From emergency to sustainable online learning: Changes and disparities in undergraduate course grades and experiences in the context of COVID-19

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ABSTRACT

The abrupt transition to online instruction has created an opportunity to improve models of online instruction. We investigated changes in student grades and experiences during emergency online learning (spring 2020) and sustainable online learning a year later (spring 2021) relative to a pre-pandemic in-person semester (spring 2019). We examine variation in outcomes by student sex, first-generation college student status, and ethnic-minority status to understand the consequences for educational equity. For students enrolled in four undergraduate courses at a U.S. research university, we combined student survey responses (N = 1290) with registrar records (N = 2375). We found that students received higher grades on average during emergency online learning, but the transition to sustainable online learning significantly exacerbated the achievement gap for ethnic-minority students. While the overall course experience improved going from emergency to sustainable online learning, we found differences between identity-based groups. Overall, historically disadvantaged students experienced lasting negative effects following the disruption. Student experiences and learning outcomes should therefore be monitored and supported to avoid exacerbating educational inequities during prolonged periods of online learning.

1. Introduction

The COVID-19 pandemic changed public experiences with and perceptions of the role of online learning in education. In spring 2020, higher education institutions around the world transitioned to remote learning to maintain social distancing and follow health guidelines (Trout, 2020). Instructors and students found themselves adapting to a new reality wherein online communication was the only available modality for teaching, learning, and social exchange (Chasi, 2022; Hofer, 2021; Lee et al., 2022).

Studies on the transition to emergency online learning in higher education have focused on the implications for student achievement and well-being during the emergency learning period (Clabaugh et al., 2021; Hofer et al., 2021). Relatively little is known about online learning in the semesters after the initial transition to online instruction. From a theoretical lens that views *times of crisis as an opportunity for change* (Brockner & James, 2008; Nicolini, 2012), we argue that the transition to emergency online learning was undoubtedly a crisis, but at the same time, it presented an opportunity for meaningful change. Viewed through this lens, a crisis represents an opportunity to ask fundamental questions and to seek out new paths; as such, it may lead to a sustainable change

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(Schneider et al., 2010). More specifically, in the context of the pandemic, as students and instructors became familiar with learning and teaching online over the course of a year, their experiences and attitudes were likely to evolve. Thus, examining the similarities and differences between the first period of emergency learning and the later period of online learning may yield helpful insights, including the formulation of a more sustainable format of online learning.

Research outside the educational domain has examined the pandemic as an opportunity for growth in economics and medicine (Pérez Sust et al., 2020; Spash, 2021). Yang and Huang (2021) examined opportunities to expedite the transformation of higher education in China post-pandemic. Their study focused on broader insights for higher education in China instead of student achievements and experiences. Our study contributes novel insights from an opportunity perspective to explore how to improve online learning in higher education and implement it as a routine and robust method of instruction.

The pandemic has shone a light on inequities in education and the ways in which prolonged periods of online instruction affect students in underserved communities. We have yet to fully understand the lasting effects of the pandemic for students from minority groups and different gender groups. This understanding can help inform ways to promote students' experiences and learning outcomes in the context of online learning. To investigate issues of equity and inclusion, we focus on female students, first-generation college students, and ethnic-minority students in the context of STEM education (science, technology, engineering, and mathematics). Information science is an interdisciplinary field that is increasingly recognized as an integral part of STEM education (Gao et al., 2020) and there is recent research examining diverse aspects of information science education in the context of STEM education (e.g., Alon et al., 2023; Cruickshank, 2019; Sung et al., 2022; Witteveen & Attewell, 2020). Female students have been historically underrepresented and still represent a minority of students in STEM fields (Makarova et al., 2019). During the pandemic, they have suffered from worse affective experience than their male peers (Zahrae-Afellat & Alipour, 2021). First-generation college students tend to struggle more in higher education and achieve lower grades than continuing-generation students due to the lack of a robust support system (Garriott et al., 2021; Stephens et al., 2014). Their support systems became even more tenuous during the COVID-19 crisis when their academic routines changed (Scharp et al., 2022). Ethnic-minority students have historically been excluded from STEM education, and studies on the pandemic show that they struggled more than their peers to maintain their academic routine (Brancaccio-Taras et al., 2021; Isteniç, 2021).

