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Conversation among Physical Chemists: Strategies and Resources for Remote Teaching and Learning Catalyzed by a Global Pandemic

ABSTRACT: In the midst of a global pandemic in spring 2020, physical chemistry faculty gathered to share strategies and resources for teaching remotely. During this conversation, instructors created a shared document compiling the challenges they faced in spring 2020 and ways to improve teaching and learning in the physical chemistry classroom and laboratory when institutions reopened in the fall. We present a content analysis of the shared document that provides a snapshot of physical chemists' thoughts at that moment in June 2020. The themes that emerged from our analysis are assessment, choice of learning objectives, course management, opportunities, resources, student motivation, and wellbeing. We have summarized the numerous strategies, resources, and implementation ideas that were shared by participants, many of which we believe will remain in use when traditional in-person instruction resumes. Finally, the conversation connected physical chemists, strengthening our community. Continued community engagement has occurred through further synchronous conversations, asynchronous conversations on our Slack workspace, and the creation of the repository PChem Inspired Pedagogical Electronic Resource (PIPER).

KEYWORDS: *Upper-Division Undergraduate, Physical Chemistry, Internet/Web-Based Learning, Computer-Based Learning, Curriculum, Laboratory Computing/Interfacing*



■ INTRODUCTION

The pivot to remote learning that happened in spring 2020 due to the COVID-19 pandemic caused students and faculty to face numerous challenges. Chemistry instructors banded together to pool resources and devise strategies to create the best learning environment for their students while navigating personal and professional upheaval. Existing communities (e.g., VIPER¹ and POGIL–PCL²) demonstrated how their resources could be used remotely. The *Journal of Chemical Education* published Virtual Issues entitled *Resources for Teaching Your Chemistry Class Online*^{3–22} in March and *Laboratory Learning*^{23–42} in June that each collected 20 articles with remote learning strategies and resources. In September 2020, the Special Issue *Insights Gained While Teaching Chemistry in the Time of COVID-19*⁴³ contained over 180 papers including a handful addressing physical chemistry.^{44–48} The Facebook group⁴⁹ “Strategies for teaching chemistry online” was created on March 10, 2020 and had more than 3000 members by summer of 2020. There was a clear need for a community in which instructors share resources and provide support.

When our tumultuous spring 2020 teaching concluded, many of us began to deliberately plan our future classroom and lab experiences. Institutions, including those of each coauthor, began announcing the format of fall courses: online only, face-

to-face only, or some hybrid version. A small group of physical chemistry instructors were interested in talking with each other about the logistics of teaching physical chemistry in these formats. Many of us were part of other physical chemistry communities⁵⁰ including the American Chemical Society Exams Institute Physical Chemistry Exams Committee, the Molecular Education and Research Consortium in Undergraduate computational chemistry, or MERCURY,⁵¹ the Process Oriented Guided Inquiry Learning–Physical Chemistry Lab network, or POGIL–PCL,² and the Engaging Students in Physical Chemistry Google Group.^{52,53} The COVID-19 crisis accelerated the push to integrate efforts to build a community among physical chemists that was already happening. A small group of us decided to open our conversation to all physical chemists. We contacted the members of the groups mentioned above and posted to the Facebook group “Strategies for teaching chemistry online” to advertise the conversation.

On June 18, 2020, more than 80 physical chemists gathered for a 2 h Zoom call to discuss the challenges we were facing, strategies for addressing those challenges, how we could implement those strategies, and ways the community could help. The meeting began with a brief introduction, and then, participants were sorted into 14 breakout rooms. A facilitator guided participants in each room through the discussion questions in [Table 1](#). During each 15 min breakout session,

Table 1. Discussion Questions for Each Breakout Session of the Physical Chemistry Zoom Call

Breakout Session Focus	Discussion Questions
Laboratory/1	Briefly: What are the primary challenges you are facing in your PChem lab this fall? What strategies have you been considering implementing?
Laboratory/2	How could you envision implementing some of the strategies discussed thus far? How could the community of Physical Chemists help you?
Classroom/3	Briefly: What are the primary challenges you are facing in your PChem classroom this fall? What strategies have you been considering implementing?
Classroom/4	How could you envision implementing some of the strategies discussed thus far? How could the community of Physical Chemists help you?

members of the group recorded their responses in a shared Google Doc (available in the [Supporting Information](#)). Groups also shared highlights with all participants using the Zoom whiteboard during a 10 min report-out time between each breakout session.

