001**	**0.002**
Apply to a master's degree or professional degree program	**9053**	**<0.001**	**0.001**
Apply to a PhD program	7710	0.094	0.2

Appendix B: Early Student Exposure Surveys

A. Post-survey for Early Exposure to Research Activities

This post-survey should be administered immediately after completion of the course or workshop that integrated the early exposure to research activities.
* = optional question

Instructions to students: Answer the following questions based on your experience in the course or workshop where the instructor sent you this link.

Gains in skills/mindsets relevant to research

1. How much did you GAIN in the following areas as a result of participating in the activities in this course?
   Question source: Team discussion, URSSA "Thinking and working like a scientist" items
   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 explain the process of research
   b. Ability to describe the impact of research in society
   c. Ability to make connections between research topics and my coursework
   d. Confidence in contacting a faculty member or supervisor to express interest in a given research topic or project.
   e. Recognition of the connections among engineering and scientific disciplines
   f. Insight into the types of research going on at my university
   g. Enthusiasm about pursuing research on a topic I'm interested in.
   h. Confidence in my ability to persuade a colleague that a discovery adds value in multiple ways (value could be technological, societal, financial, environmental, etc.)

Motivation and future plans

2. Compared to your intentions BEFORE taking this course, 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 (could also be slider if desired)
   a. Contact a professor about an advertised undergraduate research project
   b. Contact a professor with an idea for a new research project
   c. Apply for a summer undergraduate research program
   d. Apply for an academic year undergraduate research program
   e. Apply for an industry internship or position focused on research
   f. Participate in an entrepreneurship program on campus for developing a business idea
   g. Apply for an internship or position with a start-up company
   h. Apply to a master's degree or professional degree program
   i. Apply to a PhD program

3. If you are considering starting an undergraduate research project, what is your motivation to do undergraduate research? I WOULD LIKE TO DO RESEARCH TO: (rank your top three motivations)
   Question source: URSSA, reframed from yes/no to top choices
   Response options: rank top three + free response if other, also need a response option to decline to rank, e.g. "not interested in undergraduate research"
   a. Explore my interest in STEM
   b. Gain hands-on experience in my field of interest
   c. Clarify which field I want to study
   d. Clarify whether I want 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. Not interested in research
   l. Other [free response]

Workshop/activity feedback

4. How much did the following activities support your learning and success in research?
   Question source: Modified from URSSA
   Response options: did not do this activity, not at all, a little, a good amount, a great deal
   a. Research reflection
   b. Researcher interview
   c. Why Do Research reflection
   d. Exploring opportunities
   e. Technology in daily life
   f. Find a grant program
   g. Research opportunity bingo

5. Of the activities / assignments related to engineering research, which did you find most enjoyable? Please share any feedback or suggestions you have about these activities.
   Response options: Free response

Demographics and previous research experience

6. What university do you attend? *(Drop down menu)*
7. Select the course section you are currently attending with the instructor you sent you this link. *(Drop down menu with available courses)*
8. *What is your current class year? *(Response options: 1st year, 2nd year, 3rd year, 4th year or more)*
9. *What is your major? *(Drop down response)*

10. Prior to this term, have you previously participated in a science, technology, engineering, or mathematics (STEM) research experience? *(yes/no)*
11. *If yes to 9, please describe briefly below: *(Free response)*
12. *If yes to 9, What was the duration of your longest research experience? *(one semester/quarter, one summer, one year, longer than one year)*
13. *Is there any aspect of your identity that is important to you as a STEM student? *(free response)*

B. Follow-up Survey for Early Exposure to Research Activities

This survey should be sent to the same group of students one year after the post-survey above.

Instructions to students: Answer the following questions based on your experience in the course where the instructor sent you this link.

Current Research Experience

1. In the last year, have you done any of the following?
   Response options: yes/no
   a. Contacted a faculty member regarding available undergraduate research projects
   b. Utilized campus resources, such as an Office of Undergraduate Research Programs or Career Services, to learn about opportunities for undergraduate research
   c. Applied for a competitive undergraduate research program, such as a summer REU program
   d. Applied for an industry internship position focusing on research
   e. Attended an on-campus research seminar or symposium
2. In the last year, have you been actively involved in a STEM undergraduate research project or program? *(Response options: yes, no)*

If the student answers yes to 3, then continue with questions 6-9. Otherwise, skip to demographic questions at the end.

3. *Please describe below: *(Free response)*
4. *In the last year, approximately how many hours per week did you work at research-related activities during the summer? *(0-10, 10-20, 20+)*
5. *In the last year, approximately how many hours per week did you work at research-related activities during the academic year? *(0-5, 5-10, 10+)*

Motivation

6. 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 choices
   Response options: rank top three + free response if other
   a. Explore my interest in STEM
   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: Slider 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.

Gains in skills/mindsets related to research

8. *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 explain the process of research
   b. Ability to describe the impact of research in society
   c. Ability to make connections between research topics and my coursework
   d. Recognition of the connections among engineering and scientific disciplines
   e. Insight into the types of research going on at my university
   f. Enthusiasm about pursuing research on a topic I'm interested in
   g. Confidence in my ability to persuade a colleague that a discovery adds value in multiple ways (value could be technological, societal, financial, environmental, etc.)
   h. Ability to recognize and explore knowledge gaps
   i. Ability to gather data to support and refute ideas
   j. Ability to take ownership of a project
   k. Ability to identify and evaluate sources of information
   l. Development of a professional network

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: 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):

Demographics

10. What university do you attend? *(Drop down menu)*
11. Select the course section you attended **last year** with the instructor you sent you this link. *(Drop down menu with available courses)*
12. *What is your current class year? *(Response options: 1st year, 2nd year, 3rd year, 4th year or more)*
13. *What is your major? *(Drop down response)*
14. *Is there any aspect of your identity that is important to you as a STEM student? *(free response)*