

Teaching and Educational Methods

Engaging Undergraduate Students in Research: From Cross-Discipline Programs to Published Articles

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Abstract

This paper discusses the effective integration of undergraduate students into research, ensuring mutually beneficial outcomes for students, faculty, higher education institutes, and society at large. Student candidates are identified through a screening process leveraging the existing institutional resources and programs. Selection criteria, including minimum grade point average (GPA), strong writing skills, and achievements in challenging quantitative courses, are employed. Once a suitable candidate is identified, research collaboration commences. We work with the student to identify a topic aligned with our projects that piques their interest and curiosity, while ensuring feasibility within the timeframe. Subsequently, we invest a month or two in guiding the student through relevant literature, building a comprehensive understanding of the chosen subject matter. As the research question evolves, we assist the student in mastering the necessary tools and methods, providing relevant programming code or directing the student to specific knowledge domains. The structured approach mirrors the collaboration with graduate students. We deliberately avoid limiting our selection to specific disciplines, promoting diversity in student engagement. This exposure broadens their understanding of applied economics research and enriches the educational experience for both students and faculty mentors. The result is the cultivation of cross-disciplinary programs that contribute to the growth and development of undergraduate research.

1 Introduction

Undergraduate research has gained increasing prominence as a feature of the higher education experience in the United States (Ambos 2020). The Council for Undergraduate Research (CUR) defines it as “a mentored investigation or creative inquiry conducted by undergraduates that seeks to make a scholarly or artistic contribution to knowledge.”¹ According to CUR, this form of engagement is fundamentally a pedagogical approach to teaching and learning, emphasizing the education benefits derived from scholarly and creative inquiry at the undergraduate level. Given the diverse disciplines in higher education institutes, encompassing humanities, social science, physical and life sciences, mathematics, engineering, and the arts, each field presents unique demands and opportunities for engaging in such activities. Yet, a shared consensus emerges; undergraduate students typically need more training, support, and guidance than their graduate counterparts. Integrating undergraduate students into research requires planning and preparation (Webber, Nelson Laird, and BrckaLorenz 2013).

This study presents a student-centered approach that capitalizes on available resources in higher education institutes to cultivate successful undergraduate research experiences. By recruiting talented undergraduate students, this approach advances their education and knowledge, while concurrently being

¹ <https://www.cur.org/about/what-is-undergraduate-research/#:~:text=With%20an%20emphasis%20on%20process,or%20artistic%20contribution%20to%20knowledge.>

beneficial to the university and faculty involved. Utilizing undergraduate programs, we identify undergraduate students who are eager to participate in research, some of whom may be part of initiatives targeting historically underrepresented student groups, fostering diversity and inclusion. We leverage these programs to recruit students with different backgrounds and study different disciplines. Indeed, we intentionally avoid confining the selection process to specific disciplines, encouraging cross-disciplinary collaboration and learning. Other selection criterion we have employed include a minimum GPA, strong writing skills, and a track record of achievements in challenging quantitative courses.

Engaging in discussions with students to identify research questions that captivate their interests and aligning these questions with our own research has proven to be both useful and productive. After identifying the ideal candidates, we embark on a collaborative journey, where we work closely to refine research topics within students' capabilities and designated timeframes. We dedicate a month or two to guide students through relevant literature to enrich their understanding of the research topic and identify tools and methods essential for the research that students must learn and master. While these techniques might not directly correlate with the students' prior academic pursuits, they are selected to be attainable within a relatively short span of time—a few months. In this process, we may expedite the learning process by providing coding resources or directing the student toward specific areas of knowledge.

This dynamic collaboration supports undergraduate students in carving out a promising trajectory, mirroring processes undertaken with graduate students. Involving students from diverse disciplines broadens their understanding of applied economics research and enriches the educational experience for both students and faculty mentors. The result is the cultivation of cross-disciplinary programs that contribute to the growth and development of undergraduate research.

The remainder of this paper unfolds as follows. Section 2 elaborates on the benefits of undergraduate research to students, faculty mentors, higher education institutes, and society at large. Section 3 offers an in-depth discussion of the process of engaging undergraduate students in research. Section 4 concludes the paper.

2 Benefits of Engaging Undergraduate Students in Research

In this section, we elaborate on potential benefits of engaging undergraduate students in research to students, faculty mentors, higher education institutes, and society at large (see Figure 1). Recognizing these benefits can foster student-faculty interaction and advocate for increased institutional resources dedicated to undergraduate research initiatives.

