At-Home STEM Lab Kits in Higher Education

LESSONS LEARNED FROM THE COVID-19 PANDEMIC AND RECOMMENDATIONS FOR FUTURE SUCCESS

ONLINE LEARNING™ CONSORTIUM

CAROLINA DISTANCE LEARNING

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Recommended citation:

Swindell, A., McGurk, S., and McGuire, A. (2022). At-Home STEM Lab Kits in Higher Education: Lessons Learned from the COVID-19 Pandemic and Recommendations for Future Success. The Online Learning Consortium. https://onlinelearningconsortium.org/read/at-home-stem-lab-kits/

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ABOUT OUR ORGANIZATIONS

The **Online Learning Consortium (OLC)** is a collaborative community of education leaders and innovators dedicated to advancing quality digital teaching and learning experiences designed to reach and engage the modern learner—anyone, anywhere, anytime. OLC inspires innovation and quality through an extensive set of resources, including best-practice publications, quality benchmarking, leading-edge instruction, community-driven conferences, practitioner-based and empirical research, and expert guidance. The growing OLC community includes faculty, administrators, trainers, instructional designers, and other learning professionals as well as educational institutions, professional societies, and corporate enterprises. Learn more at onlinelearningconsortium.org.

Carolina Distance Learning® offers campus-quality science lab kits for online students that provide the same rigor, relevance, and results that traditional labs provide. It has leveraged 90+ years of expertise to be able to offer hands-on labs in nine subject areas that can be completed at home safely. Carolina also provides free course design, the flexibility to customize, and shipping schedules to match your timeline so you can plan and facilitate labs with ease and confidence (and without aggravation and stress). In addition to serving schools, Carolina's products have also been used by the scientific and health communities. It has a 24-hour order hotline for a special program to supply medicinal leeches to doctors and hospitals and has also supplied NASA scientists with various products for their important work. Learn more at carolinadistancelearning.com or take a look at this video.

The Carolina-OLC Partnership

With Carolina Distance Learning's dedication to providing quality at-home lab programs for college-level distance education and the Online Learning Consortium's (OLC's) dedication to creating community and knowledge around quality online, blended, and digital learning while driving innovation, a mutually beneficial opportunity has arisen to explore the evolving needs of science educators in higher education as they create quality digital, blended, and online learning experiences for their students.

"There was a real need for a distance option for some students that weren't right on campus and so in developing that, all the labs would be online. I looked to try to create labs that would be engaging, and so I wanted to use an at-home kit of some sort so that students weren't doing just animations and virtual exercises, and that has been really successful and has continued. Because of the kits, we were well prepared when the pandemic hit and we transitioned all of our in-person labs to the online format, it was all there."

- Biology Faculty, 4-Year Public University

INTRODUCTION

The pandemic has sparked a wide engagement with remote learning; however, research shows there remains a significant difference between emergency remote teaching and quality online learning. While 73% of respondents to a recent survey on STEM education during the pandemic indicated converting face-to-face coursework to remote learning, only 18% made use of online or at-home labs in their coursework. Still exigent to corporations (e.g., Carolina Distance Learning), nonprofits (e.g., OLC), and instructional support professionals who support quality digital, blended, and online learning are the barriers to adoption for resources, like at-home labs, that may exist for science-focused deans, department chairs, program coordinators, and faculty.

Many institutions are exploring strategies to leverage what they learned from and invested in during the pandemic to increase blended and online programming. Creating quality digital materials for blended and online programming, particularly in hands-on application courses like the sciences, can be quite challenging in terms of cost (e.g., time, money, resources) and quality. Science deans, chairs, program coordinators, and faculty may be unaware of the opportunities or may have barriers to adoption that corporations, nonprofits, and instructional support professionals need to be aware of to better support quality educational experiences across modalities. Students may not be receiving quality digital, blended, or online education that puts their learning and success at the center.

