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Shifts in STEM Student Perceptions of Online Classes across 18 Months

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ABSTRACT

Prior to the COVID-19 pandemic, Computer Science and STEM-related fields were among the most resistant to online courses. This is because of a perception of the need for more hands-on instruction with labs, clinicals, field studies, etc. Additionally, many STEM students had perceptions based on limited experience of an online STEM course. Therefore, investigating how the pandemic affected students' perceptions over time is very important. This study investigates the evolution of student perceptions after one and a half years relative to synchronous courses, asynchronous courses, overall satisfaction with online courses, and lab and project-based courses. Our analysis is based on two surveys conducted in the Spring 2020 and Spring 2021 terms, i.e., the first and last semesters that the university converted to a fully online mode. We hypothesize why there were significant empirical shifts in some areas and not in others, and make recommendations based on the qualitative student responses relative to best, acceptable, and poor practices. Our main findings include: 1) Students' perceptions of online classes have improved but are far from equivalent for a lot of the students. 2) Lab resources have improved a great deal, but lab experiences have only improved modestly. 3) Although students' preference between synchronous and asynchronous online modalities were evenly divided, it did not significantly affect students' perception of their learning experience. 4) Grading policies have left many students anxious and confused. Recommendations are provided at the end of the paper.

Introduction

The abruptness of the COVID-19 pandemic had a dramatic effect on higher education because of the widespread, involuntary move to fully online formats. The duration of the pandemic reduced the likelihood of a quick, symmetrical return to "normal" as improvements in online teaching, experimentation and innovation, and acclimation to the online mode occurred with different degrees of success. For example, prior to the pandemic, STEM and STEM-related students and faculty were, in general, quite averse to the provision of online laboratory component because it is difficult to deliver high-quality laboratory experiences and activity-based projects in a virtual environment (Colthorpe & Ainscough,

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2021). Yet online learning does offer valuable advantages such as time and space flexibility, convenient access to written and recorded lectures, opportunities for self-paced learning, etc. Additionally, it is likely that the extensiveness and duration of the pandemic suggest there has been some deep-seated shifts in students' experiences and perceptions and that online and hybrid learning will likely be a more strategic priority in the post-pandemic era.

The goal of this paper is to summarize the experience in teaching STEM and STEM-related courses in one university in order to understand the varied experiences of students, and from that examination, suggest lessons learned that are likely generalizable. Careful examination of the results of the enormous experiment that the pandemic caused can help better design STEM and STEM-related courses in remote or hybrid learning modalities after the pandemic. That is, the pandemic provided a special opportunity to experiment with online learning, understand student perceptions, and improve teaching presence in order to study the varying effects of exposure, experimentation, fulfillment of technological capacity, and acculturation. We evaluate the effect of online learning from three aspects: 1) Have the overall perceptions of online teaching in STEM courses changed over time? 2) Have perceptions of lab and project-based courses changed over time? 3) Have there been any significant shifts in course formats?

In this paper, we report on students' perceptions of online learning and how they evolved during the pandemic at a public university in California, USA. Our analysis is based on two surveys conducted at a college of natural sciences in the Spring 2020 and Spring 2021 terms, i.e., the first and last terms that the university converted to a fully online mode. This allowed us to compare student opinions under similar conditions, and therefore investigate how their opinions and expectations evolved over time.

Related work

This study reviews changing perceptions of students in three major areas. First, the overall perceptions of students regarding online learning in general and in STEM disciplinary courses. Second, the study examines the shifts in perceptions of lab resources, overall quality of labs, and the perceived quality of project-based courses. Third, the study looks at other major aspects of online teaching in STEM disciplines related to modality, grading, and attendance.

Overall perceptions of online teaching prior to the pandemic

Across all online teaching, when classes have a clear structure, the ability to manage one's own learning, and for plenty of opportunities to exercise and apply one's knowledge, students appreciate the flexibility that online courses provide (Paechter, Maier, & Macher, 2010). However, when looking at various student measures of overall satisfaction regarding the learning experience, students often – but not always – rate online instruction and online instructors lower than face-to-face (e.g., Allen, Bourhis, Burrell, & Mabry, 2002; Koenig, 2019; Sitzmann, Kraiger, Stewart, & Wisher, 2006; Spencer & Temple, 2021; Tratnik, Urh, & Jereb, 2019; Van Wart, Ni, Rose, McWeeney, & Worrell, 2019). Often students' perception of the experiential element is inferior because social presence related to the instructor and other students does not meet expectations. Ironically, having students proceed to activities faster, while decreasing the aural/visual component, leads them to feel they are "teaching

themselves more," even when they get more customized feedback (Oncu & Cakir, 2011). Organization is much more demanding in an online setting, but very important to students, so they can be critical of any confusion or unclear structuring they perceive (Jung, 2011).

The reactions of STEM students prior to the pandemic were generally similar to the general population of students when considering satisfaction. For example, Chen, Bastedo, and Howard (2018) found that there was a strong correlation between quality of course design with satisfaction by STEM students. When well designed, some studies have shown superior performance in online computing master's courses in terms of performance and satisfaction, although it may come at the expense of a higher perceived workload (Connolly, MacArthur, Stansfield, & McLellan, 2007). Biel and Brame (2016, p. 417) found that "well-designed online biology courses can be effective in promoting student learning." A concrete example of good design was ensuring that statistics students watch videos prior to class attendance in flipped classrooms by strong encouragement or incentivizing behavior through quizzes, etc. (Förster, Maur, Weiser, & Winkel, 2022). Thai, De Wever, and Valcke (2020) found that physiology students were most successful and content in hybrid and flipped courses as opposed to traditional or fully online courses. In general and similar to the general population, STEM students are less satisfied with online courses (e.g., Phillips, 2015; Summers, Waigandt, & Whittaker, 2005).

Overall perceptions of students to online teaching during the pandemic

A great deal of the general literature on the pandemic experience reports on the shock regarding, and pivot to, online instruction in the spring of 2020 due to the pandemic. Some of those studies tend to emphasize the negative aspects of the abrupt changes leading to student satisfaction (e.g., Blankstein, Frederick, & Wolff-Eisenberg, 2020; Crick et al., 2021), while others tend to emphasize the appreciation of students that their education could continue (e.g., Dong & Ishige, 2022). In one study reporting on the immediate impact on student perceptions compared to the effect just three weeks later, the initial perception was an enormous sense of damage to the educational experience, which subsided considerably in just three weeks (Unger & Meiran, 2020). Not surprisingly, students with more prior experience with online learning were less concerned about the wholesale conversion to online courses (Pettigrew & Howes, 2022). Some studies report on the positive effect of teaching innovations on student satisfaction and the effects of integrating online and positive traditional methods in the long term (Dhawan, 2020; Estrellado, 2021; McCarl, 2021; Wang, Han, Liu, & Xu, 2021).

