Student Responses to Remote Teaching During the Covid-19 Pandemic: Implications for the Future of Online Learning

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Introduction:

The COVID-19 pandemic brought a widespread shift in instructional practice as faculty scrambled to shift to remote instruction. One positive consequence is that this shift has inspired many instructors to think carefully about their teaching practice and the ways that technology tools and instructional strategies support their learning goals. Correspondingly, STEM educators have been investigating these needed changes and reporting them.

The overall response of chemical engineering educators is laudable, compassionate, and mirrored by university instructors in other disciplines. However, some administrators have also been quick to leverage this aspect to frame the pandemic as an opportunity to promote a widespread shift in teaching at the university. For example, two upper administrators at a prominent engineering school have described the rapid instructional activity as "the shove we need to accelerate change." [1] (Sands & Shushok, 2020). They portray a vision where a "student, staff, or faculty member should be able to be anywhere in the world participating in a learning or discovery community and still be fully engaged with the university." They go so far as to quote the bionic man from the fantasy 1970s TV series, saying "we have the technology."

Three special issues for archival journals related to chemical engineering education: *Advances in Engineering Education,* [2] *Biomedical Engineering Education,* [3] and *the Journal of Chemical Education*[4] have published 255 special issue papers address a broad span of topics including course design, content delivery, assessment practices, classroom environment, and project and laboratory work. Of the papers, eleven report on aspects of the student experience at the university level. Most studies use Likert and/or free response surveys and convenience sampling. Only Blizak et al.[6] and Vielma and Brey[15] systematically examine experiences across an entire program, as is done in this study.

Methods:

The study was conducted at a large research-intensive public university on a quarter (trimester) system. The university went to completely remote teaching during Spring term 2020 and most courses continued in remote mode during the 2020-21 academic year. Data collection occurred during Fall 2020.

A three-question free response survey was distributed to students in the chemical engineering department about their experiences with remote instructions. The survey was developed by the curriculum committee and administered through invitation in targeted core courses for students in each year of the program. Thus, most, but not all, students were invited to participate. The three questions address challenges, useful resources and strategies, and perspectives of assessment as follows:

1. Describe one big challenge you have faced as a student in the shift to remote teaching last spring or this fall.
2. What is one resource or strategy you have used to support your learning during the shift from face-to-face to remote teaching? Describe how it helped.
3. The ways that instructors give exams and other assessments of your course understanding has changed with the shift to remote instruction. Please describe any concerns you have or suggested improvements in assessment approaches.

The survey design was informed by several factors. We wanted the survey to be brief and not overburden students, so we limited it to three questions. We also sought a thick description of student experience with ample opportunity for the student voice, and did not assume to know the important aspects of their reaction to this unprecedented situation, so we choose to have free response questions.

To achieve balanced representation, a random set of 50 responses from each cohort (200 total) was selected and analyzed by open coding. The code categories emerged through an iterative analysis process with no a priori assumptions. One of the questions was recoded after about three-months and yielded almost a complete match with the original coding process, suggesting a reliable coding process. However, no formal measure of interrater reliability was completed.

Findings:

For each of the three question prompts, the common category themes are presented in the tables below, including code categories, percent response, and a sample student response for each code. Appendix A provides sample quotations for each category from each cohort and was distributed to the focus groups.

Challenges

The first question asked:

> **Q1: Challenges:** Describe one big challenge you have faced as a student in the shift to remote teaching last spring or this fall.

Results are shown in Table 2. The most prevalent challenge identified was engagement with 41% of responses coded indicating issues with motivation, paying attention, and focus. These statements tended to be broad rather than describing specific courses or environments. Other cited challenges were with social interactions (27%), instructional practices that did not suit the remote environment (24%), technology problems (24%), limited ability to get support (22%), issues with the time needed to be successful in remote learning (21%), and issues with work space.