2.1 Benefits to Undergraduate Students

The existing literature presents a diverse spectrum of advantages for undergraduate students engaged in research, as outlined in Figure 1. Engagement in undergraduate research not only enriches the overall educational experience (Russell, Hancock, and McCullough 2007), but also cultivates intrinsic motivation for expanding one's learning (Lopatto 2007). Moreover, a notable correlation emerges between participation in undergraduate research and improved academic performance, as evidenced by GPA (Maton, Hrabowski, and Schmitt 2000) and increased academic achievements (Cole and Espinoza 2008), ultimately contributing to an increased graduation rate (Maton et al. 2000; Barlow and Villarejo 2004; Jones, Barlow, and Villarejo 2010).

Furthermore, the undergraduate research experience hones critical thinking skills (Bauer and Bennett 2003; Kuh et al., 2007; Lopatto 2007), and fosters cognitive growth that enhances self-efficacy and confidence levels (Hunter, Laursen, and Seymour 2007; Russell et al. 2007; Ashcroft, Blatti, and Jaramillo 2020). This experiential learning nurtures proficiency in discussing research findings, delivering compelling research presentations, and applying ethical principles conscientiously (Junge et al. 2010), aligning with the skills highly sought by employers of recent college graduates entering the workforce (McClure-Brenchley, Picardo, and Overton-Healy 2020).

