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Pandemic Pivots: The Successful Transition of an NSF Research Internship to an Online Format

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Abstract

The Transfer-to-Excellence Summer Research Program is an exciting opportunity for community college students to conduct hands-on research in the labs of faculty at the University of California, Berkeley. Funded by the National Science Foundation and a private foundation, the program seeks to inspire students to transfer and complete a bachelor's degree in science or engineering. Typically, a nine-week residential program, the 2020 Transfer-to-Excellence program was greatly impacted by the COVID-19 pandemic and a state-wide Shelter-in-Place order. This paper details the successful transition of the Transfer-to-Excellence program to an online format, including remote research projects, mentoring, boot camp, professional development, and community building events. Analysis of quantitative evaluation data demonstrates that, despite the remote format, interns had a very positive internship experience and highly satisfying mentoring relationships with graduate students. Most notably, the internship significantly enhanced students' confidence to succeed as a student in science and engineering, and self-efficacy in their research skills. This paper and poster presentation will provide a model for similar NSF funded programs pursuing an online format. The administrative team expects such transitions to become increasingly common for various reasons, including the need to adapt to unexpected health and environmental barriers, reducing cost, and expanding access to nontraditional students unable to participate in residential programs.

Introduction

Each year, the National Science Foundation provides grants to institutions of higher education to fund research internships for undergraduate students. These internship programs, titled "Research Experiences for Undergraduates" (REUs), each "consist of a group of ten or so undergraduates who work in the research programs of the host institution. Each student is associated with a specific research project, where he/she works closely with the faculty and other researchers" [1]. The REU funding structure is intended to provide research opportunities to students who may not have access to undergraduate research opportunities at their home institution and aims to encourage more students from underrepresented backgrounds to pursue degrees and careers in science and engineering [2].

The deadly SARS-CoV-2 (COVID-19) pandemic has had widespread effects across institutions of higher education, research, and industry. While many states issued Shelter-in-Place orders and university campuses closed indefinitely, REU administrators made difficult decisions regarding the feasibility of offering a Summer 2020 program [3]. Unfortunately, thousands of students were notified that their internship had been cancelled.

Located in an urban environment with a rigid Shelter-in-Place order and high rates of COVID-19 infection, the University of California, Berkeley campus indefinitely closed on March 17, 2020. While all other campus research internships were cancelled, the administrative team of the Transfer-to-Excellence program sought to provide research exposure to as many interns as possible. This paper details the process of transitioning the program to an online format. The

paper also compares summer 2020 evaluation data to three years of historical data from past program cohorts. Findings highlight the success of the remote program.

Program Overview

The Transfer-to-Excellence Summer Research Program was developed in 2012 with the goal of inspiring community college students to transfer to a four-year university and complete a degree in science or engineering [4]. Each summer, a cohort of interns is recruited to participate in the research efforts of faculty at the University of California, Berkeley. Participants are all students from California community colleges with little or no prior research experience. Students from backgrounds or identities that are underrepresented in science and engineering are especially encouraged to participate.

After completion of a one-week research boot camp, each Transfer-to-Excellence (TTE) intern is paired with a faculty host and graduate student or postdoctoral mentor. Through the course of their summer internship, interns are expected to work full-time on an independent research project under the supervision of these mentors. At the conclusion of the summer, interns present a research poster, research paper, and slide presentation on their findings. Many interns later present their work at academic conferences.

In addition to their research efforts, interns engage in many enrichment activities. These include technical research seminars, workshops on science communication, field trips to industry research partners, and community building activities. The program values and emphasizes the community college transfer pathway. As such, interns are required to participate in individualized advising to prepare for transfer to a four-year university, and to attend workshops regarding the application process and financial aid options. At the conclusion of the internship, interns receive constructive feedback on their transfer application personal insight essays.

Transfer-to-Excellence is traditionally a residential program which provides funding for interns to travel to the UC Berkeley campus. Interns live in a traditional college residence hall for nine weeks and eat meals at a social dining facility. Additionally, they receive a $3,600 stipend as payment for their work.