Table 2. Coded response for challenges by frequency

Category	Sample response	Percent
Engagement (Attention/Focus/Motivation)	I have a really hard time staying involved during lectures and I find myself getting behind really easily. Focusing for so long over zoom is definitely a new challenge and I don't feel like I am retaining any of the information. (2nd Year)	41%
Social interactions (Difficult to collaborate)	Coping with exams that are often more difficult with the same amount of time as the previous years exams. Also not having face to face studios is difficult since many people don't actively participate in the online ones. Studios used to be where I learned the most and now its where I learn the least. (3rd Year)	27%
Instructional practice	Classes have become less organized and communication with students has worsened. It is not clear what material needs to be learned for tests, assignments are often not announced in a clear way, and changes to course structure are often not communicated to students clearly (3rd Year)	24%
Technology problems	Sometimes internet connection at home doesn't work well or working in groups online becomes tricky. (4th Year)	24%
Limited support (Difficult to get help / ask questions)	The hardest thing for me is not being able to go to office hours or tutoring/learning centers in person. It is really difficult to get help on homework over zoom because it takes so much longer and I can only show things through screen share. (2nd Year)	22%
Time (More time needed / work assigned in remote)	I never realized how much mental energy it took to simply look at a screen all day and do all your assignments online. I know it is a stupid reason, but I felt super drained at the end of each day because I was just looking at a screen the whole time. I feel like it has been a bit harder to retain information as well, and I have had to really commit time to retaining it. (1st Year)	21%
Workspace	because I have a very hard time focusing in the place I live, no matter where that may be. I have always been the type of student who would pay attention in lecture, take really good notes and not need to do much reading (though I knew this wasn't going to be possible for much longer). (3rd Year)	14%

Strategies and resources

The second question asked:

> **Q2: Strategies and resources:** What is one resource or strategy you have used to support your learning during the shift from face-to-face to remote teaching? Describe how it helped.

Results are shown in Table 3. Common themes for success included organizing work schedule (daily routine) and work space, being deliberate with study habits, finding other students to regularly (and safely) work with, using office hours, using class resources, and, importantly, taking time (even a small amount) for mental health.

Table 3. Coded response for strategies and resources by frequency

Category	Sample response	Percent Response
Study approach/work habits/ planning	I have been splitting up my work into smaller sections rather than just doing it all at once. I feel like this makes it easier to stay on top of my work and had really helped with the transition. (4th Year)	29%
Discuss with peers	I try to keep in touch with my friends who are in the same classes as I am and check in with them so we can study together. (2nd Year)	24%
Office Hours (worm hole, advisor …)	One resource is office hours from the TA seem slightly more accessible for students because you can attend them from anywhere yet they still do not seem as valuable as in person office hours. (3rd Year)	22%
Lecture videos	I really just love having lectures recorded. I come to Zoom class every day, but being able to rewatch lectures is a huge plus for me. If I didn't understand something during class, I can rewatch that part of the lecture to see if I get it the second time around. (2nd Year)	14%
Textbook / lecture notes	Reading the textbook for class as often as possible. It helps quite a bit, since I can get any necessary derivations and equations, then I only have to focus on listening during lecture. (3rd Year)	10%
Mental health (e.g. Breaks in the day)	One strategy I have done has been being aware of when I need to take a break. Depending how I feel I will either lay down for a bit, jump up and down, or go on a walk. I found that if I do not give myself a break, then I will sit at my desk for a long period of time, and feel overwhelmed. (1st Year)	8%
Online videos (YouTube, Kahn)	Youtube videos have helped me in different classes when I needed help with different assignments, learning how to do certain problems. I have also rewatched class recordings to see if I missed anything during class. (1st Year)	8%
Slack/Social media	Discord has been a way I've been able to connect with students in the same class as me. I don't have any close friends in CHE 311 or CHE 331 so I use discord as well as Slack. (3rd Year)	7%

Assessment

The third question asked:

> **Q3: Assessment:** The ways that instructors give exams and other assessments of your course understanding has changed with the shift to remote instruction. Please describe any concerns you have or suggested improvements in assessment approaches.

Results are shown in Table 4. Online assessments are inherently different than in-person assessment and many student responses reflected aspects of these differences while 20% stated they had no concerns. 31% of the responses commented on aspects of exam scheduling and delivery. Students reflected more favorably on exams that had wider time windows to begin, even if there was a fixed time to take the exam. However, it is unclear how different exams are for different students so there may be concerns with academic dishonesty with this approach. Three issues that were often connected were issues with the esubmission process (19%), exams that were too long (11%), and stress (13%). Surprisingly, only 9% of responses identified cheating as an issue. 7% advocated for more frequent low-stakes assessments.

