Capturing Student and Instructor Experiences, Perceptions, and Reflections on Remote Learning and Teaching in Introductory Chemistry Courses During COVID-19

By Pouya Bahrami, Denice Blanco, Hannah Thetford, Li Ye, and Julia Y. K. Chan

The COVID-19 pandemic forced instructors to suddenly pivot from in-person to remote teaching and students to rapidly adapt their learning strategies. During this emergency instruction period, 21 semistructured, one-on-one interviews were conducted to learn about students’ experiences and perceptions about remote instruction in two introductory chemistry courses at two public southwestern universities. Themes that emerged from the interviews include challenges experienced, adaptations, and recommendations for improving remote learning. These themes show that despite unprecedented challenges, students are capable of developing new ways of learning through a variety of approaches. Guided by action research and the Community of Inquiry framework, the two instructors acknowledged and reflected on students’ voices gathered from interview data, then designed and implemented custom pedagogical strategies in their remote courses in subsequent semesters. The collaboration and reflection between the two instructors provide an example of professional development for educators and how they can embrace challenges and transform them into opportunities for growth and learning. The article also discusses implications for improving the quality of remote instruction and connecting with relevant stakeholders.

The ongoing COVID-19 pandemic has caused and will continue to cause significant changes to the higher education landscape that may persist for some time. During the first year of the pandemic, many campuses across the United States were forced to close, consequently requiring faculty, students, administrators, and staff to work remotely to control the rapid spread of the deadly virus and to meet the safety and health guidelines set in place by federal and state officials. During that time, remote courses, remote student support services, remote conferences, and meetings became the new norm.

Both instructors and students were forced to begin teaching and learning remotely over the span of several days. Some of the main challenges encountered from transitioning from in-person to remote teaching included a lack of adequate technology, poor internet connections, and the adaptation of in-person components of the course to the remote setting (e.g., group work and discussions, poster presentations, assessments). Thus, the timing and conditions that resulted from COVID-19 created opportunities for conducting many unprecedented natural experiments in higher education (Zimmerman, 2020). There were numerous research studies conducted during the pandemic’s first year that examined faculty and student experiences of remote teaching and learning during COVID-19, the ideas and approaches attempted both successfully and not, and general recommendations for future remote teaching and learning (Gewin, 2020; Holme, 2020). It is important to recognize and understand the lessons learned from remote teaching with the goal of making remote instruction more enjoyable, effective, and sustainable. In March 2020, both institutions in the current study announced that they were going fully remote for an unknown period of time. This change provided an opportunity to study the following questions: (i) What types of learning challenges have students encountered in introductory chemistry courses during the pandemic? (ii) How do students adapt from in-person to remote learning midway into the semester? (iii) What are students’ recommendations for improving remote learning? (iv) What are some lessons learned from and actions taken in response to remote teaching? The results presented in this article represent the voices of students enrolled in two introductory chemistry courses across two different Hispanic-serving institutions (HSIs). Based on student interview data, the two instructors (corresponding authors of this article) reflected on and acknowledged the students’
recommendations and subsequently implemented custom pedagogical strategies in the two courses for the following semesters.

**Purpose of the study**

The intent of this study was to gather students’ and instructors’ perceptions and experiences of emergency remote learning in college introductory chemistry courses during the ongoing COVID-19 pandemic. Figure 1 shows a visual representation of the study.

We looked at the following research questions:
1. What are students’ perceived challenges with remote learning?
2. How do students adapt from in-person to remote learning midway in the semester?
3. What are students’ recommendations for improving remote learning?
4. What are some lessons learned from and actions taken in response to remote teaching?