Our primary goal was to develop strategies to overcome the adverse circumstances created by the COVID-19 pandemic. Community building was another goal. Virtual gatherings reduce isolation for many physical chemistry instructors, who may be the only physical chemist at their institution. We created a Slack channel⁵⁴ for ongoing conversation, and we organized more Zoom meetings through the summer and the 2020–2021 academic year. Additionally, the PChem Inspired Pedagogical Electronic Resource (PIPER⁵⁵) repository was subsequently created with the hope that the resources and support created by this group will have long-term impact on the teaching and learning of physical chemistry.

This manuscript delineates the content of notes (available in the [Supporting Information](#)) created during the initial Zoom meeting. In their conversations, physical chemistry instructors discussed the challenges they were facing. They embraced new pedagogies in both the lab and the classroom. They exchanged strategies, resources, and implementation tools (available in the [Supporting Information](#)) that will improve how physical chemistry courses are conducted amidst this global pandemic and in the future in a variety of classroom formats. The content analysis of this discussion forms a snapshot of how our community came together at this meeting.

METHODS

Content analysis,^{56–59} a qualitative research method, was performed on the notes (available in the [Supporting Information](#)) that were recorded during the virtual meeting. There were 603 individual statements that were reviewed to identify themes and develop a coding system. Each coauthor first reviewed all statements independently. Then, we met in groups of two or four in 12 meetings over the course of several

months to identify themes and codes. Themes were refined, including combining, subdividing, or adding themes, as statements began to be coded. As well, the codes were iteratively revised during the meetings before an ultimate consensus on them was reached. [Table 2](#) shows the themes

Table 2. Themes and Codes Assigned to Statements Generated during the Breakout Sessions

Themes (decreasing frequency)	Codes within Each Theme (alphabetical)
Course management	Data collection/hands-on activities in lab Dealing with sick students Flipped classroom Group work Insufficient time/resources Modifications to course structure in response to COVID (e.g., synchronous vs asynchronous content, shifted schedules, structure of in-person laboratories/classes, syllabus modifications)
Resource	Uncertainty Other Needed (coded with resource type) Shared (coded with resource type)
Resource type	Activities for students to do in class or lab Books Computational chemistry Data analysis and programming software Repository and community for physical chemists Teaching technology Videos Other
Assessment	Administering remote assessments Cheating Nontraditional assessments (e.g., oral exams, creative works, presentations) Shift to lower stakes (formative) assessments Other
Wellbeing	Emotional Physical
Student motivation/engagement	
Choice of learning objectives	
Opportunities	

and codes (subheadings under each theme) that we developed. The themes and codes were then shared with and approved by the facilitators of the 14 breakout rooms. (We are deeply grateful to the facilitators, duly named in the Acknowledgments section.) Each of the 603 statements from the meeting notes were assigned codes (typically one or two) from the list in [Table 2](#).

During the conversation, the facilitators focused participants on strategies to address new challenges in teaching physical chemistry. Facilitators were instructed to keep the conversation about challenges brief so that more forward-looking approaches for the upcoming academic year could be identified. The 603 statements were approximately evenly distributed between lab and classroom (~300 each) and across the four breakout sessions (average of ~150/session ranging from ~130 to ~180). Participants were much more likely to provide strategy, resource, and implementation suggestions than a challenge by more than 2:1.

Teaching Technologies

Student Engagement Tools: Flipgrid, Zoom breakout rooms, Blackboard embedded tests, Google Collaborate, Poll Everywhere, Perusall, Piazza, Socrative, Kritik, PlayPosit, Edpuzzle, PhET simulations, H5P, Symmetry@Otterbein, and Notability.

Communication Tools: Microsoft Teams, Slack, Zoom, GroupMe, Webex, Explain Everything, Youcanbook.me, Google Meet, EquatIO, Padlet, and Workflow.

Ideas for Student Activities

A wavefunction of the week activity, then all the parts come together to create a final paper for the course.

Students find a JCE lab that could be executed in your lab and **write a peer reviewed NSF-style proposal** to do the lab in the next semester.

Students **record a 3 minute presentation** describing a paper from a literature search.

Students **create a podcast** based on material they learn independently for a general audience.

Do an **oral exam** with each student to ask how they are in addition to ask about process.

Students **record mini-presentation** walking through a figure or equation.

Creative exercises, solve a problem and **write a series of statements** on the problem solving process.