Table 4. Coded response for assessments by frequency

Category	Sample response	Percent Response
Exam scheduling / delivery	Most of my classes offer tests in a format where you can't go back and see questions you've already answered which has made it really hard to manage time and impossible to go back and check over your work if you do have extra time. This was really frustrating because it goes against all the test taking strategies Ive been taught throughout school and I often times realize a mistake I made after I have answered but I can't go back and fix it so I end of submitting a test or quiz that doesn't accurately represent my understanding of the class content. (1st Year)	31%
No concerns	I don't have any concerns or suggestions. In terms of exams, the format and difficulty has stayed the same for all my classes. (2nd Year)	20%
eSubmission process	The extra time that has been given to take tests is a big plus. Though some classes don't give enough time, especially when you have to print out and scan work. You have to take that into account while doing the test so, in the end, the work you produce isn't the best it could be since some students are rushing to get enough time to scan everything. (1st Year)	19%
Stress	One concern I have is getting an increased workload because of the remote classes. Remote learning sometimes requires more time to understand the material, and having additional assignments and exams only makes my stress even worse. (2nd Year)	13%
Exams too long	I have noticed that professors have made the exams lengthier (including exam 1 in this class). I wish that the exam lengths could be more reasonable. (4th Year)	11%
Technology issues	My main concern is the possibility of any technical problems that might occur within the timed exam. (4th Year)	10%
Cheating	It's hard to assess the individual's learning if there's no way to stop them from working with others, using google or reviewing notes or texts. (2nd Year)	9%
More low stakes = better	In my biochem class the professor eliminated all exams and instead has weekly quizzes. I really like this low stakes format, however, in that class the questions are all multiple choice so I don't think that would work as well or at all for this class. (3rd Year)	7%

Discussion and Conclusions

The survey findings from this study are consistent with those reported in the early special issues on COVID-19. Like Morelock et al.,[10] we found that both students and instructors faced a variety of challenges in the rapid transition to remote instruction. Students reported broad issues of engagement including motivation, attention and focus, similar to those reported by students in other settings[7]-[9],[13],[15] as well as added stress in completing school work.[11] Students also adopted similar strategies to succeed such as more deliberate planning and organization and

attending to mental health.[9],[11] Both the student survey and the two focus groups suggest real challenges as the community rapidly shifted to remote teaching, but also identified dedication, resilience, and compassion of students and faculty alike. What is clear, however, is that the shift in processes and practices necessitated by COVID-19 *do not* serve as a beacon for future practice as suggested by some upper administrators.

However, there are also important lessons from this unintentional experiment. If instructors held on to a pre-pandemic view of and in-class exam, students tended to have poor experiences. Those who adapted and were flexible seemed to lead to better experiences with students. Rather than trying to reproduce the in-person learning environment, the focus groups suggest identifying realistic goals and then designing instruction and interactions around the affordances and constraints of the remote environment. It seems this is a lesson that can be extended to approaches in other instructional contexts as well.

Acknowledgements

References

1. Sands, T. & Shushok, F. (2020). The COVID-19 higher education shove. *Educause Review* https://go.nature.com/3o2vHbX
2. Chen, J., Clark, R., and Lichtenstein, G. (2020). Overview – Special Issue on COVID-19. *Advances in Engineering Education* **8**(4).
3. Saterbak, A., Huang-Saad, A. & P. Helmke, B. *Biomedical Engineering Education* and the Special COVID-19 Issue. *Biomed Eng Education* **1,** 1 (2021). https://doi.org/10.1007/s43683-020-00029-6
4. Holme, T. A. (2020). Introduction to the Journal of Chemical Education Special Issue on Insights Gained While Teaching Chemistry in the Time of COVID-19.
5. Atman, C. J. (2020). Hope, Stress, Sketch & Kvetch: Emphasizing Caring Through Reflection in Online Teaching in the Pandemic. *Advances in Engineering Education* **8**(4).
6. Blizak, D., Blizak, S., Bouchenak, O., & Yahiaoui, K. (2020). Students' Perceptions Regarding the Abrupt Transition to Online Learning During the COVID-19 Pandemic: Case of Faculty of Chemistry and Hydrocarbons at the University of Boumerdes—Algeria. *Journal of Chemical Education*, *97*(9), 2466-2471.
7. Burnett, J. W., Burke, K. A., Stephens, N. M., Bose, I., Bonaccorsi, C., Wade, A. M., & Awino, J. K. (2020). How the COVID-19 Pandemic Changed Chemistry Instruction at a Large Public University in the Midwest: Challenges Met,(Some) Obstacles Overcome, and Lessons Learned. *Journal of Chemical Education*, *97*(9), 2793-2799.
8. Jeffery, K. A., & Bauer, C. F. (2020). Students' responses to emergency remote online teaching reveal critical factors for all teaching. *Journal of Chemical Education*, *97*(9), 2472-2485.