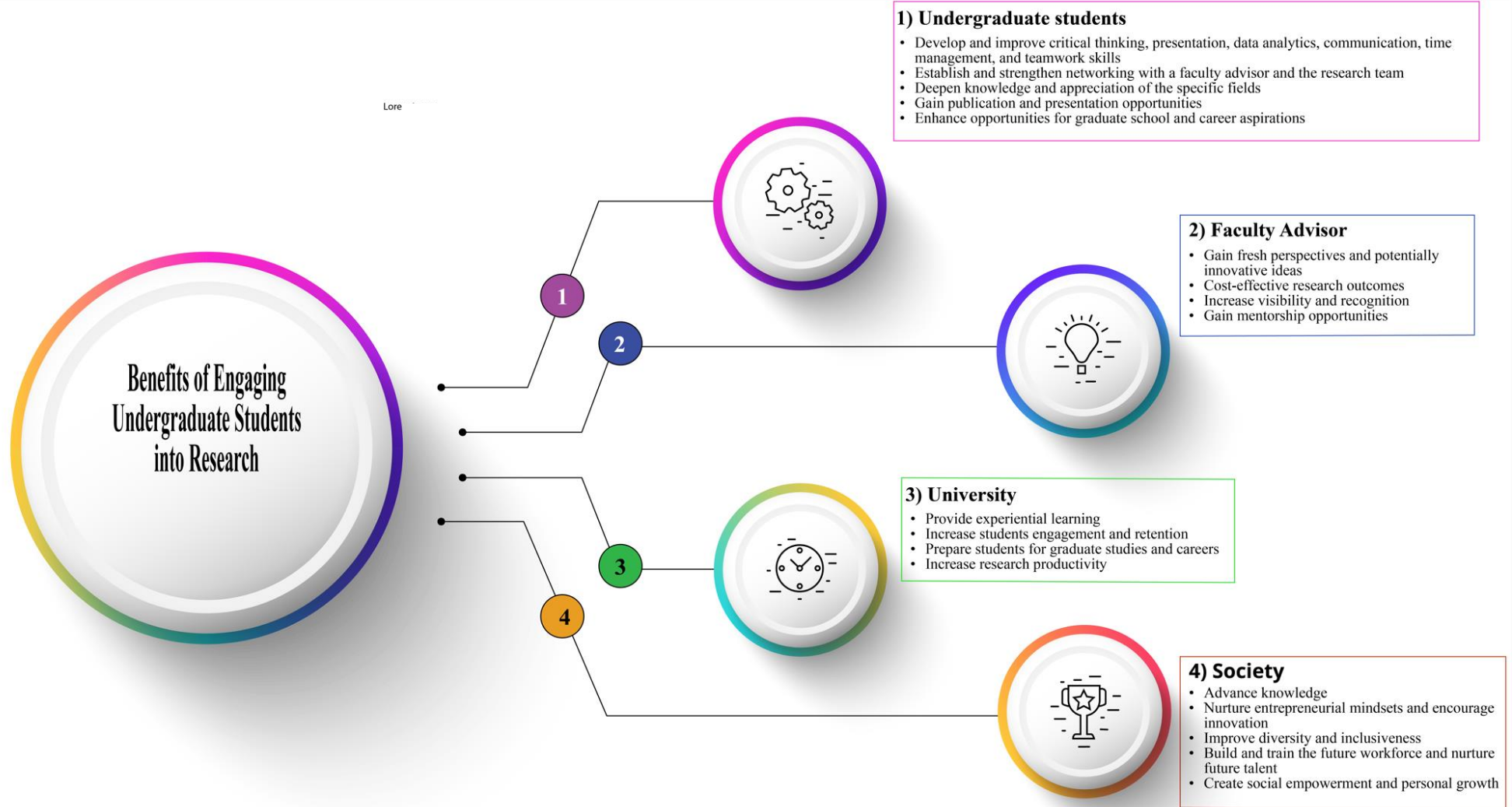


Figure 1: Benefits of engaging undergraduate students in research

Undergraduate researchers exhibit a distinct inclination toward pursuing advanced degrees, setting them apart from their non-research peers (Hathaway, Nagda, and Gregerman 2002; Bauer and Bennett 2003; Maton and Hrabowski 2004; Summers and Hrabowski 2006; Lopatto 2007; Russell et al. 2007; Blanton, Taraban, and Blanton 2008; Jones et al. 2010; Eagan et al. 2013). This inclination, stemming from an enhanced sense of fitting into the scientific community and discipline (Ryder, Leach, and Driver 1999), motivates them to pursue advanced studies and enhances their competitiveness in graduate program applications. The scholarly publications resulting from undergraduate research further amplify these benefits (Morales, Grineski, and Collins 2017).

Benefits extend to positively influencing job applications and career choices. Immersion in research offers students a deeper insight into the demands and day-to-day intricacies of conducting research, effectively facilitating socialization into the professional world (Lopatto 2004; Hunter et al. 2007; Russell et al. 2007). Consequently, this comprehensive understanding better equips students with the preparation demanded by professional pursuits (Ashcroft et al. 2020).

The advantages of undergraduate research extend well beyond graduation, as indicated by alumni surveys conducted by Bauer and Bennett (2003). These surveys show significant gains in science, math, logic, and problem-solving skills, as well as proficiency in literature, language, and mastery of context-related skills. These skills, highlighted by the National Association of Colleges and Employers (NACE; 2019; 2023), are highly sought after by employers. Furthermore, students with research experience or internship experience have advantage in their employability, as reported by NACE (2019; 2023). Engaging in research enhances employability, helping students develop qualifications, competencies, and connections that make them more desirable to employers (Carpenter et al. 2022).

The benefits of undergraduate research extend beyond research activities, including meaningful and evolving relationships that students build with their faculty mentors. These relationships significantly impact personal and professional development, fostering increased confidence and heightened competency, and shaping students' perception of themselves, their academic community, and their expectations for post-graduation endeavors (Davis and Jones 2020).

In summary, the benefits of undergraduate research extend far beyond the academic realm, positioning students for a more enriched educational journey and fortifying their pathway into subsequent professional and scholarly pursuits and being more marketable in the workforce.

2.2 Benefits to Faculty Advisors

While the benefits of undergraduate research for students are well documented, there is a paucity of research on the benefits for faculty mentors (Morales et al. 2017). Given that faculty engagement is a significant predictor of student participation in undergraduate research (Webber et al. 2013) and profoundly impacts students (Lopatto 2010), it is important to examine the rationale and effects of involving students in research.

Many faculty members genuinely aspire to influence the careers of young scholars (Zydney et al. 2002a). They firmly believe that research experiences significantly contribute to the cognitive and affective development of their undergraduate proteges, fostering traits such as intellectual curiosity, comprehension of scientific discoveries, adeptness in logical and critical thinking, and the ability to synthesize information from diverse sources (Zydney et al. 2002a; Carpi et al. 2017). This inspiration catalyzes for faculty members to engage undergraduates in research endeavors.

Undergraduate contributions to research projects can potentially improve the research productivity of faculty members (Lee and Bozeman 2005). Their unique perspectives may bring fresh, out-of-the-box ideas that lead to groundbreaking advances in research, expanding faculties' horizons. This effect is amplified when the student and faculty come from different disciplines, introducing the faculty to alternative approaches. In resource-constrained environments, leveraging resources and funding provided by higher education institutes for undergraduate research can be a cost-effective strategy for faculty members to expand and advance their research programs. Involving undergraduate

students in research can potentially increase faculty-student publications (Morales et al. 2017). Peer-reviewed publications, crucial for faculty hiring, tenure, and promotion, highly value faculty-student collaborative publications during faculty evaluations.

Interactions between undergraduate researchers and faculty members foster opportunities for mutual collegiality and the development of professional relationships that benefit both (Zydney et al. 2002a; Adedokun et al. 2010; Dolan and Johnson 2010).

When faculty members engage undergraduate students in research to address complex problems, their collective efforts often result in comprehensive and impactful findings that resonate with a broader audience. The heightened visibility contributes to the research's recognition, bolsters the institution's reputation, and fosters a sense of pride among various higher education stakeholders.

