Early Discovery: Evolving a Program to Prepare Freshman and Sophomore Students for Graduate School and Research (Experience)

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Abstract

The Early Discovery program was initially developed by Purdue University College of Engineering to broaden participation of minority students pursuing Ph.Ds. and faculty careers. Since its creation in 2016, Early Discovery has evolved - changing names, modality, and focus, however the goal of the program has always remained the same: to support freshman and sophomore level undergraduate students from different backgrounds in preparation for graduate school and research.

While there are many programs that exist to help prepare upper-level undergraduate students for graduate school, few institutions have an intentional focus to attract students early at the freshman and sophomore levels. The Early Discovery Program has existed in three different formats in the past: 1) on campus visit, 2) virtual mini-conference and 3) virtual mentoring circle program. The purpose of this study is to understand which of the three Early Discovery formats have been the most engaging and impactful for early undergraduate students over the last 8 years. We present experiences and share details of implementation and results, including benefits and drawbacks for each format, lessons learned, and feasibility (budget, staffing power, etc…). This study also details feedback from participants, number of students engaged each year and whether participants are now pursuing a graduate degree and/or research.

Overall, this evolution of Early Discovery experiences is set into the larger context of other programs that exist in the United States and enables Purdue University engineering and others to better frame outreach and engagement strategies for attracting younger students to graduate studies.

Introduction

Over the last 8 years, the Early Discovery program has taken different programmatic approaches to engage younger students from the freshmen and sophomore levels in discussions about graduate school. The broader significance of the Early Discovery Program focuses on just this: 1) engaging students earlier in the discussion about graduate school, 2) ensuring that all people, regardless of background, have access to the knowledge needed to excel in their graduate studies and 3) addressing the talent shortage of domestic graduate students in engineering in the United States. Since researchers have shown that the journey to graduate school can seem unclear, operating with a hidden curriculum and accessible only to specific populations of people [1], programs that function to demystify graduate school like Early Discovery are extremely important.

As universities aim to ensure that people of different backgrounds are represented in graduate school, some initiatives that expose undergraduate students to graduate school include on-campus visits, research, mentoring programs and more [2]-[6]. Research has shown that in-person campus visits can help students better understand the graduate school experience, specifically improving academic engagement and confidence for senior level undergraduate

students [2], [7]. Participation in summer research programs also increases the likelihood of a student enrolling in a PhD program [3],[4]. However, there are few studies that demonstrate how other types of early and frequent exposure to graduate school play a critical role in shaping students' career trajectories and enrollment in PhD studies [8].

One structure that the Early Discovery program employs is mentoring. Mentoring structures have been widely recognized as crucial for academic success [5],[6]. Whether in-person or online, mentoring programs provide essential support that helps students persist in their studies and feel a sense of belonging, especially in STEM fields [9]. In-person mentoring programs offer deep personal connections and are effective in demystifying graduate school for prospective students [6],[9]. Online mentoring programs have also been shown to increase accessibility, flexibility, and prepare undergraduate students for graduate school [5]. However, many online and on campus programs mainly target juniors and seniors. The focus on upperclassmen leaves a gap in support for freshmen and sophomores, who are at a critical stage in exploring their academic and professional interests.

Since it is estimated that the United States will need about 400,000 new engineers each year to fill all necessary jobs [10], it is even more important that mentoring programs exist to increase persistence in Engineering fields. This talent shortage can only be addressed by ensuring that every student, regardless of their background, has a fair shot at becoming an engineer and learning which career paths are possible for them with an engineering degree. One of these careers paths includes the pursuit of an advanced degree of higher education to further develop the highly skilled workforce of tomorrow. Therefore, undergraduate students should have fair representation in graduate education and the freedom to study and pursue knowledge in engineering related fields.

Specifically, our study seeks to explore the following research questions:

- **RQ1**. What are the specific benefits and limitations of each Early Discovery program format?
- **RQ2**. What are the educational outcomes of students who participate in Early Discovery? Which program format had the largest percentage of participants pursue graduate study?
- **RQ3**. What are the educational interests of students who apply to Early Discovery? Does Early Discovery reach students who have never considered graduate school, or serve to reinforce an existing graduate school interest?

This paper provides longitudinal data of the impact of different program formats to engage freshman and sophomore level students, and it provides important aspects for professionals to consider when planning to engage younger students to think about Graduate School.

