



PURM
Perspectives on Undergraduate
Research & Mentoring

Impact of the COVID-19 Pandemic on Students Doing Undergraduate Research

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Introduction

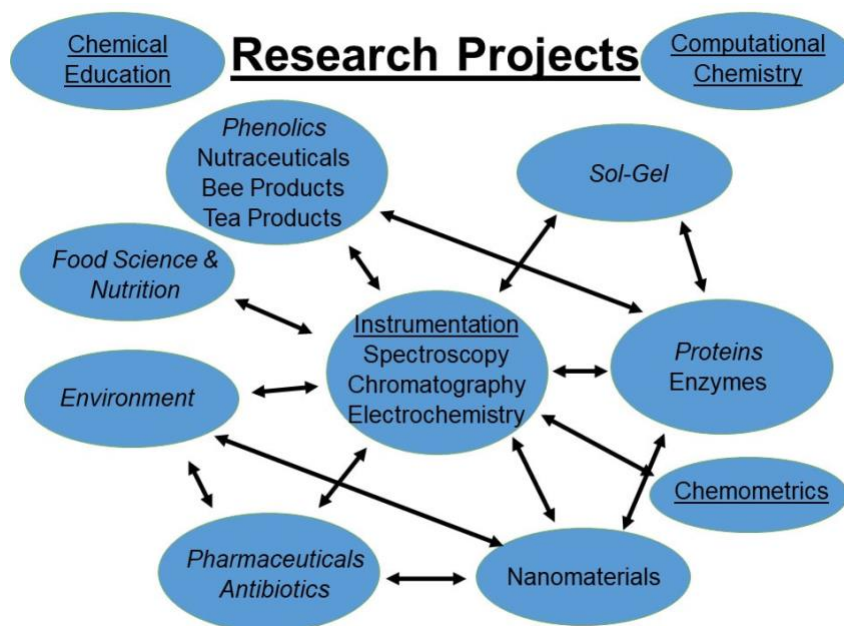
During Spring 2020, the COVID-19 outbreak affected almost every sector of our society. The resulting pandemic disrupted everyday lives, including higher education, resulting in remote learning in most colleges and universities, forcing students, faculty, and staff to adjust to this new environment (Elmer & Durocher, 2020). Nonessential institutions like universities were mandated to postpone in-person instruction. Being in the epicenter of the pandemic, access to Pace University, a private non-sectarian university based in New York City, has been limited to essential workers from late spring to summer 2020. Because of this, no physical activities were held on-campus. This set-up resulted in an increasingly uncertain environment, especially for students, because of a lack of resources to continue or complete their studies or fear of becoming seriously sick (Aucejo et al., 2020).

Aside from the quick adjustment in the transition from in-person classroom experience to a remote format in lecture and laboratory classes, students doing undergraduate research also face a great dilemma: how to continue their activities without access to laboratories. This issue is felt more by those in medicine, science, and engineering, where research is done in laboratories and on-site plants. To continue the undergraduate research activity, undergraduate research mentors and students must adjust to the new learning environment changes. This paper looks at the changes the Mojica research group at Pace University in New York City initiated to continue doing undergraduate research. It also looks at the impacts of the pandemic on students who did undergraduate research and how they overcame the obstacles brought about by the pandemic.

Research Group Topics and Laboratory Set-up

The Mojica research group specializes in analytical chemistry, using instrument-based methods (e.g., chromatography, spectroscopy, and electrochemistry) to analyze chemicals in a wide variety of samples. The group's research areas (Figure 1) include biochemistry (protein and enzymes' interaction with other chemicals), computational chemistry (theoretical calculations compared with experimental results), environmental chemistry (emerging contaminants), food science and nutrition (chemicals in human milk), material science (sol-gel and nanomaterials) and natural products (nutraceutical products like tea and bee products). Most, if not all, of these research projects, are done in-person. During Spring 2020, there are four students working on two research areas with a senior student guiding a junior student to ensure succession in personnel and continuity in completing a given project.

