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A comparison of American student and faculty experiences in mathematics courses during the COVID-19 pandemic

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A B S T R A C T

This study examined the experiences of mathematics students ($n = 2867$) and faculty ($n = 81$) at California State University, Fullerton during the fall 2020 semester during which all mathematics classes were taught in a synchronous virtual setting as a result of the COVID-19 pandemic. Survey results showed that faculty concerns centered around student participation, communication, and academic integrity, while student concerns focused on understanding the material, performance in the course, and commuting to campus. For both students and faculty, appreciation for increased time flexibility was accompanied by feelings of disconnectedness from the course. While student course outcomes did not affect student preference for virtual courses, there was evidence that faculty and students may have experienced virtual learning very differently. As educational institutions move forward there will need to be substantive discussions involving both faculty and students that address the role that academic departments can take to ensure equitable learning for all.

1. Introduction

On March 11, 2020, the World Health Organization (WHO) declared COVID-19 as a global pandemic (Branswell and Joseph, 2020). As an immediate result, universities worldwide were faced with the decision to quickly transition coursework to a virtual teaching modality. Spring 2020 classes that had begun in a traditional face-to-face format ended in a virtual format. In the fall 2020 semester, institutions were better prepared, or at least forewarned, for teaching in a virtual environment. Both synchronous (real-time) and asynchronous (non real-time) approaches, as well as a combination of the two, were planned and implemented. There were several challenges to teaching and learning at the university level specific to the context of the pandemic. Faculty members with little to no experience in online teaching, pedagogy, or course design quickly found themselves in the position of teaching all of their courses fully online. Likewise, students needed to quickly transition to taking courses from an off-campus location. Depending on one's living situation, this could mean sharing technology devices and space with others, as well as limited or unreliable internet connectivity. In addition to concerns about access to technology, a major concern among faculty and program leaders was the lack of classroom socialization and interaction (Adnan and Anwar, 2020). Documenting student and faculty experiences across countries and cultures during the pandemic is vital to understanding its long-term implications on teaching and learning (Cao et al 2020; Copeland et al 2021). This article focuses on mathematics students and faculty involved in virtual teaching and learning and how each group may have experienced it.

As part of the larger study, "Virtual Teaching in Mathematics: Assessing the Impact on Course Outcomes, Students, and Faculty," a survey was given during late October through mid-November to mathematics students and faculty in fall 2020 at California State University, Fullerton (CSUF) The survey was divided into eight blocks of questions asking about their experiences in virtual teaching (VT) classes in fall 2020 as compared with traditional face-to-face (FF) classes in fall 2019. Three research questions were posed by the larger study:

RQ1: What was the impact of virtual instruction on student course outcomes, including completion rates, passing rates, and course grades?

RQ2: What were students' perceptions of their learning experiences in a virtual instructional environment?

RQ3: What were instructors' perceptions of their teaching experiences and their students' learning experiences in a virtual instructional environment?

This article focuses on Research Questions 2 and 3 for students and faculty and reports relevant results for Research Question 1.

2. Methods

2.1. Context

The California State University (CSU) is one of the largest public state university systems in the U.S. In fall 2020, more than 480,00 students were enrolled in one of 23 campuses. The CSU is one of the most ethnically and racially diverse university systems in the U.S; one-third of its undergraduates are the first persons in their families to attend college. This study took place at California State University, Fullerton (CSUF). It is one of the largest universities in California, with more than 41,000 students enrolled in fall 2020. CSUF is a designated Hispanic Serving

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Table 1
Faculty distribution by gender and work status.

	Full-time	Part-time	Total
Male	24	20	44
Female	11	20	31
Total	35	40	75

Institution and an Asian American and Pacific Islander Serving Institution. It ranks fifth and ninth nationally in the number of baccalaureate degrees awarded to Hispanic and minority students, respectively. CSUF is largely a commuter campus, with only about 2% of students living in on campus or university-sponsored housing (News & Report, 2021). The mathematics department at CSUF enrolls some 17,000 students each year and employs about 90 faculty, including full-time and adjunct instructors. Thus, while CSUF is an American university, its diverse student body and urban setting give representation across an international spectrum of peoples and cultures.

2.2. Sample

All full-time faculty and adjunct faculty teaching during fall 2020 semester for the Department of Mathematics at CSUF were invited to complete a survey exploring their experiences teaching in a virtual teaching (VT) setting in fall 2020 compared to teaching in a traditional face to face (FF) setting in fall 2019. The survey was available to faculty members for a two-week window during weeks ten and eleven of the sixteen-week fall 2020 semester. The survey was given online using Qualtrics software and took about 8-10 minutes to complete; no identifying information was collected from the respondents and all responses were analyzed and reported in aggregate form. A total of 81 of the 97 faculty members (83.5%) completed the survey, including 37/43 full-time faculty (86.1%) and 44/54 part-time faculty (81.5%). Of the 81 faculty participants in the current study, 77 self-identified as male or female, 1 preferred not to answer, and 3 left the response blank. Among these 77 respondents, 75 indicated their status as full-time or part-time faculty. Males comprised 68.5% (24/35) of the full-time faculty and half (20/40) of the part-time faculty. Overall, full-time faculty comprised 46.7% (35/75) of this group (table 1).