Recognizing the potential to become future faculty, graduate students perceive that their involvement in guiding undergraduate researchers offers valuable mentoring and teaching experiences (Zydney et al. 2002b; Dolan and Johnson 2010). This unique dynamic enriches their academic journey and equips them with essential skills for their future roles.

2.3 Benefits to Higher Education Institutes

A positive image of a higher education institute is a valuable intangible asset, setting the institute apart within a competitive landscape. This distinction captures the attention of prospective students and their families, while aiding in student retention. Topor (1986) introduces a framework of four essential factors—research, recognition, repetition, and recollection—to establish and enhance institutional reputation in higher education. Within this framework, the integration of undergraduate research plays an important role in positively impacting these four elements.

The existing literature indicates a positive correlation between undergraduate research and various academic and personal development aspects that provide experiential learning. Engagement in undergraduate research positively influences research productivity (Maton et al. 2000; Barlow and Villarejo 2004; Jones et al. 2010). Moreover, student participation in undergraduate research is positively associated with the retention of students, both within institutions and their perspective disciplines (Nagda et al. 1998; Cole and Espinoza 2008; Eagan et al. 2013). The advantages extend to the institutional level, benefiting schools and universities through improved academic performance, improved student retention, and increased graduation rates (Maton et al. 2000; Barlow and Villarejo 2004; Jones et al. 2010; Chang et al. 2014), as well as improved employability of students (Carpenter et al. 2022; National Association of Colleges and Employers 2019). Additionally, alumni who have participated in research demonstrate greater overall satisfaction than those without research experience (Bauer and Bennett 2003). This stratification among alumni not only bolsters the institution's reputation but also has the potential to increase endowments through gifts and donations.

Furthermore, our approach to leveraging the existing resources at the different levels of higher education institutes actively involves undergraduate students in research. This contributes to the cultivation of grantsmanship, further augmenting the institution's ability to secure funding opportunities. On the other hand, various government agencies provide financial support for undergraduate research, such as National Science Foundation (NSF) prominently through the Research Experience for Undergraduates (REU) program, the Department of Agriculture through its Research and Extension Experiences for Undergraduate (REEU) program within the Education and Development (EWD) program, the National Institutes of Health (NIH), and the Department of Education.²

² NSF's REU program: <https://www.nsf.gov/crssprgm/reu/>; USDA's Education and Workforce Development (EWD) Program: <https://www.nifa.usda.gov/grants/funding-opportunities/agriculture-food-research-initiative-education-workforce-development>; NIH's Undergraduate Scholarship Program (UGSP): <https://www.training.nih.gov/research-training/pb/ugsp/>; and Department of Education's undergraduate scholarship: <https://studentaid.gov/understand-aid/types/scholarships>.

2.4 Benefits to the Society

Engaging in research not only contributes to the existing body of knowledge but also propels the frontiers of understanding. Through rigorous investigation and research, researchers, including undergraduate students, actively contribute to the expansion of knowledge, creating a foundation for future discoveries.

Undergraduate research also provides opportunities for young talents to tackle some pressing issues that societies face and offer potential solutions to challenges, including public health crises, environment sustainability, and socioeconomic disparities. Engaged research should encompass undergraduate involvement, transforming fundamental knowledge into solutions for pressing societal issues (Whitmer et al. 2010). Involving undergraduates in research also contributes to the dissemination of research outcomes. Their fresh perspectives and insights can lead to novel ways of presenting findings, translating complex concepts into accessible language, and enhancing research outreach to a broader audience and the public.

Undergraduate research fosters a spirit of curiosity and exploration that aligns closely with entrepreneurship and innovation (White et al. 2013; McKellar 2020; Vaidyanathan et al. 2020). By engaging in research, students learn to identify gaps in existing knowledge, develop creative solutions, and test unconventional hypotheses. These skills not only enrich academic experiences but also lay the groundwork for future entrepreneurial ventures and innovative endeavors.

Engaging undergraduates in research provides them with essential skills and practical experience that aligns with the demands of the future job market (Vaidyanathan et al. 2020). Therefore, institutions contribute to building a capable and adaptable workforce ready to tackle complex challenges. On the other hand, participation in research empowers students to make meaningful contributions to society, boosting their sense of purpose and impact. The journey of personal growth can potentially equip them with the tools to positively influence their communities and the world at large.

Integrating undergraduate students into research can contribute to fostering diversity and inclusiveness in academia, research fields, and future workforce (Nonnemacher and Sokhey 2022). For example, we leverage the existing undergraduate programs focusing on research at the school and university levels, where diversity and inclusiveness are always emphasized. Encouraging students from diverse backgrounds to participate in research promotes a broader range of perspective, ideas, and problem-solving approaches, contributing to a more comprehensive understanding of complex issues and ensuring a wider array of voices are heard. It helps build the capacity needed in underserved and underrepresented communities.