Figure 1. Research Areas and Projects of the Research Group



For the research group whose structure was reported (Farshi et al., 2021) to follow the Ten Salient Practices of undergraduate research mentors (Shanahan et al., 2015), the pandemic meant adjustment for students to perform research and prepare for their presentations. As early as the start of the spring semester, after the first case of COVID-19 was reported in the United States, the mentor had already implemented a plan for members. Following a procedure similar to what Elmer and Durocher (2020) adopted, the mentor (Dr. Mojica) implemented a plan for students doing research for credit and completing a thesis to fulfil the graduation requirement for graduation to maintain their pre-COVID timelines. The students were asked to double their efforts to do experiments and collect data. This plan requires students to spend more time on doing experiments to collect enough data to be analyzed, should there be a disruption later in the semester. However, the quick turnaround from the first reported case in New York City to the shift to remote learning caught some members off-guard. Some students had sufficient data to process during the shift to a virtual environment, while others could not complete their data collection. With no access to laboratories, some students opted to do computational calculations that could be done remotely. With the shift to a virtual set-up, there were changes in research activities that were incorporated. These activities include comparing theoretical Raman calculations with the experimental data, processing of raw data, and getting familiar with derivative spectroscopy and multivariate analysis. From the instrumentation-based research done in-person, most of the activities were shifted virtually by mid-Spring 2020.

As most research groups shifted their activities virtually (Collins et al., 2022; Gallegos., 2021; Samad., 2021), several changes were instituted in the Mojica research group. The first one was to remotely analyze their experimental data. The next one was for each student to conduct an extensive literature search on their respective topic. This dramatically helped students, especially the graduating ones, who completed their manuscripts for thesis requirements and for publication in scientific journals in the near future. These activities have been suggested in the literature as activities that can be used in transitioning from a wet laboratory to a virtual setting in the wake of the pandemic (Chandrasekaran, 2020; Elmer & Durocher, 2020).

The next thing was to suspend some research areas requiring in-person activities and focus more on activities that could be performed virtually. The first one suspended was any research studies in environmental chemistry because it entails the collection of samples from around the city. Electrochemistry and biochemistry-related studies dealing with biological materials like proteins and enzymes were also suspended as they included time-based experiments. As a replacement, computational chemistry gained more attention during the pandemic, where using computational software such as Gaussian to perform theoretical calculations became common. Here, students compared various experimental infra red (IR) and Raman spectra collected by previous group members. Students who registered/enrolled in physical chemistry courses the previous fall semester had remote access to the computational center at the department in this activity. Students were able to build up the structure in GaussView and then submit them for calculations to Gaussian, usually calculating geometry optimization and vibrational frequency for IR and Raman spectra. Once completed, they used the theoretical calculations to assign the functional group for each peak found in experimental IR and Raman spectra.

Another research activity that most members of the Mojica research group did was data processing. Some students performed derivative spectroscopy on the collected absorbance and fluorescence data. Derivative spectroscopy is a technique that is based on derivative spectra of a basic zero-order spectrum, such as that of absorbance and emission spectra (Karpińska, 2004; Redasani et al., 2018). This approach can be used for spectral differentiation, spectral resolution enhancement, and quantitative analysis. The group exclusively used this technique for spectral differentiation of absorbance and emission spectra of bee propolis extracts collected worldwide. Chemometrics was also introduced to the group during this time as one way of processing data they had already collected. Using available software packages such as *R* and collaborating with scientists with expertise in this field allowed some members to venture into machine learning and multivariate analysis. This was one aspect that piqued some students' interest.

The group continued to meet every two weeks to monitor each student's progress in activities and to practice for their thesis presentation until the end of Spring 2020. This was a helpful practice during the pandemic, as suggested by several articles (Parrington & Giardino, 2021; Speer et al., 2021). The group found these activities useful as the students appreciated that they could still perform research even in a remote setting. Three of the five graduating students, who were Honors students, completed and successfully presented their thesis virtually as part of their Honors requirements. All graduating students were able to graduate on time. No in-person research activities were accomplished during Summer 2020, but some graduating students wrote their manuscripts and submitted them to peer-reviewed journals.