Studies of STEM students seemed even more negative than the general population with regard to the pandemic-forced shift. For example, in one study taken shortly after the pivot it was reported that "engineering students indicated lack of engagement in class, difficulty maintaining their focus, and Zoom fatigue" (Asgari et al., 2021, p. 1) as was echoed in another engineering student study in which their course evaluations did not even reach the midpoint (Giray, 2021). Biomedical students perceived the key challenges, in order, related to an adverse home environment, the online learning model itself, personal issues, and general academic issues (Vielma & Brey, 2021). A large cross-national study found that students perceived that most of their instructors were struggling the first semester that the switch was made (Saw, Chang, Lomelí, & Z, 2020). Some of those struggles attributed to poor sense of connection or belonging in the courses converted in the emergency (Mooney

& Becker, 2021). Yet some researchers have found that "online teaching has the advantage to give more flexibility and new educational tools" (Paccagnini, 2021), and that using both prerecorded lectures and traditional lectures improved performance and satisfaction more than either separately for psychology students (Harris, Blundell-Birtill, Sutherland, & Pownall, 2021). In a longitudinal study, Hou et al. (2021) reported that student perceptions of online computer science courses improved substantially over time.

Perceptions of labs and project-based courses

Of course labs are of different modal types which has an effect on both resources and satisfaction. Kennepohl (2021) identified five types: face-to-face, virtual labs, remote control labs, home study lab kits, and self-guided field trips. Many early studies reported success with non-traditional lab experiences (e.g., Esquembre, 2015). Reflecting these positive examples, a comprehensive study of labs in STEM courses found "that these non-traditional approaches to a science laboratory experience are as effective at achieving learning outcomes as traditional labs" (Faulconer & Gruss, 2018, p. 155), but noted the studies did not report on all aspects of the educational experience (see also Colthorpe & Ainscough, 2021; McCutcheon, Lohan, Traynor, & Martin, 2015; Nikolic, Ros, Jovanovic, & Stanisavljevic, 2021; Wei et al., 2019).

Less success was reported in the rapid shift to online labs, probably because of the planning and preparation involved in finding the resources and implementing a different teaching strategy. Numerous studies reported much lower student satisfaction levels related to labs (Accettone, 2022; Hou, 2021; Mistry & Shahid, 2021; Zhang, Al-Mekhled, & Choate, 2021) than is reported in the general literature. Yet some researchers reported "opportunities" among the challenges (Choate et al., 2021; Karayilan et al., 2022; Kelley, 2021) and at least one reported the online experience to be superior for ecology students (Richter et al., 2021). STEM project-based courses reported greater levels of success (Hou et al., 2021).

Perceptions of other major aspects of online learning

As noted above, in studies simply bifurcating traditional and online courses, online achievement is often equivalent, student satisfaction is often slightly less, and increases in online enrolments continue to climb (U.S. Department of Education, 2019). When looking at the sub-types more carefully, the broader studies tend to emphasize the differential strengths and weaknesses of all types—fully face-to-face, fully online synchronous, fully online asynchronous, and various types of blended or hybrid classes. Raes, Detienne, Windey, and Depaepe (2020, p. 269) noted "a cautious optimism about synchronous hybrid learning which creates a more flexible, engaging learning environment compared to fully online or fully on-site instruction" but stopped short of providing such an endorsement of asynchronous online learning. A number of researchers found that the most satisfying mode for students—in terms of the quality of the learning experience—is a hybrid one in which some of the course is face-to-face and some is online (Estrellado, 2021; Paechter et al., 2010; Thai et al., 2020). In a large study on blended learning, Vo, Zhu, and Diep (2017) found that "the effect of blended learning in STEM disciplines is significantly higher than that of non-STEM disciplines" (p.17). Jaggars (2014) noted that student preferences were often based on the

perceived rigor of the course, with online classes being chosen more often when the subject matter was perceived to be easy.

Grading issues have primarily received attention as a proxy for performance and achievement (e.g., see Nguyen, 2015). Interestingly, Mead et al. (2020) found that although underrepresented minority students signed up for online biology courses in greater numbers, their grade performance was significantly lower. There was also modest evidence that students are more consistently successful in "career" STEM courses than elective STEM courses (Wladis, Hachey, & Conway, 2014). However, in some cases, those in online courses actually performed better than strictly face-to-face students (Connolly et al., 2007).

Attendance issues are also under-studied. Research indicated fairly clearly that attendance in an online mode or face-to-face mode was equally effective in terms of performance (Nieuwoudt, 2020). That is, hours spent in either mode are relatively equivalent in affecting performance. However, some researchers have reported reduced attendance rates in online courses (Yudko, Hirokawa, & Chi, 2008) and concomitant lower retention rates (Bawa, 2016; Herbert, 2006). Thus, when online instruction is of low quality, use of the technology is substandard, students lack good self-regulation, or home environments provide numerous distractions, attendance is likely to suffer (Wandler & Imbriale, 2017).

This paper is different from the previous studies because it provides a longitudinal basis during the COVID crisis that is spread over the entire duration of the lockdown. It investigates how their perceptions have evolved over the span of 18 months. Surveys were conducted with over 500 student participants from a college of natural sciences at a 4-year public university with an official underrepresented designation. We use statistical models to provide a detailed analysis based on students' background information such as major, gender, ethnicity, age, class standing, and employment status, among others.

Survey methods

Two surveys were created to measure students' perceptions of online learning in the College of Natural Sciences. They were conducted in the Spring 2020 and Spring 2021 quarters when the university was in the first and last mandatory online teaching terms. The first direct impact of COVID-19 to the university occurred on March 15, 2020, when the university announced that campus would be closed at the end of the Winter quarter. The Spring 2020 survey was conducted in June 2020 at the end of the 2019–2020 academic year. After three-quarters of a fully online mode (i.e., Spring 2020, Fall 2020, Spring 2021), the university returned to face-to-face mode in August 2021. The Spring 2021 survey was conducted from January through March 2021. The university in this study is the region's largest public, comprehensive university, with a student population over 20,000. In Fall 2021, Hispanic students made up over half the student population. Female students are 63% of the population, 58% of undergraduate students receive financial aid (Pell Grant recipients). The surveys were sent to the 5,500 college of natural sciences students. A total of 575 and 386 responses in Spring 2020 and Spring 2021 were received, respectively

(see Table 1). The survey was confidential and was not incentivized. In the Spring 2021 sub-sample was 53.8% male (45.9% female), 55.3% Hispanic, with an average student age of 23.9 years (range = 18 to 63).

In addition to the quantitative Likert questions, respondents were encouraged to provide personal comments about their situations and perspectives. 220 in the 2020 survey, and 155 did so in the 2021 surveys; since more than one theme could be cataloged per respondent, the final tally of thematic comments was 323 in 2020 and 231 in 2021. Themes for 2021 are found in the appendix along with representative student quotations. The study was IRB-approved as exempt research and all participants provided informed consent.