9. Kalman, R., Macias Esparza, M., & Weston, C. (2020). Student Views of the Online Learning Process during the COVID-19 Pandemic: A Comparison of Upper-Level and Entry-Level Undergraduate Perspectives. *Journal of Chemical Education*, *97*(9), 3353-3357.
10. Morelock, J. R., Sochacka, N. W., Lewis, R. S., Walther, J., Culloty, C. M., Hopkins, J. S., ... & Ofunne, C. K. Using a Novel Research Methodology to Study and Respond to Faculty and Student Experiences with COVID-19 in Real Time.
11. Petillion, R. J., & McNeil, W. S. (2020). Student experiences of emergency remote teaching: Impacts of instructor practice on student learning, engagement, and well-Being. *Journal of Chemical Education*, *97*(9), 2486-2493.
12. Ramachandran, R., & Rodriguez, M. C. (2020). Student Perspectives on Remote Learning in a Large Organic Chemistry Lecture Course. *Journal of Chemical Education*, *97*(9), 2565-2572.
13. Rodríguez Núñez, J., & Leeuwner, J. (2020). Changing Courses in Midstream: COVID-19 and the Transition to Online Delivery in Two Undergraduate Chemistry Courses. *Journal of Chemical Education*, *97*(9), 2819-2824.
14. Simon, L. E., Genova, L. E., Kloepper, M. L., & Kloepper, K. D. (2020). Learning Postdisruption: Lessons from Students in a Fully Online Nonmajors Laboratory Course. *Journal of Chemical Education*, *97*(9), 2430-2438.
15. Vielma, K., & Brey, E. M. (2021). Using Evaluative Data to Assess Virtual Learning Experiences for Students During COVID-19. *Biomedical Engineering Education*, *1*(1), 139-144.

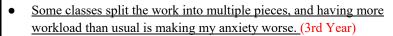## Appendix A. Sample responses to the survey questions

Q1. Challenges. Describe one big challenge you have faced as a student in the shift to remote teaching last spring or this fall.

Table A1. Sample responses for challenges from each year in the program.

Categories	Percent response	Sample Response
Engagement (Attention/ Focus/ Motivation)	41%	• It has been really difficult to maintain discipline and stay 100% on task during remote class sessions. It is much easier to multitask and not give my full attention to whatever remote class is going on, and I believe that I am not doing as well in m classes due to this temptation. (1st Year) • I have a really hard time staying involved during lectures and I find myself getting behind really easily. Focusing for so long over zoom is definitely a new challenge and I don't feel like I am retaining any of the information. (2nd Year) • I have the hardest time paying attention during lecture. For in person learning I could absorb every piece of information in lecture but with online lectures it's extremely difficult to stay engaged and a lot of information seems to get lost. Instructors also seem to have a hard time keeping lecture within the scheduled time often running over while students have other classes to go to. (3rd Year) • Motivation. It's very difficult for me to maintain interest in class when I have so few interactions with my colleagues (4th Year)
Social interactions (Difficult to collaborate)	27%	• One of the big challenges that I have faced as a student in the shift to remote teaching this fall has been becoming more involved socially within the university. While I have been able to attend class and submit assignments successfully, the lack of direct communication in a college setting has made it difficult for me to feel integrated within the college community. (1st Year) • One big challenge that I have faced in remote learning is the disconnect from my students within class. I often find I learn best through interacting with others, so not being able to talk with other students about their work or form relationships has led to a lack of motivation sometimes to complete assignments. (2nd Year) • Coping with exams that are often more difficult with the same amount of time as the previous years exams. Also not having face to face studios is difficult since many people don't actively participate in the online ones. Studios used to be where I learned the most and now its where I learn the least. (3rd Year) • Working with people in person is a lot easier than online through zoom. Physically attending class allows me to pay more attention during lecture (4th Year)
Instructional practice	24%	• Less hands-on involvement and active engagement in class. (1st Year) • I feel like I have less free time since many classes expect us to watch both prerecorded lectures and attend class at the same time. Also, even though