Collaborative annotation for literature review.

Course trailers to introduce class, students make videos to get to know each other.

Laboratory Ideas and Resources

Ideas for Remote Lab Experiments: Computational chemistry labs, POGIL-PCL labs, kinetics experiments at home (apple browning, garbanzo beans, bleaching food coloring, color change of milk of Mg with acid), spectroscopy with cell phones, build a spectrometer with DVD as grating, lab exploring the thermodynamics of PCR COVID testing, protein denaturation lab using pymol, use ACS Reviewer Lab to train students how to offer professional peer review, bomb calorimetry simulator, HPLC simulator, calibrate a thermometer using a low-cost python circuit with a thermistor, focus on data analysis with available data sets, Fourier Transform of sound (cricket chirp rate), and focus on experimental design by explaining how/why you would use this technique (How would you measure this?).

Computational Chemistry Resources: MolSSI, Psi4Education, ChemCompute, WebMO, Jupyter notebooks, Spartan, XSEDE, Anaconda navigator, OpenMD, MolCal, and SHODOR.

Figure 1. Summary of resources and ideas shared by faculty participants during the Physical Chemistry Zoom session. Additional information including weblinks for the shared resources are available in the [Supporting Information](#).

RESULTS AND DISCUSSION

The themes listed in [Table 2](#) that we identified from our discussion (assessment, choice of learning outcomes, course management, opportunities, resources, student motivation/engagement, and wellbeing) are consistent with topics of papers in the *Journal of Chemical Education Special Issue on Teaching Chemistry in the Time of COVID-19*.⁴³ The largest number of papers in the Special Issue addressed laboratory learning. Other topics in the special issue that appeared frequently included active learning and collaboration, logistics and responses to change, and testing and assessment. Clearly, these topics are on the minds of chemistry faculty everywhere.

Course Management

The course management theme had ~300 statements (50%). Many faculty faced great uncertainty as to how their institution would be operating (in person, hybrid, fully online) and how to plan for midcourse pivots. Statements such as “we’re not sure what the format will be yet; most people planning for at least some of it to be online” and questions such as “what to do if campus closes mid-semester?” represent that uncertainty. Another group pointed out that they were “having to be prepared to go online at any minute”. Concerns about how to balance synchronous and asynchronous activities or in-person and remote students were also apparent. Participants indicated that they “may have to accommodate students who choose to stay home and take all classes remotely, so need to offer both synchronous and asynchronous options” and faced “different constraints: 1/3 of students in class and other online. How to engage both simultaneously?” Suggested strategies to combat

these concerns included implementing a flipped classroom environment using class time for problem sets and discussions, making use of available teaching technology (see [Figure 1](#)) including campus Learning Management Systems (LMS) and web-meeting platforms, grouping students by time zone for those attending remotely, and recording classes for students who cannot attend for whatever reason including being diagnosed with COVID-19.

It was particularly apparent that lab courses were going to require significant adaptation. As stated by one participant, “figuring out what experiments can do without students doing the data collection is a major issue.” Faculty expressed concern that they did not have enough resources (time, instrumentation, lab space) to achieve the goals of the laboratory experience, indicating that it is “hard to reconcile physical distancing of students with limited number of available instruments, but students may not be allowed to work in pairs/groups” and asking “Will there be enough time for students to rotate and complete labs if they are not working in pairs?” More existential questions like “can hands-on experiences be effectively replaced by distance labs?” were discussed. The challenges associated with group work and hands-on data collection were mentioned repeatedly by different groups, particularly in relation to physical distancing and cleaning shared instrumentation between users. For those who were having in-person classes, some planned to “still do some hands-on labs, trying to split hands-on groups into in-person and online”. Strategies to address these challenges included pooling data, which was mentioned in several groups, as well as creating simulations, sharing data sets collected

previously, designing at-home experiments, and front-loading data collection if students were abruptly sent home midsemester. Many instructors were interested in implementing more computational chemistry; one group asked “how do you move to more modeling-based labs?” The community responded with a comprehensive list of resources and ideas as shown in [Figure 1](#) ranging from online computational tools like [ChemCompute.org](#) to training in programming and use of Jupyter notebooks. [Table S1 in the Supporting Information](#) contains a comprehensive list of the resources physical chemistry instructors shared, descriptions of those resources, and weblinks for more information.