Methods

Ethics Statement

Methods were approved by the Purdue Human Research Protection Program and Institutional Review Board (IRB), and all surveys were completed in accordance with relevant guidelines and regulations. IRB: IRB-2025-179; Assessing Student Feedback from the Early Discovery Program

Population

One of the goals of the host institution and program is to develop the largest, best prepared and most diverse talent pool in the nation, and therefore it is important a goal of the Early Discovery program is that it functions to demystify graduate education for students. Therefore, Early Discovery is focused on offering equal opportunities for success and is open to all students, regardless of race or ethnicity, who have demonstrated a commitment to broadening participation in engineering.

To understand who participates in the Early Discovery program, we evaluated the number of students who participated in each year since 2017. Early Discovery has engaged 185 undergraduate students, with an average of 23 students per year, varying based on program format and delivery mode (Fig. 1). The Early Discovery program focuses on preparing U.S. Citizens and Permanent residents who are at the freshman and sophomore level (or at least 2 years away from graduation) for graduate study and research. Early Discovery participants come from Purdue University as well as other universities across the United States and Puerto Rico. The participant selection process has varied based on program format and year and is described in the *Program framework and implementation* section for each of the three program formats below.

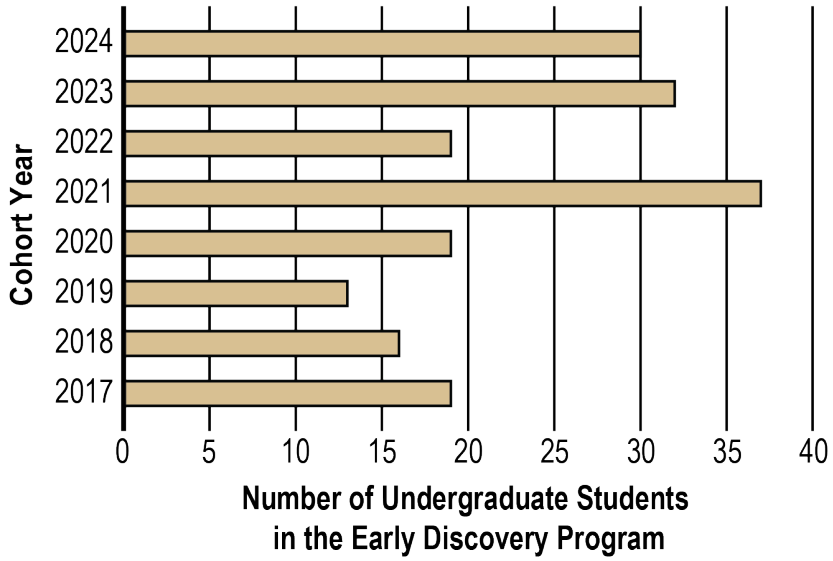

Figure 1. Number of Early Discovery participants over program lifespan (2017-2024).

Research Methodology
Data was obtained through voluntary application surveys and post-program surveys of Early Discovery participants from 2017 to 2024. Post program surveys were collected without identifiers, with no way to link the survey back to individual participants. The data was collected for internal program evaluation and assessment reasons to assess the feedback of each year's program. In early years, feedback was gathered informally through short surveys, allowing for open-ended input. As the program evolved, more consistent surveys were distributed to participants for feedback.

In addition to end of program surveys, LinkedIn and Google were used to track program participants over time and determine the Early Discovery participant career outcomes. One limitation of tracking students in this way is that many younger students do not have an online presence and institutional email addresses often become inaccessible after graduation. To address this, we have started asking for an alternative email address on the application for survey purposes.

Participants who were currently (or had previously been) enrolled in a master's or doctoral program were classified as "Attended Graduate School." If no current information could be found (LinkedIn was out of date, no online presence, no replies to email surveys, etc...) then the student was categorized under the "No Data" label. Students who were still in their undergraduate studies were marked as 'Not Graduated and still in Undergraduate Studies." This information was retained in an excel tracking document by the host institution.

Since the study encompasses the last 8 years, it is possible that a student had pursued a graduate degree, graduated and now is working in their field. For data reporting purposes, these students are characterized as "Attended Graduate School" to indicate that they pursued a graduate degree at some point after participating in Early Discovery.