The benefits of participating in the TTE program are well documented. A 2015 comparison of pre- and post-program evaluation data found that participation resulted in enhanced confidence to pursue further education opportunities and careers in science and engineering [5] [6]. A 2020 follow-up study affirmed this finding, and additionally documented that participants were better able to find scholarly resources, design ethical scientific experiments, conduct independent research, and analyze data [7]. Furthermore, interns have transferred to a four-year university to pursue a bachelor's degree at a rate more than double the state average [8]. Finally, the program provides a valuable professional development opportunity for graduate student and postdoc mentors to prepare for future careers as faculty members and professional researchers [4].

The Transfer-to-Excellence Summer Research Program is funded by a National Science Foundation Research Experiences for Undergraduates site grant, a National Science Foundation Science and Technology Center grant, and a private grant from the Hopper Dean Foundation.

Transitioning to an Online Format

The COVID-19 pandemic has had wide-spread effects across the world and brought many countries to a grinding halt during the early spring of 2020. In March, the San Francisco Bay Area entered a Shelter-in-Place order and the UC Berkeley campus closed indefinitely. At that time, the Transfer-to-Excellence program had already confirmed the summer's faculty hosts and hired a cohort of twenty interns. It was initially unclear how long the campus closure would last and if a residential TTE program would be possible. As the pandemic continued, the TTE administrative team made the difficult decision to proceed with a remote program. Eight pairs of faculty hosts and graduate student mentors determined that they would be able to transition the research project they had planned for their interns to an online format. Their selected interns were then invited to opt-in to a remote program.

When designing the remote Transfer-to-Excellence program, the administrative team had several priorities: First, the team hoped to provide as many interns as possible with a research internship. They also sought to provide an experience as similar as possible to the planned in-person program. This required that interns felt a strong sense of community with their research lab and peer interns. As the interns were all physically isolated from their peers, mentors, and faculty hosts, the administrative team sought to ensure interns felt well supported and as connected as possible. However, they acknowledged that interns would not be able to spend excessive time on video calls, due to risk of zoom fatigue or boredom [9].

Twelve faculty hosts unfortunately determined that they would be unable to offer a remote research project for various reasons, including inability to access the facilities and materials required to conduct their research, and lack of graduate student mentors due to the pandemic. The interns selected by these faculty members were notified that their internship had been cancelled and were offered priority for the 2021 program.

Research Projects

Eight research projects were successfully converted to an online format by faculty hosts and graduate student or postdoc mentors from their research group. Each TTE intern was assigned an independent research project on a topic related to their intended major, encompassing the fields of electrical engineering, computer science, chemistry, and materials science. Interns were expected to work on their project from their home approximately forty hours per week under the remote supervision of their graduate student or postdoc mentor.

In preparation for the remote program, the TTE Program Director discussed the technical needs of each project with the mentors and interns. Most interns confirmed they had sufficient internet access, computing capabilities, and data storage. An external hard drive was purchased for one participant, and another was mailed a lensless camera by her research team. Interns were enrolled in a one-unit summer course to ensure they had access to all UC Berkeley remote resources, including library databases, software downloads, and remote control of laboratory machines. Most importantly, students were each provided with a Zoom account for video conferencing. The Zoom software was used for mentor meetings, intern events, and much of their daily research activities.

The process of converting each research project to a remote format varied greatly, however each intern was able to collect and analyze data through digital modeling or manual processes. For example, one intern was able to utilize a lensless camera from her home, another investigated the

sequence and structural features of mRNA utilizing the SnapGene software, and yet another was able to participate in the data collection processes through remote desktop control and video calls with their mentor stationed in a UC Berkeley laboratory. The eight research projects were titled as follows:

- Current-Induced Switching in Antiferromagnetic Multilayer System
- Investigating Sequence Features of eIF3 and eIF4A Target mRNAs
- Unsupervised Deep Learning on Reconstructing 2D Image for Lensless Camera
- Understanding the Raman Spectra of Graphene Nanoribbons for Device Fabrication
- Design and Optimization of Lidar Beam Scanners
- An Automatic Data Processing Pipeline to Reconstruct Coherent 3D Image Volumes from Cardiac Cine MRI Data
- The Computational Apprentice: Exploring a New Approach for AI Assistance
- Sub-nanometer Control of Low-Dimensional Tantalum Tellurides via Encapsulation Within Carbon Nanotubes

Mentoring

Transfer-to-Excellence mentors participated in a remote mentor orientation prior to the start of the program. During this orientation, they were trained in project management, mentoring and providing constructive feedback, intercultural communication and inclusion, and heard advice from past TTE mentors.

