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Matter of Opinion

Reflections on hosting summer undergraduate researchers in the midst of a pandemic

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The COVID-19 pandemic continues to impact nearly every aspect of our lives, including academic research. In this Matter of Opinion, we reflect on hosting both in-person and virtual undergraduate students during these challenging times.

Introduction
How many readers of this Matter of Opinion column first engaged in science as an undergraduate student? The joys (and struggles) of exploring new frontiers and sharing our hard-earned findings have motivated many of us to pursue fulfilling careers in scientific research, policy, and education. On a large scale, undergraduate research has a substantial influence on students’ educational experiences, as students hone skills such as data analysis, hands-on lab techniques, and integrating theory to practice.1 Importantly, students also report gains across other, non-academic domains, including improved self-confidence, ability to work independently, and awareness of career pathways.1 Taken together, undergraduate research can dramatically augment the classroom experience in the short term and can impact the career trajectories of undergraduate students in the long term.

Our research group focuses on the fabrication, characterization, and application of novel optoelectronic materials and devices. These research topics attracted many students to join our group as summer undergraduate researchers, and this summer our lab welcomed five undergraduate and three high school students, nearly doubling the size of our group. The majority of the students recently completed their first year of undergraduate studies, and thus, for most of them, this was their first exposure to academic research. Juxtaposed to this enthusiasm, facilitating this year’s summer undergraduates presented a unique challenge in light of the pandemic and the ever-shifting public health guidelines. A fully in-person research experience would not be possible for many of our students, especially as COVID-19 safety requirements limited lab densities and interactions, particularly at the beginning of the summer. We had to adapt to these circumstances rapidly to ensure productive and positive summer experiences for our students, both in-person and remote, within a lab that focuses on experiments requiring specialized equipment and chemicals. As we are striving to create a culture of scientific rigor, kindness, and inclusivity in our lab, this summer pushed us to be creative and intentional, possibly more so than in a typical summer. In this Matter of Opinion, we reflect on our lessons learned from hosting our undergraduate researchers during a pandemic and how this year will shape undergraduate experiences in our group for many years to come.

Before undergraduate students arrived: Goal setting as a group
While every lab member had mentored in some capacity, the Congreve lab in its entirety had never hosted so many undergraduates at one time. Thus, we realized it was vital to set expectations internally, aiming for consistency with regards to student goals. After some behind-the-scenes planning among postdocs and Professor Congreve, a postdoc facilitated an informal meeting for the entire lab to discuss a “big picture” vision. Additionally, we agreed to similar deadlines for midpoint progress checks and group peer review sessions before the visiting students presented their research findings to the entire department at the end of the summer. To provide context for the rest of our discussion, we share our overarching goals for the summer:

1. Engaging students in an authentic research process
2. Integrating students into the greater laboratory community
3. Recruiting students to pursue science

With these goals in mind, each mentor had the autonomy to design a project and work with their student in their own way. Project scopes ranged from theoretical simulation to wet lab work, and day-to-day mentorship styles varied based on individual personalities. Each mentor and undergraduate student pursued a specific research project. Herein, we focus on selected anecdotes to demonstrate how we strived to support our undergraduates within the context of each goal.

Engaging students in an authentic research process
To us, engaging students in the research process meant providing students with the opportunity to have ownership over scientific work that was rigorous and meaningful. This required different levels of support from the mentor based on
the student background and experience. Moreover, within the larger group setting, undergraduate students should feel like their scientific ideas are valued and respected. This applies to their discussions, questions, and contributions during group meetings or casual conversations with their fellow lab mates, in addition to ideas on regarding their own work.

Even so, we faced the reality that many of our students would be joining our group virtually for the summer, so we had to design a variety of projects for students who were not able to join us in person. Some of these projects included important computational simulations of our experimental work, or modeling of excitonic processes that could be later investigated in the lab. We emphasize that fully virtual projects are rewarding for both mentor and mentee and provide strong research experiences. Still, we wondered if it was possible for us to address the challenge of providing remote undergraduate students the chance to participate in hands-on experimental research, even from thousands of miles away, particularly because our group mainly focuses on experimental research.