In this study, we investigated what lessons could be learnt from the transition from emergency online instruction at the start of the crisis to a more sustainable form of online instruction a year later, focusing on students' grades and experiences. To contextualize changes in grades with a baseline, we compared student course grades during the pandemic to a regular in-person semester a year before the pandemic for the same courses. We examined these changes among identity-based groups of students to discover ways to promote a more inclusive environment during online instruction. Our findings highlighted several lasting effects of the pandemic and suggested some core principles for promoting sustainable online instruction in higher education institutions in the post-pandemic era.

2. Background

2.1. Crisis as opportunity for change: online instruction during COVID-19

Crises are commonly described as unstable conditions that involve impending, sudden or critical changes (Grebogi et al., 1983). Crisis events pose huge challenges and have unexpected negative consequences for society, the economy, and people's psychological well-being (Pearson & Clair, 1998). An event can be considered a crisis if it meets certain criteria: the event is poorly understood, and the probability of its reoccurrence is low; it also comes as a surprise and leaves decision makers little time to respond, but immediate decision-making is required to decrease its harmful effects (Brockner & James, 2008).

The outbreak of COVID-19 is considered a crisis event in the education system (Seidl & Whittington, 2020). The pandemic caused a disruption of academic routines during the spring semester of 2020, forcing most higher education institutions to transition to online learning. On such short notice, educational leaders were unprepared to fully support instructors and students in the disruption. There was limited technological infrastructure to support emergency online learning, and decision-makers had to find fast solutions to the various needs of instructors and students (Al-Naabi & Al-Abri, 2021; Hajjej et al., 2021). Online learning demands additional competencies and skills (Hofer et al., 2021), but instructors did not get the pedagogical and technical support they needed for an effective transition at first (Kummitha et al., 2021).

This sudden transition to emergency online learning posed enormous challenges for educational leaders, instructors, and students. However, departing from the common notion of crisis, in our study, we explored crisis as an opportunity for change, moving away from focusing on deficits and challenges and considering aspects of a crisis and its management that may lead to a sustainable innovation (Nicolini, 2012). This invites a view of the crisis as an opportunity for reflection on current practices or behaviors, adjustments of existing practices, and adoption of new ones, leading to positive, sustainable change (Schneider et al., 2010). Changing existing practices is often challenging, because people tend to take the present reality for granted (Nicolini, 2012). But change is more likely to occur during times of crisis, especially if the crisis demolishes traditional practices (Seidl & Whittington, 2020).

In this study, we compared the abrupt transition to online instruction with online instruction a year later. We define the first as *emergency online learning*. This was fast and reactive, rather than well-thought-out, simply because there was no time. We define online learning that followed the first transition as *sustainable online learning*. At this point, stakeholders had more time to improve the support system and organizational infrastructure. Changes included more refined course planning and instruction, arguably leading to a better student experience (Scherer et al., 2021). We saw this as an opportunity to re-examine existing instructional practices and reframe the role of online learning in higher education, moving from the pre-pandemic to the post-pandemic era (Chasi, 2022; Dhawan, 2020; Roy, 2020).

2.2. Student grades and experience in online learning

Research on student experiences and academic achievements under online instruction goes back two decades (Martin et al., 2020). This growing body of research has established the value of well-designed online instruction for improving the accessibility of higher education and decreasing achievement gaps (Dumford & Miller, 2018; Edmunds et al., 2020; Jaggars & Xu, 2016). Faced with rising enrollments and a desire to reach a wider audience of learners, many higher education institutions integrated online instruction in their curricula (Bettinger et al., 2017; Castro & Tumibay, 2021; Kizilcec et al., 2020). However, in-person instruction was the dominant modality for teaching prior to the outbreak of COVID-19 (Dhawan, 2020; Hofer et al., 2021).

