

The ACE Scholars Program: An Integrative Approach to Undergraduate Research Training

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Abstract

College students benefit from receiving mentoring while in college and from being engaged in professional development sessions, as both avenues help them make connections and advance their goals. Though previous research addressed the two topics separately, very little work has been done on assessing them simultaneously and much less so in an e-mentoring setting. To create community and training opportunities for a diverse body of undergraduate students, we developed an e-mentoring program that incorporates alternated sessions of scientific mentoring (e.g., design a study, create a poster) and career and professional development (e.g., graduate school strategy and applications, cultural intelligence). Our program is grounded in project and team-based learning. Our teams are led by senior undergraduate researchers, which enables students to gain both leadership and research experience before applying to graduate school.

We designed and implemented the ACE Scholars program in a research center at a large southwestern public university, where 43 undergraduate research assistants were mentored via Zoom during Spring 2022. Program evaluation was conducted using the College Student Mentoring Scale, a comprehensive tool that measures students' perceived psychological and emotional support, degree and career support, academic knowledge support, and role modeling they received in the program. Students reported receiving: psychological and emotional support (82%), academic knowledge, degree and career support (96%), and role modeling (96%). Additionally, 85% of students agreed or strongly agreed that the ACE Scholars Program, with its research experience and career and professional development components, has helped prepare them for their future endeavors. Overall, 86% of students indicated that they were extremely satisfied with the ACE Scholars Program.

The ACE Scholars Program: An Integrative Approach to Undergraduate Research Training

What does the mentoring of undergraduate students look like during a public health crisis? As the COVID-19 pandemic was shutting down the world, we, at the Arizona Cancer Evolution Center (ACE), began thinking about how to best support our undergraduate researchers and how to create a sense of community for our students during times of uncertainty and anguish. As the world pivoted from face-to-face to online environments, we acknowledged that technology-enabled mentoring, or e-mentoring, could be a powerful tool in undergraduate research training. The ACE center was faced with the unique challenge of managing remote undergraduate research mentorship while our host institution, Arizona State University, focused on transitioning to remote work and education.

Participating in undergraduate research experiences can be effective in providing holistic training in the subject field(s) relevant to a student's degree program (Crisp et al., 2017). An undergraduate student's participation in research is also critical in building valuable experiences that can serve as a pathway to professional schools and career entrance (Crisp et al., 2017). In response to the challenges presented by the pandemic, the ACE Center staff were determined to provide undergraduate students access to research through e-mentoring.

E-mentoring is defined as "a computer-mediated, mutually beneficial relationship between a mentor and a protege which provides learning, advising, encouraging, promoting, and modeling that is often boundaryless, egalitarian, and qualitatively different than traditional face-to-face mentoring" (Bierema & Merriam, 2002, p. 219). E-mentoring remains under-practiced and under-studied in higher education contexts despite its many benefits. Before the COVID-19 pandemic and even more so now, over two years after the pandemic began, e-mentoring is likely to be a viable solution to engaging and helping undergraduate students succeed. E-mentoring enables access to opportunities, removes physical boundaries, and fosters collaboration among various individuals regardless of their physical location in the world (Paudel, 2021).

How Do Undergraduate Students Benefit from E-mentoring?

Much like mentoring (in-person relationships), e-mentoring (online relationships) provides undergraduate students with invaluable benefits. Previous studies have found that students who engage in e-mentoring opportunities develop more extensive networks and have access to better career and professional prospects (Tinoco-Giraldo et al., 2020). In addition,

these students performed better academically, persisted in their studies, and graduated from college at higher rates than students who did not experience mentoring opportunities (Tinoco-Giraldo et al., 2020). Studies conducted during the COVID-19 pandemic have shown that e-mentoring provided students with social support and led to reduced anxiety and depression, increased feelings of belonging, and more opportunities to engage in research (Guse et al., 2020; Mukhtar et al., 2020; Paudel, 2021).