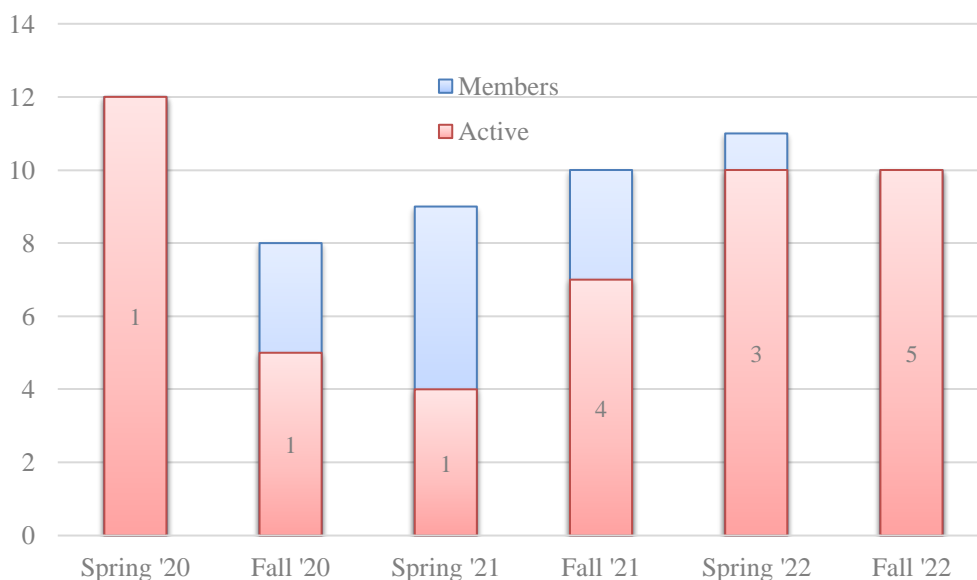
Since the research topics were cut down to activities that could be performed virtually (computational chemistry and data processing), upon the resumption of the limited in-person class from Fall 2020 to Spring 2021, the research group focused on two key projects. One project focused on analyzing the chemical composition and antioxidant activity of bee and tea products. The other project was an Honors thesis focusing on chromatographic analysis of free fatty acids in human milk.

Group Members and Activities

The transition during the pandemic also affected the number of members and their engagement. Figure 2 shows the total number of members, including members who actively continue to research during the pandemic and new members joining the group. The number of group members dropped during the pandemic. Of twelve students actively doing research before the transition to a virtual environment, five students graduated by Spring 2020. The number reduced to seven by Summer 2020. With one student joining the group in Fall 2020, only five members (including the new student) were active in doing research at this time, with three students opting to halt doing any

research activities. This led to the suspension in research areas as these students were doing biochemistry and material science research projects. Another student joined the group in Spring 2021, bringing the total members to nine, but only four students were active in doing research. This was the lowest number of students (i.e., two) recruited within a school year. Three students, one of whom were actively doing research due to the Honors thesis requirement, graduated in Spring 2021. The group recruited four new members in Fall 2021 and three in Spring 2022, which was at the typical level. Overall, the research group has reached its pre-pandemic size, but there were inactive members, which weren't seen pre-pandemic.

Figure 2. Membership in the Research Group During the Pandemic



Note: Number denotes new members joining the research group.

The reasons why students became inactive and stopped doing research were the following: 1) they stayed home since all of their classes were online; 2) they took a break because of mental issues and anxiety brought on by the COVID-19 pandemic; and 3) they got COVID-19 during the semester. Knowing the nature of the pandemic and how it has been stressful for the diverse population, students were given more freedom to continue their research. Considerations must be given to the difficulties experienced by the students during the pandemic. The pandemic posed a big challenge to research. There is no or limited laboratory access during this time. In addition, other complications due to the pandemic also happened, like student's fear of getting COVID or needing to fulfill academic requirements while moving places (Savic et al., 2021).

Even when some members became inactive, they constantly communicated with the faculty adviser and showed up when asked to validate their results. Six students left the group by the end of Spring 2022 due to graduation, while five new members joined the group during the same period, bringing the present members to ten with assigned research topics to be performed by Fall 2022. The improved membership number can also be credited to the course-modified undergraduate research experience (CURE) in CHE 221 Analytical Methods and Techniques course taught by Dr. Mojica during Fall 2021, where students were given a requirement in the laboratory class to do mini-research on consumer products. This opportunity made up for the students' semesters of online laboratory courses and gave them more hands-on experience. Of the sixteen students who took the

course, three were already group members, and four continued to do the project in Spring 2022, with three formally joining the group at the start and another one joining at the end of Spring 2022.

