

TEACHING ONLINE:

STEM EDUCATION IN THE TIME OF COVID

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I. Elaine Allen, Ph.D. Professor of Biostatistics & Epidemiology, UCSF

Nate Ralph Editor, Bay View Analytics

Independent research commissioned by The National Survey on the State of
Online STEM Education

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ACKNOWLEDGMENTS

Bay View Analytics, formerly known as the Babson Survey Research Group, was created at Babson College in 2004. Our relationship with Babson College spanned over a hundred reports and several million downloads; they were a tremendous partner.

No survey report is possible without the willing cooperation of the respondents. We wish to thank the many faculty members who took the time to provide us with their detailed and thoughtful responses amid a global pandemic. We know that you are very busy, and we appreciate your time and effort.

Special thanks to all the respondents who provided us with such detailed and useful comments. Many also provided permission for these comments to be quoted in the report – this commentary offers a rich texture to the results that would not otherwise be possible.

We want to thank our sponsors: Carolina Distance Learning, HHMI Biointeractive, Every Learner Everywhere, DigitalEd, and the Online Learning Consortium. Without their financial support and expertise, this survey would not be possible.

Research like this is a team effort. It has been a pleasure working with National Survey on the State of Online STEM Education (NSSOSE). In particular, the many conversations with Devon Cancilla, Kate Lee-McCarthy, and Lynette O'Keefe throughout this process were invaluable in this effort's success. Kate's and Lynette's tireless support as OLC project liaisons allowed us to design, test, and gather data through activities such as the OLC STEM Summit and OLC IDEATE, which were essential to the overall success and richness of the project.

Finally, we want to thank our readers. We continue to receive a steady stream of feedback on expanding and improving our reports, and this report is better for your input. Please continue to let us know how we can continue to improve.

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EXECUTIVE SUMMARY

The COVID-19 pandemic sparked a disruptive shift from face-to-face instruction to distance-learning, impacting academia in the U.S. across undergraduate and graduate levels. This study, conducted in the fall of 2020, explores the impact these changes have had on higher education faculty in STEM fields.

Findings include:

- Restrictions on gatherings and similar safety requirements have forced faculty to shift to online instruction in unprecedented numbers.
- 73% of respondents surveyed report having converted face-to-face coursework to remote learning, despite more than a third of respondents having no prior experience with online education.
- The most serious barrier to successfully implementing online STEM education, as reported by respondents, is a perceived lack of student motivation to engage with online coursework.
- While generally optimistic about the potential effectiveness of online labs, only 18% of survey respondents have made use of them in their coursework.
- Respondents believe that the transition to online-learning has exacerbated the divide between the have and the have-nots, as a lack of resources (including but not limited to access to technology, robust internet connectivity, and support services) unfairly impacts underserved student populations.
- The findings highlight the need for additional research into the effectiveness of online STEM education.

INTRODUCTION

Background

Online education has seen extraordinary growth over the last decade.¹ Academic and non-academic institutions alike are producing an extensive number of online courses and programs, incorporating an expansive array of eLearning tools and strategies.

Despite this growth, academic disciplines have varied in their acceptance and incorporation of online learning into their educational portfolios. There is no hard data on STEM enrollments in distance programs, so we can only speculate on how large an issue this is for STEM. Even without the data, there exists among some a perception that STEM does lag other disciplines, reinforced when comparing types of presentations at national conferences — consider the Online Learning Consortium’s Accelerate conference, where non-STEM related presentations significantly outnumber those within STEM fields.

Are these perceptions reflected in STEM faculty's beliefs about the efficacy of online education, or is there something inherent within the STEM disciplines (such as the need for labs) that makes online education impractical? What online teaching experiences have STEM faculty had to form their opinions and actions about online education? This survey, ***Teaching Online: STEM Education in the Time of COVID***, has been designed to investigate these questions and identify real and perceived barriers to moving STEM education online.

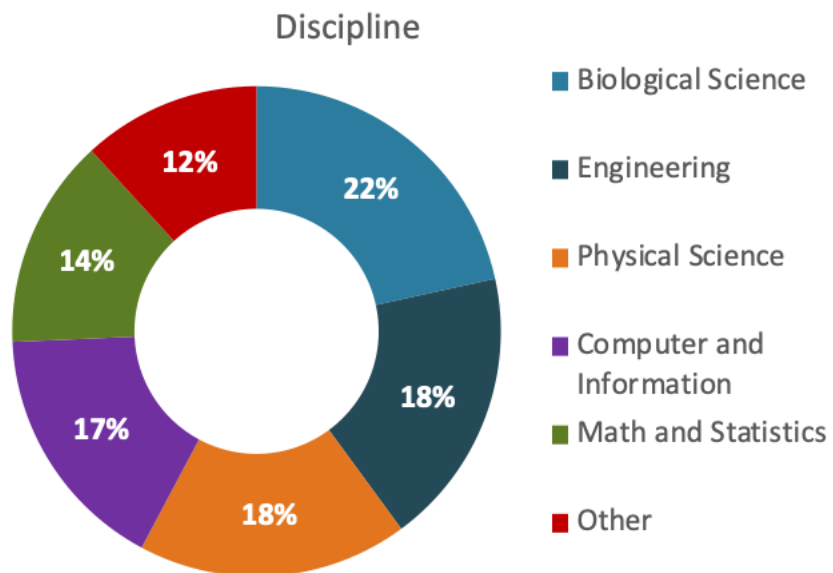
Initially scheduled to be conducted in March of 2020, most institutions' emergency response to deliver their programs online due to the growing COVID-19 pandemic required a tectonic shift in the survey's design and its underlying assumptions. The pandemic-related experience of faculty — many required to teach online for the first time — would dramatically inform their opinions. In light of this, the survey team revamped the survey to better reflect the emergency move to online teaching, and to see how the COVID-19 pandemic has informed opinions about online education, and the future of online STEM education.

¹ https://nces.ed.gov/programs/digest/d18/tables/dt18_311.22.asp

STUDY RESULTS

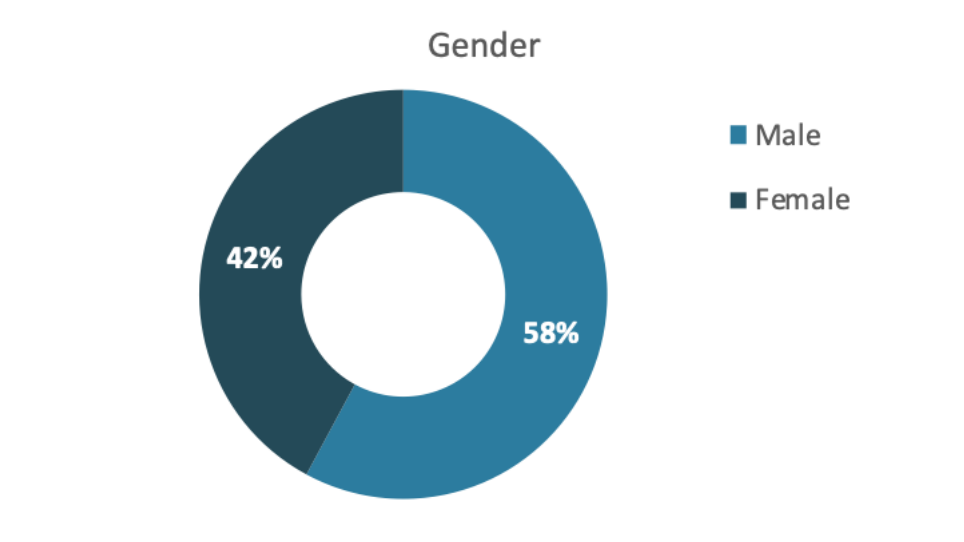
Description of Respondents

The results presented in this report are based on 896 responses from STEM (Science, Technology, Engineering, and Mathematics) faculty teaching at the graduate and undergraduate level.² Data collection was conducted during the last week of October, 2020. Respondents represented multiple STEM disciplines, with faculty from the biological sciences making up the single largest group, followed by engineering, and those teaching in the physical sciences.

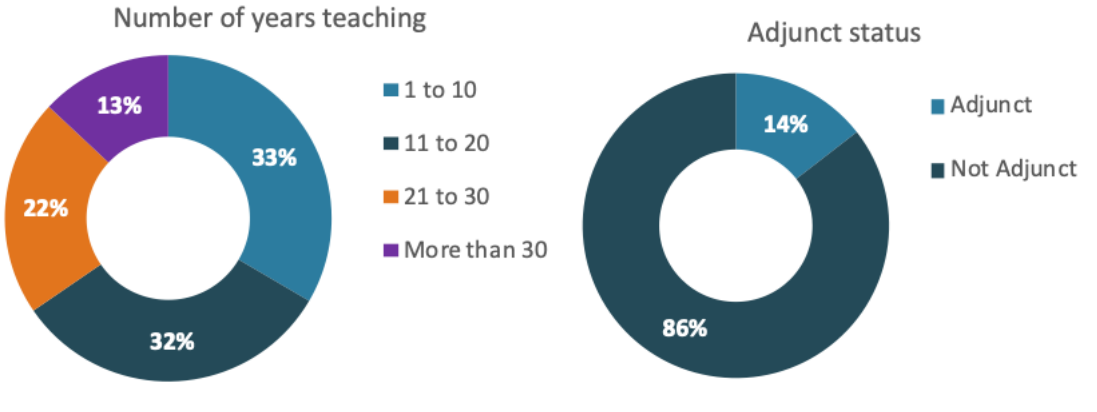


² Details on the sample used are provided in the Methods section of this report.