Our in-person students learned to perform experiments by shadowing their graduate student or postdoc mentors. To provide access to a parallel experience, video streaming seemed to be a possible solution—in theory, the virtual student would be able to see, hear, and direct what was occurring in the lab from a first-person perspective. One graduate student mentor piloted this initiative within the Congreve lab. Initially, video chatting with a smartphone seemed the most straightforward option, but this immediately raised significant challenges. Not only was it difficult to provide the remote student with good views of the experiment using the phone camera, it was an experimental challenge and a safety hazard: the mentor’s mobility was limited as they held the phone. After a few weeks of struggling, the mentor switched to a mounted GoPro camera connected to a smartphone via Bluetooth wireless connection (Figure 1). This seemingly simple technology switch transformed the course of the summer for this mentor and undergraduate student.

Initially, this provided the virtual student a much truer first-person point of view of the lab and experiments. The mentor could conduct experiments with use of both hands, and with the camera mounted to the mentor’s forehead, the student had a clear view of each step taken and could ask questions in real time. After a few weeks, the virtual student began to design their own experiments. These were then conducted by instructing their mentor in the lab through each experimental step. The student controlled all aspects of their experiments, from details as large as choosing material composition and synthesis procedures to as small as how many samples to make and what size vials to use to prepare solutions. Furthermore, using the Zoom remote desktop control feature, the student could control the screen of a lab computer remotely to collect data—in this case, photoluminescence experiments, which they later analyzed on their home device. Most significantly, this platform allowed for instant feedback, which helped to improve critical thinking and decision-making during experiments when inevitable challenges arose. In addition to scientific gains, the rest of the lab began to informally interact with the virtual student on the GoPro as they would with an in-person student in real time, discussing different projects and approaches to scientific work. Overall, this platform allowed the virtual student to develop experimental design skills on a wet lab-based project, and we highly recommend it for remote learning needs of this nature in the future.

A crucial facet of the research process is reflecting on scientific data and skills development. Visiting students met with both their graduate student/postdoc mentors and Professor Congreve for both formal and informal reflections throughout the summer. Since we mentors worked with and interacted with our summer students daily, it made sense for students to meet with their mentors for nitty-gritty, on-the-ground, and detailed reflections.

As part of our initial lab planning, mentors agreed to meet with our students on a
regular basis depending on the need—often daily, but at minimum a few times a week. While this is a practical pathway to support experimental design, execution, and data interpretation, this consistent flow of conversation is also meant to build rapport and trust. As early-career researchers, we vividly recall (and still experience) how exciting and nerve-wracking starting new projects can be. For our undergraduate students, this is even more present.

Within the Congreve lab, as graduate students and postdocs, we meet with our advisor once a quarter to take a step back and reflect on “big picture” topics related to our work and professional development. We mentors mirrored this for our undergraduate students. Within the finite summer timeline, we planned for a formal beginning, midpoint, and end-of-summer reflection to discuss the “big picture.” The first meeting allowed us to integrate our students into the group, explain the project, and set initial expectations. The midpoint check-in, arguably one of the most important formal meetings of the summer, provided both the undergraduate students and their mentors an opportunity to reflect on the summer’s scientific progress, determine areas for improvement, and realign goals. Each mentor could conduct this in their own way.

Even so, some mentors found the prospect of conducting this mid-point review meeting to be daunting. We were just learning how to do science; how were we to propel the future generation forward with regard to skill development already? To reduce the activation barrier for this process, we tailored a reflection protocol that mentors had the option to use to guide their midpoint meetings. This protocol was designed to assess the skill sets we wanted to see our undergraduate students develop, such as experimental design, productivity, record keeping, and communication. Students reflected in advance and then used the responses as a discussion guide during the meeting with the mentor. Using this protocol, we found students often identified the same areas for growth as the mentor. This changed a potentially dreaded conversation to an encouraging, action-driven dialog because the power dynamic subtly shifted. This allowed the mentor and student to be on the same “team”: no longer is the mentor prescribing an action plan to their mentee, but both could work together toward a common goal. A similar set of meetings occurred at the end of the summer.