Unlike the previous set-up, where a senior student guided new students, the faculty adviser trained the new members during the pandemic period (i.e., Fall 2020 to Spring 2021). Although the old set-up where senior students trained new students resumed by Fall 2021, the main focus on research was limited to analysis of bee and tea products. There was no more continuity on the other research projects as students had already graduated. The faculty adviser had to train new students who expressed interest in working on research projects suspended during the pandemic.

Students' Reflections

The impact of the COVID-19 pandemic on students doing undergraduate research was assessed by asking all active group members (five) during Spring 2020 to Spring 2021 five questions. Only four members responded. Three of them were Forensic Science majors: Alexandria (Ally) Papadelias (white), Lawrence Phillips (African-American), and Baylee Caudill (white), while Fernando Sanchez (Hispanic and military veteran) was a Biology major. Ally graduated in Spring 2021, and the rest graduated in Spring 2022. Ally and Lawrence served as group leaders at one time or another. All of them did research during the limited in-person period and presented their results virtually and in-person. All were asked for their reflections on the impact of the pandemic on their undergraduate research experience by answering the five questions below.

1. How was your undergraduate research experience impacted by the pandemic?
2. How does the pandemic affect your time in doing research and presentation? Will you have more studies done or presented at more conferences?
3. Do you think you will have a better experience if there is no pandemic?
4. What is/are the positive lesson(s) you learned about doing undergraduate research despite the pandemic?
5. What could have been done to improve your undergraduate experience?

The research group structure and research focus were not the only ones affected by the COVID-19 pandemic. Based on the answers to the survey questions, the students were also greatly impacted by the pandemic. The unavailability and later limited access to the laboratory affected them, especially the three students working with the Mojica research group when the pandemic hit the city. Ally stated, "We're no longer able to work in the lab." At the same time, Lawrence replied, "I could not do in-person undergraduate research," while Fernando wrote, "The pandemic significantly impacted my research experience by losing a tremendous amount of time in the laboratory experience." These answers indicate that students could have learned more if the research was done in the laboratory. Ally also stated that "the pandemic also halted in-person meetings with my research group, which was a great asset in my research experience." Lawrence, who opted to continue to do research virtually and do literature research reacted, "I analyzed data using Excel for my research professor and conducted more theory-based research on my subjects, such as reading more research articles about possible bioactive compounds in the same region or various assays results on the matter." On the other hand, Fernando commented, "Although we adapted to a literature approach to research, we lost valuable learning experiences." It is not surprising that Baylee answered, "I feel the pandemic did not impact my undergraduate research experience since I began research in 2021," since she joined the group after the transition. By that time, some order had been established, and she was trained directly by the faculty mentor.

Another immediate effect caused by the pandemic is the cancellation of scheduled scientific conferences during Spring 2020. The last in-person scientific conference event participated by the group was the Annual Meeting of a Fellows Society on the weekend of March 7, 2020, where nine

out of twelve members (including Students 1 and 3) presented their research. However, other events like the American Chemical Society (ACS) National Meeting to be held in Philadelphia later that month were canceled and held virtually instead. Out of the 11 members whose abstracts were accepted for presentation at the ACS National Meeting, only 4 could upload their posters despite most of them having data presented at the in-house event. Other scheduled events like the annual Eastern Colleges Scientific Conference (ECSC) and local meetings like undergraduate research symposia sponsored by ACS NYC Local Section and William Patterson University were canceled.

Most students lamented the lost opportunities of doing research in the laboratory and presenting at conferences. Ally, who only had one in-person presentation, remarked, "All of the presentations I was involved in were conducted virtually. If it were not for the pandemic, I would have been able to do more work in the lab, gather new data, and work on additional studies. I also would have been able to get more experience presenting in person." On the other hand, Fernando wrote: "It affected my time by only allowing me to conduct minimal work in the laboratory and gain more data to analyze. Although we transitioned to an online format in presenting, it did not help my presentation skills in person, but it did help my anxiety while presenting my research." The reaction of Lawrence is somewhat different as he stated, "My presentation was switched from an in-person poster to a PowerPoint presentation. This allowed me to closely show the judges and people interested in my poster about my research project. My time doing the research was not greatly affected as I was able to get it done in a timely manner. While at home, I had to designate research times as if I was in school." Lastly, Baylee is more positive with the transition with her statement, "Since the pandemic, many research presentation opportunities have become remote and do not always have a large (multiple days) time commitment. If remote options were not the case, I think I would have fewer presentations completed, as it is harder to travel."