E-mentoring can be employed as a vehicle to help build and foster community among undergraduate students, regardless of their backgrounds and previous experiences (Huderson et al., 2021). For traditionally underrepresented students, e-mentoring can make a significant contribution to increasing their access to and interest in academic research and even graduate school (Gish-Lieberman et al., 2021; Redmond & Gutke, 2020). Previous studies suggest that building community through e-mentoring could work particularly well when students work together in project and team-based environments, where they have the opportunity to interact with one another, learn from each other and together, and overall share the same collaborative learning experiences (Huizing, 2012; Hunn, 2014; Larmer et al., 2015).

Project and Team-Based Learning

Project-based learning is a student-centered approach in which students possess autonomy, bringing their curiosity, collaboration, communication, and reflective skills to a project team (Kokotsaki et al., 2016). Project-based learning is characterized by three principles: (1) students learn in context-specific settings, (2) students are actively involved in the learning process, and (3) students achieve their goals through social interactions and collaborative work (Kokotsaki et al., 2016). Research suggests that effective project-based learning opportunities provide students with the direction and support they need, emphasizing the idea of self-management and time management; ensure that students work well together, dividing tasks among the various team members; encourage reflection so that students can self-assess their progress and act accordingly; enable student autonomy which will result in increased student ownership towards their learning; and provide students with the support they need to achieve their goals by periodically assessing progress, roadblocks, and guiding students towards finding solutions (Kokotsaki et al., 2016).

For project-based learning to succeed, projects must be central to the curriculum and focus on questions or problems that drive students to engage with central concepts and principles of the discipline or field they are working in (Thomas & Mergendoller, 2000). Furthermore, project-based learning is effective when students participate in student-driven projects which are realistic, achievable, and centered on collaboration rather than individual work (Thomas & Mergendoller, 2000).

Team-based learning is a form of learning in which students come together to tackle various problems. It is characterized by forming small strategic teams, engaging students in activities that promote critical thinking and team development, checking in with students and reassuring them, as well as assessing the team performance and team members' satisfaction, and adjusting accordingly (Michaelsen & Sweet, 2011). Similar to project-based learning, team-based learning promotes students' autonomy, collaborative working, and open communication skills (Michaelsen & Sweet, 2011).

Previous studies found that students who engage in project and team-based learning perform better academically, are more involved in their education, and feel more prepared for their future professional endeavors (Allen et al., 2013; Koles et al., 2010). Furthermore, these forms of learning prompt students to develop higher accountability, better emotional intelligence skills, and stronger, long-lasting relational bonds among team members (Clarke, 2010; Stein et al., 2016).

The ACE Scholars Program

Although mentoring provides students with substantial benefits, only one in four undergraduate students report having had access to mentoring while in college (Crisp et al., 2017). To help address this discrepancy and to create community throughout the COVID-19 pandemic, we developed and implemented The ACE Scholars Program in Spring 2021. This program is an integrative multi-scale approach to undergraduate research training that combines scientific mentoring with career and professional development sessions. The ACE Scholars Program was co-developed and co-implemented by Cristina Baciú, a research program manager and doctoral candidate studying mentoring, and Zachary Compton, a doctoral candidate in evolutionary biology. They both serve as co-Directors of the program and are based at Arizona State University, along with Dr. Carlo Maley, the director of the Arizona Cancer Evolution Center (ACE).

In the ACE Scholars Program, students work together on research projects led by senior undergraduates. The scholars convene weekly for a whole group research meeting. Students also participate in weekly sessions that alternate between R

tutorials and career and professional development sessions. All the meetings have been remote, held over Zoom. During the R tutorials, students learn about comparative phylogenetics, RNA sequencing data, data curation, and data visualization. During the career and professional development meetings, students learn about various topics such as research writing and preparing for publication, cultural intelligence, medical school applications, and art-science collaborations. Furthermore, students are mentored in topics such as time management, networking, graduate school applications and strategy, mental health, difficult conversations, the importance of mentoring, and how to find mentors. Additionally, students can meet and work with the program co-directors one-on-one to ensure they are progressing towards their goals.