Hypothesis test

The main goal of our hypothesis test is to compare the results from the Spring 2020 and Spring 2021 terms. If student satisfaction differs significantly, two multiple-regression analysis models will be conducted to identify variables that are significantly related to satisfaction.

The following are the two hypotheses:

H1: Students are more satisfied with online courses in Spring 2021 than in Spring 2020.

H2: Students are more satisfied with online lab resources in Spring 2021 than in Spring 2020.

Because the sample size is large (n is much higher than 30), we applied a two-sample z-test to test the above hypotheses and got significant results. Moreover, we built two multiple linear regression models to identify predictors of online class satisfaction and lab resources, respectively. These results and additional information about the analyses conducted will be discussed in the following section.

Results

Overall satisfaction with online courses in STEM disciplines

To assess student perceptions about the quality of lectures, we asked about their satisfaction with online courses in general, comparing the results from the Spring 2020 and Spring 2021 terms.

The empirical data indicated that the overall satisfaction rate of online teaching had improved over the past year during the COVID-19 disruption (refer to Figure 1). A two-sample z-test (based on satisfied and dissatisfied proportions between Spring 2020 and

Table 1. Breakdown of respondent count by major.

	Biology	Computer Science	Kinesiology	Nursing	Health Science	Others*	Total Count
Spring 2020 Survey	118	182	90	59	38	88	575
Spring 2021 Survey	65	154	44	40	28	55	386

*Including: Chemistry, Geology, Mathematics, Nutrition and Food Sciences, and Physics

Spring 2021) showed students were more satisfied with online courses in Spring 2021, $z = 3.29$, $p < .0005$. Students that indicated they were satisfied (including both extremely and somewhat satisfied categories) with online courses increased from 34.0% in Spring 2020 to 51.6% in Spring 2021, while the percentage of dissatisfied respondents decreased slightly from 32.3% in Spring 2021 to 28.4% in Spring 2021. It is worth noting an encouraging trend at the two ends of the spectrum in Figure 1; students who were Extremely Dissatisfied dropped by 5.4%, and students who were Extremely Satisfied increased by 11.7%.

To identify the most significant variables that affected students' satisfaction with online courses in Spring 2021, we conducted a multiple-regression analysis. A variety of independent variables were tested in the model including preferred course format, major, course/lab load, distance to school, GPA, graduation year, and demographic factors (age, gender, race, class standing, employment, amount of family obligations, and whether the student is a first-generation college student). The significant variables are: 1) Age: older students were more satisfied with online learning; 2) GPA: students with a higher GPA were more satisfied with online learning; 3) Class format: the students who prefer asynchronous format were more satisfied with online learning compared to the students who a prefer synchronous format. These variables statistically and significantly predicted satisfaction ratings of their online courses, $F(20,348) = 3.171$, $p < .0005$, $R^2 = 0.154$. There were no correlations between equity gap indicators and student satisfaction ratings. Additionally, the multiple-regression analysis showed students' gender, race, and first-generation student status were not statistically significant predictors for online course satisfaction, $p > .05$. Finally, the analysis showed that the students' major p-value >0.05, which means that there were not significant disciplinary differences among different majors in terms of the overall course satisfaction. This result was not surprising since respondents of this study were from a single college which consists of STEM and STEM-related majors.

The qualitative comments indicate a more complex picture than the significant but modest improvement in satisfaction of online courses over the year might indicate. Interestingly, the intensity of feelings about online versus face-to-face did not abate over time. The students in the 2021 survey were evenly split between those who indicated that they thought that online classes were as good as, or better than, face-to-face classes.

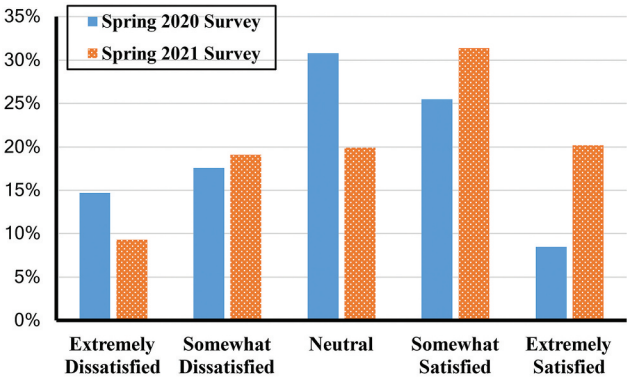

Figure 1. Overall, how satisfied are you with your online courses?

Of those that liked online classes, it is important to note that three relatively evenly split subgroups were observed: those that thought online was a superior learning mode for them, those that found them equivalent, and those that found online learning quality to be slightly inferior but more than worth it in terms of the flexibility and time savings it provided. Seven themes emerged from the qualitative analysis: convenience; ability to review material; savings of time in travel; savings in money such as ability to work more or reduce babysitting; the belief that many online classes are well taught; happiness with the fact that online was available (during a pandemic) no matter the constraints; and improvement in lab experiences (which was far from a universal sentiment, however).

Reasons given by those critical of online classes did not change much and were extensive. They included loss of interaction and sense of community; interruptions and distractions in home and non-school environments; poor and very poor teaching by some instructors; difficulty concentrating without interaction and the oppressiveness of being alone; while some online is okay, it is terrible all the time; poor course design and too much busywork; and lab experiences that were very poor in general and sometimes canceled.

It is also worth noting that students were able to discriminate among the effort and effectiveness of faculty far more in 2021 than 2020. While in the initial survey about 40% of the students said that the bulk of the faculty were doing a good job, another 40% emphasized that they were failing, primarily due to their lack of experience. In the more recent survey, very few students said that the bulk of the faculty were doing a good job with online teaching, and approximately two-thirds said that while a lot of faculty were doing a good to excellent job there were also a lot perceived doing a poor job of utilizing the online teaching mode. Approximately a quarter of the students were annoyed to angry at a significant portion of the faculty themselves (not the situation) for not doing a better job. (See appendix for the qualitative themes.)

Online modality

Lab resources

As one would expect, lab resources (not necessarily the overall experience) improved over time. Initially, faculty had less than two weeks' notice to convert their courses and labs online. By Spring 2021, there was significant improvement in students' satisfaction rate regarding the availability of online lab resources (refer to Figure 2). A z-test showed that satisfaction rating of the availability of lab resources in Spring 2021 was significantly higher than Spring 2020, $z = 8.38$, $p < .00001$. The qualitative response indicated the rapidly deployed fully online classes led to a high percentage of negative responses in Spring 2020 (i.e., 39.1% respondents indicated they were either Extremely or Somewhat Dissatisfied). In contrast, the percentage of respondents who were dissatisfied with the online lab resource reduced to 18.9% by Spring 2021.