Accordingly, the purpose of this study was to explore the evolving perspectives of science deans, chairs, program coordinators, and faculty regarding the value of online tools (e.g., at-home lab kits), the extent of their use, benefits of and barriers to adoption, and possible recommendations for future success. The research questions we sought to address specifically included:

1. How has the pandemic changed science education?
2. What have science educators been doing to offer their traditional labs online?
3. What are the biggest challenges science educators face when moving online?
4. What are the benefits and barriers to adopting online tools (e.g., at-home lab kits)?
5. How have science educators been supporting diversity, equity, and inclusion?
6. What is the role of at-home lab kits for the future of online science education?

To address the research questions, a qualitative methodology was employed to provide a deep and thorough understanding of at-home lab kits and their usage. Data collection took place in May 2022 during which time five virtual focus groups on various STEM subjects (Biology, Physics and Engineering, Anatomy and Physiology, Environmental Science, and Chemistry) lasting approximately 90 minutes were conducted with a total of 45 participants. Participants were selected to include a range of institutional types (i.e., 4-year public and private universities, community colleges, and technical colleges) and institutional roles (i.e., science deans, chairs, program coordinators, and faculty). Data were analyzed using top-down and bottom-up thematic coding and Atlas.ti qualitative analysis software to generate the key themes. In what follows, the central findings are presented across the three main categories that emerged during data analysis, including the impact of at-home lab kits on: 1) Quality, 2) Access, and 3) Institutional Support and Challenges.

QUALITY

ACCESS

INSTITUTIONAL SUPPORT AND CHALLENGES

KEY FINDINGS

QUALITY

"You just get creative with these students, and you have to adapt. You're almost spending more time with them one-on-one when you are doing Zoom meetings and students are actually holding a heart [from a lab kit] and you're both working together trying to figure out things. They're learning more."

- Anatomy and Physiology Faculty, Community College

Opportunities for Innovation

The core finding from this study was that at-home lab kits presented a number of different opportunities for innovation in teaching and learning for online, blended, and digital STEM education. The following presents the central types of innovation that emerged through data collection and analysis: 1) Creativity and Adaptability, and 2) Getting Others Involved.

Creativity and Adaptability

To better support quality educational experiences across modalities, instructors need freedom for creativity and adaptability for student success. Creating quality digital materials for blended and online programming in hands-on application courses like the sciences can be quite challenging, particularly when the goal is to maintain the same learning outcomes as traditional, face-to-face courses. Even so, many participants were able to do just that while noting how the switch to at-home lab kits, either before or after the pandemic, spurred creativity. One community college Chemistry faculty member explained, "We do a bunch of labs that haven't been updated in 50, 60, 70 years, and with [at-home] lab kits, I have to say, we've got the opportunity here to be able to update what the students can learn and what they will be able to learn." Indeed, the change to online and blended learning, albeit difficult at times especially in the emergency context of the pandemic, was commonly reflected upon not as a limitation but rather as an opportunity for creating new types of learning that improved upon the previous modalities.

The creativity was not limited to faculty and institutional staff. Students completing labs at home are completing the work themselves, not relying on lab partners to do the work for them. This requires students to develop problem-solving skills, since they must figure it out for themselves. In other words, the at-home nature of the labs forced students to be more self-reliant, which in some cases promoted more active learning. However, participants did also note that this was not always a recipe for student success and that some students undoubtedly did better in a face-to-face lab setting.