**Methods**

**Action research**

Action research is widely used by teachers and researchers to improve and change classroom practices. It has been used in chemistry education research (Grange & Retief, 2018; Stuckey & Eilks, 2014; Towns et al., 2000). This research methodology is an iterative and fluid open cycle consisting of several stages: planning, implementation, observation, and reflection (Elliott, 1991; Koshy, 2005). After each implementation phase, data are analyzed, and if modifications are required, they are made before the next phase; the entire cycle is then repeated. This cycle is valuable because one cannot act meaningfully without true understanding and deep reflection. Likewise, it is meaningless to learn about the theory and not put it into action. In our study, we used action research to guide our research and practices.

**Setting and participants**

Data were collected at two primarily undergraduate institutions in the southwestern region of the United States in spring 2020; both are federally designated HSIs. The student demographics are similar at the two institutions: About half of students (52%) are from underrepresented minority (URM) backgrounds, slightly more than half (57%) are female, and approximately 10% are freshmen. Additionally, more than half of the students are from families in which their parents did not earn a 4-year college degree, and about half of the students received the federal Pell Grant.

The students at Institution A were enrolled in a 1-semester introductory chemistry course designed as a prerequisite for General Chemistry I. Students were mostly majors in science, technology, engineering, and mathematics (STEM) and related fields. Introductory Chemistry was taught by one instructor twice each week for 75 minutes for each period. At Institution B, students were enrolled in General Chemistry I designed for science majors. General Chemistry I was taught by two instructors in two lecture sections of 130 minutes each. The two instructors at Institution B had similar exams, syllabi, and course materials.

During the first half of the semester, both courses were taught in person at the two institutions. However, after spring break in 2020, instructors at both institutions were forced to switch from in-person to remote lectures over Zoom, a videoconferencing platform, due to the COVID-19 pandemic. The instructors at both institutions incorporated collaborative group work assignments throughout the lecture. Students were assigned to do in-person, in-class collaborative activities via worksheets in the classroom before spring break. Both instructors were able to continue the collaborative activities in the online environment through preassigned breakout groups using Zoom breakout rooms, and students recorded their answers to the chemistry problems on a Google Doc. A small percentage of the course grade (5% at Institution A and 7% at Institution B) was awarded for the accuracy of answers to chemistry problems presented on the worksheets or in Google Docs.
Data collection and analysis

To understand students’ experiences and perspectives toward transitioning from in-person to remote learning during the pandemic, 21 semistructured interviews were conducted via Zoom (12 students from Institution A; nine students from Institution B) between Weeks 11 and 13 during spring 2020. The student population in the two courses consisted of 66% female students, 55% URM students, and 54% freshman students. The study sample consisted of 67% female students, 43% URM students, and 52% freshman students. The student demographics in the study sample were comparable to the population in the classes, except that the percentage of URM students was slightly lower. The average course performance of the study sample and the overall class populations was also similar.

Emails were sent out to students inviting them to participate in interviews, which were conducted between Weeks 11 and 13 by the undergraduate and graduate chemistry education researchers from the two research teams. During the interviews, students were asked to share the adaptations that they had made, the challenges they faced, and things their instructors did that were helpful during the switch to remote learning. The interviews were approximately 15 minutes long. Interviews were both video- and audio-recorded via Zoom, and video recordings were deleted to protect the participants’ identities. Thus, only the audio recordings were used to conduct the data analysis. Pseudonyms were used for all of the interviewees to ensure their confidentiality. This study was approved by the Institutional Review Board at both institutions.

All 21 interviews were transcribed verbatim, then coded by a team of undergraduate and graduate chemistry education researchers via the constant comparison method (Glaser & Strauss, 2017). The constant comparison method involves comparing data by generating abstract codes through an inductive process. By studying a range of individual cases and extrapolating patterns from them, researchers can deduce general codes. Each coder created codes independently, then compared and discussed the pertinent codes that would fit best under a common theme for each research question. After consensus was reached, one coder then used the resulting codes and themes to code the remaining dataset. Students’ open-ended responses for each research question were coded, and an inter-coder agreement of 63% was reached during the first round of coding. After discussions about the disagreement, the codes were modified, and an inter-coder agreement of 82% was reached in the second round.