A multiple regression analysis was run to predict lab resources satisfaction in Spring 2021 semester. A variety of independent variables were included in the model such as preferred course format, major, course/lab load, distance to school, GPA, graduation year, and demographic factors (age, gender, race, class standing, employment, amount of family obligations, and whether the student is a first-generation college student). The significant variables are: 1) Class format: students who prefer asynchronous format were more satisfied with lab resources compared to students who prefer a synchronous format; and 2) Number

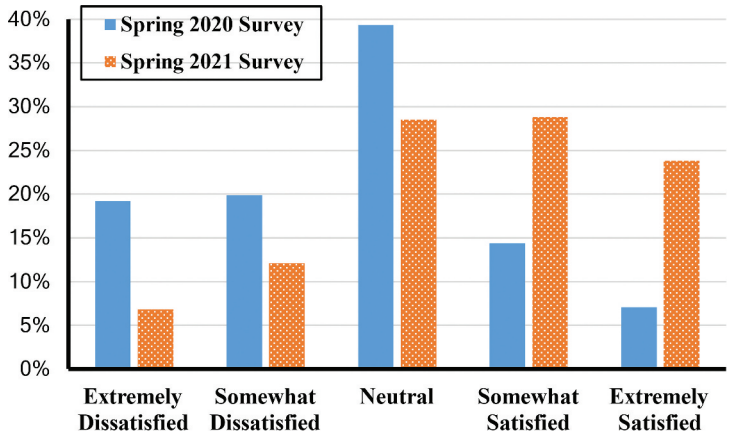

Figure 2. Overall, how satisfied are you with the availability of resources in your online labs (for example, software or technical equipment)?.

of project-based courses: students were more satisfied with online lab resources when they had fewer project-based courses, $F\ (19, 257) = 2.64$, $p < 0.0005$, $R^2 = 0.164$.

No correlations were found between equity gap indicators and student satisfaction ratings on lab resources. Multiple regression showed students' gender, race, and first-generation student status were not statistically significant predictors for satisfaction rating on lab resources, $p > .05$.

Qualitative comments reinforced the idea that lab equipment was much more available, often mailed to students, there was more hands-on experience (even if with poor monitoring), and less confusion about how to use lab resources in online classes.

Lab courses

To what degree did the improvement in lab resources influence the overall perceptions of the lab components in online courses? Comparing the data of online courses generally with those with a lab component in 2021, we found largely negative responses for courses with a lab component (refer to Figure 3). Among the 281 respondents of this question, 41.28% of them were dissatisfied with lab courses, which was 14.59% higher than those who were dissatisfied with overall online courses. Only 38.43% of the students were satisfied with lab courses, which was 12.81% lower than those were satisfied with the overall online courses. To check if there was an association between a student's major and lab course satisfaction, an analysis was done that showed that the students' major explains about 3.9% of the total variability with $p > .05$, which means that there were not significant disciplinary differences among different majors in terms lab resources satisfaction.

The qualitative results not only reinforced the numeric data but highlighted the importance of the dissatisfaction of students toward courses with labs. Importantly, many students felt that lab course weaknesses created enormous gaps in their education and feared a major handicap when going into the job market. Although the qualitative analysis in the more recent survey showed significant improvement from the dismal perceptions of labs in the first survey, the comments were still overwhelmingly negative. Themes that emerged included: lack of true hands-on experience, lack of involvement with the instructor

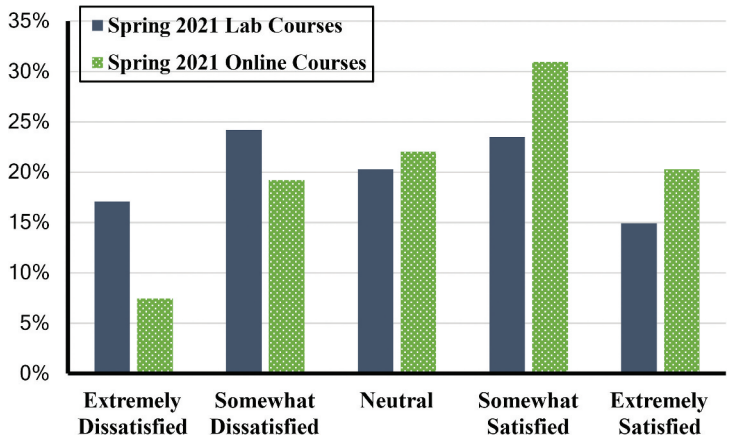

Figure 3. Overall, how satisfied are you with the lab components of your online courses?.

and other students during an experiential learning component, and a number of cancelled and truncated labs.

Project-based courses

In the Spring 2021 survey, we specifically asked students how satisfied they were with project-based courses. Among the 386 respondents in the Spring 2021 survey, 106 of them were taking online project-based courses. We compared these 106 students' perceptions of project-based courses with their overall online courses in Figure 4, which indicated less satisfaction with project-based courses. In the case of project-based courses, 48.1% of the students indicated that they were satisfied, whereas 55.86% students were satisfied with online courses in general. The results confirmed our observation that students were not keen on online project-based courses due to the difficulties of team collaboration and the shortages of equipment and facilities at which to meet.

Course formatting

Synchronous vs. asynchronous class

The past year provided a special opportunity to experiment with different course formats which can help guide online teaching after the pandemic. One aspect of course formatting in which we were interested was students' preferences between synchronous and asynchronous lectures.

When considering the preference regarding synchronous lectures (i.e., live virtual class meetings) vs. asynchronous lectures (i.e., prerecorded), the opinion was almost evenly divided (refer to Figure 5). In Spring 2020, 45.6% of respondents preferred asynchronous lectures; after one year of fully online learning, this number increased slightly to 48.4% in Spring 2021. In comparison, 42.8% of the respondents preferred synchronous lectures in Spring 2020, and it changed little in Spring 2021, at 42.6%. The proportion of respondents who preferred synchronous teaching did not significantly differ from Spring 2020 to Spring 2021, as indicated by a z-test: $z = 0.325$, $p = .374 > 0.05$. The z-test also showed that there was

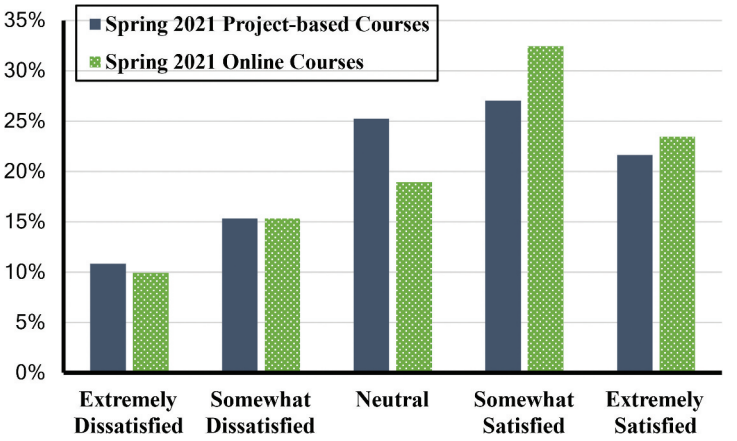

Figure 4. Question: Overall, how satisfied are you with your online project-based courses? (For example, independent study or senior project.)