Visualization of Student Feedback
To visualize the eight years of student feedback, word clouds were created. Word clouds serve as a graphical representation of text data, making it easier to identify key themes. First, participant feedback data was collected from end of program surveys from 2017 to 2024. This data included student experiences, feedback on program sessions, and suggestions for improvement. Next, feedback was separated by years (2017-2019, 2020-2023, and 2024) based on the different Early Discovery program formats and input into Open AI software (ChatGPT), with the command of identifying the most frequently used words. These frequently used words were inserted into a word cloud generator website (https://www.freewordcloudgenerator.com/) to visually represent these terms. The final word cloud result provides a visual of the student feedback and key takeaways from their experiences.

Results and Discussion

The three different Early Discovery program formats have their own goals, frameworks, benefits, and limitations (RQ1)
To determine which Early Discovery program format was the most engaging to students and produced the most students to go on to pursue a graduate degree, we conducted a review of the

benefits and limitations of each program format. This functions to determine the program format most helpful in preparing freshman and sophomore level undergraduate students for graduate school.

Format 1 | On campus visitation program

Goals and context: The first format of Early Discovery was originally called "Early Pathways," and the goal of this program was to increase the interest of younger minority students to go into faculty careers. The contextual setting of the program from 2017 to 2019 was that this program was initiated as part of a Diversity Transformation Award (DTA) by Purdue University.

Framework and implementation: To prepare the students early for faculty careers, there was an on-campus visit where small groups of students (2–6) traveled with at least 1 faculty member from a partnering Minority Serving Institution (MSI) to the host institution. The host institution paid for all travel expenses and participants were selected by the faculty from the visiting institution. The visit itself included sessions on "Why become a faculty member," tours of research labs, graduate student panels, and presentations about graduate school.

Benefits: For many participants, this was their first experience traveling by airplane or leaving their home state. The 2-day on campus visit had many benefits to the participants, including tours of campus and research facilities, graduate student and faculty panels, discussion of the importance of graduate school, networking opportunities, and a presentation on why they might consider a faculty career. The in person visit had the benefit of connecting students directly to campus and allowing for direct communication and relationship building with the Purdue University community (Table 1).

Limitations: Despite its benefits, this format presented challenges related to size, scalability, and participant selection. Program size was limited due to the significant budget required to fund travel for students and faculty, with only 3–5 partner institutions participating each year and bringing 2–6 students each (Fig. 1; Table 1). Since the host institution paid all travel expenses, there was a limitation to the number of participants, and the host institution required significant financial commitment in order to sustain the program. Additionally, since participant selection relied on faculty members at the visiting institutions, who often struggled to identify younger students interested in graduate school or faculty careers. There were sometimes participants who were selected to visit and had little interest in attending graduate school at all. In addition, since the program was geared towards preparation for faculty careers, there was little intentional focus on research, besides tours of facilities and anecdotes from panels (Table 1).

Student Feedback: To best visualize student feedback, Word Clouds were generated to include frequently mentioned terms about student experiences on the end of program surveys for each year. These post-program surveys suggested that participants were appreciative of lab tours and found them informative and engaging. Participants appreciated faculty and student panels for their unique insights and relatable stories, and networking opportunities with faculty and graduate students were also seen as beneficial (Fig. 2A). Feedback from participants also highlighted areas for improvement, such as incorporating more breaks into the schedule, providing opportunities to explore more of the campus, and offering greater detail about the graduate application process. These suggestions were seen as ways to enhance the program's effectiveness and impact.

Table 1. Benefits, Drawbacks and Focus of the Early Discovery program from 2017 to 2024.