The new norms and practices after the pandemic have been labeled the *new normal* in higher education (Neuwirth et al., 2021), but the characteristics of this new normal have not been defined or well documented in STEM education (Brancaccio-Taras et al., 2021). Comparing students' grades and experiences between the emergency and sustainable online semesters and a regular in-person semester pre-pandemic is expected to yield important insights for policy making and practice.

To understand changes in student learning moving from emergency to sustainable online learning, we examined four components: grades, learning experiences, social experiences, and affective experiences (Summers, 2005; Xu,2018). We focused on several factors of student learning that aimed to capture the overall learning, social and affective experiences of students based on validated measures (see Appendix A) that were found to correlate with students' outcomes (see Appendix B). Examining these aspects may elaborate our understanding of how student learning has changed during this timeframe. Next, we describe each of the four components and explain the specific variables that were examined in this study.

2.2.1. Student grades

The primary measure of students' academic performance, grades, can be an important consideration when comparing emergency and sustainable online learning. A number of studies have shown that online instruction reduces students' grades compared to an in-person instruction, particularly for students with lower GPA (Bettinger et al., 2015, 2017; Bettinger & Loeb, 2017). The decline was found to be most pronounced for male students, younger students, and black students (Xu & Jaggars, 2014). The gap in grades between in-person and online instruction was also found in the context of STEM courses in higher education, and specifically for elective courses (Wladis et al., 2014). However, Chirikov et al. (2020) conducted a large randomized field experiment with 325 s-year college students comparing outcomes for in-person, blended, and fully online instruction for two different STEM courses. Their findings show that grades and learning outcomes were equivalent across the three instructional modalities.

Online instruction demands that instructors gain additional skills and carefully design their courses (Edmunds et al., 2021; Moore et al., 2011). However, during the outbreak COVID-19, most instructors had no time to plan the transition to emergency online learning (Neuwirth et al., 2021). This lack of planning might have harmed student grades, but at this point, there is not enough evidence to support this assumption. Prior work has found that students were more successful when they were ready for online instruction, but this work did not examine students' achievements such as course grades (Tang et al., 2021).

Examining student grades during the pandemic is particularly important from an equity perspective, since larger gaps between minority and majority groups might widen inequities in higher education. A study on emergency online learning found female students often had higher grades than male students (Therisa Beena & Sony, 2022). However, there is no evidence on ethnic-minority or first-generation college students' grades during periods of emergency or sustainable online learning. Moreover, it is unclear how grades changed relative to pre-pandemic and in-person instruction.

2.2.2. Student learning experience

When designed well, online learning can be an effective instructional modality to engage students of diverse backgrounds (Kizilcec et al., 2017, 2020; McLoughlin, 2001; Wang, 2007). Examining student perceptions of instructions and learning can reveal how well a course is designed, planned, and executed (Nguyen et al., 2017; Rienties & Toetenel, 2016).

A vital aspect of the student learning experience is self-efficacy (Marchand & Gutierrez, 2012; Turk et al., 2022), since it reflects perceptions of the ability to tackle challenges (Pintrich & De Groot, 1990). In the pandemic, students with higher self-efficacy were better at using technology and better able to manage their time and adjust to online learning environments (Heo et al., 2021; Tang et al., 2021). During emergency online learning, female students and ethnic-minority students reported lower levels of self-efficacy (Clabaugh et al., 2021; Deng et al., 2021; Tang et al., 2021; Zahrae-Afellat & Alipour, 2021).

Studies conducted prior to the COVID-19 pandemic found STEM students to be less satisfied with online instruction compared to in-person instruction due to instructor- and course-related factors, such as instructor's explanations, quality of class discussion and expected grades (Summers et al., 2005; Xu, 2018). However, studies of student learning experiences during the pandemic have also shown that some students perceived the sudden transition to online learning as a positive step towards improving their digital competencies (Benito et al., 2021; Hajjej et al., 2021). Students generally enjoyed the emergency online instruction and appreciated the flexibility and convenience of remote learning during the pandemic (Lee et al., 2022; Muthuprasad et al., 2021). They also felt the new learning experience contributed to their skills and knowledge (Benito et al., 2021).