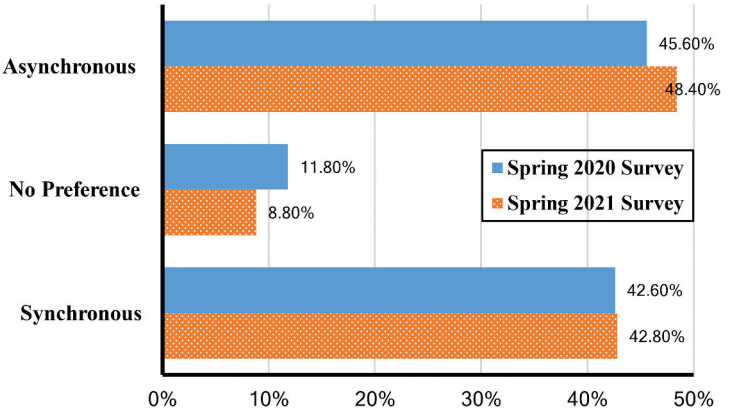

Figure 5. Question: Which type of online classes are you most comfortable with?.

no significant difference in the proportion of asynchronous teaching between Spring 2020 and Spring 2021, $z = 0.324$, $p = .374 > 0.05$.

The qualitative themes provide better insight than the quantitative data in this case. Student preferences spoke to at least four different factors: flexibility, personal importance of the material, quality of the lecture presentation, and functionality of the lecture in the course design. While the bulk of students appreciated flexibility, this was extremely important for some and not a significant factor for others (i.e., essentially bimodal responses). There was a clear conviction in the students' minds that material in their majors was more deserving of face-to-face and synchronous lectures than for general education and introductory courses (i.e., basically a linear relationship). The students indicated that the better the asynchronous lecture presentation, the more acceptable it was. There was an overwhelming preference for both synchronous and asynchronous choices being available in an online course (e.g., a synchronous videoconference session *and* availability of a "lecture capture" version). However, only providing a lecture

capture presentation (in which the primary audience was synchronous), especially if done for a previous course, was much criticized by students. Students commented appreciatively regarding high-quality, prerecorded lectures which were designed for an asynchronous audience (e.g., using scripting, better graphics, more attention to sound and aesthetics).

Grading policy

A major challenge identified in this study was the grading and assessment policy. In the Spring 2021 survey, when asked about how online testing reflects their understanding of course material, 40.9% of respondents indicated that they were satisfied with online testing, 23.7% answered in the neutral category, and 35.3% indicated they were unsatisfied. The high percentage of negative responses, unfortunately, was not surprising. The university implemented a temporary policy that allowed students to choose between credit/no-credit and letter grades on their transcript. Instructors recognized the importance of grading student performance while considering the COVID-19 impact, and some deployed a hybrid grading approach to motivate students. Most of the instructors, however, maintained a traditional grading policy.

The qualitative comments were particularly diverse on the topic of grading. Many students felt that grading was much more difficult in online courses because of the perception of an increased workload for students or their inability to accommodate a fully online learning mode. Yet a smaller number complained that online grading was easier (in terms of grades, not the amount of work). Many students were highly critical of grading in an online context, but some found it more equitable. The highly heterogeneous nature of the responses, and the varied way it was handled by instructors, indicates that it is an important topic for future research.

Class attendance

Table 2 reports class attendance from Spring 2019 to Spring 2021. The data were retrieved from course evaluation surveys from the college of natural sciences. It is interesting to note that the overall class attendance of the college increased by about 10% during the first fully online semester (i.e., Spring 2020). Although the online-only mode of learning continued in the following two-quarters, the class attendance rate returned to the pre-pandemic level: 67.2% in Fall 2020 and 67.0% in Spring 2021 compared to 69.7% in Fall 2019 (pre-pandemic semester). The initial transformation to online learning, along with various COVID-19 interruptions, seems to have led to the temporary improvement of student attendance. Qualitative comments indicate that the more important challenge may not be the minor shifts in reported attendance so much as the substantial number of students who noted

Table 2. Comparison on student self-reported class attendance.

	Spring 2019	Fall 2019	Winter 2020 *	Spring 2020	Fall 2020	Spring 2021
All	64.8%	69.70%	67.10%	**77.50%**	67.2%	**67.0%**
Almost All	32.4%	27.90%	30.50%	**17.50%**	26.6%	**25.3%**
More than Half	2.3%	1.90%	1.90%	**2.80%**	3.6%	**4.6%**
Less than Half	0.5%	0.50%	0.40%	**2.20%**	2.6%	**3.2%**
Count	10217	12481	9030	**6548**	8115	**8955**

*The university of this study switched from quarter to semester terms in Fall 2020.

challenges in listening and focusing in an online environment, as well as an inability to retain the material as effectively as in a face-to-face environment.

Discussion and recommendations

Is the glass half full or half empty? Our findings are summarized in Table 3. There has been improvement in overall perceptions of online courses, lab resources have improved substantially, project-based courses are rated nearly as good as other online courses, and attendance has not been depressed by going online. On the other hand, despite improvements and flexibility, only 51.6% of students indicated that they were satisfied with online courses, opinions about the quality of lab experiences were generally negative, and varied and poorly adapted grading policies have led to substantial student concerns.

With regard to improving the overall experience of online learning for STEM students, improvement in teaching has been achieved, but it has not been as uniform as it needs to be. Indeed, some faculty have been overwhelmed by the challenge and clearly need assistance. Areas that can use particular improvement include videoconference techniques, reduction of perceived busywork, customization of feedback, student engagement, systematic improvement of lab experiences, more consistent grading practices, and better use of learning management systems to promote attendance, participation, and practice. Specific recommendations are provided in the 14 bulleted items below:

- Recognize that as STEM instructors have gained experience, many have gotten better, but some are perceived by students as having gotten worse. Find ways to help faculty who have not adjusted well to improve or allow them to resume face-to-face teaching.
- Improve utilization of videoconferencing for synchronous courses via training, exhibitions, and modeling.
- Encourage the use of lecture capture for current courses but discourage it for future courses.
- Support utilization of small groups where appropriate but discourage overuse in STEM courses where they are generally less effective than non-STEM disciplines. Encourage faculty attentiveness to group work.

Table 3. Summary of findings.