Seventy-four of the 81 respondents indicated both gender and ethnic/racial group identities (table 2). Three largest self-identified ethnicity groups were white/non-Hispanic (62.1%), Asian/Asian-American (16.2%), and Hispanic/Latinx (13.5%).

Mathematics faculty members were asked to invite their students to take a student survey. Faculty were encouraged to give students time in class to complete the survey if possible, to post it on the course learning management site, and to send it to students via email. The survey was available for a two-week window during weeks ten and eleven of the sixteen-week fall 2020 semester. The survey was given online using Qualtrics software and took about 8-10 minutes to complete. CSUF IRB protocols were closely observed and all student responses were analyzed and reported in aggregate form. A total of 2867 out of 8188 students enrolled in a mathematics course at CSUF completed the survey for a student response rate of 35%. Of those who completed the survey, 2573 students (89.7%) self-identified their gender as either male or female and self-identified their ethnicity from one of these categories: African-American/Black, Asian/Asian-American, Hispanic/Latinx, Native American/Indigenous, Pacific Islander, or White/non-Hispanic. Per CSU protocol, students self-identifying as African-American/Black, Hispanic/Latinx, Native American/Indigenous, or Pacific Islander were classified as being from underrepresented minority groups (URM). Students self-identifying as white/non-Hispanic or Asian/Asian-American were classified as being from non-underrepresented minority groups (non-URM). Of the 2573 students, 1402 (54.5%) were URM students and 1171 (45.5%) were non-URM students. Hispanic/Latinx students comprised 93.0% of the URM group and Asian/Asian-American students comprised 67.2% of the non-URM group (table 3).

More than half (57.9%) of the students indicated that they were the first in their families to attend college and nearly seven-tenths (69.3%) indicated that they were receiving financial aid (table 4). Freshmen students comprised slightly more than half (51.8%) of the student sample with non-freshmen students comprising 48.2%.

3. Theoretical Framework

Two large-scale studies helped to inform the survey instrument for the present study. The first is the National Science Foundation-funded National Study of STEM Faculty and Students (NSSFS): Challenges and Support during the COVID-19 Pandemic (Network for Research and Evaluation, 2020). The student component of this study focused on the effects COVID-19 has had on their relationships, academic work, and mental health. The second is the Conference Board of the Mathematical Sciences (CBMS) Special COVID-19 Impact Study survey, which was sent to mathematics departments regarding the impact of COVID-19 on mathematical sciences instruction (Conference Board of the Mathematical Sciences, 2020). The CBMS survey focused on departmental and institutional practices as well as instructors' perceptions of their students' experiences in synchronous and asynchronous instructional environments.

These studies were pivotal in shaping the survey instrument used in the present study. For example, the CBMS survey included two open-ended questions asking about the greatest benefit and greatest challenge adapting to online learning; the survey for the CSUF study asked the same questions of student and faculty respondents. The NSSFS survey asked about the effectiveness of "e-communication" compared to face-to-face when engaging in mentoring activities; the CSUF survey asked similar questions about different facets of teaching and learning. The CSUF study is unique because it focuses more on assessing the experience of mathematics teaching and learning from a student perspective. The CSUFstudy focusing on student and faculty experiences may serve as research that complements the CBMS and NSFSS studies which examines the impact of virtual learning more from an institutional perspective.

The CSUF mathematics faculty and student surveys were separated into eight blocks of questions, including Likert-scale items and background information (Table 5). In addition, faculty and students were asked to briefly respond to two open-ended questions regarding the greatest benefit and greatest challenge of virtual courses for them. While some of the survey items were specific to students and some specific to faculty, 25 of the 33 items (student survey) or 37 items (faculty survey) were either identical or parallel. For example, in Block 1, Experience in the Course, the first item on each survey reads as follows:

> Student survey: My understanding of the material was (1) much better in VT; (2) somewhat better in VT; (3) about the same in BT or FF; (4) somewhat better in FF; or (5) much better in FF.
>
> Faculty survey: My students' understanding of the material was (1) much better in VT; (2) somewhat better in VT; (3) about the same in VT or FF; (4) somewhat better in FF; or (5) much better in FF.

All mathematics courses were taught in a synchronous (real-time) environment. Missing data were handled using pairwise deletion. All statistical analyses were done using SPSS, Version 27.

For all common survey questions in Blocks 1-3, a lower value (1 or 2) on the five-point Likert scale indicates a preference for VT classes, a higher value (4 or 5) indicates a preference for FF classes, and a value of 3 indicates no preference either way. Common survey questions in Blocks 5-8 used a typical Likert scale, rating agreement with the item from 1 (low) to 5 (high), with the exception of modality preference (Block 5), which utilized the same scale as questions in Blocks 1-3. Common questionnaire items and response coding values are given

Table 2
Faculty distribution by gender and ethnicity (number).

	Afr-Am/Black	Asian/As-Am	Hisp/ Latinx	Nat Am/Ind	Pac Isl	White/non-Hisp	Other	Total
Male	0	9	5	0	0	29	2	45
Female	1	3	5	0	0	17	3	29
Total	1	12	10	0	0	46	5	74

Table 3
Student distribution by gender and ethnicity (percent).

	Afr-Am/Black	Asian/As-Am	Hisp/ Latinx	Nat Am/Ind	Pac Isl	White/non-Hisp	Total
Male	1.0	17.3	21.1	0.0	0.6	7.8	1229
Female	1.4	13.3	29.6	0.1	0.8	7.1	1344
Total	2.4	30.6	50.7	0.1	1.4	14.9	2573

Table 4
Demographic characteristics of student survey participants (percent).