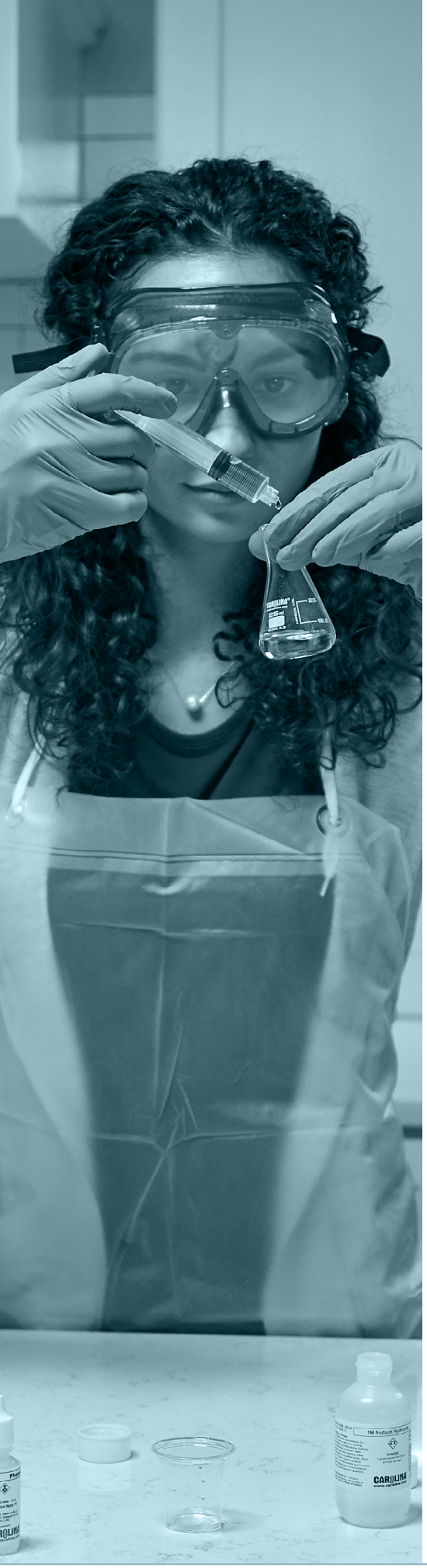
Getting Others Involved

One surprising finding of this study was that at-home lab kits allowed for the families of students to get actively involved in their learning. That is, if a student was doing a lab at home, their children, friends, or other family members would often join in and learn themselves. Participants noted how this unexpected outcome greatly increased student enjoyment of the activities for some, though others experienced it as a barrier. One participant elaborated that "A sign of the immediate success of the student is that at-home labs are getting more people involved. I just love it when I see my students' children, roommate, parent, or significant other, being involved in the lab as well, either because they must demonstrate that they can take their blood pressure, or because you know the kids doing the videography while the student is pointing out the structures in the dissection."

Learning Outcomes and Accreditation

Findings showed that in large part, learning outcomes were met by the lab kits. An Anatomy and Physiology faculty member at a 4-year private institution noted, "When we offer our online courses, we supplement with a lab kit, so students get that hands-on experience." Indeed, many participants felt they could deliver the same quality lab experience and teach the same learning objectives with the use of the at-home kits.

Even though most participants mentioned learning outcomes remained the same, accreditation remained an issue for many. This was especially true with state or institutional accreditation bodies that, despite the perceived positive learning outcomes by faculty, did not accept online or blended labs for the same credit as in-person lab courses. One reason for this was the concern that accrediting bodies may not approve the



online course/program if it was perceived that the learning outcomes are changed when a traditional science lab class is moved online. According to one focus group member, "Starting the course design with learning outcomes … made a huge difference, and we can easily point to our accreditors that we have an equivalent program for our online students." The pandemic also arose as a factor in state accreditation agencies temporarily approving online courses with at-home labs, but those exceptions have slowly gone away as campuses resumed in-person classes.

Academic Feedback and Integrity

The final element of quality education that arose was surrounding academic feedback and integrity. Sharing substantive feedback with students who are completing science labs at home presented interesting challenges. During the Physics focus group, a Physics chair from a 4-year private school commented, "What I really like about [in-person] labs is kind of walking around the room and hearing students talking. You know, if they're saying the wrong thing, they're thinking the wrong thing. How do I preserve the interaction?" Some of the advice given by many of the focus group attendees, not just those in the Physics group, included: "You can share the screen." You can even ask the student to take the screen and post something." "Have a Zoom call like this with them synchronously." "You just have to have policies that require them to interact with you." Ultimately, most participants felt that giving truly useful and corrective feedback was easier in-person but that there were workarounds for online labs that proved useful.

Regarding integrity, most focus group participants noted integrity and cheating online was an issue but found that it was avoidable and more of an issue with online or blended learning generally than specific to at-home labs. A Physics faculty member from a 4-year college needed to find a way to verify the integrity of students doing the actual labs and recommended, "One of the ways I like to try to do it is to have them take a photo of what they did and upload it." Another Physics faculty member in the group asked their students to make a video for each lab they completed.