		• I have a few friends in my classes, it is harder to collaborate. (2nd Year) • Classes have become less organized and communication with students has worsened. It is not clear what material needs to be learned for tests, assignments are often not announced in a clear way, and changes to course structure are often not communicated to students clearly (3rd Year) • Seeing example problems and understanding the conceptual and mechanical concepts have been more difficult. It would be nice to see real world examplesa and additional video examples on canvas. Also, other classes had review sessions before midterms. (4th Year)
Technology problems	24%	• I had to attend one of my lab sessions online and the video was very choppy and it was difficult to tell what was happening because of network connectivity issues. (1st Year) • My WiFi cutting out constantly. I live with 7 roommates, all of which are full time students like me and we constantly have zoom classes overlapping or at the same time. (2nd Year) • I always studied at the library because I am in a very small house with no desk or room for one. And internet access is a problem too. (3rd Year) • Having all my resources available to me at home has taken some time to build up and adjust to. Before, I would spend majority of my day at the library after my classes would end. I would be on campus from 8 AM to around 6 PM everyday. Go home to eat and then go back to campus to study and do work in the library until around 10 PM. Sometimes internet connection at home doesn't work well or working in groups online becomes tricky. (4th Year)
Limited support (Difficult to get help / ask questions)	22%	• It is harder to find places if you need help with an assignment. Especially because some teachers just don't reply to emails. (1st Year) • The hardest thing for me is not being able to go to office hours or tutoring/learning centers in person. It is really difficult to get help on homework over zoom because it takes so much longer and I can only show things through screen share. (2nd Year) • It is difficult for me to go to the office hour since I have time different with the US. So, the only two ways I can ask for help are in studio and email to the professor or TA. (3rd Year) • Access to help when I need it. I know there are office hours, but sometimes I can't make them or I haven't started working on the hw yet because I have 3 other classes to keep up with. (4th Year)
Workspace	14%	• It can be a challenge sometime to focus in class when you're sitting at home or in a dorm room and there is always something going on around you. Or it is easy to just sit on your bed to do class and then get tired and zone out for a minute. Sometimes it can be hard to focus when your house or dorm is not only where you live but also where you learn. I know I definitely got frustrated because a lot of times there was not really a place to go where I could be in class or do homework and not be interrupted. It is also hard when you don't known anyone else in your

		class, to either ask questions or for help. It is also just harder to ask questions or have conversations with teachers or TA's over email or zoom. (1st Year) ● I think a big challenge for be is staying focused and keeping myself accountable for my own progress. <u>I live with 2 other roommates, which can be pretty distracting when we all have different schedules and are trying to do our own thing</u>. Additionally, it has been hard trying to stay on top of my work for my fully asynchronous classes. (2nd Year) ● I am a very social person and I loved to spend time moving around campus and doing working with many different people. One of the best strategies I have for learning anything is to try and teach it to someone else. I never did homework at home because <u>I have a very hard time focusing in the place I live, no matter where that may be. I have always been the type of student who would pay attention in lecture, take really good notes and not need to do much reading (though I knew this wasn't going to be possible for much longer)</u>. My one big challenge I've faced is having almost everything I enjoyed about school, learning and life in general be cancelled or moved online. I do not blame OSU of course, I'd rather hate school than have a COVID outbreak. Due to long term mental health issues I have virtually no intrinsic motivation, <u>so sitting in my room doing school for over 12 hours a day every day is sucking what little life I had left out of me.</u> (3rd Year) ● It is extremely hard to focus being at home. There is nobody holding us accountable, and <u>most of us are doing class from our bedrooms. We are constantly in the same room, and having to stare at computers all day and really missing the human interactions we get on campus.</u> I am not sure what the solution to this is though, and I'm not sure there is a simple one other than having understanding professors. I really appreciate when professors are more lenient with remote learning. For example, allowing us to drop our lowest hw/test, because circumstances at home can make things a challenge. In addition to the political climate right now, I know many of us are really struggling. I know it must be hard as a professor though as well. I just think we all need to be really understanding of each other and do what we can to make it easier. (4th Year)
Time (More time needed / work assigned in remote)	21%	● <u>I never realized how much mental energy it took to simply look at a screen all day and do all your assignments online. I know it is a stupid reason, but I felt super drained at the end of each day because I was just looking at a screen the whole time. I feel like it has been a bit harder to retain information as well, and I have had to really commit time to retaining it.</u> (1st Year) ● <u>There is a lot more work that professors give us, like prelecture videos that add about 2 hours each day to our work load.</u> It is hard staring at a screen for 14 hours of the day while also trying to be a functioning human. Access to help is a lot more limited now that school is online and it's hard trying to attend office hours or a zoom tutoring call and trying to explain the problem and what we are confused about. (2nd Year)

		- <u>Some classes split the work into multiple pieces, and having more workload than usual is making my anxiety worse.</u> (3rd Year) - It is more difficult to focus on homework. I feel stuck trapped working at home and I don't feel as engaged in an online lecture environment. <u>The homework load takes longer as I have to catch up and review a lot of material</u>, and I feel more disconnected from my peers. The teaching staff is doing a great job accommodating everyone, it's just hard to get used to a new environment. (4th Year)

Q2: Strategies and resources: What is one resource or strategy you have used to support your learning during the shift from face-to-face to remote teaching? Describe how it helped.