Team Organization and Management

Fundamental to a successful mentoring relationship is a mutual interest between the mentor and mentees in the projects the students are pursuing. When we implemented the ACE Scholars Program, in Spring 2021, students' interest in participating in undergraduate research and the overlap between their and our center's shared research interests were our only selection criteria. Acknowledging the power of project and team-based learning, we have employed this model for our program. As students joined our center, we assigned them to different projects and teams based on their interests and backgrounds. Despite the variety of projects that students can pursue, we found it critical to encourage an open conversation regarding students' interests and ultimate career goals. Removing the rigidity that surrounds our own priorities for research projects has sprouted numerous productive undergraduate projects that expand the reach of the center's research scope.

At any given time, the ACE Scholars Program has close to a dozen of different research projects derived from the intersection of evolutionary theory and cancer biology, the psychology of cancer, and our center's science communication and outreach efforts. These projects are led by senior undergraduate students who oversee the daily management of the teams and projects. This opportunity enables students to take ownership of the projects and to practice their leadership and communication skills. In this mentoring model, undergraduate students get hands-on training in team leadership at a level typically not experienced until late in graduate school. In addition, the students learn from one another and tackle important research questions as a team. Student leadership has allowed us to scale up the program to over 40 students by releasing program directors from much of the day-to-day management and troubleshooting inherent to research endeavors.

Extracurricular Activities: R Tutorials & Career and Professional Development

A holistic approach to undergraduate research mentorship emphasizes the instruction of both hard and soft professional skills (Crisp et al., 2017). Our undergraduate cohort has spent most of their college career in the COVID-19 pandemic. Where college should typically be a time of heightened interpersonal interaction, both socially and professionally, which tends to lead to developing extended networks and laying the ground for future potential professional collaborations, many students have had to experience a dramatically hindered version of this experience. To address this, we have implemented by-weekly R training tutorials and career and professional development seminars.

Most of our ongoing research projects utilize computational biology and bioinformatics methods, which are taught on alternating weeks from the professional development seminars. In designing the learning materials for these programming tutorials, we are acutely aware that only a minority of the students will actually rely on these specific methodologies. To address this, we have designed a majority of teaching curricula to address broad-scale applications in data science and statistics. In appreciating the variety of career paths our students are preparing for we can assist in providing them with a skill set that is marketable to a wide career market.

During our career and professional development meetings, students learn from guest speakers about various topics such as research basics (with a guest librarian), research writing and preparing for publication (with a guest speaker from the university's Writing Center & Graduate Academic Support Center), cultural intelligence (with guest Senior University International Educator), and art-science collaborations (with guest Scientific Research Curator). Furthermore, students are mentored in topics such as time management, networking, emotional intelligence, graduate school applications and strategy, mindfulness, difficult conversations, and the importance of mentoring.

Findings

During Spring 2022, the ACE Scholars Program served a diverse group of 43 students, including veterans, online students, adult learners, and students from historically excluded backgrounds. Of those, 31 students participated in program evaluation efforts conducted in May 2022, which revealed that:

- 25% of respondents were responsible for the care of children or other family members
- 47% worked part-time, and 22% worked full time
- 56% encountered personal and/or professional challenges during the semester
- 82% felt they received psychological and emotional support as well as degree and career support while in the program
- 96% indicated that they felt they received academic knowledge support and benefited from role modeling while in the ACE Scholars Program
- 85% agreed or strongly agreed that the program, with its research experience and career and professional development components, has helped them be prepared for their future endeavors
- 86% said they were extremely satisfied with the ACE Scholars Program.

The program has received positive reviews from our students who have shared their feedback. They have described the program as the most impactful program they have experienced in their college careers. One student said, "I feel like the ACE Scholars Program, other than helping me and moving me towards achieving my goals (gain research experience, learn R), it built a sense of community." Another said, "Although the internship was online, I had a strong sense of being part of a community and made connections with highly knowledgeable professionals and students of very diverse backgrounds." And yet another student commented, "The experiences gained over the last four months will advance me light-years beyond where I would be without this group."