The majority of respondents were male, though there is a strong representation of female STEM faculty. Very few respondents — a total amounting to less than a percentage point — identify as Non-binary.



A third of the respondents surveyed have been teaching between one to ten years. Another third of those surveyed have taught for between 11 and 20 years, while the remaining third have more than 20 years of teaching experience. Of the responses collected, 14% were from adjunct faculty.



Online Teaching Experience

Faculty Voices:

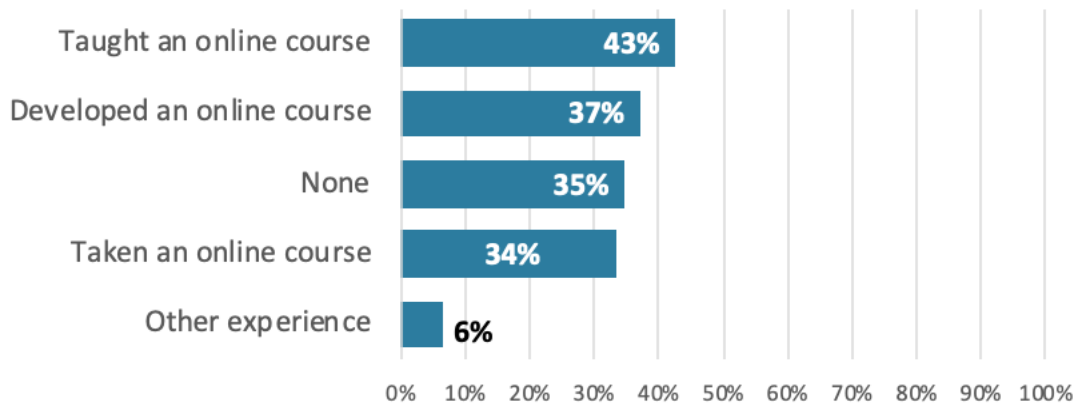
“For math, sharing an iPad screen, using video, and recording lectures, not much is lost compared to lecturing in person.” - Mathematics Faculty

“Given where we started and the unique aspects in STEM, it is amazing what has been done and there is so much potential for what we can do.” - Engineering Faculty

“STEM courses are best taught in the classroom as many of my students have confessed. The online experience cannot replace what is done in a face-to-face, hands-on class.” - Computer and Information Sciences Faculty

More than a third of respondents had no online experience prior to the COVID-19 pandemic. Just over 40% report having taught an online course, while 37% report having developed one.

Online experience prior to pandemic



Faculty Voices:

*"I think we will get better at teaching STEM online with more experience and support."
- Mathematics Faculty*

*"As we learn to deliver content online, our students will become better online learners."
- Mathematics Faculty*

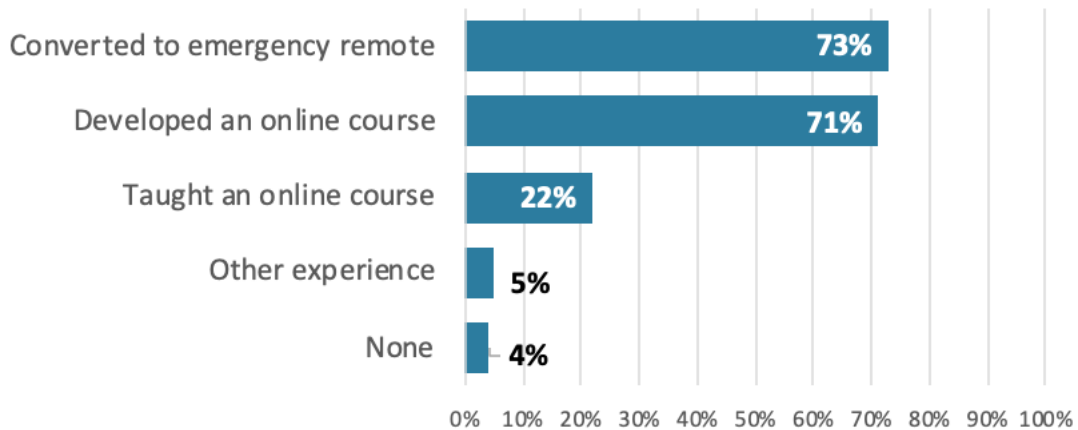
*"What makes education valuable is the direct fresh contact with faculty."
- Mathematics Faculty*

*"It is a *lot* more work to get everything where it should be and I am not sure if that is helping my students learn."
- Engineering Faculty*

*"I feel that teaching online has significantly hindered effective interaction between teacher and student, as well as between students, which is an important aspect of learning new material. Students aren't learning as well or understanding material as deeply. Not exactly sure why, but I've seen lower scores and a much bigger dispersion in scores."
- Mathematics Faculty*

These positions transformed dramatically with the onset of the pandemic. The proportion of respondents with no online experience dropped to just 4%, with 73% of respondents stating that they've converted their courses to emergency remote learning.

Online experience since the pandemic



Faculty Voices:

"I like that this new way of doing things helps some students. They can log in and re-watch my lectures which is a big positive (my daughter is a University student so I have also seen the benefit of this first hand). I dislike how it presents a big challenge for some due to learning style and other issues, for example for students who don't have good internet and/or a home environment that supports learning." - Engineering Faculty

"It is very hard to teach when looking at a screen filled with names; many or all students do not turn their video on. I can sympathize with them (it is hard to stare at a screen the whole day), but it also makes it hard to interact: they see you but you do not see them. :)" - Mathematics Faculty

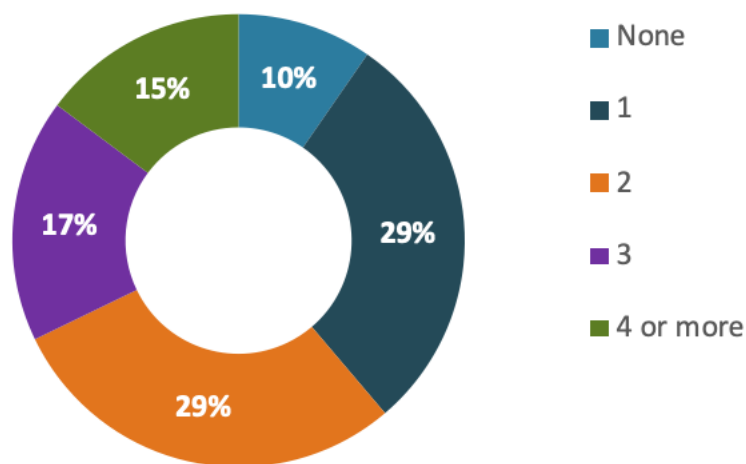
"My students are succeeding in the online environment. They love the remote synchronous format." - Mathematics Faculty

"Collaboration of materials between other instructors in my field (geology) has been the most important for the development of my lab classes." - Physical Sciences Faculty

"For computer programming the on-line experience has some advantages, particularly the ability to quickly do screen sharing." - Computer and Information Sciences Faculty

Ninety percent of the respondents surveyed were teaching one or more STEM courses for the Fall 2020 term. A further third were teaching two courses, while 17% and 15% of respondents were teaching three and four courses, respectively. Teaching multiple STEM courses in a single term may impact the perceptions of online education due to the additional workload of converting multiple classes online, as opposed to just one.

Number of STEM courses teaching this term



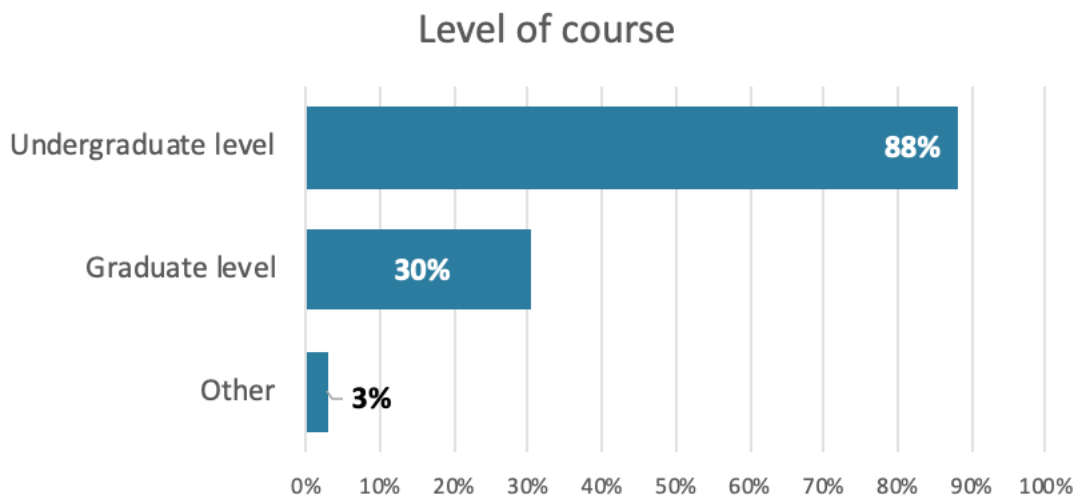
Faculty Voices:

“Everybody (students, faculty, staff, parents) hates online education, and are anxious to return to a normal, traditional college education process. I think on that we can all agree. But as I said before, we can't do that until there's a clear end to this worldwide pandemic. So, we're all doing the best we can with the options we have available to us.” - Engineering Faculty

“It's tough, especially exams etc., but actually gives the opportunity to some shy students to chat and ask questions. The same students would never raise their hand and ask in front of a huge class. That's the only good thing I have noticed.” - Physical Sciences Faculty

“It is a challenge but with effort and creativity I can make it work at some level, maybe not as well as in person but good enough for the time being (not long term though).” - Biological and Biomedical Sciences Faculty

Respondents were overwhelmingly teaching at the undergraduate level, with just 30% teaching courses at the graduate-level.