On average, interns met with their mentors two to three times per week for an hour. These meetings were longer and more involved at the beginning of the summer while interns were being trained on their respective research methods. The meetings became less common as the summer progressed and interns became more familiar with their research project. Interns also received mentoring from their faculty host and other members of their research group through weekly or biweekly remote lab meetings. All interns presented their research to their research group prior to the conclusion of their internship.

The TTE Program Director also met individually with each intern monthly. This provided an opportunity to learn more about the interns' experiences and their relationships with their mentors. When interns did have concerns about their research project, their mentoring relationship, or personal circumstances, the Program Director was able to discuss and address these proactively before the issues escalated. Follow-up meetings were also scheduled to track progress.

The TTE Program aims to facilitate long-term, sustained, and formalized mentoring relationships for all participants. Therefore, participants continued to receive mentoring from their graduate student or postdoc mentor following the conclusion of the 2020 TTE Program. These mentoring pairs receive a monthly prompt to discuss via Slack or Zoom, leading to conversations about (1) the application process to prepare for transfer to a four-year institution, (2) encouraging interns' pursuit of future undergraduate research opportunities, (3) retaining and further stimulating interns' interest in graduate school, and (4) continuing to help guide interns in their career choices.

Intern Boot Camp

All interns participated in a week-long boot camp prior to beginning work on their research project. The boot camp, led by the TTE Program Director, featured many presentations from guests, including past interns, librarians, and the Diversity and Executive Directors of the Center for Energy Efficient Electronics, an NSF Science and Technology Center. Through these presentations, interns learned about time management, ergonomics, mindfulness, intercultural communication, scientific notetaking, library resources, laboratory safety, and how to read, write, and publish research papers. The interns also attended two technical talks from faculty regarding nanotechnology and Moore's Law.

When offered in person, the Transfer-to-Excellence Boot Camp is nine hours per day for five consecutive days. While designing the remote program, the administrative team worried about interns spending too much consecutive time on their computer and experiencing "zoom fatigue" [9]. As such, the boot camp days included many breaks and were shortened to no more than five hours per day. In their free time, interns worked independently on remote tutorials relevant to their research projects.

Professional Development Events

The Transfer-to-Excellence program was able to transition all planned research seminars, professional development workshops, and enrichment activities to an online format via the Zoom video conferencing software. The breakout room and polling features were used to make the sessions as interactive as possible.

Initially, field trips to two industrial research facilities were planned for the in-person program. One such event was transitioned to a remote format, including guest speakers from Lam Research and videos of the organization's research facilities. A second field trip to a biological and chemical engineering facility was cancelled.

Each Transfer-to-Excellence intern typically concludes their internship with an interactive poster session and a formal research presentation. While 2020 interns were required to create a research poster, the poster session was cancelled in favor of a remote research symposium. During this research symposium, each intern presented a thirteen-minute slide presentation, followed by time to answer all audience questions. Due to the remote format, this event was open to interns' loved ones, their research groups, and members of the UC Berkeley and California Community College communities. All eight interns were later selected to participate in a research poster session at the remote SACNAS Diversity in STEM conference.

Building Community

In a typical year, TTE interns enjoy living in communal dormitories, sharing meals in the dining halls, bonding in a game room, going to parties together, and engaging in other recreational activities. In 2020, the TTE administrative team feared that remote interns would feel isolated and unsupported without these in-person interactions. As such, the program calendar was adjusted to include regular casual morning meetings. Several times a week, interns started their day by checking-in with each other, the TTE Program Director, and the TTE Program Assistant via Zoom. These meetings facilitated an ongoing and familial sense of community among the cohort.