	Underrepresented minority group	First in family to attend college	Receiving financial aid
Male	47.4	54.3	66.4
Female	60.9	61.2	71.8
Total	54.5	57.9	69.3

Table 5
Student and faculty survey areas.

Block	Number of Questions StudentSurvey	FacultySurvey	Student Survey Areas	Faculty Survey Areas
1	7	7	Experiences in the course	Perceptions of st. exper. in the course
2	5	7	Time spent on classes	Time spent on classes/prof. activities
3	4	3	Responsibility and stress levels	Responsibility and stress levels
4	0	6	N/A	Tools used in virtual teaching
5	8	6	Overall VT experience	Overall VT experience
6	4	4	Technology and space	Technology and space
7	4	3	Transportation and parking	Transportation and parking
8	11	8	Background information	Background information

in Appendix 1. No statistically significant differences were observed between full-time and part-time faculty on any questions pertaining to faculty experiences; consequently, faculty results are based on aggregate data for the entire group of faculty respondents.

Significance levels in educational studies are typically set at $\alpha = .05$, indicating that five percent of the time the researcher would erroneously reject a true null hypothesis. Research on "effect size," however, suggests that for large sample a smaller value for alpha may be more appropriate for safeguarding against these (type I) errors (Cohen 1992; Good 1982). The sample size for the faculty group was 81 whereas that for the student group was 2573. Applying Good's standardized significance level formula, $p_{stan} = p * \sqrt{\frac{N}{100}}$, a p-value of .0098 would be appropriate as a significance threshold for student data analyses. Thus, the current study will use $\alpha = .05$ as the threshold for statistical significance for faculty data analyses and $\alpha = .01$ for student data analyses. Significance levels are noted with one ($\alpha = .01$) or two ($\alpha = .001$) asterisks.

4. Results

4.1. Student/Faculty Comparisons

Data from the seven variable items from Block 1, Experiences in the Course/Perceptions of Students' Experiences in the Course, were compared between the groups of student respondents and faculty respondents. T-test analyses for unequal sample sizes showed significant differences in four of the variables, including understanding of course material ($t = 2.067$, $p < .05$); participation in class ($t = 5.286$, $p < .001$); academic integrity ($t = 10.856$, $p < .001$); and experience in the course ($t = 3.841$, $p < .001$). In each case faculty responses indicated that they felt that their students had or would have had a better experience in a face-to-face class significantly more than student responses indicated. Among the three highly significant outcomes ($p < .001$), the average student response score was 3.41 while the average faculty response score was 4.19, a difference of 0.78 on the five-point Likert scale. For the entire block of seven questions, the combined average student and faculty response scores were 3.38 and 3.83, respectively, a highly significantly difference as well ($t = -3.458$, $p < .001$) (Table 6).

Other statistically significant differences between student and faculty groups were also observed. Faculty reported spending significantly more time preparing for VT courses as compared to FF classes than did students ($t = -8.661$, $p < .001$). Conversely, students felt that communication with their instructors was better in FF as compared to VT classes to a greater degree than did faculty ($t = -2.30$, $p < .05$). While both groups reported increased levels of family-related and school-related responsibilities, as well as increased overall stress level for fall 2020 over fall 2019, the stress level increase may have been more acute for faculty ($t = 2.231$, $p < .05$). There were no significant differences between the student and faculty groups on their assessment of exam fairness or whether students had kept their webcams on during the synchronous class sessions which was relatively low for both groups ($\bar{x}_{student} = 2.66$, $\bar{x}_{faculty} = 2.57$). Although both groups preferred FF over VT formats for being able to communicate effectively with their instructor or students, this preference was more acute for faculty ($t = 4.826$, $p < .001$). Students reported that their overall experience in their VT mathematics course was about as they had expected it to be ($\bar{x}_{student} = 3.11$); however, faculty reported that the VT experience was somewhat better than they had expected it to be ($\bar{x}_{faculty} = 3.40$; $t = 2.413$, $p < .05$). Tech-

Table 6
Comparison of students and faculty responses for common survey items.