Faculty Voices:

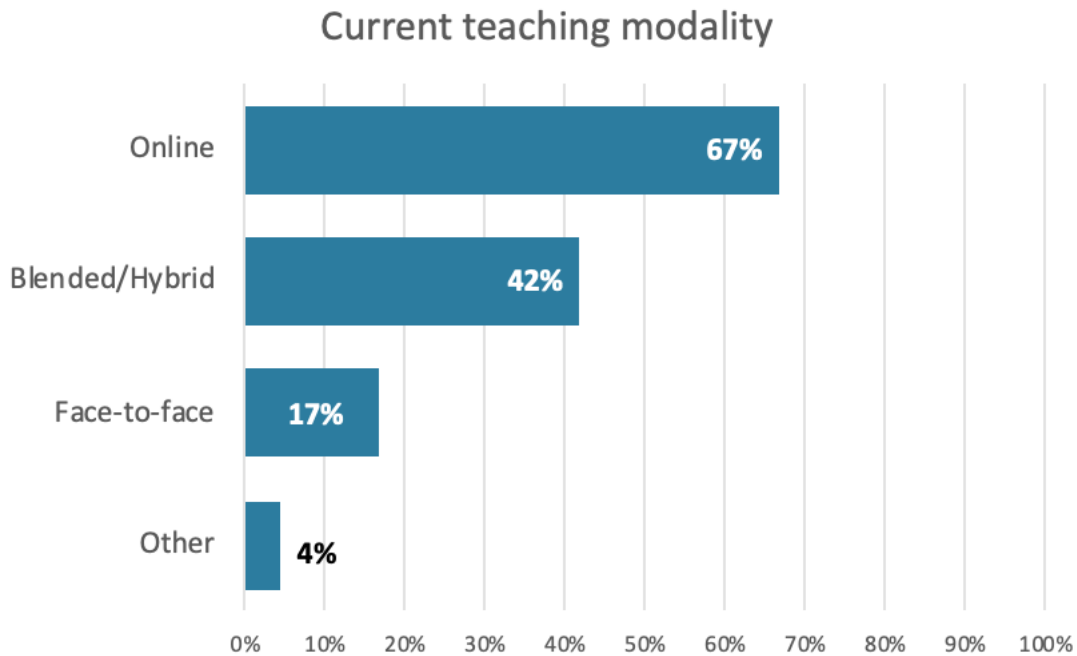
“STEM courses, specifically laboratory courses, provide a subpar education when taught online with no hands-on experience.” - Biological and Biomedical Sciences Faculty

“Zoom has been a savior. I made my students spend about \$60 on hardware because they need to do the lab at home. That means then scheduling zoom demos to see they can build it and written reports and reading all their code...this is with the idea if they are going to cheat when we evaluate all 3 of those results we are more likely to catch them.” - Engineering Faculty

“Re-designing hands-on work so that it can be done in-home often means dumbing it down a little, but I find the work still has merit. Everyone (student, prof, other) just has to lower their expectations a bit around the professionalism aspects.” - Engineering Faculty

“The use of the online whiteboard does not offer the same impact as using an in-person whiteboard. Students say there is sometimes a delay and I am unsure if that is a technological issue on my end or theirs.” - Mathematics Faculty

In a large departure from their previous experience, only 17% of the respondents were currently teaching a face-to-face course.



Viewed as whole, these results tell the story of a hurried transition for higher education STEM faculty and their charges, as they were forced to dive headfirst into the world of remote instruction with little prior experience.

Barriers to Online STEM

One of the first steps that the National Survey on the State of Online STEM Education (NSSOSE) took to understand what faculty perceived as the most critical barriers to providing online STEM education was the half-day OLC Accelerate 2019 STEM Research Summit. The participants, STEM faculty and administrators, were queried about which barriers might prevent wide adoption of online STEM education. A participant survey before the workshop was used to get initial feedback on what faculty and administrators believed were the most critical issues. These were discussed in depth during the session, and followed up with a post-workshop survey to get further validation of the issues. All of this was prior to the pandemic.

The emergence of the pandemic, and the experience of many STEM faculty moving their courses to emergency remote learning in the Spring of 2020, may have changed faculty views. A test survey was conducted at the end of spring term 2020, and while it was clear that many barriers identified pre-pandemic were unchanged, many faculty had reconsidered the issues.

Additional guidance on identifying the revised view of barriers to online STEM education came from the OLC Ideate Labs for Online STEM: Innovating STEM Education, August 19-21, 2020. The topics listed as potential barriers was revised based on a combination of a pre-survey, and online sessions during the conference, as well as a follow-up post conference survey of the participants. A few items were dropped, a few new ones added, and several had wording changes based on this feedback. The final questions used for this survey include a dozen potential barriers listed, each coming directly from faculty suggestions, as well as an open-ended response where any other issues could be added.

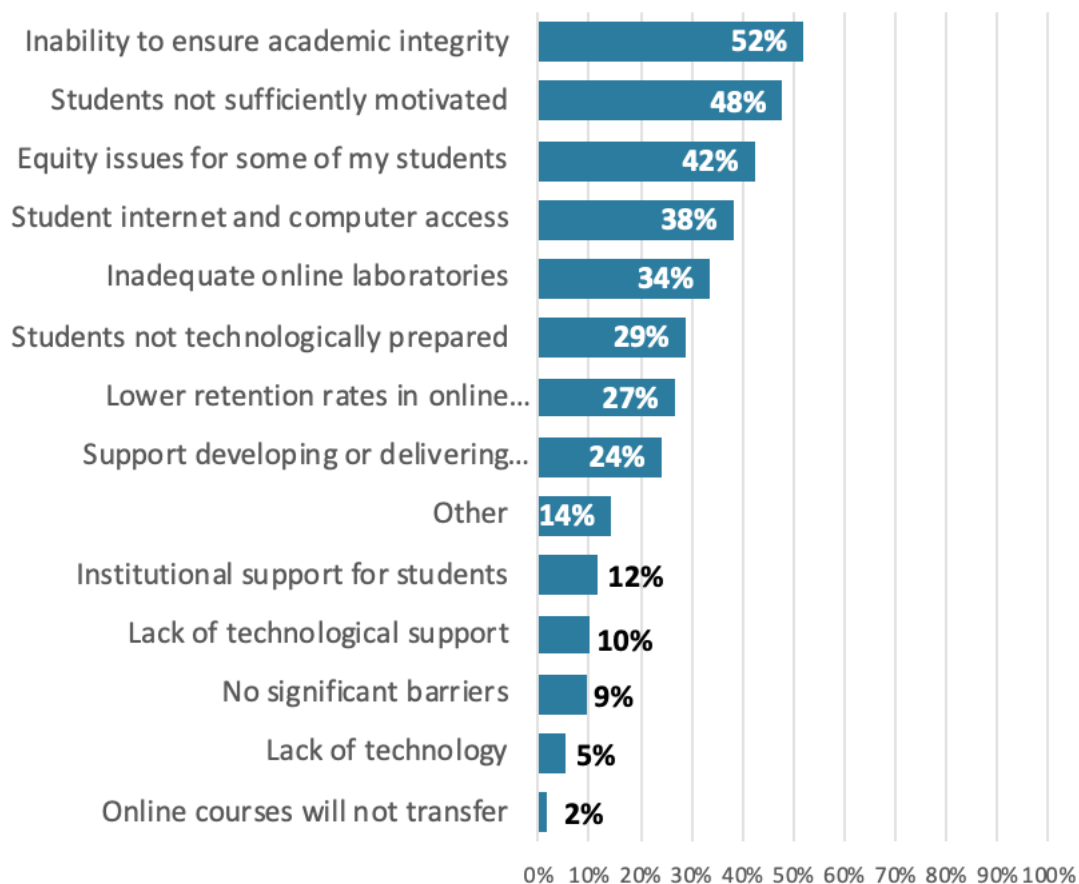
It is important to keep the timing of these responses in mind. Faculty were responding to the question about barriers while in the middle of a term where most of them were teaching a course online out of necessity. Faculty did not have the luxury of time to design the best teaching approach, so their perception of the barriers is flavored by this experience.