Cohort year	Format Mode of delivery	Focus	Benefits	Drawbacks
2017 2018 2019	On-campus (2 days) Small groups visit campus from select schools with 1 faculty member	Preparation for Faculty Careers	• First-time traveling for many students • Insight into campus life and culture • Tours of campus and facilities • Networking opportunities • Direct communication and relationship building with current graduate students and faculty • In person panel discussions and meetings • Cohort structure	• Logistical Challenges: expensive to travel (paid by host university) • No intentional focus on research • Limited number of students that can be supported (not scalable) • Visiting universities select student attendance • Student selection for interest in graduate school is sometimes difficult to determine as freshman and sophomore • Requires significant financial commitment
2020 2021 2022 2023	Online mini-conference (1-2 nights) Panels, Workshops, Group Sessions in Zoom meeting	Preparation for Graduate School and Research	• Ability to log on anywhere (accessibility) • Cost effective • Provides flexibility • Ability to engage more students online • Ability to Scale • Increased networking opportunities as students are from all over the country • Some years, incorporated virtual space community building (Gather.town), which provides exposure to new technology	• Online format – students not physically able to be on campus and make connections • Distractions and engagement • Technical challenges • Time zone constraints • No cohort structure
2024	Online mentoring circles (3 nights) Short Discussion and then breakout into mentoring circles (2 mentors; 4-6 mentees)	Preparation for Graduate School and Research	• Ability to log on anywhere (accessibility) • Cost effective • Provides flexibility • Ability to engage more students online • Ability to Scale • Increased networking opportunities as students are from all over the country • Mentoring circle allows connection to new mentors (and peers!) from across the country • Multiple university perspectives from mentors • Increased customized mentorship options • Cohort structure	• Online format – students not physically able to be on campus and make connections • Distractions and engagement • Technical challenges • Time zone constraints • Group mentoring circles might mean limited personal connections

Format 2 \| Online Mini-Conference Program

Goals and context: The second format of the Early Discovery program from 2020-2023 was an online mini-conference that ranged from one to two nights (Table 1). This shift was prompted by the COVID-19 pandemic, which made in-person travel under the first format of the on-campus visitation program impossible. This gave program organizers an opportunity to re-evaluate the purpose, benefits, and intended outcomes of the program. Also, administrators started to notice that many of the students who visited in the first program format were not interested in faculty careers, let alone research or graduate school. Therefore, the focus of the program shifted more intentionally to the goal of demystifying the preparation for graduate school and research.

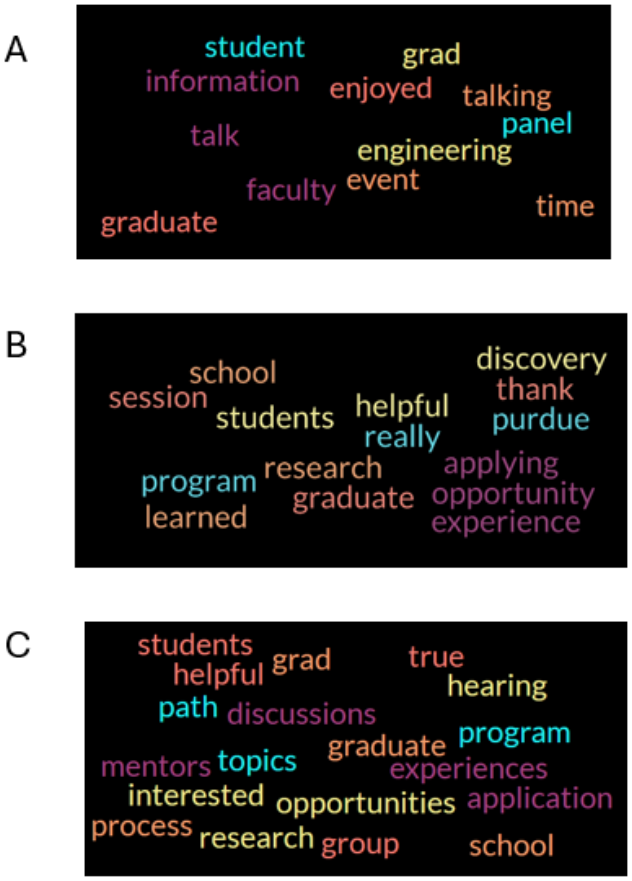

Figure 2. Undergraduate Student Feedback highlighting Early Discovery participant experiences throughout program evolution (2017-2024). Years are separated based on different program formats during (4) 2017 - 2019 (on campus visit), (B) 2020 - 2023 (online mini conference), and (C) 2024 (online mentoring circle program). Word Cloud includes frequently mentioned terms on end of program surveys about student experiences as well as other feedback about program suggestions.