Results

A series of questions were asked during the interviews to understand the challenges that students experienced and their adaptations due to the unforeseen change from in-person to remote learning in the two introductory chemistry courses at both institutions. Table 1 presents an overview of emerging themes and subthemes from the dataset. These include challenges experienced by students, adaptations, and recommendations to improve remote learning.

<p>| TABLE 1 |</p>
<table>
<thead>
<tr>
<th>Emerging themes and subthemes from interview data.</th>
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<tbody>
<tr>
<td><strong>Themes</strong></td>
</tr>
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</table>
| Challenges experienced by students in remote learning | • Distractions at home  
• Technical issues  
• Lack of communication with others  
• Lower motivation |
| Student adaptations to remote learning | • Creating a new routine  
• Adapting to new study environments  
• Understanding and learning more about technology  
• Having a positive mindset/thinking about the big picture  
• Adjusting learning strategies and using more resources |
| Recommendations from students to improve remote learning | • Instructor: teaching, communication, social-emotional support  
• University: resources and communication  
• Family: understanding and support |

Challenges experienced by students during remote learning

Most participants reported that they experienced unexpected challenges due to the sudden change from in-person to remote learning, including distractions at home, technical issues, a lack of communication with others, and lower motivation. Interestingly, we noticed that the majority of comments about challenges experienced during remote learning pertained to URM students. These students frequently reported having distractions at home because they shared rooms with others or experienced technical issues such as inadequate internet services or unfamiliarity with technology tools during remote lectures. Here are a couple of examples of these challenges:

“At home, there’s a lot of distraction. Having a quiet place is hard to find.” —Martha, URM, female, grade C

“For me, it would be mostly technical issues.” —Sarah, URM, female, grade B
In addition, participants reported that it became much more difficult to connect with instructors or peers after switching to remote learning, and they felt less motivated to learn. These student quotes demonstrate the lack of connection and motivation after switching to remote learning:

“Whoever I did talk to in my classes, I don’t really talk to them anymore (online).” —Tanya, non-URM, female, grade D

“Mentally, I would say I've just become more unmotivated since being at home.” —Allison, non-URM, female, grade D

The instructors also noticed the motivation change for a proportion of students after the switch to remote learning because of the lack of peer-to-peer interactions. It is worth noting that all comments about experiencing lower motivation as a result of transitioning to remote learning were mentioned by non-URM students. Furthermore, during virtual office hours, students shared that they felt more isolated and had to rely more on themselves for learning in the remote environment.

**Student adaptations to remote learning**

According to the participants, a home environment is far different from what students were used to on campus. Most participants were experiencing this transition for the first time in their lives and tried a variety of approaches to thrive. For instance, some students started to create a new routine for themselves and tried to arrange a quiet time or space for remote classes.

“I’ve definitely had to rearrange my schedule. It’s harder to find a good workspace here because I don’t really have a desk or anything.” —Allison, non-URM, female, grade D

Moreover, many URM students reported that they had to make adaptations to the new study environment, such as finding a quiet place in a shared living area to focus on schoolwork and separating their home life from their school life.

“A new environment because I do have to worry about like my parents coming in.” —Judy, URM, female, grade C

“Create a place of study and a place just to really focus on schoolwork to separate my home life from my school life in a way.” —Tom, URM, male, grade B

“I had to move from my apartment off campus to home, and I definitely had to find a space within my room to be quiet because I do share a room with my sister, and that’s an adaptation.” —Catherine, URM, female, grade C

These types of concerns regarding having distractions from other family members in shared living spaces were not echoed by the non-URM students.

Another adaptation made by students was the need to understand and learn more about technology to keep up with remote learning.

“Now I find myself in front of the computer most of the time. Mentally, I feel like it’s just a new thing that I have to go through.” —Sarah, URM, female, grade B

“Making sure that everything functions properly on the technical side.” —Phoebe, non-URM, female, grade A

Furthermore, the interviews showed that the challenges to remote learning are not only impacting students physically but also affecting their psychological well-being significantly. However, some participants were able to embrace positive mindsets and keep the big picture in sight despite the challenges and uncertainties of remote learning.