ACCESS

"So, by being a very rural area, we have to reach out to our communities. And so, we're a community college so if the community can't come to us, then we have to go to the community, so we will bring education to them."

- Physics and Engineering Faculty, Community College

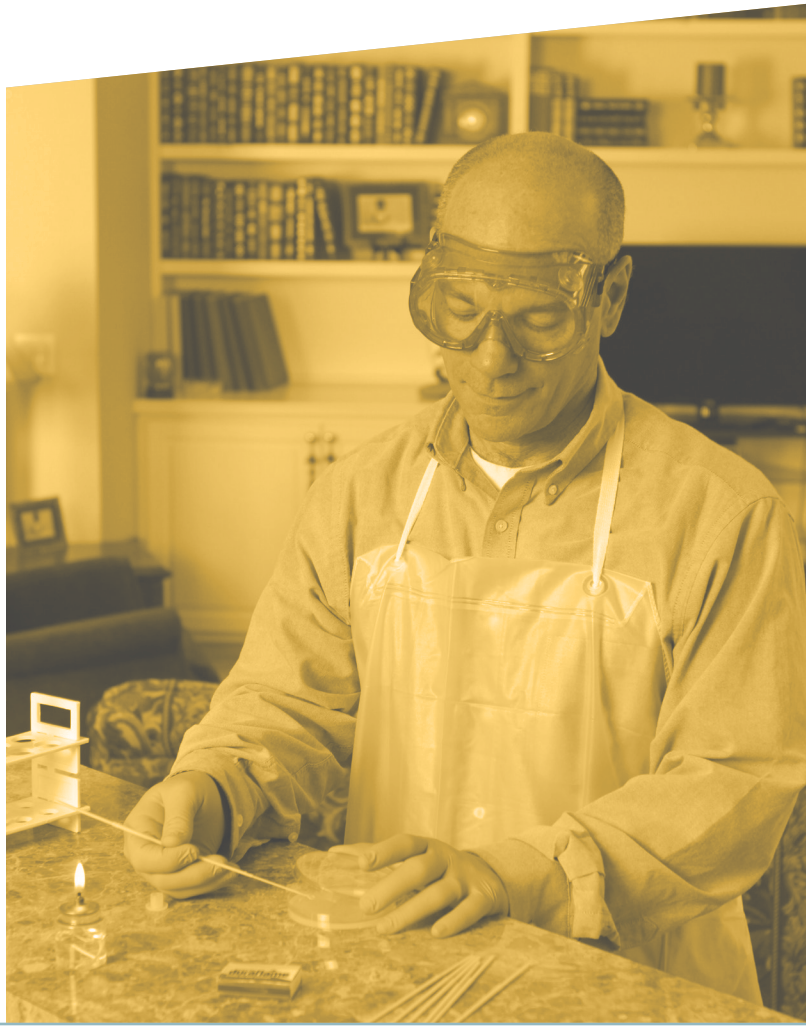
Increased Access to Higher Education

One of the most common themes that emerged was that at-home lab kits greatly improved the number of students that could access STEM courses. Many participants noted that even before the pandemic, they transitioned to at-home lab kits so that students who had a busy work schedule or lived in a rural area that was too far to commute could take courses.

Increased access due to usage was also noted by participants, particularly for Black, Latinx, Indigenous, poverty-affected, rural, and first-generation students. One Chemistry faculty at a community college specifically added that "Black and Hispanic students had a hard time getting to us. Also, students working a midnight shift. The at-home kits for STEM classes were game changing [to reach these student populations]."