	Students		Faculty		t-test	
Block 1: Course experience F2020VT compared to F2019 FF	**Mean**	**St. dev.**	**Mean**	**St. dev.**	**t**	**P**
Understanding of material	3.66	1.195	3.94	.871	2.067	.039
Attendance	2.96	1.201	3.20	1.011	1.759	.079
Participation	3.47	1.151	4.16	.873	5.286	< .001**
Academic integrity	3.19	.899	4.30	.798	10.856	< .001**
Feedback on work	3.28	1.187	3.54	1.001	1.928	.054
Course performance	3.52	1.233	3.56	.822	.287	.773
Course experience	3.57	1.267	4.12	.714	3.841	< .001**
Block 2: Time Spent on Classes						
Preparing for class	2.88	1.173	1.73	.779	-8.661	< .001**
Interacting with instructor/students	3.84	1.142	3.54	1.211	-2.30	.022
Block 3: Resp. and Stress Levels						
Family-related responsibility level	3.66	1.021	3.86	.957	1.720	.086
School-related responsibility level	3.71	1.166	3.97	.947	1.964	.050
Overall stress level	3.99	1.187	4.29	.845	2.231	.026
Block 5: Overall Experience						
Communicate effectively	3.49	1.022	4.05	.835	4.826	< .001**
Kept video screen on	2.66	1.483	2.57	1.449	-.532	.595
Fair course exams	3.41	1.032	3.63	.914	1.875	.061
Overall experience in VT format	3.11	1.060	3.40	.785	2.413	.016
Prefer VT/FF format	3.75	1.323	4.02	1.204	1.793	.073
Block 6: Technology and Space						
Consistent computer access	1.61	.927	1.53	.838	-.759	.448
Consistent internet access	2.11	1.088	1.85	1.026	-2.098	.036
Quiet place for classes	2.56	1.331	2.15	1.246	-2.705	.007*
Quiet place for preparing	2.65	1.397	2.19	1.379	-2.888	.004*
Block 7: Trans. and Parking						
Not having to drive to campus	3.67	1.346	3.26	1.292	-2.674	.008*
Not having to find a parking place	3.78	1.330	3.11	1.332	-4.417	< .001**
Not having to pay for parking	3.91	1.308	2.65	1.324	-8.443	< .001**
Block 8: Background Information						
Prior experience in VT courses	1.98	.876	1.69	1.020	-2.889	.004*

nology and space-related issues impacted students more than they did faculty. Students reported greater challenges having consistent internet access (t = -2.098, $p < .05$); having a quiet place to take classes (t = -2.705, $p < .01$); and having a quiet place to study (t = -2.888, $p < .01$). Students also felt that the benefits of not having to drive to campus, find a parking place, and pay for parking made the virtual format "worth it" to a greater degree than did faculty ($|t| > 2.6$, $p < .01$).

Neither students nor faculty reported much prior experience taking or teaching virtual courses ($\bar{x}_{student}$ = 1.98, $\bar{x}_{faculty}$ = 1.69), although a significant difference between these data points was noted (t = -2.889, $p < .01$). When asked if they preferred VT or FF formats overall, both groups indicated a preference for FF classes ($\bar{x}_{student}$ = 3.75, $\bar{x}_{faculty}$ = 4.02); the difference between the two groups was not statistically significant (t = 1.793, $p > .07$).

Table 7
Regression analysis for faculty preference for teaching VT v. FF courses.

Variable	Standardized beta	t	p
Students' participation (VT compared to FF)	.385	3.895	< .001**
Students' understanding of material (VT compared to FF)	.281	2.648	.010*
Students kept video screen on	.257	2.656	.010*
Students' academic integrity (VT compared to FF)	.250	2.396	.019
df = 74 R = 0.656 R^2 = 0.431 F = 12.110 sig. F < 0.001**			

4.2. Regression analyses

Regression analyses were performed to explore which variables may best predict faculty and student preference for VT versus FF classes. Student and faculty preference for teaching mathematics courses in a VT or FF format (ordinal variable) was regressed upon all of the common items included in both surveys plus gender and URM status. A stepwise linear regression was used with pairwise exclusion of missing data. As described in Section 3, regression analysis for faculty were performed with significance level $\alpha = .05$ and regression analysis for students were performed with significance level $\alpha = .01$.

Four variables centering on perceptions of student learning and academic behaviors entered the equation for faculty: participation in class comparing fall 2019 (FF) with fall 2020 (VT), understanding of the material comparing fall 2019/20, video screen usage during VT class sessions, and students' academic integrity comparing fall 2019/20. The positive beta values indicate that these four variables were predictors for faculty preference of FF over VT teaching. Each of the variables had a standardized beta coefficient of .25 or higher and yielded a combined R^2 value of 0.431. Thus, these four variables explained 43% of the variation in faculty members' preference of FF v. VT teaching. Variables associated with gender (dichotomous m/f), ethnicity (dichotomous URM/non-URM), prior VT experience, technology and space, responsibility and stress levels, transportation, and time did not enter the equation for faculty (Table 7). Neither the power nor order of the four predictive variables changed when faculty-specific survey items were considered, including full-time/part time work status at CSUF or child care responsibilities during the fall 2020 semester.

The same analysis was then performed for the student data, using all common items in the student survey to predict student preference for VT or FF modality. Eight variables entered the equation; the five variables with the most predictive power were: overall course experience comparing FF to VT, understanding of the material comparing FF to VT, performance in the course comparing fall FF to VT, not having to drive to campus in fall 2020, and overall experience in a VT mathematics course. Course experience, understanding of the material, and performance in the course comparing FF to VT were associated with a preference for FF courses, while not having to drive to campus and overall experience in a VT mathematics course were associated with a preference for VT courses. Also entering the regression equation were, in decreasing order, overall stress level comparing fall 2019/20, not having to live near campus, and underrepresented minority group membership. Overall stress level was associated with a preference for FF courses; URM group membership and not having to live near campus (included in the student analysis) were associated with a preference for VT courses. All variables combined gave a combined R^2 value of 0.538, thus explaining 53% of the variation in students' preference for FF v. VT courses. Variables associated with gender, prior VT experience, technology and space, and time did not enter the equation for students (Table 8). Neither the power nor order of the predictive variables changed when student-specific survey items were included as additional input variables in the regression, including grade in the course, success/non-success status in the course (dichotomous), age group, number of units taken in fall 2020, number of hours working per week, financial aid status (dichotomous), or first in family to attend college status (dichotomous).