Resources and Resource Types

The physical chemistry faculty who participated in this conversation were primarily focused on identifying strategies, resources, and implementation ideas for their courses. As a result, there were ~300 statements (50%) that mentioned a resource. Nearly a third of those shared a teaching technology (campus Learning Management Systems, web-meeting platforms, educational apps, platforms for asynchronous communication) with a small handful requesting help with managing that technology to accomplish their learning goals. Applications such as WebEx, Zoom, Canvas, Blackboard, Perusall, Socrative, Piazza, Slack, Microsoft Teams, Explain Everything, Notability, Padlet, Flipgrid, and Google Meet were mentioned. [Figure 1](#) provides a list of shared resources and their function. Additional information on each application as well as how to access it can be found in the [Supporting Information](#) where readers can find a table with information on 15 Student Engagement Tools, 12 Communication Tools, five Remote Lab Experiments, and 11 Computational Chemistry Resources.

The next most common subthemes under resource type were specific activities for students to perform in class or lab and ways the community of physical chemists could be a resource. Eight of the 14 breakout groups discussed POGIL–PCL activities, and a number of at-home laboratories were shared. A collection of computational chemistry resources and ideas for experiments were also shared in addition to data analysis and programming activities, all of which were deemed a valuable strategy for possible remote learning environments in the 2020–2021 academic year and beyond. The shared resources and ideas are in [Figure 1](#), while the table with how they are used and where to access them is in the [Supporting Information](#).

Assessment

Members of every breakout room discussed assessment. Many faculty were deeply concerned about the ability to assess students in an online environment, particularly with regard to cheating. One group reported that “exams were difficult to administer in virtual (sic) environment. ACS standardized test (sic) are not an option. Attempts to lock questions and require students to answer one at a time before advancing did not significantly reduce dishonesty.” A number of groups discussed shifting to more frequent, lower stakes assessments, an important strategy to reduce the achievement gap.⁶⁰ For example, the advice was shared to “avoid major exams and instead, use more low stakes assessments. Weekly quizzes instead of no (sic) midterms. Junior and senior students are receptive to that.” Instructors are clearly willing to assess critical thinking and problem solving in different ways as evidenced by the statement “for assessment, intentionally allow guesstimate, but ask them when and how they used it. Cite their

sources. Encourages reflection. Metacognition: ‘what do I need to answer this question?’” It was also suggested that faculty can ask students to “write a series of statements on the problem solving process”, “incorporate Excel into exams”, or make use of open book exams that may “reduce the anxiety of moving online (they were already used to working that way)”.

Faculty were embracing new assessment ideas. Many groups discussed implementing oral exams, essays, presentations (including video recordings), and podcasts. One faculty member “gave an essay for the final exam (evaluate a John Donne poem in the context of the 2nd law of thermodynamics)”. These assessments provide students opportunities to improve their communication skills and reduce the role of academic dishonesty. For example, one participant had “students create a podcast based on material they learn independently”. The process “required interpretation for a general audience”. Instructors who assigned discussion board posts or oral exams also talked about the opportunity those provided to check in with each student individually. In discussing oral exams,^{48,61,62} instructors were quick to mention strategies for putting students at ease initially and ensuring fair grading with a well-established rubric. These strategies were connected to concern for the physical and emotional state of students after the abrupt transition to remote learning.

Wellbeing

Approximately 50 statements (8%) referred to either the emotional or physical wellbeing of students and instructors. Concern for students’ emotional wellbeing centered around abrupt transitions and the difficulty of balancing academic and family responsibilities from their homes. Participants realized that “students were working, dealing with family”, asked “how can students pivot if they need to in the middle of the semester”, and suggested that faculty “go outside your comfort zone to reach out to your students and meet with them to “talk to/checking-in on” them; do what you can to as many as (sic) of them as possible”.

Any reference to physical or social distancing was coded as physical wellbeing. Lab activities and other group work are particularly difficult to manage in an environment requiring physical distancing and masks. Participants wondered “how do students work together when they are six feet apart?” and noted the challenges of communicating and working with organic solvents while wearing masks. Beyond enforcing adequate personal protective equipment, participants also pointed out that instrumentation and lab equipment will need to be cleaned between student groups. To address these challenges, groups suggested “having only one lab group come face-to-face each week and they share their data with the rest of the class” and “plan to run lab as usual with social distancing, alternating weeks with one group doing virtual”.