Everyone answered affirmatively that they would have a better research experience if there were no pandemic. Ally stated, "If there were no pandemic, my undergraduate experience would have been more standard. However, the pandemic allowed me to grow stronger and learn to work around the obstacles presented. What I missed the most during this time was my in-person interactions with my community. Virtual meetings helped ease the absence of in-person contact, but nothing can compare to interacting one-on-one with your research group and leader." On the other hand, Lawrence wrote, "I would have had a better experience without a pandemic in a practical sense. I would have learned more techniques and polished the techniques I already learned in the lab." In contrast, Baylee wrote, "I think the experience would be just as great, but different experiences would have been achieved. I would have developed more research-based public speaking skills if there had been no pandemic." Lastly, Fernando wrote: "My research experience would have been much more beneficial if there was no pandemic."

In terms of things that could have been done to improve the undergraduate experience during the pandemic, two answers were related to research. These responses were surprising since group members were asked to prioritize their well-being and academic requirements during the transition. Lawrence bemoaned, "I would have liked to get into research sooner so that I could have more published papers and more experience with the conferences." At the same time, Baylee wrote, "More university-based presentation opportunities could have still been completed on campus (although there were some)." Ally answered, "During the pandemic's beginning, everything was chaotic, making the focus and direction of research more difficult. In the pandemic setting, a defined schedule could possibly help ease the lack of structure that working from home can bring." Fernando agreed with the comment of Ally, "I believe the University did a great job reacting to the pandemic. Still, circumstances like personal life events made adapting to the provided structure more challenging."

Despite the reported difficulty experienced by most students during the pandemic, particularly the transition from a physical to a virtual environment, all four respondents shared some positive lessons they learned about doing undergraduate research during this period. Ally wrote, "The pandemic has taught us all a multitude of lessons. For me, a key thing I learned is that even when things seem impossible, we always find a way to make it through. Before the pandemic, I wouldn't have imagined presenting at conferences and having research meetings virtually becoming a standard. Still, we learned that we could make anything happen when pushed to our limits." Lawrence added, "I learned that research could be conducted despite the limited chances, such as an online format." Baylee also agreed by writing, "By doing research within the pandemic, I learned that it is extremely important to put a lot of effort into visual representations and speaking aids. Constricting a lot of data and information into one poster is very important since not everyone will see a full paper." Only Fernando disagreed, "I think there wasn't much that could've been done at the time unless the university provided an area where we could've decontaminated and [donned] personal protective equipment to allow us to enter the lab."

Results and Outcomes

Although the pandemic resulted in adjustments in the structure and focus of the research group, the Ten Salient practices (Shanahan et al., 2015) were still followed. There were lot of pre-planning activities to cater to the students' need in doing research ranging from doing virtual experiments to doing limited in-person experiment. After being able to adjust with the situation, clear expectations were set for each member and the faculty mentor took over and trained new members, teaching skills, methods, and techniques needed for a given research. The faculty mentor and other members were able to continue the community built pre-pandemic, helping new members to adjust in the group and giving emotional support to members greatly impacted emotionally and mentally by the pandemic. As the conditions improved by Fall 2021, the remaining salient practices (Shanahan et al., 2015) were reestablished, including one-on-one, hands-on mentoring, increased student ownership of the research, and presentations in conferences resulting in networking. The only difference is that all of these presentations were done virtually until Spring 2022, when some scientific conferences were held in-person. At this time, the pre-pandemic environment had been reestablished.

Based on the comments given by the students, the necessary adjustments made during the pandemic proved helpful for them. Despite the circumstances, they were still able to take advantage of the opportunities offered by undergraduate research. The virtual environment and cancellation of events where they have the chance to present their results allowed them to spend more time polishing their papers to submit for publication. Overall, seven group members during Spring 2020 produced several articles published the following year. Two of these members were still in the line-up and led the group in the following years and have passed the benefits of undergraduate research like having published papers to the succeeding members. The continuous communication of the faculty mentor with the group members during the pandemic proved helpful for the group's resilience and success. The change in the structure and research focus has allowed the group to continue its productivity despite the initial setback the group members experienced. In addition, the option to have virtual presentations in ACS meetings allowed opportunities for students to disseminate their results.