Framework and implementation: This format of the program was opened to all U.S. Citizens and Permanent Residents in the United States and Puerto Rico who were at least 2+ years from graduation and interested in pursuing an engineering graduate degree. The application process was updated to be an open call for all undergraduate students, especially those from our previous partner institutions. Students applied directly to the online mini conference by using a Qualtrics application, and applications were reviewed by the host institution. Zoom was used for virtual programming, which included presentations about graduate school, graduate student panels, and virtual tours of research facilities. Presentations included topics like developing a statement of purpose, handling impostor syndrome, networking with faculty, etc...

Benefits: The benefits of the online mini-conference program format were consistent with many of the same themes that occurred in the previous in-person visitation format, including the development of virtual laboratory, facilities and building tours. Unlike the in-person format, which relied on faculty recommendations, the online format allowed a broader range of students

to join, lowering barriers to participation and expanding access to key elements of graduate school preparation. This also increased participant numbers as well as accessibility and flexibility for participants, as they could log in from any location with a reliable internet connection. A benefit was the implementation of new technology that emerged during the COVID-19 pandemic. For two years of the early mini-conference format there was the incorporation of virtual space communities, such as Gather.Town, to try to add more of the cohort and community to the online event. Further, the host institution was able to engage more students and scale, as an online program was much more cost effective (Table 1). Overall, the online mini-conference program format allowed us to reach more students to talk about graduate school as a next step.

Limitations: Administering a fully online program also came with drawbacks, including time zone constraints and the possibility of technical computer challenges. Further, since students were not dedicating time to travel, distractions in their home environment could potentially increase and consequentially decrease engagement. Participants also missed the opportunity to visit the campus in person, which limited their ability to assess whether Purdue University was the right fit for them and to build in-person connections with faculty and peers (Table 1). It is also important to note that the on-campus format of the program leaned heavily on having a cohort from specific institutions, and this mini-conference format lost this programmatic element.

Student Feedback: Students found the mini conference to be very helpful and informative, specifically emphasizing how they liked networking and the graduate application workshops (Fig. 2B). However, some students indicated areas where certain sessions were less relevant or difficult to engage with due to timing or differing levels of relevance to where they were in their specific stage of the process. After completing the online mini-conference program, overall participants felt more informed, engaged, and motivated to consider or apply for graduate school.

Format 3 | Online Mentoring Circle Program

Goals and context: The goal of the third format of Early Discovery in 2024 was to develop a structured and scalable mentoring community, so that younger students could connect and visualize themselves as graduate students. In terms of context, this programmatic change was implemented following the Supreme Court decision in June 2023 (Students for Fair Admissions (SFFA) v. Harvard University and University of North Carolina cases). This was during a time when universities across the country started removing community building, recruitment, and retention programming activities for minority students. Since mentoring and community building are important mechanisms for all students to demystify graduate education, the Early Discovery program was expanded to be open to all domestic students, especially those who shared their previous work in broadening participation in engineering. Community is integral to excellence and therefore the third format of the Early Discovery program was centered around community through mentoring circles. The overall curricular focus continued to be on preparing younger students for graduate school and research early in their undergraduate careers, like the mini-conference in format 2.

Framework and implementation: This format of the program was opened to all U.S. Citizens and Permanent Residents in the United States and Puerto Rico who were at least 2+ years from

graduation and interested in pursuing an engineering graduate degree. The application process was an open call for all undergraduate students, especially those from our previous partner institutions. The opportunity was open to all students, regardless of race or ethnicity, who demonstrated a commitment to broadening participation in engineering. Students applied directly by using a Qualtrics application, and applications were reviewed by the host institution.

In terms of implementation, Zoom was used for all virtual programming, which consisted of meeting for three 1.5-hour sessions in early spring 2024. Meetings were held in close proximity, with a sequence of meetings on a Wednesday and then the following Monday and Wednesday. Mentoring circles were assigned before the program started and did not change. Circles were made up of 6-8 undergraduate student mentees and two mentors. Mentors included one student who was a senior level undergraduate and the other student who was a current graduate student from the host institution. These 2 mentors and 6-8 mentees made up a mentoring circle unit that was scalable and constant.

The mentoring circle meetings focused on preparing younger students for graduate school and research early in their undergraduate careers. Each meeting followed a structured format: a 30-minute group or panel discussion on Zoom, followed by 1-hour guided mentoring circle sessions within Zoom breakout rooms. Themes for the group discussions included “Everyone is a Researcher: What Type of Researcher Are You?”, “Is Graduate School for Me?”, and “How to Prepare for Graduate School?” Mentors and mentees were also encouraged to set up at least one 1:1 meeting together outside of established meeting times.