In essence, involving undergraduate students in research creates a ripple effect that extends to society's betterment through knowledge advancement, innovative solutions, and the cultivation of a capable future workforce and leaders.

3 The Journey of Engaging Undergraduate Students in Research

An indispensable element in the successful execution of undergraduate research is the presence of adept and influential faculty mentors (Linn et al. 2015). Will-directed faculty guidance significantly contributes to the positive outcomes of undergraduate research endeavors (Russell et al. 2007). Among the pivotal components supporting undergraduate research, meticulous planning and thorough preparation stand out (Webber et al. 2013). From the perspectives of a faculty mentor, we delve into the narrative of involving undergraduate students in research (Figure 2), with a specific focus on insights within social science.

Initial pool of students

University multi-disciplinary programs.

Initial point : The undergraduate students

2) Topic selection

- Discuss with student, and help identify a well-defined and focused research question
- Use the literature
- Help student identify a topic feasible in terms of timing, skill sets, and planned deliverables

02

Topic selection

1) Screening

- Student demonstrates curiosity and thirst for knowledge
- Student exhibit entry-level skills in writing, quantitative, and critical thinking

01

Screening

3) Tool kit

- Use past research and existing literature to guide the student of the tools used
- Mentor student and help the learning of new tools that are more appropriate
- Team up new students with more experienced students

03

Tool kit

4) Research plan

- Design the required and planned deliverables
- Target publication outlets
- Motivate students to work with experienced student

04

Research plan

Outputs

Student outputs

- Professional development

Academic outputs

- Publications
- Posters
- Presentations

Figure 2: The procedure to guide undergraduate students in active and productive research

3.1 Identifying and Screening Candidates for Undergraduate Research

3.1.1 Leverage University Programs to Identify Candidates for Undergraduate Research

Many higher education institutes actively promote undergraduate research through a variety of programs. Take Rutgers-New Brunswick as an example. First, the Honors College is a unifying platform that brings together undergraduates from all schools, integrating research into the student experience. This commitment manifests in various ways, from the interdisciplinary first-year mission course (Forum) to the culmination of specialized, faculty-supervised Capstone projects in the senior year.

Second, Rutgers University offers a spectrum of campus-wide signature programs, each providing unparalleled opportunities for undergraduates, including Aresty Research Center, RISE at Rutgers, Ronald McNair Scholars Program (RMSP), Louis Stokes Alliance for Minority Participation (LSAMP), Innovation, Design, and Entrepreneurship Academy (IDEA), and the Undergraduate Research Writing Conference (URWC).³ These programs cater to various student cohorts with their distinct focuses.

The Aresty Research Center, established in 2004, has already collaborated with more than 2,000 students and 1,500 faculty, contributing approximately \$2.2 million to support undergraduate research endeavors. Through Aresty, undergraduates across disciplines and backgrounds engage in scholarly research under faculty mentorship and showcase their findings at the university-wide annual symposium.

Case Study: The Process of Selecting Undergraduate Students for Research Projects through the Aresty Research Center at Rutgers University

One of the university's undergraduate research programs, Aresty, ask its faculty to write short summaries of their research topics and projects, which are then circulated to students through the program. Students interested in becoming Research Assistants (RAs) explore these summaries written by faculty from multiple disciplines. They then decide which projects to apply to. The selection process emphasizes the importance of a strong GPA, proficiency in quantitative courses, and English language skills.

Selected students are interviewed by the faculty and evaluated based on the criteria discussed in the solicitation. If deemed qualified, the program facilitates matching students with appropriate projects. However, the final decision on the match is a collaborative one, requiring agreement between the student and the faculty. In addition to gaining research experience, the selected students also earn research credit through the Aresty program.

Following the matching process, the faculty organizes an introductory meeting with the selected student to understand his/her interests, strengths, and backgrounds. This initial assessment informs the development of a well-defined research question for the student.

Once the research question is identified, the faculty provides necessary resources and tools, such as selected papers in the related fields, possible data sources, and readings of potential methodologies. These resources help the student conduct a more extensive literature review and learn various methods to address the identified research question. The faculty also assists the student in writing software codes or teaching statistical software, as needed.

The faculty encourage students to engage collaboration and knowledge-sharing among students working on similar research questions or projects. This approach not only fosters independent and interdependent learning, but also potentially leads to the combination of their work

³ Details can be found at <https://newbrunswick.rutgers.edu/undergraduate-research>. Last access on November 10, 2023.

Case Study continued.

into more comprehensive and complementary projects.