In addition to these meetings between students and their mentors, it was important that our advisor met individually with each summer student to discuss their general progress and experiences for a global, high-level reflection, in the same beginning/middle/end-of-summer pattern. This allowed students to build personal relationships with our advisor and discuss long-term career goals, providing the guidance and experience necessary to help the students along their path, while also allowing the students to demonstrate their scientific achievements in a one-on-one setting.

At a minimum, formal and informal reflection throughout the entirety of the summer provided students the opportunity to demonstrate scientific understanding and ask questions. For our remote students, these check-ins further ensured that they were able to make progress on their projects and engage as active members of the lab. Over time, intentional reflection also provided a platform for students to understand their research in the broader context of the scientific goals of the Congreve lab and their own career goals in addition to how we could improve as a mentor-mentee team.

**Integrating students into the greater laboratory community**

It is also important for our students to interact with the group socially outside of the lab setting. For our in-person students, this was easy: we scheduled weekly group lunches and social hours. To include remote students in these social events, it seemed natural to extend these offers over Zoom and have hybrid Zoom/in-person events. Even so, some gatherings, like a socially distanced, outdoor game night at a park, did not translate well to a live-streamed counterpart. But with extra planning, everybody in the group could participate in most team building activities. For instance, toward the end of the summer, we spent a few hours providing pointed, specific feedback before summative undergraduate presentations to the entire Electrical Engineering department. Since most students had never received iterative feedback in this way, we began the afternoon on a light note with a team-building activity. The challenge: a tower-building construction competition, where participants worked with a partner to build the tallest and most stable tower out of marshmallows and spaghetti noodles in a limited time frame. This activity was intended to be a surprise, and with a little planning, this still translated well over Zoom. A postdoc ordered the materials for the in-person lab members and sent the list of materials to “proxies” (e.g., a parent or roommate) to purchase the materials for the students joining virtually—this way, all group members started on an equal playing field, just as we would if we were all participating in person. Even from a distance, we were able to synchronously enjoy this activity together—and our Zoom participant, unable to work with a lab mate, crushed the competition (Figure 2). More importantly, we lightened the mood for all students before the undergraduates practiced presentations and received candid, raw feedback. With the trust and positive relationships built over the course of the summer, aided by being intentional in our planning, we could integrate group members into our formal and social gatherings, regardless of their physical location.
Recruiting students to pursue science

By the end of the summer, a majority of our undergraduate students—a combination of students who participated in person and remotely—expressed interest in joining our group. Several have expressed potential interest in pursuing graduate education after their bachelor’s degree as well. There was also interest from all our summer students to continue work beyond the time frame of their research experiences, even if they could not participate in research during the academic year due to other commitments. Moreover, while all summer undergraduate students presented to the department, our lab’s summer students desired to present at an in-person poster session with the group even after the program’s conclusion, once more students would be on campus. This energizing extended commitment, pride, and ownership our students have shown in their summer work inspires us to keep working toward our goals of fostering an inclusive team.

Conclusion

Flexibility and adaptation were particularly poignant in a year where so much has been uncertain due to the challenges of the pandemic. We integrated technology to provide remote students the ability to design and carry out hands-on synthesis and data collection, and we were intentional with social gatherings to normalize on-screen and real-life interactions. As we conclude, it is important to highlight how we, as graduate students, postdocs, and faculty, have grown this summer. For those of us in the lab every day, we learned alongside our undergraduate mentees. We honed our own mentorship, communication, and problem-solving skills. Particularly for early graduate students mentoring undergraduates, this summer provided an opportunity to better understand our own work through the process of sharing it with others less familiar with it.

We hope the reader sees that this entire article revolves around an inclusive group culture and believing that every person in the group can contribute and have great ideas. It has taken significant time, trial, and experimentation to work toward our goals outlined above, and we did not always succeed. Along with these high points, we also learned from the occasional flop. As individuals and a group, we always have much to learn and to improve on. In this Matter of Opinion, we highlighted what we were particularly proud of as a group and recognize that these gains were predicated on the group culture we had been cultivating over time since the Congreve lab began and the flexibility to experiment with out-of-the-box tactics to meet our goals. We look forward to future undergraduate mentorship in the years ahead, now knowing we can face any challenge.

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