Research Question	Finding
RQ1: Have the overall perceptions of online teaching in STEM courses changed over time?	Yes, they have improved but they are far from equivalent to face-to-face classes.
RQ2a: Have perceptions about the availability of lab *resources* changed?	Yes, they have improved from a very low level.
RQ2b: Do perceptions about the *overall quality* of labs match online classes for STEM students in general?	No, they still lag substantially behind the non-lab components of courses even though there has been some improvement over time.
RQ2c: Are perceptions about *project-based courses* as good as online classes in general?	No. They are close, but not as good as the evaluations of online classes in general.
RQ3a: Have there been any significant shifts in synchronous versus asynchronous preferences?	No. The preferences continue to be based on situational and personal factors.
RQ3b: Have there been any significant shifts in grading policies?	The findings are mixed and heterodox. Needs further research.
RQ3c: Have there been any significant shifts in attendance patterns?	Initially attendance increased but returned to previous levels. More important than attendance itself seems to be a substantial number of students complaining about the ability to focus and retain information.

- Remind faculty that perceptions of busywork are likely if there is not meaningful and timely feedback regarding all activities. Recommend more customized communication and feedback to exercises and individual assignments.
- Encourage faculty to provide faster and better responsiveness to e-mails.
- Provide advice on the many technologies that enhance student engagement and sense of fun.
- Continue to support faculty to investigate new lab resources and to continuously improve them.
- Establish faculty task teams to explore best technologies and lab practices, make better use of hybrid lab learning, and provide discussions about restoring fully face-to-face labs in some cases, even if lectures are online.
- Encourage faculty to improve course design by creating multiple lecture choices for each course where possible (over time).
- Provide and/or increase the quality of prerecorded lectures: by pointing out that the greater time commitment is compensated by re-use opportunities and higher evaluations than lecture-capture videos.
- Provide instructor training about different methods of grading activities and tests.
- Institute instructor roundtables to discuss comparative grading practices.
- Provide instructor training about how to utilize learning management systems to track and encourage attendance and participation.

After the one-and-a-half-year experience of online courses, STEM and STEM-related students in this study are becoming more accustomed to online courses in general. In Spring 2021, only 52.6% of the respondents were satisfied with online classes, while 19.9% reported them as neutral. Given the advantages of convenience, scheduling flexibility, and travel reduction, online and hybrid education will likely be a strategic priority after the COVID-19 pandemic requiring faculty involvement with continuous improvement initiatives as well as research that tracks and reports on the successes and weaknesses in the formats utilized.

Conclusion

In this paper, we report on the in-depth analysis of the change in students' perceptions of online learning. Focusing on the STEM and related fields, we study students' overall satisfaction with online courses, their preference of class format, and their perceptions regarding online labs and projects. We conducted two surveys that covered both the first and last terms that the university moved to fully online instruction. It allowed us not only to capture students' opinions but also to investigate how their opinions and expectations evolved during the pandemic.

The major findings of this study were as follows: 1) Perceptions of online classes have improved but are far from equivalent to a face-to-face experience for a majority of the students. 2) Lab resources have improved a great deal but lab experiences have only improved modestly. 3) Preferences between synchronous classes are complex because they are based on both situational factors related to the perceived quality of learning experience and important personal factors related to flexibility and the relative need for live interaction. 4) Grading policies have left many students anxious and confused. While students were facing various challenges during the pandemic, the correlation analysis

showed that majors, gender, and ethnic categories did not have a significant impact on students' perception of online learning.

The data are from a single university setting which significantly reduces generalizability. Different universities coped with the pandemic in a variety of ways, so the sample of perceptions in this study needs to be integrated with other fine-grained analyses with different student demographics. A second limitation is that while the response numbers were substantial, the response rates were low and there was no nonresponder analysis.

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References

Accettone, S. L. (2022). Student perceptions of remote chemistry laboratory delivery models. *Journal of Chemical Education*, *99*(2), 654–668. doi:10.1021/acs.jchemed.1c00757

Allen, M., Bourhis, J., Burrell, N., & Mabry, E. (2002). Comparing student satisfaction with distance education to traditional classrooms in higher education: A meta-analysis. *The American Journal of Distance Education*, *16*(2), 83–97. doi:10.1207/S15389286AJDE1602_3

Asgari, S., Trajkovic, J., Rahmani, M., Zhang, W., Lo, R. C., Sciortino, A., & Saqr, M. (2021). An observational study of engineering online education during the COVID-19 pandemic. *PLoS ONE*, *16*(4 April), e0250041. doi:10.1371/journal.pone.0250041

Bawa, P. (2016). Retention in online courses: Exploring issues and solutions—A literature review. *Sage Open*, *6*(1), 2158244015621777. doi:10.1177/2158244015621777

Biel, R., & Brame, C. J. (2016). Traditional versus online biology courses: Connecting course design and student learning in an online setting. *Journal of Microbiology & Biology Education*, *17*(3), 417–422. doi:10.1128/jmbe.v17i3.1157

Blankstein, M., Frederick, J. K., & Wolff-Eisenberg, C. (2020, June 25). Student experiences during the pandemic pivot. *Ithaka S+ R*. doi:10.18665/sr.313461

Chen, B., Bastedo, K., & Howard, W. (2018). Exploring design elements for online STEM courses: Active learning, engagement & assessment design. *Online Learning*, *22*(2), 59–75. doi:10.24059/olj.v22i2.1369

Choate, J., Aguilar-Roca, N., Beckett, E., Etherington, S., French, M., Gaganis, V., . . . Zubek, J. (2021). International educators' attitudes, experiences, and recommendations after an abrupt transition to remote physiology laboratories. *Advances in Physiology Education*, *45*(2), 310–321. doi:10.1152/advan.00241.2020

Colthorpe, K., & Ainscough, L. (2021). Do-it-yourself physiology labs: Can hands-on laboratory classes be effectively replicated online? *Advances in Physiology Education*, *45*(1), 95–102. doi:10.1152/advan.00205.2020

Connolly, T. M., MacArthur, E., Stansfield, M., & McLellan, E. (2007). A quasi-experimental study of three online learning courses in computing. *Computers & Education*, *49*(2), 345–359. doi:10.1007/s11423-019-09709-9

Crick, T., Knight, C., Watermeyer, R., & Goodall, J. (2021). An overview of the impact of COVID-19 and "emergency remote teaching" on international CS education practitioners. *SIGCSE 2021 - Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*. 10.1145/3408877.3439680

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. doi:10.1177/0047239520934018

Dong, Y., & Ishige, A. (2022). Studying abroad from home: An exploration of international graduate students' perceptions and experiences of emergency remote teaching. *Education Sciences*, *12*(2), 98. doi:10.3390/educsci12020098

Esquembre, F. (2015). Facilitating the creation of virtual and remote laboratories for science and engineering education. *IFAC-PapersOnLine*, *48*(29), 49–58. doi:10.1016/j.ifacol.2015.11.212

Estrellado, C. J. P. (2021). Transition to post-pandemic education in the philippines: Unfolding insights. *International Journal of Scientific and Research Publications*. doi:10.29322/IJSRP.11.12.2021.p12074