Benefits: The program’s online structure was accessible, cost-effective, and flexible, allowing for scalability and enabling participation from diverse geographic locations. Further, students could log in from all over the country so there were multiple perspectives from mentees and mentors from different universities, increasing the level of customized mentorship options. Peer mentoring also occurred between the two mentors, where the senior undergraduate mentor could learn from the graduate student mentor. Another key benefit of the Early Discovery mentoring circle structure was bringing back the cohort aspect that was the foundation of the first on-campus program format (Table 1).

Limitations: The drawbacks of the virtual format included not being able to physically be on campus, however since students were younger it enabled organizers to share information about programs that could engage them on campus in the future (summer research, graduate visitations, etc...). Another challenge could be the group-based mentoring structure, which has the potential to result in less personalized engagement (Table 1). To mitigate this, mentoring groups were kept intentionally small, ensuring stronger connections within the circles. Further, in traditional one-on-one mentoring structures, if mentors are unable to show up to a meeting, then the mentoring structure falls apart. Since the host institution has significant experience in implementing mentoring circle programs [5], [11], we have shown that there is a direct benefit to having 2 mentors in this structure - if one mentor is unavailable, then mentoring can continue with the other mentor. This is therefore a very minor limitation.
Student Feedback: Upon evaluation of student feedback, many students appreciated the opportunity to connect with peers and mentors, noting that the 1:1 mentor meetings and small group discussions were particularly impactful. Specific topics, such as tips for applications,

personal experiences shared by mentors, and advice about preparing for graduate school, were repeatedly mentioned as helpful (Fig. 2C). Many participants reported feeling more confident about pursuing graduate studies, with mentoring discussions reducing imposter syndrome concerns and increasing interest in graduate school. Students expressed feedback for the mentoring circle structure, including having even more networking opportunities, inviting people with more varied experiences for the early career panel (industry, master's versus PhD, etc...) and having deeper discussions about career paths and maintaining mentor relationships.

Overall, this new structure and feedback from students suggests that the mentoring circle structure is helpful in demystifying the graduate school process. Feedback suggests that it is a helpful first step to prepare students for a new career path after their undergraduate studies. It also functions as a pathway into Purdue University's summer research program and graduate school mentoring program focused on Juniors and Seniors.

One in every three Early Discovery participants pursue a graduate degree (RQ2)
A method to evaluate the effectiveness of each of the three Early Discovery program formats is to understand whether participants ultimately decide to enroll in a graduate degree. To understand what the educational outcomes of students who participate in Early Discovery are, we tracked the career trajectories of Early Discovery participants over specific cohort years (Fig. 3).

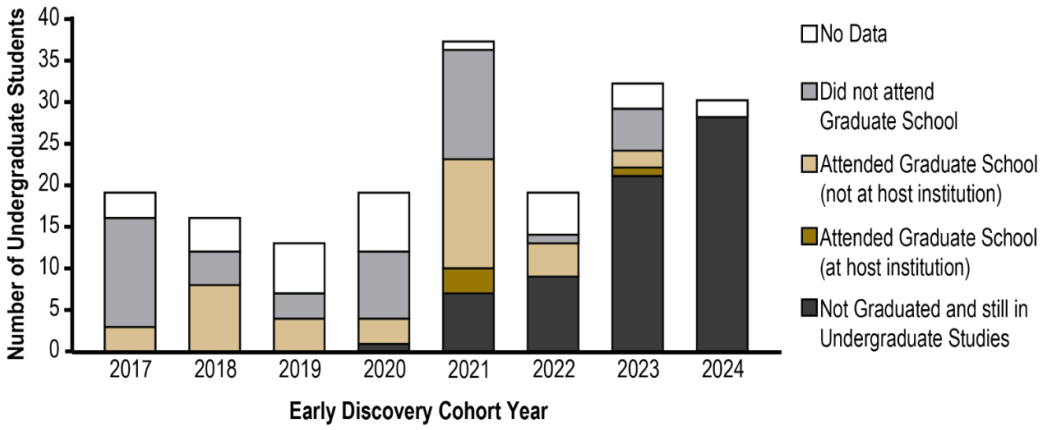

Figure 3. Tracking of Early Discovery participants after completion of the Early Discovery program over cohort years. Tracking categories include students who are still in their undergraduate studies, students who attended graduate school (either at the host institution or at another university), students who did not attend graduate school, or if there is no data on a given student.