Studies suggest online learning experiences might be more challenging for students from minority backgrounds, causing them to achieve lower grades and drop out at higher rates (Lagier, 2003; Richardson, 2012, 2015). This is especially true if courses are not well designed and planned, or instructors do not address students' needs (Edmunds et al., 2021). Wladis et al. (2015) found that Hispanic and Black students are less likely to enroll in online STEM courses compared to their peers; however, the researchers did not examine students' learning experiences or achievement in these courses.

Studies have found that during the period of emergency online learning at the start of the pandemic, ethnic-minority students

struggled more with the transition and faced more obstacles (Brancaccio-Taras et al., 2021; Istenič, 2021). These obstacles included a disruptive change in their financial situation, challenging living situations, and an environment that did not promote their learning needs (Molock & Parchem, 2020).

To the best of our knowledge, no studies have looked at the student learning experience over time (i.e., emergency versus sustainable online learning) from the perspective that this crisis was an opportunity for positive change. Based on the existing studies of emergency online learning, we anticipated the student learning experience would evolve as online instruction improved, and students became accustomed to this instructional method.

2.2.3. Student social experience

Engaging and interacting with supportive peers can promote well-being and help people cope with crisis events and transitions (Huerta & Fishman, 2014). This applies to the educational context, where social interactions are known to improve student experience and motivation (Turk et al., 2022). Students who perceive their peers as supportive and feel comfortable approaching them for help report higher overall satisfaction with their studies (Dumford & Miller, 2018; Lee et al., 2011; Tang et al., 2021). In online environments, social interactions occur in or with the use of information and communication technologies (ICTs). A systematic review of peer interaction in online learning in higher education found online peer support is beneficial to learners and improves their engagement (Tibingana-Ahimbisibwe et al., 2020).

Despite the recognized importance of peer interaction in online learning environments, there is limited research on peer interactions during the period of pandemic-induced emergency online learning. One study of the pandemic found that peer-to-peer support was essential to elevate student motivation, self-efficacy, satisfaction, and overall readiness for online learning (Tang et al., 2021). We contribute to this knowledge by examining how students perceived peer interaction first during emergency online learning (spring 2020) and then during sustainable online learning (spring 2021).

Another important aspect of social interaction is students' sense of belonging. Belonging is a feeling of being connected to a group, having a group identity, interacting openly with peers, and collaborating with them to achieve certain goals (Garrison & Cleveland-Innes, 2005; Walton & Cohen, 2007). A stronger sense of belonging to a group was found to predict better student experiences and social interactions during the first period of emergency online learning (Turk et al., 2022). However, we do not know what happened over time, as online learning became the new normal.

The social experiences of some identity-based groups (i.e., female students, first-generation college students and ethnic-minority students) may differ from those of the majority groups; but studies examining social interactions in online learning environments have not addressed this topic. However, we do know that ethnic-minority students find it harder to initiate interactions with peers in academic settings (Huerta & Fishman, 2014). We therefore examine if and how the social experiences have changed for these groups of students moving from emergency to sustainable online learning.

2.2.4. Student affective experience

Affective experience refers to the feelings and emotions elicited by engaging in an activity (Martin et al., 2020). The affective experience is an inseparable part of the interplay between students and learning, and it has an impact on both learning experience and grades (Marchand & Gutierrez, 2012). During online learning, students may experience a range of positive and negative feelings, including anxiety, confusion, frustration, boredom, and concentration (Kort et al., 2001). These feelings might be more positive if students can interact with peers and have an instructor with significant social presence during class time (Turk et al., 2022).