4.3. Open-ended questions

Students and faculty were asked two open-ended questions at the end of the survey:

Q1. What was the greatest benefit of VT courses for you?
Q2. What was the greatest challenge of VT courses for you?

A total of about four thousand student open-ended responses were analyzed for Q1 (n = 1999) and Q2 (n = 1986) representing 69.7% and 69.3% of the student sample, respectively. Sixty-nine of the 81 faculty members (85.2%) responded to Q1 and 67/81 (82.3%) responded to Q2. An open coding qualitative scheme based on keyword frequencies was used to categorize the responses for both student and faculty surveys. Five categories emerged for responses to Q1 on benefits of VT: Commuting advantages, professor's adaptation to the VT environment, schedule advantages, access to the course, and other. Eight categories emerged for responses to Q2 on challenges of VT: Lack of student engagement, faculty/student communication, feelings of disconnectedness, increased time spent on classes, academic integrity, space and technology issues, perceived impact on course performance, and other.

Commuting advantages and course access were identified as the greatest benefits by student respondents, accounting for 83% of the responses. Developing new skills to adapt to VT and commuting advantages were identified as the greatest benefits by faculty respondents, accounting for 67% of the responses. Faculty also identified benefits associated with schedule flexibility (17%) as did students but to a lesser degree (8%) (Fig. 1). Lack of student engagement was identified by both students (30%) and faculty (25%) as the primary challenge associated with VT. Students (14%) and faculty (24%) also identified challenges with faculty/student communication. Students identified feelings of disconnectedness (18%) and perceived impact on course performance (15%) at much higher rates than did faculty members (2% each). Conversely, faculty identified increased time spent on VT courses (16%) and concerns about academic integrity (15%) at much higher rates than did students (2% and 5%, respectively) (Fig. 2).

5. Discussion

Survey item open-ended survey responses indicated that the greatest challenges associated with teaching virtual courses for faculty centered around lack of student engagement, student/faculty communication, increased time spent on courses, and academic integrity. Greatest challenges associated with taking virtual courses for students centered around lack of student engagement, feelings of disconnectedness, perceived impact on course performance, student/faculty communication, and issues associated with space and technology. These responses support and augment the findings from the Likert-scale items in survey.

Table 8
Regression analysis for student preference for taking VT v. FF courses.

Variable	Standardized beta	T	p
Course experience (VT compared to FF)	.247	10.331	< .001**
Understanding of the material (VT compared to FF)	.212	9.134	< .001**
Performance in the course (VT compared to FF)	.124	5.247	< .001**
Not having to drive to campus	-.081	-2.677	.007*
Overall exper. in a VT math course	-.125	-6.168	< .001**
Overall stress level (F19 compared to F20)	.080	4.700	< .001**
Not having to live on or near campus	-.074	-3.464	< .001**
Underrepresented minority status	-.046	-3.268	.001*
df = 2507 R = 0.737 R^2 = 0.538 F = 109.004 sig. of F < 0.001**			

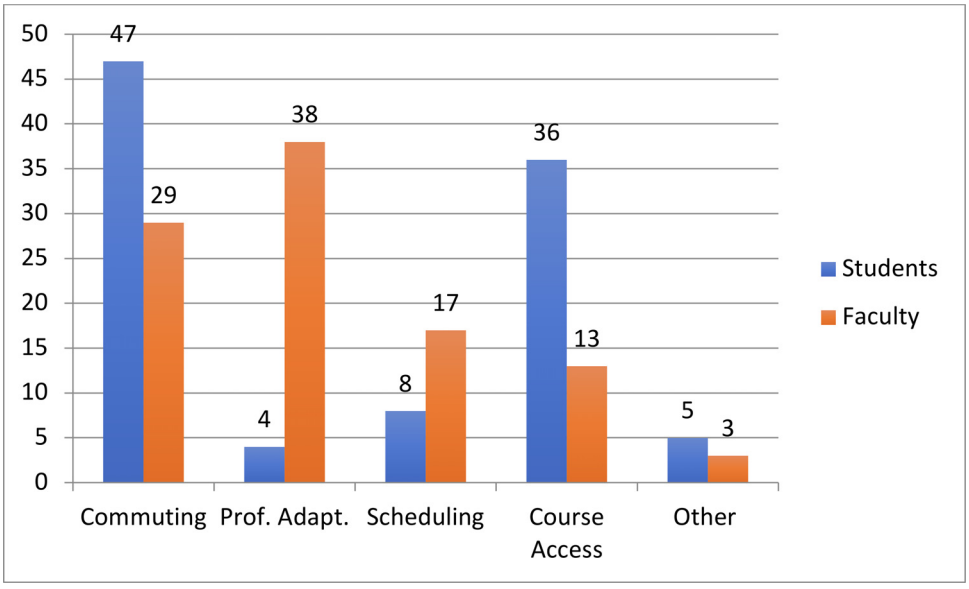

Fig. 1. Greatest benefits of VT courses for students and faculty (pct).