Cost as Prohibitive

While the central finding regarding access was an increase due to usage of at-home lab kits, cost was consistently discussed as a barrier, both at the programmatic and student level. Faculty, staff, and programmatic leadership universally agreed that when students had to pay for the lab kits as a supplementary fee to their tuition (i.e., textbooks), it was a barrier for some to sign up for the class or a hardship for those who were enrolled. However, some participants noted that absorbing the cost of the at-home kits into the lab fees or tuition more than covered the cost for students and was significantly less than the price to operate a brick-and-mortar laboratory on campus. Interestingly, participants from larger institutions (e.g., more than 5,000 students) were more likely to have the lab kits built into tuition than those working at smaller institutions. An Anatomy and Physiology professor stated that for her, "It's actually cheaper to take in the online format than the face-to-face format, because our kit is cheaper than our



lab course fees." Others supplemented with Open Education Resource (OER) textbooks, so students were not purchasing both textbooks and lab kits.

Though not directly related to cost, and despite the overwhelming sentiment that online and at-home opportunities increased access, some participants also noted a general decrease in enrollment at their institution over the past few years. It was difficult to separate the use of at-home lab kits from the emergency context of the pandemic or other general socio-economic trends nationwide, though this is one potential area for future study.

The Digital Divide was a Barrier

> *"So [many of our students] live up by the Appalachian trail, and for them they all have the same internet provider, the campus has a strong ethernet connection, but off campus, if the internet goes down, it goes down everywhere. There is nowhere they can go to get internet and they can do some online with their phone with their data, but it is costly. So that is something that is a little bit of a challenge in terms of equity."*
>
> *- Environmental Science Faculty, Technical College*

As is the case with many facets of our digital and online world, the access to online and blended STEM courses that used at-home lab kits was dependent on reliable and affordable Internet. As such, the "digital divide" was a common theme amongst participants when speaking to their students who lacked consistent access to Internet. An additional challenge with at-home lab kits was that students needed access at their homes for activities like synchronous lab experiments where students and faculty were conducting experiments together. The need for this type of home access added an extra layer of difficulty for students who could otherwise complete their coursework at a library or other free Wi-Fi access point. The digital divide was more evident for poverty-affected students and those in rural communities with only one or no Internet provider.

INSTITUTIONAL SUPPORT AND CHALLENGES

"We have a teaching and learning center and in order to teach an online course, they developed a training you have to take. It goes through how to develop your course, they have one for full online, hybrid, and for enhancing a traditional course. Your course doesn't go live until the teaching and learning center says it is ready. They are there to support you through the whole process. We have an instructional designer to work with the faculty, and then the center also offers what we call faculty academy sessions where every couple of weeks there is a session on something like using case studies, problem solving skills, and just different things that the different faculty have put into their digital course. It's faculty led and I did one on incorporating lab kits for those who maybe were still struggling, and when the pandemic hit In spring of 2020, we extended our spring break, and the teaching and learning center along with about 10 of us faculty who were already online and we just spent a week trying to help all of our faculty get online who weren't online. These were instrumental and I will say that my institution has done a lot to support for us."

- Anatomy and Physiology Faculty, Community College

Support is Critical but Varied Widely

Institutional support and buy-in was widely discussed by participants as being central to whether or not their online and digital courses that employed at-home lab kits were a success. At the most basic level, participants universally agreed that support from their program chairs or institutional leadership was the first step. However, simply allowing at-home lab kit use for classes was not enough. Some faculty expressed positive attitudes about the flexibility and space for creativity that came with no support, but that being on their own was ultimately time consuming and difficult. Faculty who had access to support services like instructional designers, teaching and learning centers, or even just peer groups felt more comfortable teaching online and more confident in their pedagogy. Instructional support, however, was not consistent across participants, with some noting that they had incredible colleagues who went above and beyond, while others discussed more limited training that didn't meet all their needs. One Anatomy and Physiology faculty member at a rural community college articulated this challenge in their context:

"We have instructional designers at each of our campuses that help faculty to create their online class and to make sure it has all the components, but what I see lacking is that additional step that takes it to the next level and adds those components that foster the use of the lab kits and being creative. There's no one that I found yet that gives me ideas on how to be more creative, and I find that I don't get that at the campus level. I get that when I go to conferences. That's when I start seeing the creative side coming out, and how you can use these lab kits and make it more exciting and creative, but I don't get that on campus."