Studies on the affective experience of emergency online learning have examined the occurrences and implications of various feelings among students in higher education, such as anxiety, frustration, and boredom. Student anxiety was higher during the pandemic (Arribathi et al., 2021; Deng et al., 2021). Many students did not have extensive experience in online learning; this, accompanied by the fear of the pandemic, increased anxiety during the first transition to online learning (Zapata-Cuervo et al., 2021). Frustration was also reported to increase (Dasinger & Gibson, 2022; Dhawan, 2020; Therisa Beena & Sony, 2022). This could be related to the effort to maintain an academic routine during the pandemic, and the pressure to achieve in an unfamiliar instructional modality (Dasinger & Gibson, 2022).

Studies consistently report gender differences in students' affective experience. During emergency online learning, female students reported higher levels of anxiety and frustration (Clabaugh et al., 2021; Deng et al., 2021; Tang et al., 2021; Zahrae-Afellat & Alipour, 2021). But less is known about the affective experiences of students in later semesters, following the first transition to emergency online learning, and of first-generation college students and ethnic-minority students. In general, ethnic-minority students were reported to be more likely to experience negative emotional outcomes because of the pandemic (Clabaugh et al., 2021).

2.3. Research goals and questions

Prior work has shown that the COVID-19 pandemic significantly impacted college students' learning experiences, social experiences, and affective experiences (Castro & Tumibay, 2021; Istenič, 2021; Neuwirth et al., 2021). However, there is a gap in the literature regarding the evolution of these impacts over time. To address this gap, we examined the transition from regular in-person learning prior to the pandemic, to emergency online instruction in spring 2020, and sustainable online learning a year later in spring 2021. Our study takes a unique approach by comparing students' grades and experiences during these three semesters to better understand longitudinal changes in the learning environment during the COVID-19 pandemic. Specifically, we pose the following research questions.

RQ1. How did student grades change moving from emergency to sustainable online learning compared to regular in-person learning**?**

RQ2. How did student experiences (learning, social, and affective) change moving from emergency to sustainable online learning**?**

Moreover, prior work has highlighted the importance of considering social identity (gender, ethnicity, first-generation college student status) in examining the impact of the pandemic on college students' learning experiences (Brancaccio-Taras et al., 2021; Therisa Beena & Sony, 2022). However, there is a lack of research that specifically examines how these social identities are related to students' grades and experiences during the transition from emergency to sustainable online learning. Our study aims to fill this gap by exploring how student grades and experiences change during this transition based on their social identity**.** Specifically, we pose the following research question.

RQ3. How did student grades and experiences (learning, social, and affective) change moving from emergency to sustainable online learning based on their social identity (gender, ethnicity, first-generation college student status)?

3. Methods

3.1. Research context

We examined students in four large-scale undergraduate courses in the Department of Information Science (i.e., STEM courses) at a large research university in North America. The courses had transitioned from an in-person to an online instructional modality in spring 2020 (i.e., emergency online) and were re-offered in an online learning modality in spring 2021 (i.e., sustainable online). All four courses were also offered in an in-person modality in spring 2019 (i.e., regular in-person). The courses varied in content and level and covered the following topics: data science and statistical analysis (introductory level), programming and web design (introductory level), web applications and data visualizations (intermediate level), and natural language processing in social contexts (advanced level).

To examine the institutional and instructional shifts from emergency to sustainable online learning, we conducted semi-structured interviews with four course instructors. Each interview lasted 45–60 min and included six guiding questions about changes made to the course during the transition to online learning (both emergency and sustainable). The interview questions covered various aspects of the course, including lectures, activities, discussions, assessment, sections, office hours, and teaching assistants. We also inquired about what worked well and what did not, and any changes made to the class, assessment, sections, office hours, or teaching assistant tasks. In addition, we asked about differences between the spring 2020 and spring 2021 semesters and what led to those changes.