“At least I have the benefit of knowing how remote classes are. ...I feel like everybody is trying. ...If you have a bright mentality...in the end, everything is going to be OK. It's a learning experience.” —Sarah, URM, female, grade B

Moreover, participants adjusted their learning strategies and employed more remote resources to improve their remote learning. Some effective learning strategies mentioned by students include watching and replying to recordings of remote lectures shared by the instructors, rereading and comprehending lecture notes, working on problems consistently, and taking more time to complete and fully understand homework assignments. Additionally, a few participants mentioned using virtual tutoring and office hours more often during remote learning.

“I would actually now try to use office hours. [During in-person learning], I really wouldn’t because I was able to ask in class and talk to the professor.” —Martha, URM, female, grade C

“Now I start to go like more tutoring classes than before.” —Joe, non-URM, male, grade B

Some students used YouTube videos or other tutorials to understand the chemistry concepts more thoroughly.

“I’ve been looking up a lot more tutorials on problem-solving and more than I usually would. I’m watching more online videos, like YouTube how-tos more than I was before.” —Zoey, non-URM, female, grade C

Overall, both URM and non-URM students realized that they had to
make adjustments to their study habits and use outside resources to keep up with lecture material.

**Recommendations from students to improve remote learning**

Participants were asked to reflect on things they found helpful during the transition from in-person to remote learning and recommendations they had for improving remote learning in the future. Responses were analyzed and separated into three categories: instructor, university, and family. First, participants commented on how the instructors’ teaching, communication skills, and social-emotional support helped them thrive during remote learning. Students were more satisfied when postclass notes were posted and lectures were recorded by the instructor.

“She [the instructor] records the lectures, and for example problems, she writes, helps us write them down on the slides, and then she saves them and then she posts them on her Canvas.”—Emily, non-URM, female, grade A

Regular and frequent communication was also necessary to keep students motivated in the remote environment.

“Whether it’s emails or announcements or reminders on Titanium, everything is based on you seeking out the information. ... There’s a lot that I need to make sure, so I don’t miss a single deadline.”—Sanaz, non-URM, female, grade D

Students also mentioned how they appreciated instructors’ use of other platforms for communication, such as GroupMe, a mobile application for chat, in addition to sending out regular emails and notifications through the learning management system. Using multiple platforms helped enhance the efficiency of communication at both levels: instructor to student and student to student. Surprisingly, many students felt comforted and emotionally supported by instructors. This type of social-emotional support was as simple as asking about students’ well-being at the start of class, acknowledging the difficulty of remote learning, being understanding and flexible by extending deadlines for assignments, staying on Zoom a few minutes after class ended to answer questions, or holding multiple times for virtual office hours so more students could attend. Here are a couple of examples that students mentioned that illustrate the value of showing empathy for and understanding about students’ well-being:

“We understand that this is very difficult. It’s a very cliché statement, but spending the extra 2 minutes to say this cliché statement really meant a lot to some students.” —James, non-URM, male, grade B

“She always made sure we were OK; she always told us to email her if we had any questions.” —Judy, URM, female, grade C

Overall, all students, regardless of ethnic groups, sex, and academic performance, appreciated the instructors’ support for their mental well-being.

Furthermore, students stressed the importance of family support during the transition to remote learning. However, they expressed concerns for a family’s lack of understanding and awareness in terms of giving them personal space or time in the new learning environments at home. They suggested that universities directly communicate with parents and other family members via letters or videos to help them understand the new challenges and adaptations students faced. This recommendation is explained by a URM student:

“Sending letters to parents or having even a video for parents to see so that they can understand that there has to be a little bit of space between the students just so that we can be able to still focus. ... There has to be just a tiny little bit of distance so that we can be able to do the work and then help out wherever they need.” —Catherine, URM, female, grade C

Additionally, students recommended that the university should provide more accessible virtual resources such as drop-in sessions for academic advising, counseling, and tutoring.