In addition to the casual morning meetings, the TTE Program Assistant hosted intern socials on three Friday afternoons throughout the summer. During these socials interns participated in an escape room and played remote games. Interns also participated in a group Discord thread and cocreated a TTE 2020 music playlist.

Finally, the interns were required to collaborate in small groups on educational videos for high school students throughout the course of the summer. This project required interns to schedule regular meetings and unite on a creative effort. The assignment resulted in recorded lectures on solar energy and binary code.

Financials

Due to the reduced cohort size, the TTE administrative team opted not to utilize the program's NSF REU Site grant in 2020. Alternative funding was utilized. Furthermore, because the 2020 remote interns were not provided with housing or meals, their summer stipend was increased to $4,000. The program cost approximately $7,000 per participant, as compared to $12,000 when offered in person.

Challenges Encountered

The TTE Program Director expected to encounter many challenges developing and executing a fully remote program with limited time to prepare. However, very few problems were experienced over the course of the summer. Perhaps most prevalent and unsurprising, the program was impacted by occasional technical difficulties. Two interns infrequently experienced limited internet bandwidth. While this impacted their ability to participate in the occasional cohort meeting, it did not hinder their research work or escalate to the point of needing rectification. Furthermore, one intern was accidentally removed from the research symposium Zoom call. Once removed, they were unable to rejoin the call and rushed to log-in from a family member's account and present their slides from their smartphone.

As a residential program, TTE interns would typically be physically removed from their loved ones and fully immersed in the program experience. The remote format did not allow for this, and interns were, on occasion, interrupted or emotionally impacted by those they cohabitated with.

Evaluation Methods

Participants

The 2020 Transfer-to-Excellence cohort consisted of eight California community college students with sufficient academic background in math and science. Applicants were required to have completed a year of calculus and three science or engineering courses. Participants submitted an online application consisting of personal insight essays, copies of their transcript, letters of recommendation, and a sample of past work. They were selected for the program by the TTE Program Director and their respective faculty host.

The 2020 cohort consisted of five females and three males. Four participants were from racial or ethnic groups underrepresented in science and engineering. Two participants were Pell grant

recipients and three were the first in their family to attend college. Seven interns resided in Southern California, and just one lived close to the UC Berkeley campus.

Data Collection

The TTE REU administrative team has historically conducted a holistic program evaluation of using online survey software and videoconferencing capabilities. This approach was also used during the summer 2020 experience. Each year, the program evaluation includes pre- and post-program surveys that gauge participants' perceived changes in their research self-efficacy, perceptions participants have in their research and communication skills compared to peers, career and academic goals, and their knowledge about the transfer process. Questions use a five point Likert scale and are detailed in tables below [10]. A mid-program survey is also conducted to provide formative assessment. Questions examine the degree to which students are interacting with their mentor and the quality of that interaction. Items also ask about the general student experience and what their experience has been like working on their research projects. The information that is collected is used by the program staff to make any changes in mentor/mentee assignments and consider what additional programming might be needed for the participants.

Participants also participate in a focus group interview with an external evaluator. Questions ask participants to reflect on their experiences during the summer program, how the program has impacted their career and academic goals, and how the experience has developed confidence in different research skills.

Data Analysis

A subset of eleven questions that considered students' overall satisfaction, confidence, and self-efficacy in their research skills were considered for this study. The research team calculated and compared participants' mean scores on both the pre-program evaluation and post-program evaluations. The mean ratings from the remote program were then compared to corresponding data points from three years of in-person programs, as examined in [7]. The in-person data consists of a sample of thirty-five interns from the 2017 through 2019 TTE cohorts.

Protection of Human Subjects

This study was reviewed and approved by the University of California, Berkeley Institutional Review Board (IRB) for the Protection of Human Subjects. All participants voluntarily completed an informed consent form and received a copy of the consent form for their own records. Identifying information was kept separate from evaluation data and is not included in this report.

Evaluation Data

Satisfaction with Overall Experience

When asked about their satisfaction with the summer experience, all eight members of the 2020 remote cohort rated their experience as a 5, the maximum possible level of "very satisfied". This compares to the average rating of a 4.74 from the 2017-2019 in-person cohorts. When asked about the support they received from their graduate student or postdoc mentor, all 2020 interns again rated their experience as "very satisfied". The average rating for the in-person interns was

a 4.51. Thus, the remote TTE program was rated 0.25 points higher for overall experience and 0.49 points higher for mentor support.