Table A2. Sample responses for strategies and resources from each year in the program.

Categories	Percent response	Sample Response
Study approach/work habits/ planning	29%	- I have made an electronic calendar with all due dates and a to do list for each day, since different professors may use different sites and emails to let you know your assignments. It has helped me stay on top of my work despite not having physical assignments and papers that I can see I need to do. (1st Year) - Last week I realized that If I do the various assignments all in a 2-3 hr session the night it's due it makes it a lot harder. I was doing assignments like this because I was pretty much always treading water in my classes trying to finish these assignments by the due date. So I've been splitting up my assignments into multiple parts and doing the throughout the week. This also means I have more time to get help on them. (2nd Year) - I have started retaking notes after lecture to make sure I am tracking with the class. I'm not sure why I didn't need to during in-person classes. Maybe I'm more focused when things are in-person or maybe it was easier to follow along. (3rd Year) - I have been splitting up my work into smaller sections rather than just doing it all at once. I feel like this makes it easier to stay on top of my work and had really helped with the transition. (4th Year)
Discuss with peers	24%	- Having study chat groups with students from the class has been pretty helpful with understanding what took place during the class session and with understanding the differences in "answers" for various assignments and labs. (1st Year) - I try to keep in touch with my friends who are in the same classes as I am and check in with them so we can study together. (2nd Year) - Working with others and getting more comfort in studio type is unavailable, we can use each other as a source of resource and gain knowledge that way. (3rd Year) - I've connected with my friends through Discord/Zoom on studying and working on homework assignments. This has helped me learn the content as it is much easier to work together as a team. (4th Year)
Office Hours (worm hole, advisor …)	22%	I have tried my best to attend virtual office hours. It helps to get even some interaction with your professors and

		understand concepts. (1st Year) ● I have been going to more professor office hours and finding others that have similar classes to do more virtual study sessions to get ready for the exams. This helps me stay focused during times of possible increased distraction. (2nd Year) ● One resource is office hours from the TA seem slightly more accessible for students because you can attend them from anywhere yet they still do not seem as valuable as in person office hours. (3rd Year) ● Attending the office hours and frequently contacting the TAs and professors outside of class. (4th Year)
Lecture videos	14%	● Stay on top of things. Thats the one good thing about being remote is for me at least it has been super easy to stay on top of things. Since a lot of the teachers already post their lectures online before class I would always go ahead and watch them before class so I can start my homework right away. (1st Year) ● I really just love having lectures recorded. I come to Zoom class every day, but being able to rewatch lectures is a huge plus for me. If I didn't understand something during class, I can rewatch that part of the lecture to see if I get it the second time around. (2nd Year) ● The recorded lectures have been an extremely valuable resource since they allow me to not worry about taking notes during class. (3rd Year) ● Returning to recorded lectures to get through homework. it helps to be able to go back and listen to the teacher explain whats happening. (4th Year)
Textbook / lecture notes	10%	● The best strategy for me during remote learning was to prioritize going over the textbook and watching videos to teach concepts to myself before classes that way class acted as a buffer to fill any gaps I may have had as opposed to relying on a space where I could not ask as many questions or go as in-depth as I would have liked in order to solidify my understanding. (1st Year) ● I would watch more outside videos or read from the book if I couldn't learn from online lecture (2nd Year) ● Reading the textbook for class as often as possible. It helps quite a bit, since I can get any necessary derivations and equations, then I only have to focus on listening during lecture. (3rd Year) ● My main resource is working together with classmates to piece together our understanding of the material. Also the textbook is helpful. (4th Year)