After summarizing and transcribing the interviews, we used a bottom-up content analysis to extract themes from the responses following Moustakas's (1994) approach. To cluster the themes, we sorted the statements by similarities and differences and evaluated their relevance to the identified themes, following Miller and Crabtree's (1999) method. We refined the themes and conducted a reliability check of the coding through dialogic discussion among the researchers, reaching a consensus on the final set of themes. Our analysis identified two major institutional-level changes, including goals set by institutional stakeholders and institutional support systems, and three major course-level changes, including course structure, content organization and delivery, and student evaluation.

(a) Changes at the institutional level:

Goals set by institutional stakeholders: During emergency online learning, the main goals of the university and the department were to transition to online courses as quickly and successfully as possible. Goals changed very rapidly, and instructors did not have enough time to adjust their teaching methods to fit them. In contrast, during sustainable online learning, goals for teaching and learning were defined in advance and remained relatively stable. Instructors had enough time to plan their courses and adjust their teaching to the institution's goals.

Institutional support *systems*: During emergency online learning, the university and department gave instructors resources to assist them with the transition to teaching online, including resources to improve their expertise in digital tools, pedagogical practices, and video editing. No structured or formal support systems were available. Hence, most of the online transition was done entirely by the instructors and their teaching assistants, based on their past teaching experience and discipline-specific expertise. In contrast, during sustainable online learning, the support system offered by the university and the department was more organized and structured, and more resources were available.

(b) Changes at the course level:

Course structure: During emergency online learning, instructors had to revise their course from in-person to online within three weeks. The revisions were based mostly on the instructors' experience and their students' feedback. However, as they moved towards sustainable online learning in the second year, instructors had time to plan and refine their courses. Some had also used online instruction in other courses during fall 2020, which made them more confident making changes to their spring 2021 courses.

Content organization and delivery: Due to the limited timeframe and resources during the transition to emergency online learning, instructors did not have sufficient time to plan their content organization (projects or modules) and delivery methods (synchronous or asynchronous activities, technological tools, etc.). However, by spring 2021, instructors were able to adjust their content organization and delivery to reflect their teaching goals, as well as their students' needs. They re-structured content around project milestones or

modules, were able to implement more collaborative activities, and used digital tools more expertly (e.g., editing videos of recorded lectures).

Student evaluation: Another change made by instructors between the two online semesters was related to student evaluation. The evaluation criteria and assessment procedures became looser during emergency online learning. Instructors reported that they omitted projects and assignments, and some made the final exam optional. Many projects and assignments had flexible submission dates, and students were graded according to more lenient criteria. During sustainable online learning, the evaluation process was more structured. Instructors were able to structure more sustainable assessment criteria, and projects and final exams were better constructed.

Table 1 shows examples of the instructional changes in two courses during the two online semesters.

3.2. Participants

Participants were 2375 undergraduate students (54.7% female; 45.3% male). They were enrolled in one of four large-scale courses during the spring 2019, spring 2020 or spring 2021 semesters in the Department of Information Science at a large research university in North America. The sample for spring 2019 included 777 students, the sample for spring 2020 included 756 students, and the sample for spring 2021 included 842 students.

A total of 1381 students who took one or more of the four courses during the spring 2020 and/or spring 2021 semesters completed a survey on their learning, social, and affective experiences. We collected 741 responses for spring 2020 and 640 responses for spring 2021. We removed 19 and 21 duplicate responses in 2020 and 2021, respectively, where students responded multiple times to the same survey, and 24 and 27 incomplete surveys, respectively, where students submitted an empty or an incomplete survey. This yielded 1290 responses: 698 responses in spring 2020 and 592 responses in spring 2021. Students enrolled in multiple courses were counted for each enrollment, as their experience might have differed from course to course.

Table 2 summarizes the sociodemographic characteristics of the participants based on data provided by the university registrar.

3.3. Measures

We collected data using a student survey at the end of the course and retrieved data from the university registrar.