Table I.

Measure *1=Very Unsatisfied; 5=Very Satisfied*	*Mean In-Person Program Rating*	*Mean Remote Program Rating*	*Difference*
I would rate my summer experience as:	4.74	5	0.26
I would rate my overall support from my mentor as:	4.51	5	0.49

Figure 1: Comparison of program evaluation data regarding overall experience.

Enhanced Confidence

Next, the evaluation team analyzed two evaluation questions that assessed how the TTE program affected interns' confidence as engineers or scientists. When asked if they had experiences that affected their confidence in their ability to perform tasks that will allow them to succeed as a student in science and engineering, interns in the remote program indicated an average 0.88 increase over the course of the program. This compares to an average 0.42 point increase during the 2017-2019 in-person programs. When asked about their confidence in their science and engineering ability, remote interns again indicated an average 0.88 gain over the course of the program. The average gain for the in-person program was 0.63.

Table II.

Measure *1=Strongly Disagree, 5=Strongly Agree*	*Mean Pre-Program Rating*	*Mean Post-Program Rating*	*Difference*
I have had experiences that made me confident in my ability to perform tasks that will allow me to succeed as a student in science and engineering.	4	4.88	0.88
Confidence in science and engineering ability:	3.5	4.38	0.88

Figure 2: Comparison of pre- and post-program evaluation data regarding confidence from the 2020 remote program.

Table III.

Measure *1=Strongly Disagree, 5=Strongly Agree*	*Mean Increase for In-Person Program*	*Mean Increase for Remote Program*
I have had experiences that made me confident in my ability to perform tasks that will allow me to succeed as a student in science and engineering.	0.42	0.88
Confidence in science and engineering ability:	0.63	0.88

Figure 3: Comparison of evaluation data regarding enhanced confidence during past in-person programs vs. the 2020 remote program.

Improved Research Skills

Finally, the evaluation team examined seven data points that assessed interns' confidence in their research skills and technical abilities, including understanding of the research process, ability to find resources on a scientific topic, ability to design research experiments, ability to carry out research experiments, familiarity with lab techniques and instrumentation, ability to analyze and interpret data, and understanding of the ethical implications of research. Remote interns indicated increased confidence on all questions, ranging from a .13 point increase (ability to analyze and interpret data) to a 1.5 point increase (understanding of the research process).

When compared to in-person cohorts, remote interns showed greater enhancement in confidence on five research skills. However, the in-person cohorts did report larger gains in confidence regarding their ability to design research experiments and their ability to analyze and interpret data.

Table IV.

Measure *1=Well Below Average,* *5=Well Above Average*	*Mean Pre-Program Rating*	*Mean Post-Program Rating*	*Difference*
Understanding of the research process	2.75	4.25	1.5
Ability to find resources on a scientific topic	3.63	4.38	0.75
Ability to design research experiments	2.75	3.38	0.63

Ability to carry out research experiments	3	3.5	0.75
Familiarity with lab techniques and instrumentation	3.75	3.88	0.5
Ability to analyze and interpret data	2.63	4.25	0.13
Understanding of the ethical implications of research	2.63	4.25	1.62

Figure 4: Comparison of pre- and post-program evaluation data regarding research skills from the 2020 remote program.

Table V.

Measure *1=Well Below Average, 5=Well Above Average*	*Mean Gain for In-Person Program*	*Mean Gain for Remote Program*
Understanding of the research process	0.83	1.5
Ability to find resources on a scientific topic	0.66	0.75
Ability to design research experiments	0.83	0.63
Ability to carry out research experiments	0.72	0.75
Familiarity with lab techniques and instrumentation	0.49	0.5
Ability to analyze and interpret data	0.37	0.13
Understanding of the ethical implications of research	0.89	1.62

Figure 5: Comparison of evaluation data regarding enhanced research skills during past in-person programs vs. the 2020 remote program.