Faculty views on barriers they faced moving STEM courses online were varied. Only one issue (academic integrity) was selected by a majority of the respondents. Only 9% of the respondents reported that they did not think there were any significant barriers.

Open-ended responses were added by 14% of the respondents. Several themes emerged from these free-text responses. The most common theme was a feeling of being disconnected from students, and missing the person-to-person interaction of their face-to-face course. The second most-common reply was a feeling that the online education experience was "not as good," or that "in-person delivery is more effective."

Many faculty also used this option to expand of the choices they made from the list of barriers, including details on their worries about academic integrity and their inability to get students engaged (or even to attend classes).

Barriers to online STEM education

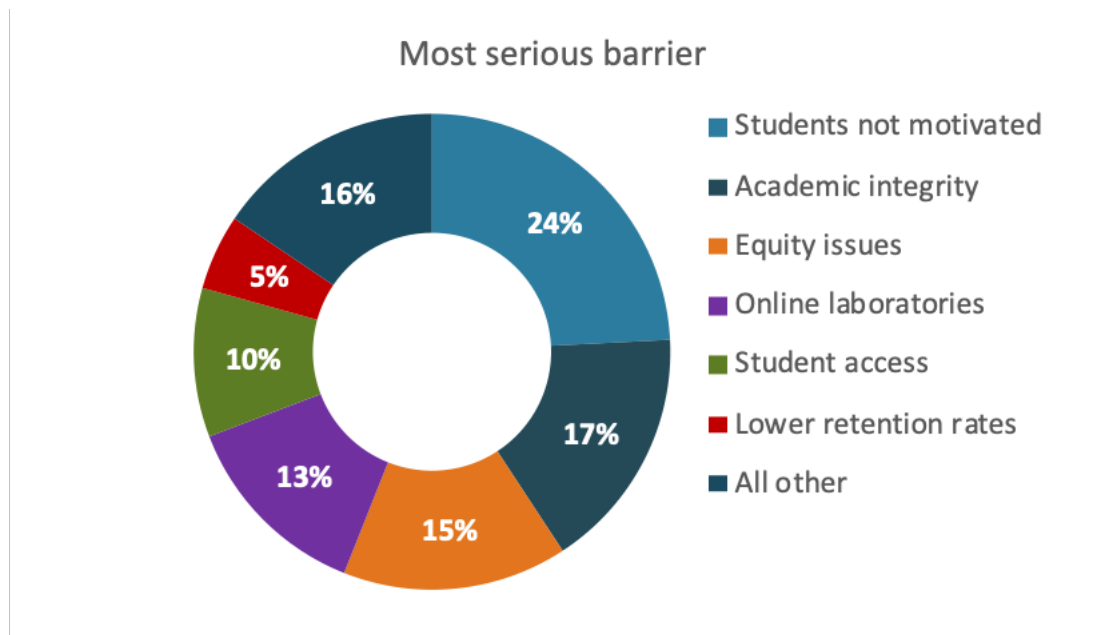


Faculty Voices:

"If we cannot deliver engaging content, retention will be difficult, which impacts enrollment and funding of the institution." - Physical Sciences Faculty

"It is a very difficult situation right now. Although I provide as many interactive things as I can, my students still will not engage. I have between 20 and 30 who attend my live class, and only 6 or 7 will interact with me. I have tried many things to get them to interact and open up, but they will not." - Mathematics Faculty

On average, faculty members selected three or four barriers from the list. All faculty who selected more than one barrier were asked which of the barriers was the most serious. The most common cited barrier in this ranking was that "Students are not sufficiently motivated to succeed in online courses," selected by just under one-quarter of all respondents. Respondents cite instances of students that don't show up to lectures, shy students who are reluctant to participate or activate their webcams, and students who leave a lecture early, as supporting evidence for this belief.



For all of their concern with student engagement, faculty do not put all the blame on students. There is an understanding of the "we are all in this together" aspect of the term, with students having their own high degree of stress impacting their role as a student. Many faculty attribute this to the move to online instruction, and the lack of interpersonal contact between student and teacher.

Faculty Voices:

"Students spend their time on how to cheat or use online resources to do the problems for them, rather than trying to learn anything. This is creating a generation of incompetent engineers!" - Engineering Faculty

"We have to rethink evaluation and assessment... My assessments are open book, open notes and collaboration — with a focus on ability to solve problems." - Computer and Information Sciences Faculty

"I would prefer to use lockdown browser and to monitor my students in real time since my only choice now is to tell them after the fact that I think they cheated." - Mathematics Faculty

"I would say the integrity issue is more severe in STEM. Other disciplines can assign essays or questions that will have answers unique to each student. That is hard to do in a pre-calculus course, for example, unless you create a different assessment for each student which is not reasonable from a time perspective." - Mathematics Faculty

The second-ranked barrier, the "Inability to ensure academic integrity" was ranked as most serious by 17% of faculty respondents. As with the issue of student engagement, faculty often see this as the result of the shift to online teaching, either because less checking possible, or because overwhelmed students are just looking to get through the class.

Faculty Voices:

"I do worry... how many disadvantaged students we will lose or have lost due to equity and financial issues that are a result of the pandemic." - Biological and Biomedical Sciences Faculty

"I think there is a great opportunity to make education more widely available and flexible for students with the new tools and approaches we are using in right now due to COVID. I am cautiously optimistic based on this, but I don't see a strong future vision from the University." - Engineering Faculty

"A major challenge will be equity issues in the broadest sense. How do we reach all of those wanting or requiring a STEM education?" - Biological and Biomedical Sciences Faculty

Belief that "Online courses pose equity issues for some of my students" was ranked third. Online STEM coursework's reliance on speedy internet connections, capable computer hardware, and specialized lab equipment presents unique challenges for members of underserved populations. These issues are explored in greater detail later on in this report.

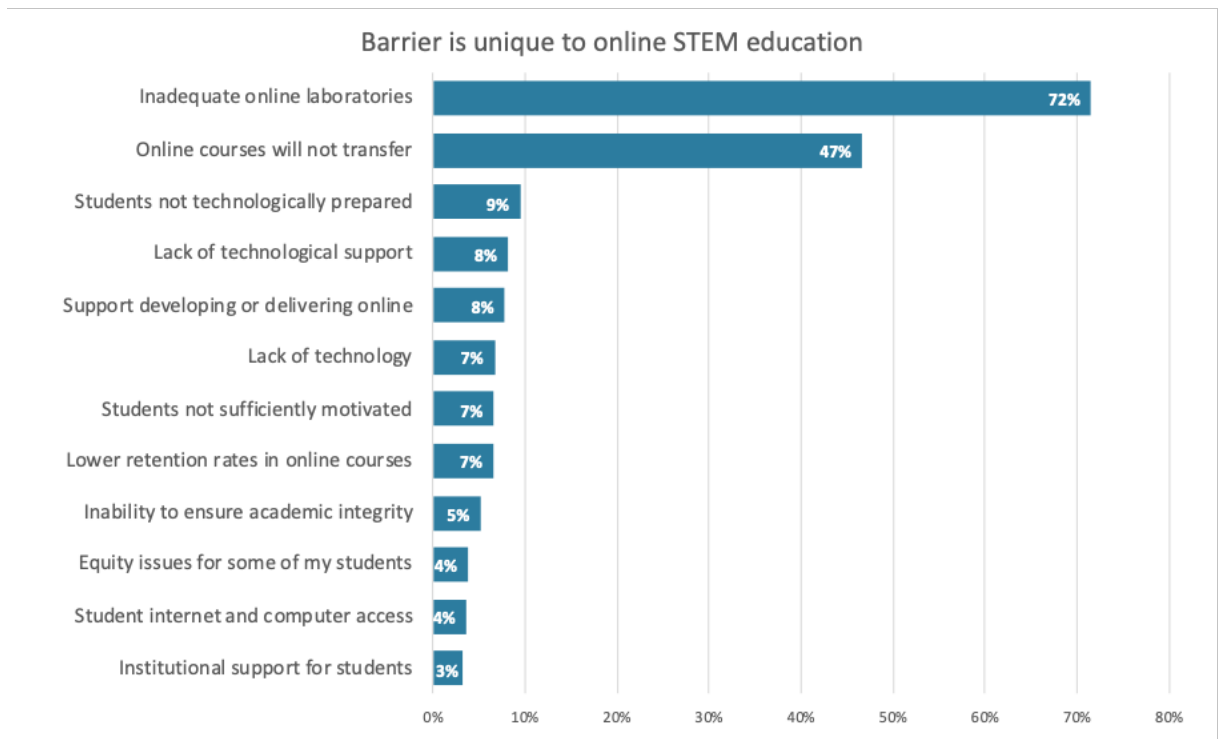
Faculty Voices:

“Our upper level investigative labs are unique and designed to mirror faculty research, so pre-made or “canned” online labs do not work for us — although it might be possible to use some for basic training.” - Biological and Biomedical Sciences Faculty

“The primary barrier to effective STEM teaching and learning online is lack of access to lab equipment and materials.” - Biological and Biomedical Sciences Faculty

“I am very concerned about my upcoming semester that involves a lab class. If we convert to 100% online I don't know how to conduct experiments remotely. Plus the significant time it will take to make this conversion.” - Engineering Faculty

Respondents believe that almost all barriers they face in teaching STEM courses online are the same as those faculty in non-STEM discipline face. The only barrier that a majority of STEM faculty feel is unique to their disciplines is the need for online labs where 72% felt this was unique to STEM. A further 47% thought that problems in transferring credits was unique to STEM. No other barrier had over 10% who reported it as a unique STEM issue.