References

Aucejo, E. M., French, J., Ugalde Araya, M. P., & Zafar, B. (2020). The impact of COVID-19 on student experiences and expectations: Evidence from a survey. *Journal of Public Economics*, 191, 104271. <https://doi.org/10.1016/j.jpubeco.2020.104271>

Chandrasekaran, A. R. (2020). Transitioning undergraduate research from wet lab to the virtual in the wake of a pandemic. *Biochemistry and Molecular Biology Education*, 48(5), 436-438. <https://doi.org/10.1002/bmb.21386>

Collins, J., Polen, A., Jernigan, I., Colón-Burgos, D., McSweeney, K., & Spandri, M. (2022). An analysis of virtual research experiences for undergraduates programs in light of the COVID-19 Pandemic. *Bulletin of the American Meteorological Society*, 103(3), E954-E972. <https://doi.org/10.1175/BAMS-D-20-0231.1>

Elmer, S. J., & Durocher, J. J. (2020). Moving student research forward during the COVID-19 pandemic. *Advances in Physiology Education*, 44(4), 741-743. <https://doi.org/10.1152/advan.00153.2020>

Farshi, J., Papadelias, A., Iannone, G., Zapata, J., Javornik, A., Symczak, K., Baria, M., & Mojica, E.R.E. (2021). Reflections on the impact of exposing students outside the classroom through presentations and publications. *Perspectives in Undergraduate Research and Mentoring*, 10(1), 1-12. https://eloncdn.blob.core.windows.net/eu3/sites/923/2022/02/Farshi_T2102.pdf

Gallegos, A. O., Ahmed, G. H., Schloemer, T. H., & Congreve, D. N. (2021). Reflections on hosting summer undergraduate researchers in the midst of a pandemic. *Matter*, 4(10), 3074-3077. <https://doi.org/10.1016/j.matt.2021.09.013>

Karpińska, J. (2004). Derivative spectrophotometry-recent applications and directions of developments. *Talanta*, 64(4), 801-822. <https://doi.org/10.1016/j.talanta.2004.03.060>

Parrington, B. A., & Giardino, W. J. (2021). Zooming into the Lab: Perspectives on maintaining undergraduate biological research through computationally adapted remote learning in times of crisis. *Journal of Microbiology & Biology Education*, 22(1). <https://doi.org/10.1128/jmbe.v22i1.2563>

Redasani, V., Patel, P., Marathe, D., Chaudhari, S., Shirkhedkar, A., & Surana, S. (2018). A review on derivative uv-spectrophotometry analysis of drugs in pharmaceutical formulations and biological samples review. *Journal of the Chilean Chemical Society*, 63, 4126-4134. <http://dx.doi.org/10.4067/s0717-97072018000304126>

Samad, T., Fleming, H. E., & Bhatia, S. N. (2021). Virtual undergraduate research experiences: More than a pandemic stopgap. *Med*, 2(2), 118-121. <https://doi.org/10.1016/j.medj.2021.01.007>

Savic, M., Kothapalli, N. R., Lanier, H., Freeman, E., Ratliff, L., Hillermann, E., & Martin, C. (2021). Positioning humanity before progress: Students' and mentors' perceptions of the COVID-19 impact on undergraduate research. *Scholarship and Practice of Undergraduate Research*, 5, 31-38. <https://doi.org/10.18833/spur/5/1/10>

Shanahan, J. O., Ackley-Holbrook, E., Hall, E., Stewart, K., & Walkington, H. (2015). Ten salient practices of undergraduate research mentors: A review of the literature. *Mentoring & Tutoring: Partnership in Learning*, 23(5), 359-376. <https://doi.org/10.1080/13611267.2015.1126162>

Speer, J. E., Lyon, M., & Johnson, J. (2021). Gains and losses in virtual mentorship: A descriptive case study of undergraduate mentees and graduate mentors in STEM research during the COVID-19 pandemic. *CBE-Life Science Education*, 20(2), ar14. <https://doi.org/10.1187/cbe.20-06-0128>