When students’ comments about adaptations, challenges, and recommendations for remote learning were differentiated by academic performance (i.e., overall course letter grade) and sex, no differences were found.

**Discussion**

**Connecting to existing studies and what happens next**

To understand how students responded to the changed learning environment, a handful of studies have reported challenges and student adaptations during COVID-19 in chemistry courses (Davidson & Voronova, 2020; Jeffery & Bauer, 2020; Nickerson & Shea, 2020). For instance, Jeffery and Bauer (2020) surveyed students in a variety of chemistry courses in spring 2020 and found that students reported the greatest change from active hands-on experiences to passive observations in online chemistry laboratory courses as compared with in-person labs.

For lecture courses, not much change was reported (Jeffery & Bauer, 2020). Students were sorted into five hierarchy profiles based on their perceived challenges and adaptive behaviors: Okay, Keep calm, Structure-seeking, Loss, and Lemons. Okay and Keep calm profiles showed
representations of students’ positive and neutral responses to engagement, emotions, and motivation prompts, and Structure-seeking, Loss, and Lemons were characterized by the primarily negative responses to the three prompts in the open-ended survey. The loss of rich peer interaction was indicated to be the possible cause of changes in students’ motivation and engagement in remote learning. Our study found similar challenges encountered by students, such as motivation and social interactions issues.

However, our findings differ from those reported from the private and research-intensive public universities where students reported fewer distractions and technology issues (Huang, 2020; Hurst, 2020). These differences in findings may be attributed to differences in students’ demographics and family backgrounds and the availability of institutional resources to support students for remote instruction. For instance, our campuses have a higher proportion of URM, first-generation, and low-income students, which is a different demographic than that seen in some studies. The types of challenges (e.g., shared living spaces with family, distractions, and internet issues) experienced by URM students in our study are thus different from the challenges faced by students from institutions with fewer URM students.

Instructor reflections and the evolution of teaching from the study

The opportunity to collaborate on this research study allowed both instructors to actively reflect and share effective teaching strategies throughout the COVID-19 pandemic. As a result of many conversations, a list of custom pedagogical strategies was developed in response to analyzing the student data and themes (see Table 2). Some of these pedagogical strategies have been adapted from the science education literature (Armstrong et al., 2021; Casselman & Atwood, 2017; Cook et al., 2013; Dressel, 2020; Hew et al., 2010; Humphrey et al., 2020).