Indeed, some participants felt like they did have access to support that both met the structural needs of designing an online course and gave them creative pedagogical ideas, though this was certainly not universal.

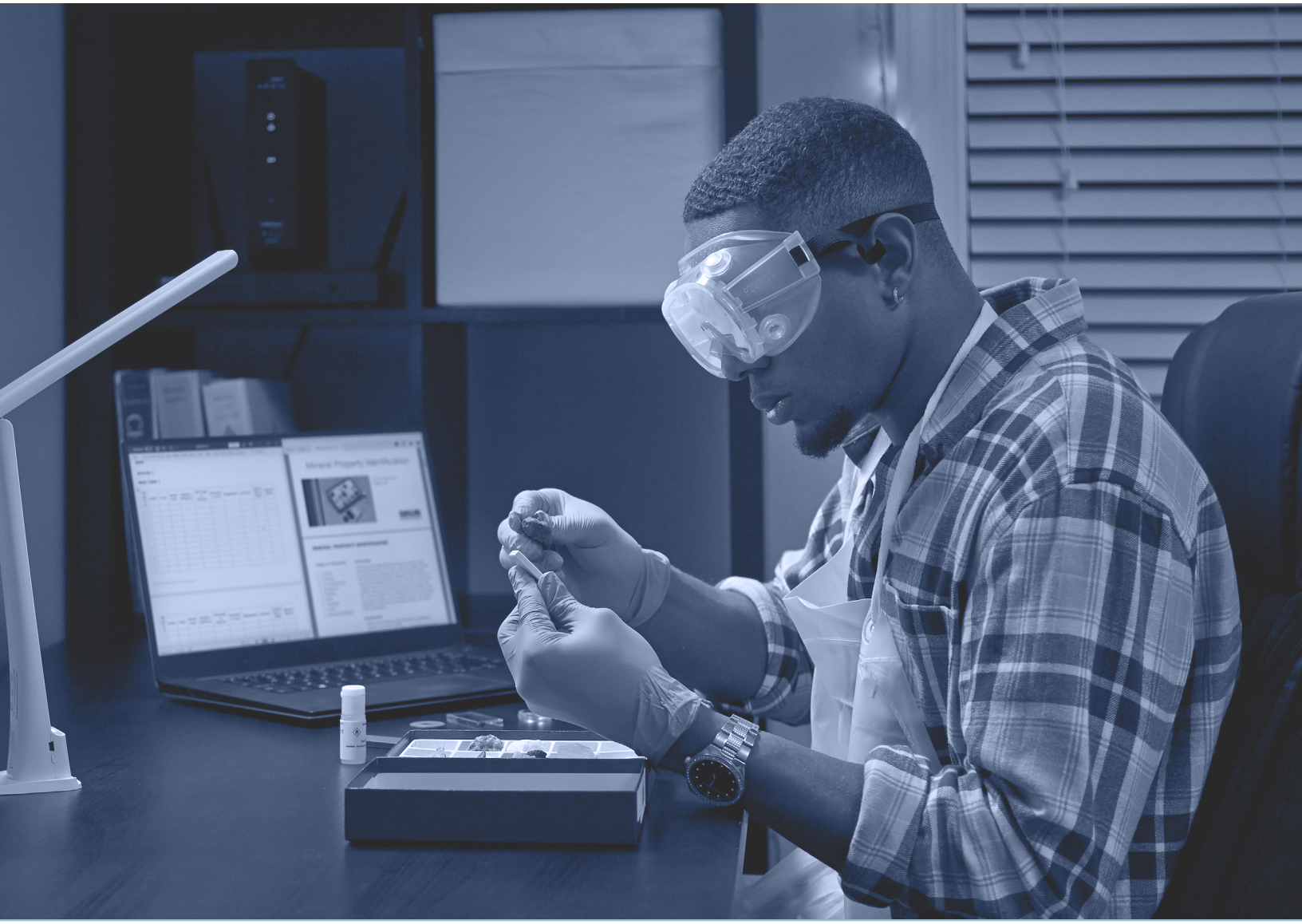
Administrative and Legal Barriers

Especially before the pandemic, several faculty participants recalled the pushback they received from fellow faculty as well as programmatic and institutional leadership regarding a switch from face-to-face labs to at-home labs and online courses. One Environmental Science faculty member at a 4-year private institution noted their administration's initial hesitation but explained to them, "If we are taking this online, we are still going to have a hands-on lab experience. So that was a non-negotiable, and that was accepted by the administration." Even after the pandemic, a Biology faculty member at a 4-year college recalled that administration declared, "We're getting rid of all lab kits. So that's gonna be kind of a fight for me…to look at that language and…design the lab kits to fit accreditation requirements and all that…. the college is going to continue to…support the lecture components being online…. Unfortunately, they're in the mindset that nobody wants online labs and laptops, and it'll all be back to normal in the fall." While it

is beyond the scope of this study to determine if in-person or at-home labs result in better student outcomes, it is worth noting that some faculty are now reluctant to go back to in-person labs after having successfully implemented and adapted their courses for online and at-home lab teaching.

Finally, legal liability issues were raised by many participants, especially for subjects like Chemistry that might present more danger to students conducting unsupervised experiments. Many Chemistry group participants discussed using “Kitchen Chemistry” or ad hoc lab kits as a creative solution, though preference amongst participants was generally to have a pre-assembled kit that they knew would work and was backed by a company. A Chemistry faculty member at a 4-year private university noted that “We have been doing [at-home] labs for about 10 years. We have never done our own, we’ve always gone with a vendor kit because of liability issues.”

In other words, the cost of purchasing at-home kits from a vendor that took legal responsibility for the contents was well worth the cost.



RECOMMENDATIONS FOR FUTURE SUCCESS

Given the in-depth conversations and breadth of topics that arose, the following are a series of recommendations that might apply to colleges and universities that are using or considering a switch to online or blended STEM courses and supplementing the in-person lab experience with hands-on kits.

HyFlex—offering both to increase access