STEM Laboratory Coursework

Faculty Voices:

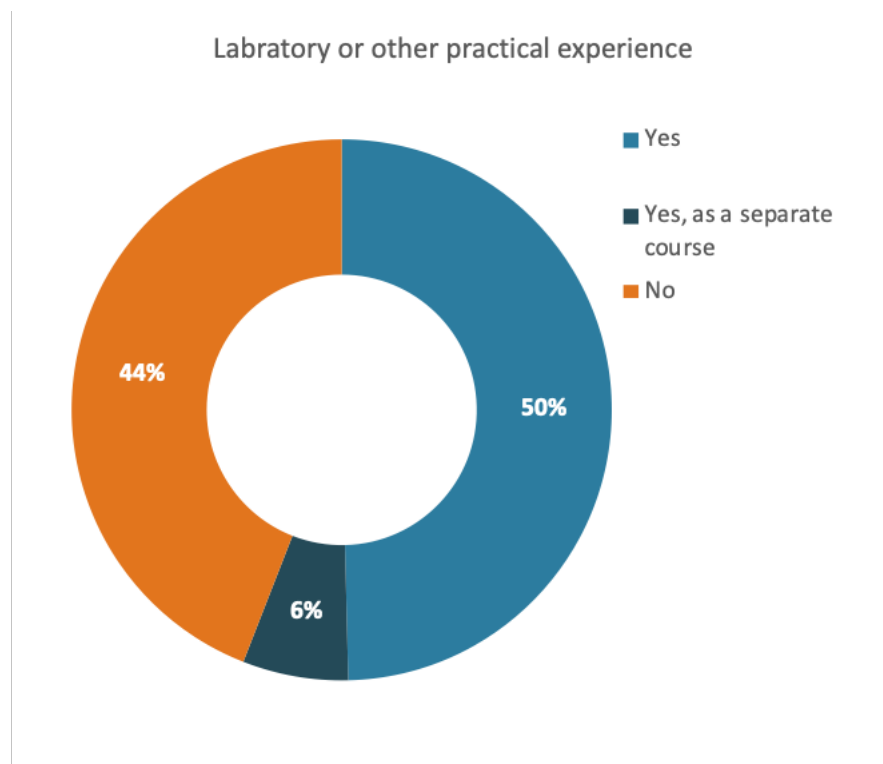
"There is a physical technique associated with quite a bit of the chemistry lab work that I value. Students need to feel the pipette, move the stop-cock with their hands, etc." - Physical Sciences Faculty

"My strategy has been "if students can't go to the lab, the lab must go to the students". They have acquired basic instrumentation to do hands-on work at home, with reimbursements provided by the department." - Engineering Faculty

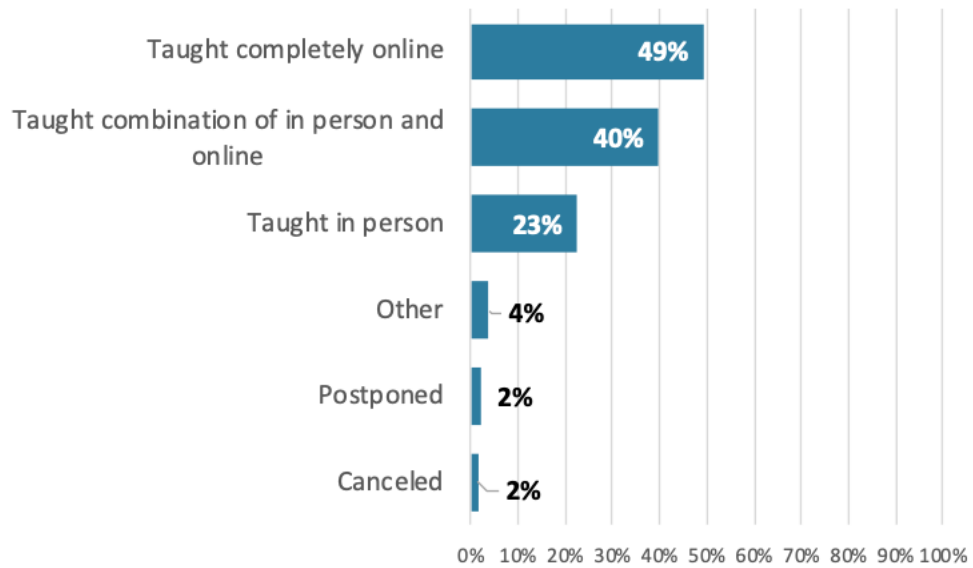
"I think that some laboratory concepts can be taught online, but there really is no good digital substitute for physical skills such as dissection and microscopy unfortunately." - Biological and Biomedical Sciences Faculty

The hands-on experience provided by labs is an important part of many STEM courses. Health and safety requirements enacted to curtail the COVID-19 pandemic have hampered the ability to conduct these in-person elements of coursework. The difficulties inherent in conducting meaningful lab exercises online have been a recurring item of concern raised by survey respondents.

A slight majority of all respondents report having a lab associated with one or more of their courses.



Status of the laboratory



Due to pandemic-related restrictions, less than a quarter of STEM professors are currently teaching their labs entirely in person. The inability to perform in-person, hands-on labs has forced some instructors to turn to alternative activities online such as simulations, the use of kits, or other laboratory experience.

Online STEM Laboratory Coursework

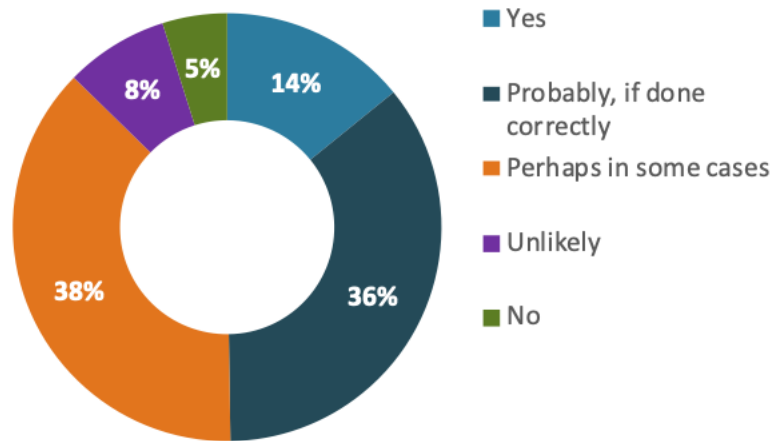
Faculty Voices:

"I think it is possible to have BETTER laboratory experiences online than in person, but it takes a lot of thought, time, and development effort to make that happen. The need for lab experiences online to be more self-directed forces a positive change in lab experiences in general in engineering." - Engineering Faculty

"It takes one to be creative and think out of box to provide a lot of the lab experiences. While all those expensive equipment are nice to have and use, we can actually teach a lot without them too." - Engineering Faculty

STEM faculty are generally optimistic about the potential for online labs, despite the great deal of concern expressed about their current state.

Can an online laboratory be an effective teaching tool



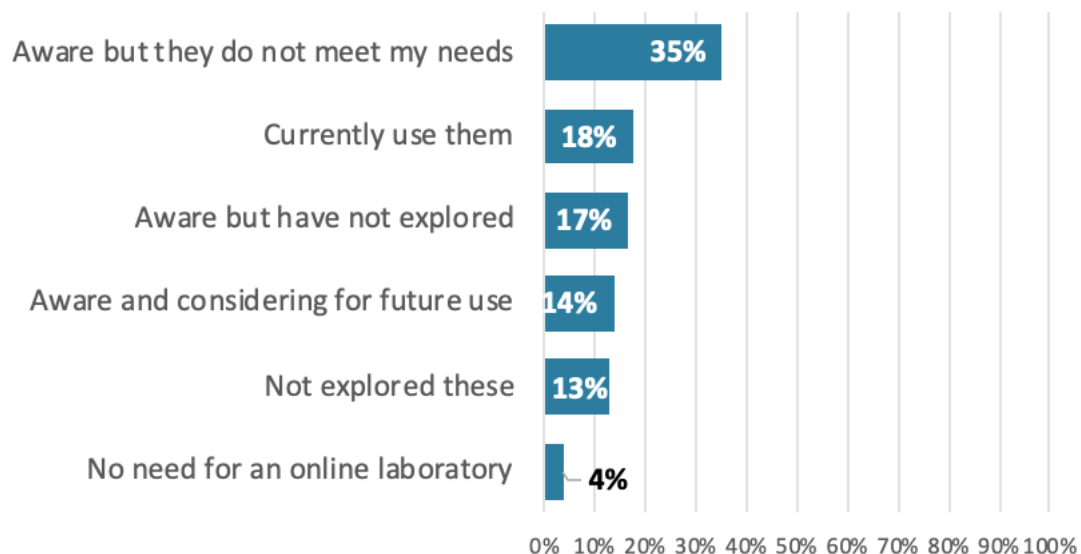
Faculty Voices:

"I think that online labs might be sufficient for lower level chemistry courses, but certainly not for organic and above. I can't believe a whole cohort of students are going to get through the entire organic series without having touched a piece of glassware, run an instrument, or even run a reaction?! Unacceptable." - Physical Sciences Faculty

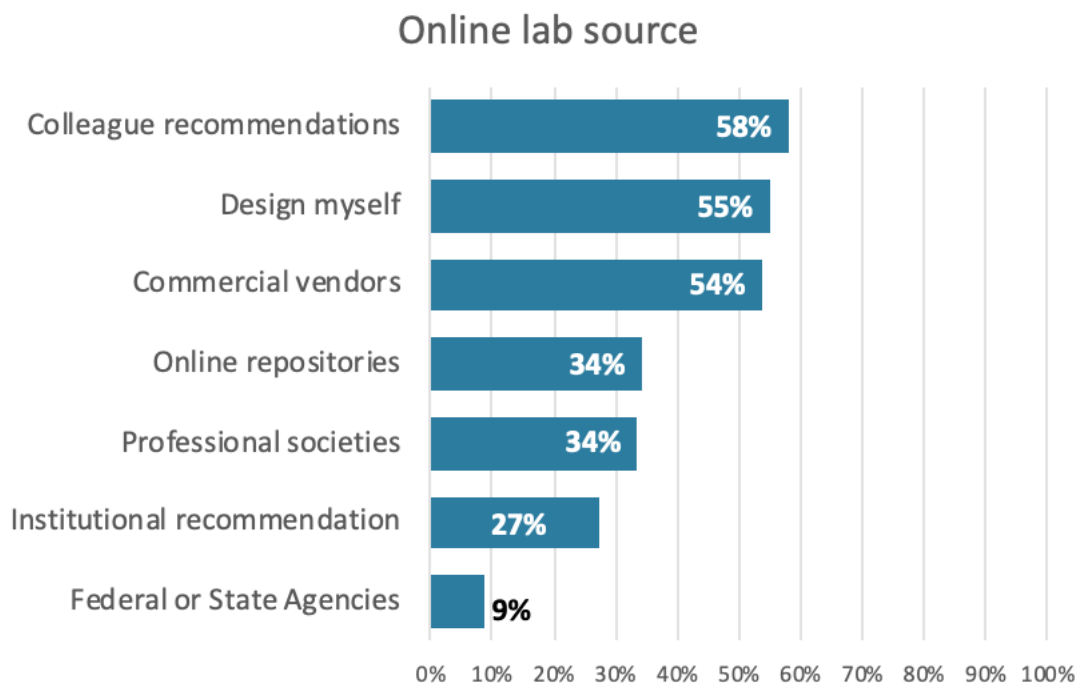
"In some ways my students are getting a richer introduction to the lab work as we have time that would otherwise be used in waiting for setting up the activity and waiting for the organisms to grow." - Biological and Biomedical Sciences Faculty

Only a small minority of respondents (18%) currently make use of online labs. A slightly smaller number of respondents (14%) are aware of online labs, and are considering implementing them for coursework in the future. The largest group of respondents (35%) are aware of online labs and online lab practices, but feel that these don't meet their instructional needs.

Explored any online laboratories or online laboratory practices



Faculty who do make use of online labs are acquiring them from a varied array of sources. Commercial vendors make up the bulk of these, with 54% of respondents stating that they acquired their labs from a commercial source. Federal and State agencies, by contrast, provide online lab resources to just 9% of respondents.



Recommendations also play an important role in choosing an online lab. An institutional recommendation played a role in selecting an online lab for 27% of respondents, while the majority of respondents, at 58%, chose an online lab based on a colleague's recommendation.

Equity Issues

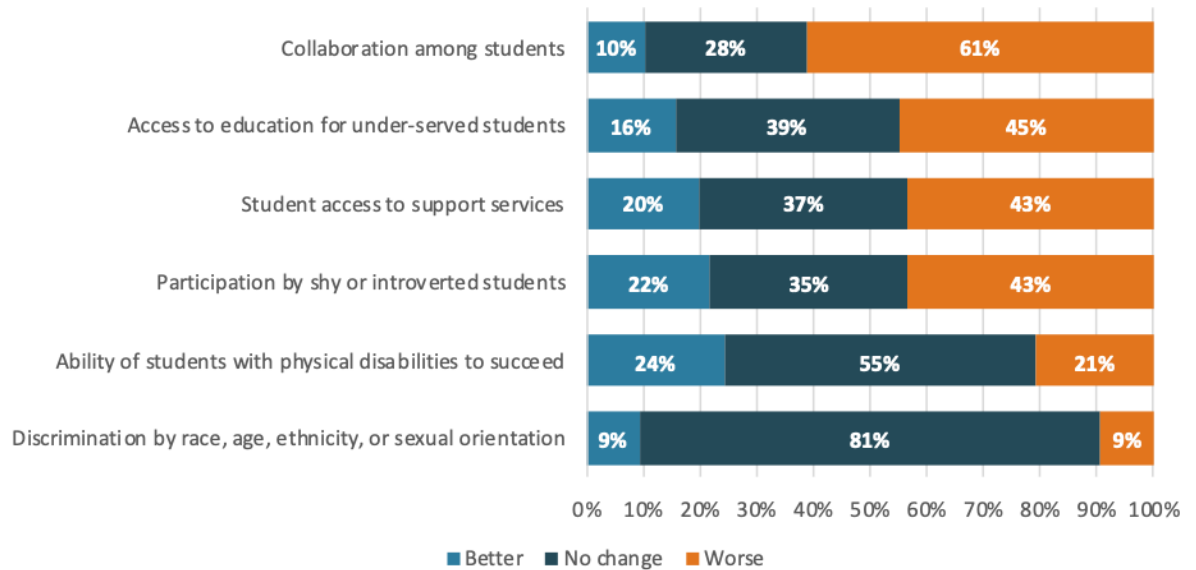
Faculty Voices:

“There is a new urgency for quality, diverse, and inclusive STEM education that gives us a fuel and opportunity to make change happen. I am very optimistic for change to happen, but pessimistic about Higher Education's upper administration's willingness to follow through.” - Physical Sciences Faculty

“Diversity and inclusion are extremely important for the future of STEAM and our youth. The frustration that our white students are feeling during the pandemic is a mere “tip of the iceberg” for the constant battle our marginalized students deal with.” - Biological and Biomedical Sciences Faculty

Respondents report that the transition to remote learning has had a deleterious effect on the equity of educational opportunities in several segments of their student population.

Equity changes for teaching online



Sixty-one percent of respondents believe that collaboration among students has grown worse, while 10% reported an improvement. Forty-three percent of respondents saw a decline in participation by shy or introverted students, while 22% saw an improvement. Eighty-one percent of respondents reported that they thought moving courses online would not impact levels of discrimination by race, age, ethnicity, or sexual orientation. This does not mean that they believed that discrimination did not exist, only that moving a course online, by itself, would not reduce or add discriminatory actions.

Next Steps

This survey, *Teaching Online: STEM Education in the Time of COVID*, provides insights into the experiences of STEM faculty who underwent a hurried transition into remote education, and how that experience informed their opinions of online education's effectiveness. As with all research, the survey raises additional questions, suggesting additional research and future work.

One of the key questions to explore is the source and reliability of information used by faculty to guide them in addressing their perceived issues with online labs. Colleagues and vendors were a primary source of information on tools to facilitate remote education for faculty, while professional societies and institutional support services played a lesser role. Does this present an opportunity for these groups to expand their roles within the STEM fields? What awareness do faculty have of peer-reviewed activities within national Open Educational Resource repositories? How can professional societies better assist STEM faculty in developing and evaluating strategies to teach online effectively?

Another area of interest is the perception that labs represent a unique challenge within the STEM disciplines. Hands-on or skills-based activities occur in non-STEM disciplines. Could online practices within fields such as art, dance, or music be adopted into STEM fields, to facilitate a hands-on experience? What core activities across these disciplines meet the learning objectives associated with hands-on experience?

Finally, COVID-19 has caused a significant shift in how faculty view online education within the STEM fields. As with any sudden change, the experience of faculty teaching online has been varied – some good, and some bad. Overall, results suggest that faculty are cautiously optimistic about the future of online STEM education. This optimism suggests that individuals and institutions will use their experience in response to the COVID-19 pandemic as an opportunity to reassess how STEM education is currently delivered, and will be more open to new approaches that incorporate online education and digital learning into their curricula. Understanding how to better develop, deploy, and evaluate the tools and strategies faculty could employ for successful outcomes in online learning could prove crucial in the years to come.

METHODOLOGY

This report's data comes from survey results using a national sample of faculty and designed to represent the overall range of all STEM teaching faculty in U.S. higher education. A multi-stage selection process was used for creating the stratified samples.