ACE Scholars Accomplishments Spring 2022

When they join the ACE Scholars Program, students are encouraged to make progress toward their personal and professional goals while working to create tangible results that they can claim on their CVs as enriching and foundational experiences. During Spring 2022, besides making progress towards their own personal and professional goals, students claimed the following significant accomplishments:

- An undergraduate student team leader was invited to present at the Biodesign Annual Fusion Conference at Arizona State University.
- ACE scholars earned 10 awards at the 29th Annual School of Life Sciences Undergraduate Research Symposium, including 1st, 2nd, and 3rd prize awards in Cancer Studies Category, 1st and 3rd prize awards in the Health Education Category, and 3rd prize awards in the Biology Education and Bioinformatics Categories.
- There are currently six manuscripts in progress, with student lead authors and co-authors.
- One team was awarded a seed grant of \$2,600 to fund data collection for a pilot study examining the language of cancer.

Discussion

The ACE Scholars Program demonstrates that project and team-based undergraduate research mentoring is a promising path toward including students of all backgrounds and interests, and providing them with valuable mentoring opportunities. Furthermore, our e-mentoring integrative model, blending traditional scientific mentoring with career and professional development sessions, is proving to be efficient in assisting students to gain much-needed skills for their professional futures. When we implemented this program, we sought not only to train undergraduate students in biology research techniques but also to create community and to enable them to learn from one another. According to students' feedback, we accomplished these goals. Students shared:

I am truly grateful for this research experience and all the opportunities it has provided. I never thought I would be able to present research at a research symposium, and I have had the pleasure of presenting at two separate symposiums just this semester. I look at the other members of the ACE Scholars Program as friends, and I have grown attached to each person. I hope to grow in my friendships with others and to continue to serve ACE as it has served me!

I have gained important skills that are going to be very useful in my career as a researcher. I was part of a vibrant interdisciplinary research team that was highly supportive and open to everyone's varying experiences and worldviews. Although the program was online, I had a strong sense of being part of a community and made connections with highly knowledgeable professionals and students of very diverse backgrounds.

Furthermore, we consistently encourage our students to communicate openly during normal times, and even more so, during challenging times, and we strive to create an environment where everyone feels comfortable bringing their whole selves to work. Therefore, it was gratifying to receive the feedback of one student leader who said:

After his [father in law] inevitable passing, my world became consistently challenged. They [the undergraduate team] offered support in various ways I never knew would be possible from a mentee. This opened my eyes to the importance of vulnerability, honesty, and cooperation in the workplace. My dedication to my team was directly mirrored in the helping hands they extended to me. Although technical lessons are undeniably crucial to enriching my research career, I believe that life lessons like the one mentioned above are more essential to promote effective leadership in our world. My team's empathy towards me will forever remind me of the impact we have on one another as humans – a lesson I vow to incorporate as the foundation of my care model as a physician someday.

Conclusion

Program evaluation showed that access to e-mentoring through the ACE Scholars Program positively impacted undergraduate students. Based on the results of our Spring 2022 survey and on our experiences running the program, we have learned that there are a few characteristics of successful mentoring opportunities for undergraduate students:

1. It is essential to scale the mentoring style to match the volume of mentees served. A decentralized leadership strategy where research projects are primarily led by a senior undergraduate ensures students have reliable access to guidance and feedback while enabling them to tackle issues as a team and learn from one another.
2. Emphasize a holistic approach to mentorship and provide guidance on research projects together with instruction on professional development and marketable career skills (e.g., computer programming).
3. Create and foster a sense of community to ensure that students feel their participation and contributions are valued.

Our measured outcomes demonstrate that employing these tenets has robust benefits to mentees, who report increased satisfaction with the program in terms of meeting their personal and professional goals, connecting meaningfully, and collaborating to advance science and form long-lasting relationships.

During Fall 2022, the ACE Scholars Program will welcome its largest cohort to date, approximately 55 students. Of these, half will be returning students and half will be new to the program. To be able to continue providing meaningful and impactful mentoring to our students, we aim to keep our cohorts at about 50–55 students per semester and have them continue to work in a project and team-based, highly collaborative environment. Students will continue to tackle projects such as evolutionary trait models of cancer risk, an evolutionary perspective on cancer in non-human primates, a life history model of reproductive cancer risk, cancer-like phenomena in coral, a cancer patient guidance project, the language of cancer project, and science communication and outreach. To learn more about the ACE Scholars Program, we invite you to visit our website <https://www.acescholarsprogram.com>.

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