When looking at the population of participants that are served by the Early Discovery program, many of them are freshman and sophomores. Therefore, many students in recent program years have not yet graduated from their undergraduate studies, represented by the dark grey bar in Figure 3. Over time, these students will graduate from their undergraduate institution. At this point, they move into a new category of either 1) attended graduate school at host institution (dark gold), 2) attended graduate school at another institution (light gold) or 3) did not attend graduate school (grey) (Fig. 3). Unsurprisingly, many participants from the most recent cohorts

(2022–2024) remain in undergraduate studies, which aligns with the program's target audience of freshman and sophomore students (typically 2+ years from undergraduate graduation). Specifically, when we evaluate only participants who have graduated from their undergraduate studies, we find that across all Early Discovery cohort years one in every three Early Discovery Participants who have graduated from their undergraduate studies have pursued a graduate degree (34.45%; Fig. 3; Table 2). One important question is whether we identify a difference in the rate at which participants attend graduate school based on the Early Discovery year and program format that they participated in. When we evaluate a participant's career trajectory based on Early Discovery program format, we find that there is little difference between the first two Early Discovery formats in terms of graduate education outcomes. For example, 31% of participants from the on-campus visitation program (Format 1, 2017–2019) have enrolled in graduate school, compared to 38% of participants from the online mini-conference format (Format 2, 2020–2023) (Table 2).

Table 2. Total number of participants in graduate school based on Early Discovery program format

	Total in graduate School (of all graduated participants)	Total in Graduate School at host institution (of students who attended graduate school)
All cohort years (2017 - 2024)	**34.45%**	9.76%
Format 1 | On campus Visitation Program (2017-2019)	31.25%	0.00%
Format 2 | Online Mini-Conference Program (2020-2023)	37.68%	15.38%
Format 3 | Online Mentoring Circle Program (2024)	0.00%*	0.00% *

*no students have graduated from this cohort as of publication date

Students who did not attend graduate school are now working in either industry or government fields. It is also important to note that there are no Early Discovery participants who have graduated yet from the 2024 mentoring circle structure (Format 3), and therefore further study is needed to assess these student's outcomes.

The online mini-conference format has the largest percentage of participants who pursue graduate study (RQ2)

To understand which program format has the largest percentage of students attending graduate school, we evaluated the total percentage of all graduated participants who are now in graduate school over each program format type. To date, we find that the online mini-conference format has had the largest percentage of Early Discovery participants who have graduated and enrolled in graduate programs (Table 2).

To understand which graduate programs and universities Early Discovery participants decide to enroll in, we first looked at the percentage of students who decided to enroll at the host institution. Of the participants who pursued graduate education, only 10% across all cohort years

enrolled at the host institution. No students who were financially supported to travel to the on-campus visitation program (Format 1) chose to attend the host institution for graduate studies (Fig. 3 Table 2). Participants of the Early Discovery mini conference (Format 2; 2020-2023) exhibited a slight increase up to 15% in enrollments at the host institution (Table 2).

It is surprising to find that the online mini-conference format performed slightly better than on-campus recruitment visits, as historically on-campus events are thought to be favored over online to increase connections to campus. The online mini-conference also functioned as a better recruitment mechanism for the host institution compared to the on-campus visitation (Table 2). This could potentially be due to increased program size and accessibility of the online format.

Over half of Early Discovery mentoring circle applicants are already interested in graduate school before the start of the program (RQ3)

Two important questions to ask are, 1) what are the educational interests of students who apply to Early Discovery? and 2) is the program reaching new students who may have never considered graduate school before? We propose that the Early Discovery program could work in two ways: it could be exposing new undergraduate students to graduate school, or it might be reinforcing a younger student's interest in graduate school. To understand the educational interests of Early Discovery applicants, we asked on the application for the 2024 mentoring circle program, "What is your level of interest in graduate school?"