One theme that resonated within each focus group was choice. Students need and require the choice of whether they take their science courses in the traditional, face-to-face modality or online modality. There is no one-size-fits-all solution, and institutions may be well served to offer online or blended courses for students who might otherwise not be able to take an in-person course or learn better with that modality. A Physics and Engineering faculty member at a community college noted, "We serve 17 counties and … some people would have to drive two and a half hours each way to get to us, and that's gonna mean the enrollment goes way down. So, I have to offer the online courses in order to keep …(enrollment) up." Similarly, a separate Physics and Engineering faculty member said, "We're a community college so you know if the community can't come to us then we have to go to community, so we will bring education to them." Put simply, one of the clear advantages of at-home lab kits is that they allow more people to access higher education. The more flexibility institutions offer for students, the more needs of diverse student bodies can be met.

Absorbing costs like in-person lab

Cost was consistently mentioned as a central, if not the main, barrier to adoption of at-home lab kits. However, one important distinction was that institutions that wrote the kit cost into their tuition did not struggle with this like institutions that required students to buy kits on their own. When possible, at-home kits may meet with less student pushback if they are absorbed into other course fees.

Emergency online vs. planned

Like any other type of online, digital, or blended learning, context is crucial. At-home lab kits that were implemented quickly as an emergency response to the pandemic were generally discussed as presenting more challenges than courses that had been planned out in advance. As campuses grapple with the future of STEM classes and which courses to offer online or in person, faculty and staff using at-home lab kits must be given adequate time to adapt and design their courses properly.

More flexible state boards for accreditation

Finally, both governmental and non-governmental accreditation boards must adapt standards to online, blended, and digital learning environments that utilize at-home lab kits. Particularly, when students, faculty, and staff for specific courses agree that learning outcomes are met or exceeded by kits, accreditation boards must take notice.

LIMITATIONS AND FUTURE STUDY

This qualitative study was exploratory in nature and thus did not result in any generalizable conclusions. We hope the themes of quality, access, and institutional support that are presented above can be used by researchers and practitioners alike to spur further research while also providing practical advice for higher education faculty, staff, and students.

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