Faulconer, E. K., & Gruss, A. B. (2018). A review to weigh the pros and cons of online, remote, and distance science laboratory experiences. *International Review of Research in Open and Distributed Learning*, *19*(2). doi:10.19173/irrodl.v19i2.3386

Förster, M., Maur, A., Weiser, C., & Winkel, K. (2022). Pre-class video watching fosters achievement and knowledge retention in a flipped classroom. *Computers & Education*, *179*, 104399. doi:10.1016/j.compedu.2021.104399

Giray, G. (2021). An assessment of student satisfaction with e-learning: An empirical study with computer and software engineering undergraduate students in Turkey under pandemic conditions. *Education and Information Technologies*, *26*(6), 6651–6673. doi:10.1007/s10639-021-10454-x

Gupta, P., Chaffee, R., Hammerness, K., MacPherson, A., & Anderson, K. (2022). Supports and challenges in an educational crisis: The impact of the COVID-19 pandemic on youth STEM pathways. *CAISE*. https://www.amnh.org/content/download/368814/5598356/file/AMNH+NSF+RAPID+Research+Brief.pdf

Harris, R., Blundell-Birtill, P., Sutherland, E., & Pownall, M. (2021). Students' perceptions of online lecture delivery: An empirical mixed-methods investigation. *Psychology Teaching Review*, *27*(1), 69–78.

Herbert, M. (2006). Staying the course: A study in online student satisfaction and retention. *Online Journal of Distance Learning Administration*, *9*(4), 300–317.

Hou, Y., Muheidat, F., Ghasemkhani, A., Sun, Q., Qiao, H., McIntyre, M., & Van Wart, M. (2021). The adaptation of online project-based learning in computer engineering education settings. *International Conference on Interactive Collaborative Learning*, 947–955. 10.1007/978-3-030-93907-6_101

Hou, Y., Muheidat, F., Usher, T., Prado, W., Guo, X., & Van Wart, M. (2021). Evaluation of the COVID-19 shock on STEM laboratory courses. *IEEE Global Engineering Education Conference, EDUCON, 2021-April*. 10.1109/EDUCON46332.2021.9453900

Jaggars, S. S. (2014). Choosing between online and face-to-face courses: Community college student voices. *The American Journal of Distance Education*, *28*(1), 27–38. doi:10.1080/08923647.2014.867697

Jung, I. (2011). The dimensions of e-learning quality: From the learner's perspective. *Educational Technology Research and Development*, *59*(4), 445–464. doi:10.1007/s11423-010-9171-4

Karayilan, M., McDonald, S. M., Bahnick, A. J., Godwin, K. M., Chan, Y. M., & Becker, M. L. (2022). Reassessing undergraduate polymer chemistry laboratory experiments for virtual learning environments. *Journal of Chemical Education*, *99*(5), 1877–1889. doi:10.1021/acs.jchemed.1c01259

Kelley, E. W. (2021). LAB theory, HLAB pedagogy, and review of laboratory learning in chemistry during the COVID-19 pandemic. *Journal of Chemical Education*, *98*(8), 2496–2517. doi:10.1021/acs.jchemed.1c00457

Kennepohl, D. (2021). Laboratory activities to support online chemistry courses: A literature review. *Canadian Journal of Chemistry*, *99*(11), 851–859. doi:10.1139/cjc-2020-0506

Koenig, R. (2019). Most students and faculty prefer face-to-face instruction, EDUCAUSE surveys find. Digital Learning in Higher Ed. Accessed 29th May 2019. https://www.edsurge.com/news/2019-12-11-most-students-and-faculty-prefer-face-to-face-instruction-educause-surveys-find

Margulieux, L. E., McCracken, W. M., & Catrambone, R. (2015). Mixing in-class and online learning: Content meta-analysis of outcomes for hybrid, blended, and flipped courses. *CSCL*. International Society of the Learning Sciences, Inc.[ISLS].

McCarl, C. (2021). An approach to designing project-based digital humanities internships. *Digital Humanities Quarterly*, 15(3).

McCutcheon, K., Lohan, M., Traynor, M., & Martin, D. (2015). A systematic review evaluating the impact of online or blended learning vs. face-to-face learning of clinical skills in undergraduate nurse education. *Journal of Advanced Nursing*, *71*(2), 255–270. doi:10.1111/jan.12509

Mead, C., Supriya, K., Zheng, Y., Anbar, A. D., Collins, J. P., LePore, P., & Brownell, S. E. (2020). Online biology degree program broadens access for women, first-generation to college, and low-income students, but grade disparities remain. *PloS one*, *15*(12), e0243916. doi:10.1371/journal.pone.0243916

Mistry, N., & Shahid, N. (2021). Design and delivery of virtual inquiry-based organic chemistry experiments. *Journal of Chemical Education*, *98*(9), 2952–2958. doi:10.1021/acs.jchemed.1c00571

Mooney, C., & Becker, B. A. (2021). Investigating the impact of the COVID-19 pandemic on computing students' sense of belonging. ACM Inroads, 12(2), 38-45

Nguyen, T. (2015). The effectiveness of online learning: Beyond no significant difference and future horizons. *MERLOT Journal of Online Learning and Teaching*, *11*(2), 309–319.

Nieuwoudt, J. E. (2020). Investigating synchronous and asynchronous class attendance as predictors of academic success in online education. *Australasian Journal of Educational Technology*, *36*(3), 15–25. doi:10.14742/ajet.5137

Nikolic, S., Ros, M., Jovanovic, K., & Stanisavljevic, Z. (2021). Remote, simulation or traditional engineering teaching laboratory: A systematic literature review of assessment implementations to measure student achievement or learning. *European Journal of Engineering Education*, *46*(6), 1141–1162. doi:10.1080/03043797.2021.1990864

Oncu, S., & Cakir, H. (2011). Research in online learning environments: Priorities and methodologies. *Computers & Education*, *57*(1), 1098–1108. doi:10.1016/j.compedu.2010.12.009

Paccagnini, A. (2021). Teaching quantitative courses online: An international survey. https://mpra.ub.uni-muenchen.de/108330/

Paechter, M., Maier, B., & Macher, D. (2010). Students' expectations of, and experiences in e-learning: Their relation to learning achievements and course satisfaction. *Computers & Education*, *54*(1), 222–229. doi:10.1016/j.compedu.2009.08.005

Pettigrew, J. E., & Howes, P. A. (2022). COVID-19 and student perceptions toward a swift shift in learning format: Does experience make a difference? *American Journal of Distance Education*, 1–18. doi:10.1080/08923647.2021.2013749

Phillips, J. A. (2015). Replacing traditional live lectures with online learning modules: Effects on learning and student perceptions. *Currents in Pharmacy Teaching and Learning*, *7*(6), 738–744. doi:10.1016/j.cptl.2015.08.009