Mental health (e.g. Breaks in the day)	7%	- One strategy I have done has been being aware of when I need to take a break. Depending how I feel I will either lay down for a bit, jump up and down, or go on a walk. I found that if I do not give myself a break, then I will sit at my desk for a long period of time, and feel overwhelmed. (1st Year) - I try to take breaks from the screen once in a while by going for a walk or just going outside in the backyard and breathing fresh air. (2nd Year) - I've gone to more office hours for help with homework problems because it is a lot more convenient than in person. I go on runs/walks every day to stay sane. I turn my phone on do not disturb while doing school work so I can separate studying and relaxing. (3rd Year) - One resource that has helped me is to make sure to step outside for a few minutes every day and get some exercise and time to adjust your mind from being on the computer for so long. It is important to unplug once in a while, as with lecture and homework, I and many of the other students are spending more than 12 hours a day on the computer. (4th Year)
Online videos (YouTube, Kahn)	8%	- Youtube videos have helped me in different classes when I needed help with different assignments, learning how to do certain problems. I have also rewatched class recordings to see if I missed anything during class. (1st Year) - I have used a lot of online videos to explain what I don't understand in class. The videos have helped me to understand what I have to do in the problems. (2nd Year) - watching more videos online that go into more depth. It has helped me understand but not necessarily translated into better scores. (3rd Year) - I used Youtube videos, called other friends on Facetime and discussed problems with them. These are the only two resources alongside with the teaching team. (4th Year)
Slack/Social media	7%	- N/A (1st Year) - I have used slack a lot more for help on problems, especially with CBEE 102 in the spring and physics this term. (2nd Year) - Discord has been a way I've been able to connect with students in the same class as me. I don't have any close friends in CHE 311 or CHE 331 so I use discord as well as Slack. (3rd Year) - Utilizing online chat forums (slack in particular) has been a big support strategy. Also having weekly zoom study sessions with my friends in CBEE to review homework/work to all process the material has been extremely helpful. (4th Year)

Q3: Assessment: The ways that instructors give exams and other assessments of your course understanding has changed with the shift to remote instruction. Please describe any concerns you have or suggested improvements in assessment approaches.

Table A3. Sample responses for assessment from each year in the program.

Categories	Percent response	Sample Response
Exam scheduling / delivery	31%	• Most of my classes offer tests in a format where you can't go back and see questions you've already answered which has made it really hard to manage time and impossible to go back and check over your work if you do have extra time. This was really frustrating because it goes against all the test taking strategies Ive been taught throughout school and I often times realize a mistake I made after I have answered but I can't go back and fix it so I end of submitting a test or quiz that doesn't accurately represent my understanding of the class content. (1st Year) • I like when the exams are open for an extended period of time so I know that I can take it when I feel most prepared, and when my house is a good environment. (2nd Year) • i know for transport they gave us 48 hours from start to finish to work on the exam as we needed. i know that is a bit dramatic, but being less rushed on time helps significantly for demonstrating ive learned the material. (3rd Year) • One has used proctorio which I did not like it was the worst testing experience ever. I liked the 2 hour window on canvas was alright. I think that having tests open note is the way to go since it's your notes that you had in class. I have concerns that exams will try to be as "normal" as they can be when it can't be normal with remote learning. I also think that exams in general are not reflective of a student's learning but that probably will never change so :/ (4th Year)
No concerns	20%	• In all honesty, exams have become much easier. Most professors have begun to allow open notes. While the inherent difficulty of the questions may have increased, the tests have gotten easier. (1st Year) • I don't have any concerns or suggestions. In terms of exams, the format and difficulty has stayed the same for all my classes. (2nd Year) • No concerns (3rd Year) • I think the current ways are fine for me. (4th Year)

eSubmission process	19%	• The extra time that has been given to take tests is a big plus. Though some classes don't give enough time, especially when you have to print out and scan work. You have to take that into account while doing the test so, in the end, the work you produce isn't the best it could be since some students are rushing to get enough time to scan everything. (1st Year) • One of my biggest concerns with online tests is the added stress of scanning in work or submitting it rather than simply handing in a test. Most professors have been considerate of this and added extra time to turn things in which is very appreciated. (2nd Year) • Some possible improvements in assessment approaches is giving more time for the given amount of work to accommodate more for other variables such as internet or scanning. (3rd Year) • I just have trouble with submitting the exams. The scanning software can malfunction and scanning can take longer than anticipated so it is just a little stressful (4th Year)
Stress	13%	• Sometimes the software crashes or it's too slow, which makes causes stress and then I can't totally get focused. (1st Year) • One concern I have is getting an increased workload because of the remote classes. Remote learning sometimes requires more time to understand the material, and having additional assignments and exams only makes my stress even worse. (2nd Year) • I suggest completely changing the exam format, rather than trying to uphold the antiquated method. Take home tests that require complex problem solving are far better tests than a 50 minute race. Tests with longer time periods reduce stress and are more fitting for the student. (3rd Year) • Exams have become more stressful as online is never a good way to take a test especially a timed exam. Assessments as a whole seem to be much harder than they would be before. Some other courses have limited the amount of exams and have shifted towards multiple quizzes that are lower stake. (4th Year)
Exams too long	11%	• I don't really like how a lot of teachers have approached Canvas tests. They use very short time constraints which add pressure because there isn't enough time to really check your work. And they don't allow you to go back and look at previous problems so you have to know how to answer the question at that exact moment which doesn't work for a lot of people. Some suggested improvements are to just give a little more time for the questions so the tests don't feel as rushed and maybe if you don't want us to go back and look tell us the types of questions that will be on the exam before so we know