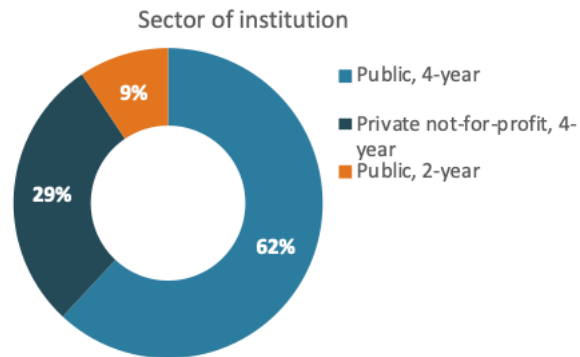
The process began by obtaining data from a commercial source, Market Data Retrieval, which has over one and a half million faculty records and claims that its records represent 93% of all teaching faculty. All faculty who taught at least one course in a STEM field were selected for this first stage. Individuals were then randomly selected from the master list in proportion to the number contained in each Carnegie Classification, to produce a second-stage selection of STEM teaching faculty. This list was then checked against opt-out lists, as well as for non-functioning email addresses.

A total of 869 faculty responded to a sufficient number of questions to be included in the analysis, representing the full range of higher education institutions (two-year, four-year, all Carnegie classifications, and public, private nonprofit, and for-profit), and the complete range of faculty (full- and part-time, tenured or not, and all disciplines).

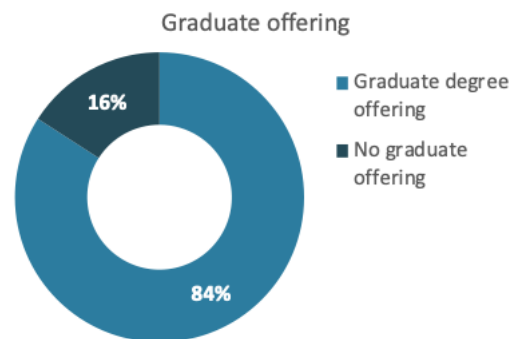
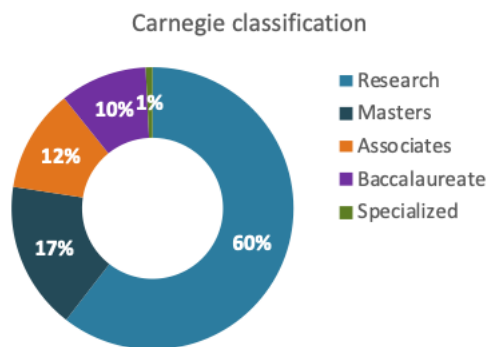
Institutional descriptive data come from the National Center for Educational Statistics' Integrated Postsecondary Education Data System (IPEDS) database. After the data were compiled and merged with the IPEDS database, respondents and nonrespondents were compared to ensure that the survey results reflected the characteristics of the entire population of schools. The responses were compared for 35 unique categories based on the 2015 Carnegie Classification of Institutions of Higher Education.

Participants

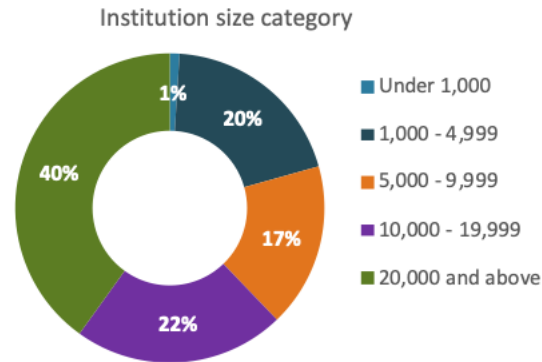
Responses were collected from a total of 896 higher education faculty. Participants represented 49 states and the District of Columbia. The largest group of respondents (62%) were from four-year public institutions, while 29% were from four-year private institutions, and 9% from two-year institutions.



Participant institutional affiliation was matched to the IPEDS database, to retrieve institutional characteristic data allowing for analyses to be conducted by type of institution. The IPEDS data show that 84% of the respondents were from an institution with graduate-level offerings, 60% of which had a "research" Carnegie classification.



The responding STEM faculty are primarily from the larger institutions. A majority are from institutions with more than 10,000 total enrollments, with a full 40% at institutions with 20,000 or more students. Only 1% are at institutions with less than 1,000 total students.



Procedures

All data were checked for completeness, missing values, or erroneous codes. All responses entered as “other” were reviewed to determine if they should also be coded as one of the fixed responses. Respondents could skip any question, though very few respondents did; all surveys where less than three-quarters of the eligible questions were not completed were deleted from the analysis.

Respondents were asked if they would provide permission for their open-ended responses to be quoted in this report; 76% of respondents agreed. All open-ended responses were checked to ensure that no personally identifiable information was contained, and only those respondents who provided explicit permission to be quoted are contained in this report.

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The National Survey on the State of Online STEM Education

The National Survey on the State of Online STEM Education (NSSOSE) represents the work of many individuals and organizations striving to better understand the opportunities, barriers, and potential of online education within the STEM disciplines. Developed through community input, the survey was designed to benchmark the current state of online STEM education and to lay the foundation for further growth in online STEM education. The survey results highlight the need for additional research into the evaluation and design of effective online tools, strategies, and practices, particularly around online laboratories.

Origin

The motivation for a national survey was originally based on an assumption that STEM educators were reluctant to incorporate online strategies and tools into the STEM curriculum. This assumption was supported by comments made in 2007 by Myles Boylan, then of the National Science Foundation who stated: *“In almost every discipline, I could point to a variety of really effective, wonderful sets of instructional materials and instructional practices, and say that if we could magically click our fingers and get everybody using them, there would be a huge improvement in undergraduate education that would happen instantaneously, but we’re nowhere near that.”*³ As true today as it was in 2007, understanding the factors that limit the adoption of instructional materials and practices, especially in online STEM education, is critical.

The first steps in developing the NSSOSE came from recommendations put forward by STEM educators, administrators, and STEM-based educational companies participating in a STEM focus group as part of OLC’s 2019 National Innovate conference.

Through a moderated focus group, participants highlighted the need to better understand the opportunities available to educators and the potential to expand online STEM education by developing a community of practice. A key outcome was the acknowledgment of significant data gaps in understanding the awareness, effectiveness and acceptance of online STEM education within the broader STEM community. To address this data gap, the focus group recommended developing a national survey to benchmark the state of online STEM education.

³ Myles G. Boylan, NSF, Chronicle of Higher Education, The Tough Road to Better Science Teaching, August 3, 2007

To accomplish this, educators from a number of organizations began the work of developing the survey. Recommendations for the types of questions that would provide the greatest amount of insight into the state of online STEM education were solicited from the broader community throughout the year. Additional activities included trial surveys, and input from working groups as part of the OLC Accelerate 2019 STEM Research Summit and OLC IDEATE 2020 conferences.

The survey was scheduled for national release in March of 2020. The national emergency declaration caused by the COVID-19 pandemic stalled its release. The sudden shift to online instruction in response to the pandemic provided the working group with the opportunity to re-design the survey, to capture this experience. Many STEM faculty had little or no previous experience with online education, and support provided by institutions was variable. The non-voluntary shift to online instruction and the resulting experience was important to capture to better understand the overall perceptions of online education by STEM faculty. The re-designed survey was released in the fall of 2020 to a national sampling of STEM educators.

In addition to input from conference participants and other volunteers, the survey was developed by a STEM working group in consultation with a STEM advisory group. The Working Group was charged with the development and management of the survey, including analyzing survey results, developing the final report, and disseminating results. The Advisory Committee and Reviewers provided feedback, advice, expertise, and review of the STEM survey and final report.

STEM Working Group and Affiliations

- **Devon Cancilla**, Ph.D., Co-chair, Cancilla Digital Education
- **Jeff Seaman**, Ph.D., Co-chair, Bay View Analytics
- **Kate Lee-McCarthy**, MA, Director of Grants, OLC
- **Lynette O’Keefe**, Ph.D., Director of Research, OLC
- **Isabel Allen**, Ph.D., Professor of Biostatistics & Epidemiology, UCSF

Advisory Committee and Reviewers

- **John Whitmer**, Ph.D., Senior Fellow, Data Science, Federation of American Scientists
- **Melissa Csikari**, Program Manager, HHMI Biointeractive
- **Shannon McGurk**, Director, Distance Learning, Carolina Distance Learning
- **Siobhan Paul**, Director of Global Marketing, DigitalEd
- **Justin T. Dellinger**, Associate Director, LINK Research Lab, Center for Research on Teaching and Learning Excellence, U of Texas Arlington, Digital Learning Research Network, Every Learner Everywhere
- **Chaohua Ou**, Assistant Director, Learning & Technology Initiatives, Center for Teaching and Learning, Georgia Institute of Technology

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QUESTIONNAIRE

State of Online STEM Education: National Online STEM Education Survey

The Online Learning Consortium (OLC) in partnership with Every Learner Everywhere, HHMI BioInteractive, DigitalEd, and Carolina Distance Learning and, in collaboration with Bay View Analytics, is conducting a National Survey on the State of Online STEM Education. This important benchmarking survey will provide critical information on both the opportunities and barriers of online STEM education.