To help the students manage their time effectively and meet the program's deliverables, the faculty also sets milestones throughout the year, with regular weekly or biweekly meetings between the faculty and the students. Group meetings occur twice a semester, particularly if students are collaborating on a joint project.

As the project progresses, the faculty guide students through the process of presenting their findings. This may involve creating a poster or preparing a peer-reviewed paper, depending on the outcomes and their quality, as well as the program's requirements. Overall, the structured approach of the Aresty program provides students with valuable research skills and hands-on research experience in their chosen field.

RISE, a nationally renowned ten-week residential summer program, invites outstanding undergraduates from diverse backgrounds to engage in pioneering, interdisciplinary research guided by carefully matched faculty mentors. The federally funded RMSP prepares undergraduates for their doctoral studies by immersing them in essential research and scholarly activities.

The IDEA empowers undergraduates to confront complex societal challenges through research, design initiatives, and entrepreneurial activities. The URWC showcases exceptional research projects that undergraduates complete within Rutgers's writing program courses.⁴

Some programs, such as the Douglass Women in Science and Engineering (WiSE) program, specifically target underrepresented women students in science and engineering where there is a historical and continued gender disparity at the university level and in the workforce.⁵ LSAMP provides research opportunities to students from historically underrepresented groups who wish to enter non-medical STEM professions.⁶

Third, Rutgers-New Brunswick features distinct Honors Programs within each school, tailored to meet the unique needs of students within that specific school. These school-based honors programs not only cater to academic enrichment but also offer research opportunities for undergraduate students. For example, the School of Biological and Environmental Science (SEBS) provides its honor students with early exposure to research experiences. Many of these students demonstrate their research capability and skills by completing a Gorge H. Cook Honors Thesis.⁷ The George H. Cook Scholars Program, specifically designed for SEBS undergraduates, is an independent research and senior honors thesis program. Participating students engage in original basic and applied research in the field they choose, guided by an approved advisor. Project planning commences no later than the end of the second semester of the junior year, culminating in the presentation of results through a written thesis and an oral presentation at a research symposium during the second semester of the senior year.

Each of these programs at Rutgers has unique eligibility criteria and dedicates funding to support undergraduate research. It is worth mentioning that other land-grant universities offer comparable programs. Students who participate in these programs often develop strong bonds with faculty mentors, forged in the intimate settings of seminar-sized honors-designated courses (Kinkead 2003). The

⁴ The Rutgers Writing Program provides instruction in writing, utilizing inclusive and responsive forms of pedagogy, to support students in their writing and thinking at the university and beyond. Details of this program can be found at <https://wp.rutgers.edu/>. Last access on February 3, 2024.

⁵ Details of WiSE are provided at <https://douglass.rutgers.edu/wise>. Last access on November 10, 2023.

⁶ Details of LSAMP are provided at <https://newbrunswick.rutgers.edu/undergraduate-research>. Last access on November 10, 2023.

⁷ Details are provided in "General Honors Program" at <https://sebshonors.rutgers.edu/general-honors/>. Last access on November 9, 2023.

resulting familiarity, coupled with the innate motivation of these students, propels them toward scholarly research pursuits that significantly enhance their overall education experiences (Russell et al. 2007; Cole and Espinoza 2008).

3.1.2 Screening Candidates for Undergraduate Research

Undergraduate students exhibit various traits shaped by their personalities, backgrounds, and experiences. When screening candidates for undergraduate research, we seek specific qualities that potentially facilitate their engagement in research. Curiosity, represented by enthusiasm, inquisitiveness, and a thirst for knowledge, stands out as a pivotal trait. It drives undergraduate students to explore new ideas, concepts, and subjects within their academic journey. Many undergraduates set personal, academic, and professional goals for themselves, and work diligently to achieve them. Undergraduate education places a strong emphasis on critical thinking skills, leading students to learn to analyze information, evaluate sources, and develop well-reasoned arguments. Time management is another skill that students must master to balance coursework, extracurricular activities, social life, and potentially part-time jobs. Given the prevalence of group projects and collaborative assignments in undergraduate programs, students also develop effective teamwork and interpersonal skills through their academic experiences.

The transition to college often marks the first step toward independent living for many young adults, fostering a sense of autonomy and independence. This transition can be academically and personally challenging, demanding them to have the capability to adapt to new environments, interact with diverse individuals, and confront new challenges. It requires an agility in embracing changes and diverse perspective as well as resilience, as they encounter setbacks and overcome obstacles.

Whether in arts, sciences, or other fields, undergraduates often explore their creative inclinations. They may engage in artistic pursuits, innovative problem-solving, or entrepreneurial initiatives. Many undergraduates use their college years as an opportunity to discover new interests and hobbies beyond their academic studies. Proactive engagement, resource-seeking, and active participation in events are common traits among undergraduates.