Student Motivation

More than 30 statements (5%) refer in some way to student motivation. A participant indicated there were “problems with student motivation” and that “my motivation too was an issue. I’m not worried about lecture, but labs are a concern.” While another pointed out that “some students just stopped ‘attending’ class in the spring.” Faculty wanted to know “how to build community online.” Ways to answer this question include suggestions to “be sure to poll your students as to what formats they prefer and how they want content delivered”, “separate lecture into 20 min chunks so (sic) that engage students”, and assign “getting-to-know-you exercise (have

students make TikTok video?) to get rapport". It was easy for students to become overwhelmed in an online format. Suggestions to combat that challenge included "make deadlines visible and clear!" and spend time during the first week teaching students how to learn online. Several faculty noted that attendance at office hours was lackluster after the pivot to remote learning. Suggestions for improving use of office hours included having students "make 15 min appointments every week, in addition to office hours", "make each student attend an office hour on Zoom with the waiting room enabled. For example, 'Wednesday is *your* opportunity is (sic) one-on-one session with professor' - messaging was key," and "call them 'tutoring hours' instead of 'office hours'".

Choice of Learning Objectives

A few statements refer to making choices about learning objectives, particularly from the discussion on the lab experience. When students have limited lab time, faculty have to select the most essential content and skills. Participants asked questions such as "what is most important for students to get out of lab?" and suggested that instructors "switch the goals of lab to different, but still valuable skills such as exposure to primary literature, giving presentations, data analysis, etc" and "put more emphasis on data analysis and the learning objectives there". Groups suggested having students "focus on figuring out 'How would you measure this?' Explain how/why you would use this technique (focus on design)?" It was clear that instructors must "make choices about content" to focus on "takeaway skills".

Opportunities

We recognize that, although the pandemic has been incredibly disruptive, there are opportunities for the physical chemistry community. As we are forced to implement new ideas and technology, we can also develop lasting improvements of the teaching and learning of physical chemistry. For example, we have the opportunity to increase accessibility by continuing to allow students to attend class remotely. Students, even those who attended synchronous sessions, benefit from viewing recorded class activities so they can prepare for an exam or clarify content. Deploying technology strategically can increase student engagement, facilitate student learning, and improve equity.⁶³ Thoughtful use of LMS features can benefit students in fully in-person classes. Collaborative platforms like Google Docs, Sheets, or Jamboard allow students to respond to a prompt and then see what their peers have created to investigate themes or common misconceptions. As instructors, we have had to think creatively about every aspect of our courses, and many of the new ways of doing things should become routine.

A more expansive set of transformational opportunities exists too. These are opportunities to fundamentally rethink the purpose and reasoning of current educational goals and learning outcomes. In short, we seldom consider why we teach a particular topic or why we use certain educational tools and techniques. For example, shifting to computational chemistry experiments and using programming tools teaches our students skills and knowledge that they may not have had pre-COVID. In being forced to replace in-person activities with remote learning options, we can embrace a portion of our discipline that is widely recognized as important but not always taught at the undergraduate level. Faculty have adopted computational laboratories and programming activities as a

replacement for traditional in-person activities, and they should remain in the curriculum.

However, the inclusion of more computational chemistry into physical chemistry instruction highlights a significant tension in the chemistry curriculum. The breadth and scope of physical chemistry presents a significant challenge in improving instruction and learning. Indeed, physical chemistry is so expansive it is simply not reasonable to adequately cover all topics in the undergraduate setting. Individually, we all intuitively recognize this to be true, and we commit ourselves to teaching just the most important parts of the curriculum. However, as is true in other subdisciplines, it is becoming apparent that there is little consensus as to what the most important parts really are. We currently have the opportunity to focus on this conversation and evaluate the balance of breadth and depth of the curriculum.

George Bodner originally described the dominant educational paradigm in chemistry as the *vaccination model*.⁵⁶ In this model, instruction is like a vaccination that prevents illness; exposing students to a topic, even if only briefly, is beneficial for them in case they encounter the topic later in their career. Exposure in an early course such as general chemistry is sufficient protection so that further instruction later in a course like physical chemistry is not necessary. Simply stated, in the vaccination model, proper instruction is synonymous with covering many topics. Breadth is preferable to depth. While COVID-19 did not create the feeling that there is too much to cover and not enough time to cover it all, the disruptions certainly aggravated it. This tension has always been one that instructors have had to manage. However, the pandemic shed light on how traditional instruction can encourage students to adopt superficial learning strategies (e.g., short-term memorization) rather than engage in meaningful learning.⁶⁴ It is clear from the conversation that instructors are actively seeking ways for meaningful learning to occur, including guided inquiry and creative assignments as indicated in the [Resources and Resources Types](#) and [Assessment](#) sections above.