Raes, A., Detienne, L., Windey, I., & Depaepe, F. (2020). A systematic literature review on synchronous hybrid learning: Gaps identified. *Learning Environments Research*, *23*(3), 269–290. doi:10.1007/s10984-019-09303-z

Richter, C. F., Lortie, C. J., Kelly, T. L., Filazzola, A., Nunes, K. A., & Sarkar, R. (2021). Online but not remote: Adapting field-based ecology laboratories for online learning. *Ecology and Evolution*, *11*(8), 3616–3624. doi:10.1002/ece3.7008

Saw, G., Chang, C., Lomelí, U., & Z, M. (2020). Gender disparities in remote learning during the COVID-19 pandemic: A national survey of STEM faculty and students. *The Network for Research*

and Evaluation in Education (NREED) Data Brief 2. Accessed 29th May 2021 https://par.nsf.gov/servlets/purl/10221710

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology*, *59*(3), 623–664. doi:10.1111/j.1744-6570.2006.00049.x

Spencer, D., & Temple, T. (2021). Examining students' online course perceptions and comparing student performance outcomes in online and face-to-face classrooms. *Online Learning*, *25*(2), 233–261. doi:10.24059/olj.v25i2.2227

Summers, J. J., Waigandt, A., & Whittaker, T. A. (2005). A comparison of student achievement and satisfaction in an online versus a traditional face-to-face statistics class. *Innovative Higher Education*, *29*(3), 233–250. doi:10.1007/s10755-005-1938-x

Thai, N. T. T., De Wever, B., & Valcke, M. (2020). Face-to-face, blended, flipped, or online learning environment? Impact on learning performance and student cognitions. *Journal of Computer Assisted Learning*, *36*(3), 397–411. doi:10.1111/jcal.12423

Tratnik, A., Urh, M., & Jereb, E. (2019). Student satisfaction with an online and face-to-face business English course in a higher education context. *Innovations in Education and Teaching International*, *56*(1), 36–45. doi:10.1080/14703297.2017.1374875

Unger, S., & Meiran, W. (2020). Student attitudes towards online education during the COVID-19 viral outbreak of 2020: Distance learning in a time of social distance. *International Journal of Technology in Education and Science*, *4*(4), 256–266. doi:10.46328/ijtes.v4i4.107

U.S. Department of Education. (2019). Distant learning. *National Center for Education Statistics. Digest of Education Statistics*: Table 311.15.

Van Wart, M., Ni, A., Rose, L., McWeeney, T., & Worrell, R. (2019). A literature review and model of online teaching effectiveness integrating concerns for learning achievement, student satisfaction, faculty satisfaction, and. *Pan-Pacific Journal of Business Research*, *10*(1), 1–22.

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. doi:10.1007/s43683-020-00027-8

Vo, H. M., Zhu, C., & Diep, N. A. (2017). The effect of blended learning on student performance at course-level in higher education: A meta-analysis. *Studies in Educational Evaluation*, *53*, 17–28. doi:10.1016/j.stueduc.2017.01.002

Wandler, J. B., & Imbriale, W. J. (2017). Promoting undergraduate student self-regulation in online learning environments. *Online Learning*, *21*(2), n2. doi:10.24059/olj.v21i2.881

Wang, R., Han, J., Liu, C., & Xu, H. (2021). How do university students' perceptions of the instructor's role influence their learning outcomes and satisfaction in cloud-based virtual classrooms during the COVID-19 pandemic? *Frontiers in Psychology*, *12*, 1032. doi:10.3389/fpsyg.2021.801191

Wei, J., Treagust, D. F., Mocerino, M., Lucey, A. D., Zadnik, M. G., & Lindsay, E. D. (2019). Understanding interactions in face-to-face and remote undergraduate science laboratories: A literature review. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1–16. doi:10.1186/s43031-019-0015-8

Wladis, C., Hachey, A. C., & Conway, K. (2014). An investigation of course-level factors as predictors of online STEM course outcomes. *Computers & Education*, *77*(1), 145–150. doi:10.1016/j.compedu.2014.04.015

Yudko, E., Hirokawa, R., & Chi, R. (2008). Attitudes, beliefs, and attendance in a hybrid course. *Computers & Education*, *50*(4), 1217–1227. doi:10.1016/j.compedu.2006.11.005

Zhang, X., Al-Mekhled, D., & Choate, J. (2021). Are virtual physiology laboratories effective for student learning? A systematic review. *Advances in Physiology Education*, *45*(3), 467–480. doi:10.1152/advan.00016.2021

Appendix

Summary of themes emerging from analysis of 2021 qualitative (open-ended) responses (Table A1).

Table A1. Summary of themes emerging from analysis of 2021 qualitative (open-ended) responses.

Comparison of online learning experiences to face-to-face experiences in general were …		
	Theme	Representative student statements
Worse	–loss of interaction, sense of community –interruptions, distractions in home and non-school environments –difficulty concentrating without interaction, being alone –ok sometimes but terrible all the time –poor teaching by some instructors –poor responsiveness, course design, too much busywork –lab experiences very poor in general and sometimes canceled; often confusing and poorly designed	"it can be very difficult to concentrate in my home setting" "I have missed the structure" "As a visual learner, sitting in the front row was vital for me" "online courses often have a lot of technical problems, because we are all using our personal computers" "tests or quizzes are pointless now, at least the way they are given by most profs" "Basically paying professors to post old lectures from last year, and not providing students with direction is not fair" "You guys somehow gave us MORE work now than when we were taking classes like normal. It overwhelmed me." "I have seen way too many professors floundering" "I would hope professors would be more responsive to emails"
Same or better	–convenience –ability to review material –savings of time in travel –savings in money –many classes well taught –excess of online and lack of choice understandable; happy it was available –improvement in lab experiences	"my chemistry class has virtual labs with pre-recorded videos of another person doing the lab and demonstrating the results … it works good for me." "I enjoyed the flexibility" "[online classes] allow me to save money by not having to drive to class and pay a babysitter" "Honestly, I love online classes … " "Ever since online classes begun, it's been much more stress-free in the comfort of my home. I can not only focus on my classes, but also help my family" "Now that all classes have been offered online, I am able to continue pursuing my degree." "Classes that are synchronous tend to be much better for most subjects." "I have been more successful in online classes"
Mixed reactions	–some features very good such as synchronous lectures but labs are poor –some faculty have gotten better, but some have gotten worse because they replay old, poor quality videos –some online is great, but having all of your courses be online is highly problematic	"I have had some of the best teachers I have ever had in my entire college career in my online classes, but I have also had some of the worst." "good job …, but like all things there are areas that need improvement" "I enjoy taking 1–2 online classes while taking 3 or 4 in person. However, taking all my classes online is overwhelming." "I would not be mad at the increase of implementation of hybrid classes where we meet on campus once a week and then the other day is online." "Frankly, [going fully online] has been a blessing and a curse"