		how to allocate our time. (1st Year) • <u>My physics 212 class does an atrocious job of giving students enough time to answer all the questions and upload to grade scope. I hope we are given adequate time to do this. Thats my only worry, that the test is able to easily be completed in the allotted time, as well as take pictures, convert to a pdf and then email it to my computer and upload to gradescope..</u> (2nd Year) • <u>Keep exams similar to in person if timed, if not, don't make them overly long. We have other work to do, and a take home exam taking 4-5 hrs is oftentimes what pushes people into elevated stress.</u> (3rd Year) • <u>I have noticed that professors have made the exams lengthier (including exam 1 in this class). I wish that the exam lengths could be more reasonable.</u> So far, I prefer the quiz type assessments where you are given a quiz weekly/biweekly, and either have two time-limited attempts, or say 24 hours to complete the questions. I have found that it keeps me more up on pace with the class material. (4th Year)
Technology issues	10%	• <u>Sometimes the software crashes or it's too slow, which makes causes stress and then I can't totally get focused</u>. (1st Year) • Sometimes tests and quizzes are more stressful because I'm taking them at home. Wifi isn't always reliable, and I lack a quiet room I can work in. (2nd Year) • The number one concern I have is having enough time to finish an exam. With it all being online now, sometimes uploading documents/files take a while and we experience technical difficulties. Or problems with canvas crashing or wi-fi going out all has happened to me personally. (3rd Year) • <u>My main concern is the possibility of any technical problems that might occur within the timed exam.</u> I'm very pleased with the structure of the last exam. Mainly the ability to take it at any time within the 24 hr window and the submission of one pdf. (4th Year)
Cheating	9%	• <u>The only thing I can think of is the fact that some teachers give assessments that bar any kind of notes the student may have. There isn't a way to truly proctor what the student is doing, so maybe instead of having that restriction, designing quizzes and test in an open-note format would be more suitable (CH 231 does a great job at this).</u> (1st Year) • I don't have any answers for how to achieve accurate assessment online. <u>It's hard to assess the individual's learning if there's no way to stop them from working with others, using google or reviewing notes or texts.</u> I think courses need to become less reliant on assessment scores to judge student performance but as for a substitute I don't really have any

		good answers. There's also the fact that the students who decide to be dishonest have an easy route to getting an advantage over honest students unlike in a in person test. (2nd Year) ● I think that exams have been the hardest thing to transfer to online learning. Exams are already high pressure and a race against the clock. These online ones are typically open note and sometimes timed, with an uploaded submission (rather than canvas quiz). Understandably, these exams have to be made harder to compensate for the fact that the exam is open note/book. However, this also makes exams far more difficult than they would have been if they were closed note and in person. It is also frustrating that since they aren't moderated, that peers may be academically dishonest and skew class averages to where there is no longer a curve. I'm not sure how much of this can be improved, I would just ask that you keep these things in mind if you aren't already. (3rd Year) ● It has become very easy for students to collaborate on exams. it may be better to embrace this collaboration than fight it. (4th Year)
More low stakes = better	7%	● There are fewer strict exams and finals. Which I really like because it has always been hard for me to take tests in that way. (1st Year) ● It is really helpful when teachers "break up" the midterm. So instead of one midterm and one final, we have multiple quizzes that way it provides a much more comprehensive look on what we are struggling on and we can have specific questions for office hours. It is hard to know what you don't know if that makes any sense, but the weekly/biweekly quizzes help me to know what I need work on and be more prepared when the final comes. (2nd Year) ● In my biochem class the professor eliminated all exams and instead has weekly quizzes. I really like this low stakes format, however, in that class the questions are all multiple choice so I don't think that would work as well or at all for this class. My concern about remote assessments is that professors can not directly see how the students are doing during the exam (are they flustered or upset or confident). Therefore it's harder for you to understand our level of understanding. I really like the shift away from time constrained exams and completely closed note/book exams because they don't reflect the real world. (3rd Year) ● Honestly i like the 411 model that Prof. XX has, hw and weekly quizzes with two attempts make up the bulk of the grade. i like to learn from my mistakes in the first try (4th Year)