Of the 48 applicants, 58.33 % selected "I am definitely interested and plan to go to graduate school," 37.5% selected "I am considering it, but still on the fence," 2.08% selected "I really don't know, but I am excited to learn!" and 2.08% selected "Graduate school? nah- not for me!" This data suggests that the majority of 2024 applicants, who were freshman and sophomore engineering students, either planned to attend graduate school or were considering it. This indicates that Early Discovery is engaging very small numbers of students who are exploring conversations about graduate school for the very first time. Therefore, the primary audience of Early Discovery appears to be students with some prior consideration of graduate school and may not be attracting many students who have not previously considered graduate school as an option.

Early Discovery participants are more interested in graduate school after engaging in the mentoring circle program format (RQ3)

To continue to understand how the Early Discovery program might serve to reinforce a participants existing interest in graduate school, we evaluated post-program surveys of the 2024 online mentoring circle program. Our hypothesis is that if a student attends and participates in the Early Discovery program, then it will help increase their interest in graduate school.

Specifically, in the 2024 post-program surveys participants were asked, "What is your opinion about graduate school now that you have participated in Early Discovery?" In response to this question, 82% of the survey participants selected "I am more interested in graduate school" compared to 18% of students who selected "no change in interest." None expressed a decrease in interest in graduate school. This preliminary data suggests that Early Discovery is an impactful program that reinforces an existing interest in graduate school for freshman and sophomore level engineering students.

Taken together, Early Discovery functions as a strong engagement and learning program for freshman and sophomore students. This is good, and if the program can expose students to research and graduate school, then students can learn and make an informed decision to attend (or not attend) in their career exploration journey. Even if participants decide not to go to graduate school, then this program provides them with the information to make an informed decision. This is a programmatic win and is in alignment with programmatic and institutional goals to develop the largest, best prepared and most diverse engineering talent pool in the nation.

Conclusion

The Early Discovery program has an important significance in addressing major gaps including, 1) engaging students earlier in the discussion about graduate school, 2) ensuring that all people, regardless of background, have access to the knowledge needed to excel in their graduate studies and 3) addressing the talent shortage of domestic graduate students in engineering in the United States. We described the three different Early Discovery program formats, sharing benefits and drawbacks for each program format. Based on previous literature, the mentoring circles format is suggested to be the most promising [5], [11]-[13], especially for engaging younger students to then feed into other impactful programs like summer research.

It is important to note that assessment on graduate school focused programs geared towards younger students is challenging, as there are not immediate results like engaging senior level students. This fact reinforces the impact and importance of this particular study over 8 years. Evaluating program efficacy often requires time (at least 2-4 years) to observe whether a program is achieving its intended effects. The data presented here suggests that engaging with students early is helpful. Surprisingly, we show that on campus and online programs had similar successes in the context of engaging younger students, with the online program having more participants attend graduate school, compared to the on-campus program (Table 2). This suggests that universities might not need to use as much budget to bring younger students to campus and can engage some prospective graduate students in an online setting.

Early Discovery functions as a strong reinforcement program, increasing the number of "touch points" for participants who are already interested in graduate school. In the future the host institution plans to continue the program and explore the possibility of collaborating with other peer institutions to expand Early Discovery further and increase student impact. Since few programs exist to broadly serve freshman and sophomores across the country (regardless of university affiliation), a collaborative approach with multiple universities could be impactful. This would ensure that all engineering students in the Unites States, regardless of their background, can gain exposure to graduate school and engineering career paths [10]. Future study should also evaluate additional experiences of participants through more in-depth surveys, focus groups, and interviews. Engaging with Early Discovery participants who have now entered graduate school could provide deeper insights into how the program shaped their paths, what challenges they faced, and what aspects of the program were most beneficial.
Over the past eight years, the Early Discovery program has engaged almost 200 undergraduate students through three distinct program formats, with the focus on promoting research experiences and graduate school. On average one of every three Early Discovery participants (34%) enroll in a graduate program, a result that is slightly greater than the national average at

20-30% of all engineering undergraduate students [14]. The experiences and reflections shared here on the three program formats provide a foundation to increase access to graduate education through sustainable programmatic structures, including centering the current program format on community building through mentoring. Understanding programmatic nuances will not only inform administrators but also has the potential to increase the achievement of all undergraduate students, especially students from different backgrounds.

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