Discussion & Conclusion

This paper has detailed the process of transitioning the Transfer-to-Excellence summer research program to an online format. Due to the COVID-19 pandemic, eight interns each completed a remote research project in a science or engineering field. Interns also participated in mentoring, a boot camp, professional development workshops, and community building activities via the Zoom video communication software. The administrative team sought to ensure interns felt supported and connected to their peers without experiencing Zoom fatigue or boredom [9].

Evaluation data indicates that remote interns had a very satisfactory internship experience and felt very supported by their mentors. Comparison of pre- and post-program evaluation data found that the program enhanced interns' confidence as scientists and their confidence in their research abilities. Furthermore, comparing these increases to past in-person cohorts shows that interns in the remote offering experienced greater confidence on seven of nine measures. The data collection process did not explore possible explanations for discrepancies between the in-person and remote cohorts. However, the evaluation team has several theories.

First, faculty hosts and graduate student mentors were given the option to cancel their research project and delay their intern's participation until the following year. However, the eight research teams that completed the 2020 program actively opted-in to participating in a remote program. The administrative team found these faculty hosts and graduate student mentors to be especially committed to the mission of the Transfer-to-Excellence program, and to the task of supporting a community college intern. As such, the team believes that their level of involvement may have been higher than past years, when the program occurred in-person. Similarly, the eight community college interns each chose to participate in a remote internship opportunity. Thus, one can conclude that they were committed enough to gaining research exposure to participate despite not being offered a social residential experience. The administrative team found that the 2020 interns were also especially hard-working and committed to their research project. One student who was offered a remote internship experience chose not to participate and his research project was reassigned.

Additionally, the evaluation team concludes that interns had a positive experience because the program provided the correct level of contact and support. Qualitative data demonstrates that the regular morning check-ins were essential to interns' comfort in the program and their sense of community. Additionally, interns noted that the small group video lecture assignment and regular intern socials ensured they felt well connected to their peers. At the conclusion of the summer program, interns shared that their peers had become close friends, despite never meeting in person.

The administrative and evaluation team hypothesizes that the absence of a social residential program led to interns experiencing fewer competing priorities and distractions. Unlike in-person cohorts, interns were not simultaneously working to complete a research project, find their way around a new campus, learn the local public transportation system, and cohabitate with a roommate. Some past members of in-person cohorts have also struggled with adjusting to living away from their family, including experiencing homesickness, and learning how to wash their own clothing. Because members of the remote TTE program did not travel to the UC Berkeley campus and instead lived where they had resided throughout the academic year, interns appeared to be able to focus more energy on their research projects. As such, several interns were able to

complete and surpass their planned project tasks over their eight-week internship. The administrative team believes that the 2020 interns showed a greater level of engagement with their research work than witnessed in recent cohorts.

Finally, it is important to note that the 2021 remote interns had not previously participated in internships and thus did not have much to compare their remote internship to. As such, they were not fully familiar with the benefits of an in-person experience that they may have been missing. Furthermore, the interns were aware that many of their classmates' and peers' internships had been cancelled, including twelve other students accepted to the TTE cohort. As such, they were especially grateful to be offered an opportunity to conduct research and may have provided the program and its staff with some additional grace.

At the time the 2020 Transfer-to-Excellence program was transitioned online, the administrative team believed it would be a unique experience. The team expected to return to an on-campus internship in 2021, inviting the 2020 interns to visit campus. In the months since the initial Shelter-in-Place order, the pandemic has continued, infection rates have increased, and the capacity of the healthcare system has been tested. Internship programs across the country will be impacted, and many that cancelled their 2020 offering may be preparing for a shift to a remote format for Summer 2021. We hope this paper and poster presentation provide a helpful model for such a transition.

Furthermore, the TTE team believes that development of online options will prove beneficial beyond the pandemic context. Traditional residential REU programs have long run the risk of being inaccessible to many different types of students, including those with caregiving responsibilities, those with disabilities, and those unable to travel. By creating online internship and remote research options, REU program administrators can welcome a broader range of students, introducing them to the exciting world of undergraduate research. This will further facilitate the National Science Foundation's goals of attracting a more diverse pool of talented candidates and expanding student participation in research [2].

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