Instructor reflections and pedagogical strategies implemented in subsequent semesters in response to the interview data.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Subthemes</th>
<th>Instructor reflections and actions taken</th>
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</thead>
<tbody>
<tr>
<td>Challenges experienced by students in remote learning</td>
<td>Distractions at home</td>
<td>• Provided information about infrastructure with quiet spaces and stable internet and device loaner programs for electronic devices from the universities</td>
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<tr>
<td></td>
<td>Technical issues</td>
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<tr>
<td></td>
<td>Lack of communication with others</td>
<td>• Created and monitored collaborative chemistry problems/tasks via Google Jamboards or discussion threads via learning management systems • Created group chats in apps such as GroupMe or Remind to send reminders of important deadlines of assignments or tasks</td>
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<tr>
<td></td>
<td>Lower motivation</td>
<td>• Sent personalized early-alert motivational messages to all students during semesters via a tool named Canvas Insights • Used frequency formative assessments and employed more interactive tech tools such as the Pear Deck program or Kahoot game to increase engagement and feature exemplary student responses to improve motivation • Incorporated a real-world application group project based on student interest to increase student perceived task value, motivation, and peer-to-peer communication skills</td>
</tr>
<tr>
<td>Student adaptations to remote learning</td>
<td>Creating a new routine</td>
<td>• Helped students establish a weekly calendar</td>
</tr>
<tr>
<td></td>
<td>Adapting to new study environments</td>
<td>• Shared instructors’ personal stories and used icebreakers to connect with students</td>
</tr>
<tr>
<td></td>
<td>Understanding and learning more about technology</td>
<td>• Provided handout and gave brief instruction on tech tools during lectures • Provided information about virtual IT training/tech support for students from universities</td>
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<td></td>
<td>Having a positive mindset and thinking about the big picture</td>
<td>• Integrated an online module to teach growth mindset</td>
</tr>
<tr>
<td></td>
<td>Adjusting learning strategies and using more resources</td>
<td>• Integrated an online module to teach effective learning strategies</td>
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As both instructors worked together to incorporate research-based interventions to support their students, they found the Community of Inquiry (CoI) framework particularly helpful. The CoI framework is the process of collaborative constructivism through the development of three interdependent dimensions: teaching, cognitive, and social presence (Garrison, 2007). For example, teaching presence refers to the design and organization, facilitation, and delivery of instructional activities. Cognitive presence refers to students’ construction of learning through metacognitive self-reflection (e.g., self-testing). Social presence refers to the ability to portray authenticity and vulnerability through open communication, affective expression, and group cohesion. Instructors may promote social presence by incorporating collaborative activities, sharing personal (related) experiences of learning challenges, and creating weekly check-in announcements or summary videos. These three presences work interdependently to help students develop a deeper level of community to support their learning. As an example, the CoI framework was used as a guide to rearrange and evaluate the existing pedagogical strategies of the two instructors (see Figure 2).

**Conclusions and implications**

The study shows that despite unprecedented circumstances, students are
resilient and capable of finding new ways to adapt to change during the mandatory switch from in-person to remote learning in college introductory chemistry courses. Specifically, some of these adaptations include creating new routines, adapting to new study environments, learning more technology tools, having positive mindsets and looking at the big picture, and developing new learning methods through a variety of approaches. Through the process of action research, the two instructors listened to and acknowledged students’ voices by actively conducting self-reflections, having regular pedagogical conversations, and modifying pedagogical strategies to improve remote teaching. This approach is valuable because when students know their voices are heard and implemented in our practices, they feel more important, which consequently empowers them to become more engaged in their learning. Sudden, unanticipated changes can present a level of discomfort and are sometimes inevitable, but learning how to adapt to such changes through cultivating and actively practicing a growth mindset is essential for both students and instructors (Canning et al., 2019).

As a start, these teaching stories can be shared and discussed in department and college meetings or at academic conferences so others can learn from and adopt these innovative strategies in their classrooms. At the university level, setting up more infrastructures such as quiet spaces with stable internet and electronic devices is needed to support students and close opportunity gaps between student groups; other campus resources such as technology training for students and more “walk-in” virtual tutoring and academic advising and counseling sessions would also facilitate and improve students’ learning experiences. With support and collaboration from administrators, institutions, and campus resources, innovative resources developed during this period can be salvaged, improved, and sustained on a larger and wider scale. Future research might consider conducting in-depth interviews with students, instructors, and related stakeholders (e.g., tutors, advisers, instructional designers) in the postpandemic era to investigate how perceptions and expectations of learning and teaching in college introductory sciences courses have shifted due to the pandemic.

Looking ahead to the postpandemic era, we encourage instructors to work collaboratively, participate in professional development workshops, continue learning, and implement evidence-based pedagogical strategies to improve the quality of remote instruction. Furthermore, it may be helpful to collaborate with an instructional designer with expertise in reviewing remote and hybrid courses. When developing or improving the quality of their online courses, instructors can consider additional resources, including quality metrics from the Online Learning Consortium Quality Scorecard Suite or Quality Matters. Finally, we suggest instructors, where and if possible, salvage and repurpose effective components of their emergency remote courses and strategically incorporate them into future in-person, online, and hybrid classes.

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**References**


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