Nevertheless, these traits vary significantly among individuals, and not all undergraduate students will manifest them to the same extent. Each student's unique background, experiences, and personal development shape the traits they exhibit during college. The challenge lies in effectively screening students, identifying those most likely to contribute positively to successful research outcomes.

Undergraduate students choose a major or field of study from various diverse disciplines, such as humanities, social sciences, natural sciences, engineering, arts, business, and more. They take courses in their chosen field, from introductory to advanced levels, earning credits for each completed course. Higher education institutes measure their progress through a GPA, providing a numerical representation of their academic performance.

To identify undergraduate students eager to participate in research, we employ a comprehensive screening process that draws upon the university's various cross-discipline programs. We initiate the process with students expressing interest in these programs, utilizing selection criteria such as minimum GPA, strong writing skills, and achievements in challenging quantitative courses. Importantly, we intentionally avoid confining our selection to specific disciplines.

During the screening process, we evaluate resumes and cover letters. We encourage students to ask questions and seek to identify a topic that genuinely excites them during interviews. This initial interaction allows us to grasp the student's interests, which we then align with our research projects, considering the student's background and strengths as reflected in their coursework and resume. Furthermore, we utilize resumes, cover letters, and interviews to identify traits in students that may contribute to their potential success in research experience.

3.2 Selection of Research Topics

Lopatto (2003) provides a comprehensive overview of the crucial elements of undergraduate research perceived by faculty mentors from esteemed liberal art colleges, including Harvey Mudd, Wellesley, and Grinnell. Among the top thirteen features, faculty mentors emphasize the significance of students formulating meaningful research questions that mirror their ingenuity and creativity. Furthermore, students can collaboratively brainstorm, meticulously design, and ultimately crystalize their research questions.

To guide the student in selecting a research topic, we employ two alternative approaches. First, undergraduate students can initiate the process by acquainting themselves with the ongoing research projects of their faculty advisor. This involves identifying specific areas that capture their interest and align with its overall project objectives. Second, an alternative approach involves delving into a literature review of a particular field of interest. Through this approach, students can identify research questions that resonate with their interests and the expertise of faculty advisor, establishing a mutual foundation for exploration.

In practice, during the first few meetings, the student usually conducts a literature review, and we engage in discussion to refine the research question progressively. This iterative process involves narrowing down the focus and utilizing data to pinpoint a specific topic for the year-long project. Individualized approaches are essential, as not every student follows the same path. For example, a senior student majoring in sociology had a strong interest in children's mental health. During the initial month, we guided him in formulating research questions that had not been fully explored in the literature and helped identify available data to address this research question. Conversely, in interviews with computer science or statistics students, we identified their keen interest in coding and statistical analysis. Building on these interests, we centered the project around using R software, creating projects that connected with our ongoing work. This requires the students to learn specific R packages (which we assist in identifying), gather and clean data, and perform statistical analysis.

In alignment with our commitment to fostering undergraduate research, we actively promote our research projects within our school and university, particularly through programs dedicated to undergraduate research. This strategy enables us to reach qualified students and engage them in project-based research based on their passions and the available research opportunities.

Throughout this process, we have recognized the importance of candid and iterative discussions with students. These dialogues serve as a crucible for refining research topics and create a dynamic space where questions are welcome. Furthermore, by openly debating new ideas, we foster an environment that encourages students to feel comfortable, enabling them to actively contribute their insights and perspectives.

Guiding students in their literature review is another crucial component. Encouraging them to delve into existing research enhances their understanding of the subject matter and empowers them to identify gaps, challenges, and potential pathways for their investigation. This practice gives students a sense of ownership over their research journey, propelling them to ask probing questions and seek innovative solutions.

Strategically decomposing a broader research question into manageable sub-questions is pivotal. This segmentation approach ensures that each facet of the research is attainable within designated timeframes and aligns with the evolving skill sets of the participating students. By breaking down the research questions into smaller, actionable components, we facilitate a systematic and structured approach that accommodates diverse proficiencies. This approach accompanies them throughout their research journey, creating an environment where we celebrate achievements of each stage as meaningful milestones.

To sum up, as shown in Figure 2, the fusion of interactive discussions, guided literature exploration, and thoughtful subdivision of research inquiries creates a robust framework that propels students toward comprehensive and impactful research outcomes. This systematic approach instills and

accumulates valuable research skills and cultivates a sense of purpose and accomplishment as students progress and achieve noteworthy milestones at each stage of their research journey.