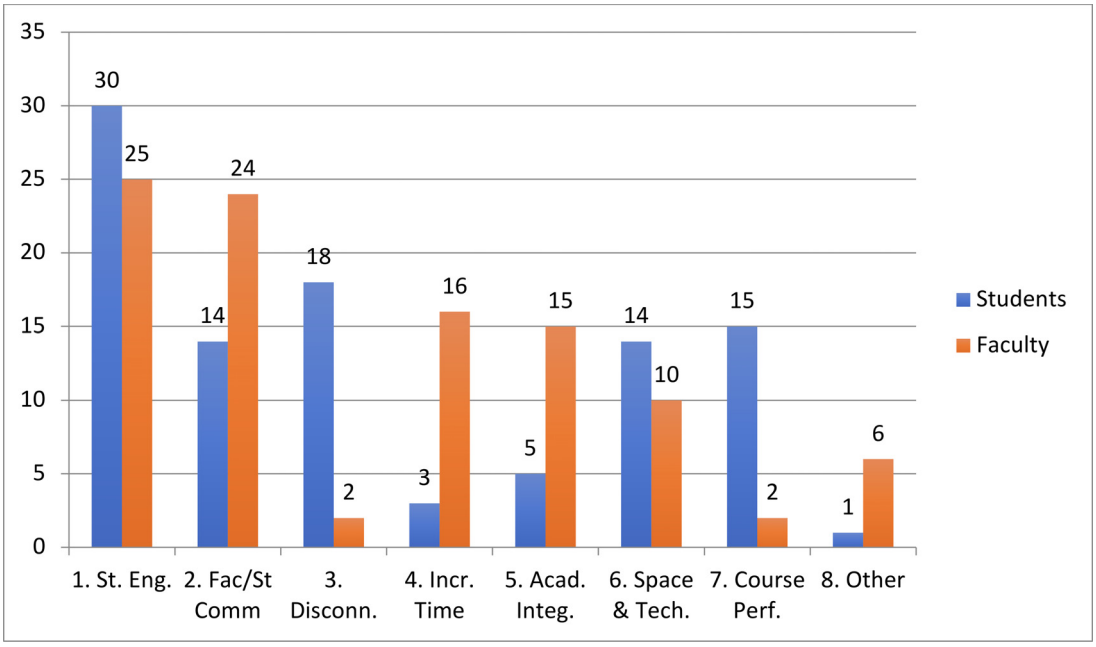

Fig. 2. Greatest challenges of VT courses for students and faculty (pct).

Table 9
Comparison of student course outcomes for fall 2019 and fall 2020.

	Fall 2019		Fall 2020		t-test	
	No. of students	Aver.	No. of students	Aver.	t	P
Course grade	8158	2.273	8665	2.274	-.049	.961
Success rate	8158	72.8%	8665	72.6%	.291	.385

Regression analyses of faculty preference for VT v. FF courses based on survey responses showed that more than forty percent of the variation in VT/FF course preference was explained by four variables associated with student behaviors and experiences: course participation, webcam usage, understanding of material, and academic integrity. The first two variables, participation and webcam usage, come under the open-ended response category of student engagement. The fourth variable, academic integrity, appeared as a separate keyword category in the open-ended responses. Thus, three of the four predictive variables in the regression equation were directly reflected in faculty open-ended responses. Notably, three of the four strongest predictors for faculty preference of VT or FF courses were not their own experiences, but their perceptions of the experiences of their students.

Regression analyses of student preference for VT v. FF courses showed that five of the nine variables that entered the regression equation had standardized beta coefficients greater than 0.10: overall VT course experience compared to FF, understanding the material, performance in the course, VT course experience relative to expectation, and not having to drive to campus. Course experience, performance, understanding the material, and expectations come under the general category of perceived impact on performance. Thus, four of the five most predictive variables in the regression equation were reflected in the student open-ended responses. Notably, neither actual course grade nor success/non-success outcome in the course entered the regression equation. Although course outcomes are often considered as the dependent variable in regression analysis, they were included as independent variables for this study when predicting VT or FF preference in order to measure if students were academically successful in VT also preferred VT modality. The findings from the regression indicate students' course performance did not have a relationship with their preference for VT or FF course modality. However, students' *perceptions* of their course experience did. Based on their open-ended responses, students and faculty agreed that a substantial benefit of virtual courses was flexibility in commuting. However, none of the variables associated with this category (Block 7 in the survey) entered the regression equation for faculty. Thus, the most positive aspect of VT identified by students and the second-most by faculty was not statistically predictive of VT/FF preference for either group.

Comparison of student outcomes between fall 2019 and fall 2020 indicated that the new modality of virtual classes had no impact on aggregated student grade outcomes among students completing the course. There were no changes in institutional or departmental practices such as curriculum or class size from fall 2019 to fall 2020. Based on course outcome data for all students who were enrolled in a mathematics course in fall 2019 (8158 students) and fall 2020 (8665 students), the overall grade point average in each semester was essentially identical: 2.273 in fall 2019 and 2.274 in fall 2020. Similarly, the success rates (grade of C or higher in the course) for each year were almost identical: 72.8% for fall 2019 and 72.6% for fall 2020 (Table 9). Institutional records showed that 7.2% of students received a W/WU/NC grade in Fall 2020, compared with 4.4% in Fall 2019. Thus, if there was a direct impact of the pivot from FF to VT classes, it may have been in the proportion of students who did not complete the course.