For the purposes of this survey the term STEM education refers to all teaching and learning in the fields of science, technology, engineering, and mathematics.

Please tell us a bit about yourself. Note: This information is used only to classify the survey responses. No individual-level data will be released. Information that you provide in this survey will not be used to target you for any marketing.

Please indicate your adjunct status.

- Adjunct
- Not Adjunct

Please indicate the number of years you have been teaching.

- 1 to 10
- 11 to 20
- 21 to 30
- More than 30

Gender

- Male
- Female
- Non-binary
- Other
- Prefer not to answer

Please indicate discipline of your home department.

- Aerospace, Aeronautical and Astronautical Engineering
- Applied Mathematics
- Astronomy and Astrophysics
- Atmospheric Sciences and Meteorology
- Biochemical Engineering
- Biochemistry, Biophysics and Molecular Biology
- Biological and Biomedical Sciences, Other
- Biology, General
- Biomathematics, Bioinformatics, and Computational Biology
- Biomedical/Medical Engineering
- Chemical Engineering
- Chemistry
- Civil Engineering
- Computer and Information Sciences
- Computer Engineering
- Electrical, Electronics and Communications Engineering
- Engineering Technologies/Technicians
- Engineering not listed elsewhere
- Materials Sciences
- Mathematics
- Mechanical Engineering
- Nanotechnology
- Neurobiology and Neurosciences
- Physical Sciences not listed elsewhere
- Physics
- Statistics
- Other

EXPERIENCE WITH ONLINE AND BLENDED/HYBRID COURSES

What is your experience with online or blended/hybrid courses **prior to the pandemic**?
Please check all that apply.

Online Course: A course in which all, or virtually all, the content is delivered online. Typically have no face-to-face class meetings (with the possible exception of proctored exams).

Blended/Hybrid Course: A course where sufficient content is delivered online to create a reduction in the number of face-to-face class meetings.

- I have taken an online or blended/hybrid course
 - I taught an online course
 - I (alone or with others) developed, substantially modified, or converted a face-to-face course to online or blended/hybrid
 - Other experience with online or blended/hybrid courses
-
- None of the above

What is your experience with online or blended/hybrid courses **since the start of the pandemic**? *Please check all that apply.*

- I have taken an online or blended/hybrid course
 - I converted a face-to-face course to emergency remote learning
 - I (alone or with others) developed, substantially modified, or converted a face-to-face course to online or blended/hybrid
 - Other experience with online or blended/hybrid courses
-
- None of the above

COURSES BEING TAUGHT

How many STEM courses are you teaching this current fall term?

- None
- 1
- 2
- 3
- 4 or more

At what level are you teaching?

- Undergraduate level
- Graduate level
- Other _____

How are your courses delivered?

- Face-to-face
- Blended/Hybrid
- Online
- Other _____

Do any of your current courses require a laboratory or practical experience (e.g. field work, clinical experience, studio)?

- Yes, there are labs or other practical experience that are part of my courses
- Yes, there are labs or other practical experience, but they are part of a separate course
- No, there are no labs

LABORATORY, STUDIO, OR PRACTICAL EXPERIENCE

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

What elements are included in the laboratory or practical experience for your courses?

- Visits to locations or field work remote from campus
- Observation or interaction with subjects or patients
- Hands-on use of engineering, mechanical equipment, or scientific instrumentation
- Hands-on use of electronic or computer equipment
- Studio
- Dissection or other exploration of specimens
- Other _____

What is the status of the laboratory portions of your courses?

- It is being postponed until it can be taught in person
- It has been canceled
- It is being taught in person
- It is being taught using a combination of in person and online
- It is being taught completely online
- Other _____

BARRIERS TO ONLINE STEM EDUCATION

In your personal opinion what would be (are) significant barriers to teaching your courses online? Please select all that apply.

- There are no significant barriers
- Inadequate or non-existent online laboratories
- Need for support from my institution in developing or delivering the online course
- Students are not sufficiently motivated to succeed in online courses
- Students are not technologically prepared to succeed in online courses.
- Inability to ensure academic integrity
- Lack of internet and computer access for online students
- Lack of technology at my institution
- Lack of technological support at my institution
- Lack of institutional support for online students
- Online courses will not transfer
- Lower student retention rates in online courses
- Online courses pose equity issues for some of my students
- Other _____

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

Why do you think the transferability of online STEM courses is a barrier to developing these types of online courses? Please select all that apply.

- Inability to match course sequences across institutions
- Course learning outcomes are not aligned across institutions
- Credit hour allocations for laboratories differ
- Skill outcomes for laboratories differ
- Online courses do not have the rigor required for majors

Other _____

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

Only Display Selected Choices from "In your personal opinion what would be (are) significant barriers to teaching your courses online?"

Are these barriers unique for online STEM courses or do they impact all online courses?

	STEM-only issue	All online courses
There are no significant barriers	<input type="radio"/>	<input type="radio"/>
Inadequate or non-existent online laboratories	<input type="radio"/>	<input type="radio"/>
Need for support from my institution in developing or delivering the online course	<input type="radio"/>	<input type="radio"/>
Students are not sufficiently motivated to succeed in online courses	<input type="radio"/>	<input type="radio"/>
Students are not technologically prepared to succeed in online courses.	<input type="radio"/>	<input type="radio"/>
Inability to ensure academic integrity	<input type="radio"/>	<input type="radio"/>
Lack of internet and computer access for online students	<input type="radio"/>	<input type="radio"/>
Lack of technology at my institution	<input type="radio"/>	<input type="radio"/>
Lack of technological support at my institution	<input type="radio"/>	<input type="radio"/>
Lack of institutional support for online students	<input type="radio"/>	<input type="radio"/>
Online courses will not transfer	<input type="radio"/>	<input type="radio"/>
Lower student retention rates in online courses	<input type="radio"/>	<input type="radio"/>
Online courses pose equity issues for some of my students	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

Only Display Selected Choices from "In your personal opinion what would be (are) significant barriers to teaching your courses online?"

Which of the barriers that you selected do you believe is the most serious?

- There are no significant barriers
- Inadequate or non-existent online laboratories
- Need for support from my institution in developing or delivering the online course
- Students are not sufficiently motivated to succeed in online courses
- Students are not technologically prepared to succeed in online courses.
- Inability to ensure academic integrity
- Lack of internet and computer access for online students
- Lack of technology at my institution
- Lack of technological support at my institution
- Lack of institutional support for online students
- Online courses will not transfer
- Lower student retention rates in online courses
- Online courses pose equity issues for some of my students
- Other _____

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

Do you believe that it is possible for an online laboratory to be an effective teaching tool?

- Yes
- Probably, if done correctly
- Perhaps in some cases
- Unlikely
- No

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

Have you explored any online laboratories or online laboratory practices?

- I have no need for an online laboratory
- I have not explored these
- I am aware that these exist, but have not explored them for my own use
- I am aware that these exist, but found that they do not meet my needs
- I am aware that these exist and I am considering them for future use
- I currently use an online laboratory kit, simulation, or exercise

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

What sources of online laboratories or online laboratory practices have you explored or are planning to explore?

- Those I have designed myself
- Commercial vendors
- Professional societies
- Federal or State Agencies
- Recommendations from colleagues
- Recommendations from institutional teaching and learning or instructional design teams
- Online repositories (such as the National Science Digital Library (NSDL), PhET, or Merlot).
- Other _____

[OPTIONAL] We welcome any thoughts you may have on the use of laboratories, studios or practical experiences in online STEM courses.

FUTURE OF STEM EDUCATION

Based on your experiences to date, your view of your institution's past and future prospects, and your overall opinion of higher education in general, how optimistic or pessimistic are you...

	Optimistic	Neutral	Pessimistic	Unsure
About the future of STEM education?				
About your personal role in higher education?				

[OPTIONAL] Please let us know why you provided the ratings that you did.

Equity/Accessibility

Have the pandemic-induced changes at your institution improved access and equity issues for your students or made them worse?

	Better	No change	Worse
Student access to support services (e.g., peer tutoring, academic coaching).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Access to education for under-served students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Participation by shy or introverted students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Collaboration among students.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discrimination by race, age, ethnicity, or sexual orientation.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability of students with physical disabilities to succeed.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Every Learner Everywhere is a network of diverse educational organizations that work collaboratively to improve student outcomes. Every Learner Everywhere is committed to understanding issues of equity and diversity in online STEM education. Please take a moment to answer three questions around race and ethnicity. This section is voluntary and will provide additional context to better understand the overall results from the survey.

You may skip all of the following questions by pressing the arrow button at the bottom of this page.

What race do you primarily identify as?

Do you have a secondary race that you identify as?

- Yes
- No

The following question was only displayed to the respondent if they provided a qualifying answer to a previous question

What is it?

(Optional) Do you have any final thoughts related to teaching STEM courses online?

Thank you for your time in completing this survey. All respondents will receive a copy of the project report when it is released.

May we quote your responses? Responses will be identified only by the subject area of the faculty member (e.g., Chemistry Faculty, Mathematics Faculty, etc.).

- Yes
- No