3.3 Developing the Skill Set

When it comes to conducting research, students can leverage a diverse array of tools to gather information, analyze data, and present their findings effectively. We guide undergraduate students through these tools, directing them to resources that we believe will be most beneficial in addressing their research questions. This includes search engines and databases, data analysis, and visualization tools, as well as survey and research design methods.

We highly value two distinct but intertwined categories of skill set for undergraduate research. The first category encompasses learning skill sets thoughtfully curated to empower aspiring students to foster a noticeable enhancement in their research efficiency. These cover fundamental aspects such as selecting viable research topics, skillfully formulating hypotheses, literature review skills, and adeptly navigating data analysis. Additionally, these skill sets extend to time management, enabling students to balance their research commitment with academic pursuits. We guide students to strategically utilize resources such as databases, online repositories, and the wealth of prior research outcomes of faculty advisors. The publication process, often considered daunting for students, is demystified as students prepare their manuscripts and posters and navigate the peer review process. Moreover, we provide students with opportunities to polish their skills in research communication, collaboration, and dissemination through interactions with peers, attendance at professional conferences, and presentation of research findings.

The second category comprises technical skill sets specifically tailored for social science research, with data analysis techniques and programming skills standing out as paramount. Given that most university or school programs support individual undergraduates for one year, and students typically are required to complete their studies within that time frame, it is uncommon for us to recommend undergraduate students to enroll in a formal course for specific areas or skill sets. We equip undergraduate researchers with a comprehensive understanding of qualitative and quantitative data analysis techniques, along with interpretation techniques to draw meaningful findings from data analysis. To expedite students' mastery of programming skills, we encourage collaboration with more experienced undergraduates or graduate students. Additionally, we offer prompt assistance to help overcome challenges and refer students to online tutorial resources.

These learning and technical skill sets are valuable in ensuring the success of undergraduate research, and their benefits are well beyond individual research projects. We also guide students through various tools for writing and organizing drafts, from reference management tools to document creation and writing a scientific paper via Microsoft Word or LaTeX. Facilitating collaboration and communication between students and advisors, as well as among peers, is crucial. Our emphasis on using tools such as Google Workspace or Microsoft Teams enhances collaboration among students, enriching the outcomes of each project. Throughout the research process, these tools streamline tasks, organize information, and promote collaboration.

3.4 Establish Action Plans

Figure 2 presents some important action plans to ensure the success and productivity of undergraduate research. Activities fostering effective research include engaging in discussions with mentors, participating in group meetings, delving into guided research literature, documenting observations in weekly journals, and synthesizing insights to create research proposals, reports, presentations, posters, and even journal articles (Linn et al. 2015).

Students disseminate their research through conferences (Mabrouk 2009; Kneale et al. 2016; Little 2020), providing opportunities to present research findings through poster and oral presentations at

professional meetings and in research communities. In some circumstances, the research outputs led to published peer-reviewed journal articles. Such dissemination is a key facet of undergraduate research, as acknowledged by faculty mentors (Lopatto 2003). Since we leverage various programs for undergraduate students in a higher education institute, oral and/or poster presentations are often required. We find that such presentations at school and college levels, as well as in professional conferences, serve as highly encouraging and rewarding experiences for our students.

The entire process illustrated in Figure 2, spanning from identifying students to completing research projects, is iterative and dynamic. For example, a student expressed interest in exploring the impact of policy on adoption. Through subsequent meetings, we guided the student to relevant literature and facilitate the search for existing datasets, providing direction to sites where such data might be available. Once the students had a good grasp of the literature and available question, we introduced them to R packages deemed useful for addressing the refined research question. The faculty's proficiency in the topic, coupled with an understanding of how to approach and answer the question, plays a crucial role in guiding the students effectively. This iterative process ensures continuous refinement and adaptation, fostering a productive research environment for both mentors and students.

4 Conclusions

This paper presents a student-centered approach to engaging undergraduate students in research by leveraging existing resources and undergraduate programs to generate valuable outcomes for students, faculty mentors, higher education institute, and society at large. Our experience suggests that a student-centered research model stimulates students' curiosity and instills a sense of ownership, fostering a fruitful and rewarding collaborative endeavor that benefits everyone. While mentoring undergraduate students is more demanding, the rewards span dimensions and contribute to the enrichment of the work of all those involved.

In this paper, we have presented an argument that research experience facilitated by faculty members is highly beneficial for both students and faculty. These programs are also crucial in addressing societal biases by targeting underserved communities. Therefore, it is recommended to allocate additional funding to support and expand these programs, with a particular emphasis on targeting underrepresented undergraduates. It is also suggested to conduct further research to quantify and monetize the value of these programs, providing more precise guidance to funding agencies when allocating resources to diverse educational initiatives that involve undergraduates in research.

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