6. Conclusions

6.1. Limitations

There are several limitations to the current study. First, all data were collected at a large public comprehensive institution in an urban area. While this setting helped to create a diverse sample of students, it is unclear the extent to which results presented here are applicable to other types of institutions. Second, student surveys were given towards the end of the semester so that students had enough time to experience virtual learning in their mathematics courses. Thus, student participants were limited to those who were still enrolled in and/or still attending virtual classes at that point in the semester. The overall student response rate of about 35% suggests that it is possible the results may be subject to a completion bias; that is, students who were likely to complete the survey may have had different characteristics or preferences compared to those who did not complete it. It should also be noted that institutional records showed that the rate of no credit, withdrawal, or unauthorized withdrawal grades in mathematics courses was higher in fall 2020 as compared to the previous fall 2019 (7.2% versus 4.4%). Only about 12% of those who withdrew or earned no credit grades completed the survey and thus were included in the study. Third, all courses in this study were taught in a synchronous environment. Asynchronous, HyFlex, or other blended course modalities would likely result in different experience outcomes.

The focus of this study was to compare the experiences of student and faculty groups as an aggregate. This investigation did not separate out possible differences between subgroups by variables such as gender, ethnicity, or other socio-economically related factors. Thus, the consistency of student outcomes presented in Table 9 should not be interpreted as evidence that equity gaps remained unchanged in the virtual modality. Similarly, the aggregate averages of questionnaire items presented in Table 6 do not account for possible variations in experience. In particular, equity gaps may have been affected by lack of access to technology and quiet space. Even for those students who had adequate digital access, there are still significant issues. Williamson et al (2020) write, "These economic realities do not go away as a result of laptop scheme. Indeed, as this pandemic continues, more and more young people and their families will be in financial hardship and inequalities in society are likely to widen" (p. 111).

Finally, although institutional factors such as class size, curriculum, and enrollment remained consistent from fall 2019 compared to fall 2020, no data about changes in pedagogy, assessment, or other course practices were collected as part of the study. Yet, both the student faculty survey responses, especially the open-ended questionnaire items, suggest a significant level of course redesign or revision for the virtual environment. The questions of how instructors adapted their courses to virtual learning and the effects on both students and instructors are still unknown, but have generated a great amount of interest. A Facebook group *Pandemic Pedagogy* was created on March 11, 2020; by May 6, 2020, the group had 30,000 members (Schwartzman, 2020). Research centered around these questions is critical to understanding the long-term implications of virtual teaching on instructors and students.

6.2. Recommendations and further research

The findings presented here suggest that faculty and students at California State University, Fullerton may have experienced virtual learning very differently. While neither group reported a greater level of experience with virtual classes prior to the fall 2020 semester, responses to Block 1 survey items indicated that students generally may have been more comfortable overall with virtual instruction than were faculty. Faculty felt that student participation, student interaction, and student/faculty communication were clearly stronger in the FF format. Concerns around academic integrity were also a bigger issue for faculty than for students. This is consistent with findings by Rapanta et al (2020) that faculty may need to rethink what their "presence" in the virtual classroom might look like moving forward. While both student and faculty groups agreed that students tended to keep their webcams on less than "some of the time" during synchronous class sessions, this may have had a greater impact on instruction than it did on learning. Conversely, many students reported challenges of having access to a quiet place for school-related work. Nearly one-fourth of the 2867 students in the sample indicated that consistent access to a quiet place to take classes was "extremely" (11.3%) or "very" (13.6%) challenging, while nearly thirty percent indicated that consistent access to a quiet place to study was "extremely" (14.5%) or "very" (14.3%) challenging, a finding that was recently reported by Arisovnik (2020) as well. While the survey did not ask directly about factors that may have impacted this such as living situation, space constraints may have impacted students' ability and willingness to engage in virtual class sessions both visually and communicatively (McCormick 2020). These results are consonant with recent studies documenting the depressive effects of COVID on college students (Son et al 2020). Browning et al (2021) found that health risks associated with depression from COVID-19 effects may be even more acute for women.

Despite these concerns a significant proportion of both students and faculty indicated that they still preferred VT over FF formats. One-fifth of the respondents - more than six hundred students - indicated that they "somewhat" (13.2%) or "strongly" (8.1%) preferred virtual over in-person courses. Although based on a much smaller sample, 11 of the 81 faculty respondents (13.5%) indicated that they somewhat (7.3%) or strongly (6.2%) preferred virtual over in-person courses. In their survey responses regarding background information, ten of these faculty members self-identified their gender as male or female; of the ten preferring the VT format, nine were female, suggesting that the flexibility of virtual instruction may have held greater appeal for female faculty members than it did for males.

While not meant to be prescriptive, the current study suggests that there may be aspects of the VT experience that can be implemented into traditional FF classes or into hybrid (combined FF/VT) classes moving forward. Based on both student and faculty comments, having "24/7" online access to course materials was extremely helpful. Students whose instructors had recorded their virtual class sessions reported that this also was a useful resource for re-watching portions of the lecture, especially in mathematics courses where the lesson was often broken down by concept or specific example. There was evidence that virtual communication between student and instructor, as well as between student and student, was more comfortable for some students who characterized themselves as being "shy." Overall, having increased electronic access to course lectures/lessons, assessments, assignments, and grades seemed to provide a locus of control that was helpful, and perhaps reassuring, for many students (Hossein-Mohand, Gómez-García, Trujillo-Torres, Hossan-Mohand, & Boumadan-Hamed, 2021; Trujillo-Torres et. al, 2020).