Instructors are also wrestling with the goals of chemical instruction, further complicating the breadth vs depth issue. Traditional chemistry instruction has focused almost exclusively on chemical content knowledge. However, it is becoming apparent that developing students into chemical professionals includes skills, behaviors, and modes of thinking that are not in a textbook table of contents. Instead, a significant component of the educational process involves acculturation into the chemical community through interpersonal interactions. During the pandemic, physical distancing and separation exacerbated the challenges of engaging with peers, instructors, and content, as noted by many comments in our conversation. As we have learned through extensive research in the K-12 setting, when instructors focus too narrowly on traditional content, students are less likely to be able to apply their learning in real, practical, and meaningful ways.⁶⁵⁻⁶⁸ Instead, students are left with a very naive understanding of the actual inquiry-based nature of science. Holistic approaches that also include science processes and practice decrease the likelihood that student learning is little more than a series of isolated, unconnected topics. Forcing instructors to consider which learning outcomes are truly necessary can shift instruction to more holistic approaches rather than an overreliance on content-based approaches. Holistic pedagogical approaches provide opportunities for innovative assessments that align with the knowledge, skills,

behaviors, and modes of thinking students need to become practicing chemical professionals.

Community Needs and Follow-Up Activities

It was apparent from the turnout and discussion that there is a real desire for physical chemists to gather and share resources, strategies, and support. During the breakout sessions, faculty were asked to identify how the community could be of assistance. Many faculty requested a repository of resources “for remote learning such as computational experiments, videos, or data/results from experiments”, which has since been created as the PIPER repository.⁵⁵ The PIPER repository contains articles, books, computational resources, data sets, laboratory activities, links to other useful Web sites, and additional resources. Faculty may contribute resources to the repository through the “Help us Build” link on the web page. It was designed for instructors to find and share resources for teaching physical chemistry. We strongly encourage the interested reader to explore the PIPER repository as well as the resources in the [Supporting Information](#) of this article.

Additionally, a Slack workspace with over 130 members now exists for asynchronous communication within the community.⁵⁴ Four additional synchronous conversations have taken place via Zoom since the initial meeting: a discussion of Flower Darby’s *Small Teaching Online*⁶⁹ in June, a discussion focusing on challenges in the laboratory in August, and check-in conversations in October 2020 and April 2021. Each of these follow-up conversations, which were on more focused topics, had about 30 participants, and in each, a crowd-sourced set of notes was created. These tangible outcomes from the community conversation came from requests at the initial meeting in June.

■ CONCLUSION

Given the challenges and uncertainties associated with the global coronavirus pandemic, faculty were focused on how to teach effectively under these new circumstances. By June 2020, the community had largely identified most of the major challenges associated with teaching physical chemistry in the current environment. The large number of suggestions and resources that were shared prove that faculty were already familiar with technological solutions and likely had experience with them prior to the start of the pandemic. This observation highlights one reason the community is so important. Individually, we recognize the gaps in our own skill set to address various challenges and problems. However, collectively, the community has a broad range of expertise and backgrounds.

Many of the comments from the meeting speak to a desire for a high-quality learning experience in our new environment. Faculty wish to retain engaging material and keep vital interactions intact. As a result, we find ourselves rethinking how we structure our classes, what we ask students to do, how we assess learning, and how we maintain motivation and wellbeing during a difficult time. We found that our colleagues have discovered creative and innovative ways of doing all of this, and we can learn from each other through the community of physical chemists. Ultimately, in addressing the challenges presented by the coronavirus pandemic as a community, we will not only teach better in the current environment but also teach better as we return to the traditional face-to-face interactions. It is too early to know the long-term impact of these changes. We cannot yet answer questions such as how

many faculty will continue to use the resources and ideas identified during the conversation and collected in [Figure 1](#) or if computational chemistry will be more integrated into the physical chemistry curriculum, for example. We implore the physical chemistry community to continue to engage with each other, use and contribute to the PIPER web page, reflect on the changes they have made as a result of disruptions caused by the COVID-19 global pandemic, and evaluate those that have improved the teaching and learning of physical chemistry.

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