In summary, this study found that the shared course experiences of virtual teaching and learning may have manifested themselves differently for mathematics students and faculty. For students, benefits associated with commuting to campus were mitigated by concerns over decreased understanding of material, course performance, and problems related to space and technology. For faculty, appreciation for increased time flexibility was accompanied by feelings of disconnectedness and concerns about student learning. As institutions move forward there will need to be substantive discussions involving both faculty and students that address, or at least acknowledge, these concerns and the role that academic departments can take to ensure equitable learning for all.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix 1. Mathematics Student and Faculty Common Survey Items

	Student Survey	Faculty Survey
Block 1 Codes:	**Block 1: Students' Experiences.** The following items ask you to	**Block 1: Faculty Perceptions of Students' Experiences.** The
VT much better (1)	compare your perceptions and experiences in your VT and FF	following items ask you to compare your perceptions of your students'
VT somewhat better (2)	mathematics courses.	experiences in your VT and FF math courses.
Both about the same (3)	Understanding of the material	Students' understanding of the material
FF somewhat better (4)	Attendance in class	Students' attendance in class
FF much better (5)	Participation in class	Students' participation in class
	Academic integrity of class	Academic integrity of students
	Receiving feedback on work	Giving feedback on student work
	Overall performance in the course	Students' overall perf. in the course
	Overall experience in the course	Students' overall experience in the course
Block 2 Codes:	**Block 2: Time Spent on Classes.** The following items ask you to	**Block 2: Time Spent on Teaching.** The following items ask you to
VT much more time (1)	compare the amount of time you spent on the following activities this	compare the amount of time you spent on the following activities this
VT more time (2)	semester Fall 2020 in a VT setting as compared to the Fall 2019	semester Fall 2020 in a VT setting as compared to the Fall 2019
Both about the same (3)	semester in a FF classroom setting.	semester in a FF classroom setting.
FF more time (4)	Time spent doing homework	Time spent preparing courses
FF much more time (5)	Time spent interacting with instructor	Time spent interacting with students
Block 3 Codes:	**Block 3**: **Responsibility and Stress Levels.** The following items ask	**Block 3**: **Responsibility and Stress Levels**. The following items ask
Much greater fall 19 (1)	you to compare your responsibility and stress levels in	you to compare your responsibility and stress levels in
Somewhat gr in fall 19 (2)	Fall 2019 and Fall 2020.	Fall 2019 and Fall 2020.
Both about the same (3)	Family-related responsibility level	Family-related responsibility level
Somewhat gr fall 20 (4)	School-related responsibility level	Work-related responsibility level
Much greater fall 20 (5)	Overall stress level	Overall stress level
Block 5 Codes:	**Block 5: Overall Mathematics Course Experience.** The following	**Block 5: Overall Teaching Experience.** The following items ask
	items ask about your overall experience of taking mathematics courses	about your overall experience of teaching mathematics courses in a
	in a VT format this semester.	VT format this semester.
Strongly disagree (1) to	Comm. effectively with instructor and	Communicate effectively with students
strongly agree (5)	peers via chat, microphone, etc.	via chat, microphone, etc.
None (1) to all (5)	Kept video screen on __ of the time on	Students kept their video screens __ of
	during lessons	the time on during lessons
Strongly disagree (1) to	Course exams fairly and accurately	Course exams fairly and accurately
strongly agree (5)	assessed students' understanding	assessed students' understanding
Much worse than exp (1)	Overall experience taking mathematics	Overall experience teaching mathematics
to much bet th. exp (5)	courses in VT format	courses in VT format
Strongly prefer VT (1) to	Prefer VT or FF format for taking math	Prefer VT or FF format for teaching math
strongly prefer FF (5)	courses	Courses
Block 6 Codes:	**Block 6: Technology and Space.** How challenging were the following	**Block 6: Technology and Space**. How challenging were the following
Not at all challenging (1)	aspects of technology and space taking classes in a VT setting for you?	aspects of technology and space teaching in a VT setting for you?
Slightly challenging (2)	Consistent computer access	Consistent computer access
Moderately challenging (3)	Consistent internet access	Consistent internet access
Very challenging (4)	Cons. access to quiet place to take classes	Consistent access to quiet place to teach
Extremely challenging (5)	Consistent access to quiet place to prepare	Cons. access to quiet place to prepare
Block 7 Codes:	**Block 7: Transportation and Parking.** The following items ask about	**Block 7: Transportation and Parking.** The following items ask about
Strongly disagree (1)	transportation and parking while taking classes in a VT format this	transportation and parking while teaching in a VT format this
Somewhat disagree (2)	semester.	semester.
Neither agree nor disagree	VT was worth it since I did not have to	VT was worth it since I did not have to
(3)	drive to campus	drive to campus
Somewhat agree (4)	VT was worth it since I did not have to	VT was worth it since I did not have to
Strongly agree (5)	find a parking place	find a parking place
	VT was worth it since I did not have to	VT was worth it since I did not have to
	pay for parking	pay for parking
Block 8 Codes:	**Block 8: Background Information.** The following items ask about	**Block 8: Background Information.** The following items ask about
	background info.	background inform
None (1) to a lot (4)	Prior exper. taking courses in VT setting	Prior experience teaching in VT setting
Male (1)/Fem (2) dichot	Gender identity	Gender identity
URM(1)/nonURM(2) dich	Group identity	Group identity

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