3.3.1 *Student survey*: The survey was developed to measure students' learning experience, social experience, and affective experience during online learning in the course (survey items with response scales provided in Appendix A). The first part of the survey measured the following aspects of the learning experience with eight statements rated on Likert response scales: overall learning experience in the course, course organization, clarity of learning goals, difficulty level of the course, how easy or difficult it was to catch up with course materials, perceived knowledge gain in the course, perceived activeness in the course, and perceived engagement with high-level learning skills. We also examined student self-efficacy, based on an adapted scale from Pintrich and De Groot (1990). The self-efficacy scale included four items rated on a 7-point Likert scale from −3 (strongly disagree) to 3 (strongly agree) (Cronbach's α = 0.85): for example, "I believe I will receive an excellent grade in this class"; "I am certain I can master the skills being taught in this

Table 1
Examples of instructional changes in two courses.

Course	Semester	Online learning modality	Course content & activities	Assignments & projects	Assessment & evaluation
Web applications and data visualizations	Emergency online	- Synchronous lectures & asynchronous recorded lectures	- Shorter lessons - No activities - No mandatory attendance	- Omitted some assignments - Omitted the final project - Flexible submission dates	- More assessment criteria, extra credit - Final exam was optional
	Sustainable online	- Synchronous lectures & asynchronous recorded lectures	- Reorganized recorded lectures - Interactive activities - Mandatory attendance	- Added assignments - Reinstated the final project - Fixed submission dates	- Structured assessment criteria - Final exam was still optional
Programming and web design	Emergency online	- Asynchronous recorded videos	- No discussion sections - Omitted content - Organized content in modules - No mandatory attendance	- Omitted some assignments - Flexible submission dates	- Instructor graded assignments due to a TA shortage
	Sustainable online	- Asynchronous recorded videos	- Reinstated discussion sections - Improved content organization - Mandatory attendance	- Reinstated the assignments - Structured submission dates	- TAs graded assignments

Table 2
Participant demographics in the overall and survey samples based on registrar data.

Demographics		Enrolled students N=2375			Survey respondents N=1290	
		Spring 2019 N = 777	Spring 2020 N = 756	Spring 2021 N = 842	Spring 2020 N = 698	Spring 2021 N = 592
Sex	Female	52.5%	54.9%	56.5%	55.6%	59.3%
	Male	47.5%	45.1%	43.5%	43.1%	4.5%
	Unknown[a]	N/A	N/A	N/A	1.3%	0.2%
Race/Ethnicity	Asian	39.8%	45.4%	45.7%	43.4%	44.1%
	White	23.8%	24.3%	22%	22.3%	22.3%
	Two or more races	11.1%	1.7%	11.3%	1.9%	10%
	Black	5.4%	5%	5%	4.9%	4.7%
	Hispanic or Latino	2.6%	0.7%	1.1%	0.9%	1.0%
	Hawaiian or Pacific	0%	0.1%	0.1%	0.1%	0.2%
	American Indian	0.1%	0%	0%	0%	0%
	Unknown	17.2%	13.8%	14.8%	17.5%	17.7%
First-generation college students		15.3%	13.6%	13.1%	9.2%	16.1%
Ethnic-minority students[b]		8.1%	5.8%	6.2%	5.9%	5.9%

[a] Unknown sex is related to incorrect student IDs entered by students in the survey.
[b] According to registrar data, ethnic-minority students include students with the following ethnicities: Black, Hispanic or Latino, Hawaiian or Pacific, and American Indian.

class".

The second part examined students' social experiences using one statement rated on a Likert response scale (e.g., the frequency of collaboration with peers) and the number of peers with whom students collaborated. We also examined students' sense of belonging using a scale adapted from Walton and Cohen (2007). Students rated nine items, seven reversed, on a 7-point Likert scale from −3 (strongly disagree) to 3 (strongly agree) ($\alpha = 0.83$): for example, "I think the same way as people who do well at [name of the University]"; "Sometimes I felt worried that other students could think I am less capable".

The third part of the survey examined students' affective experience by asking them how frequently they encountered the following affective states in the course: concentration, boredom, frustration, confusion, and anxiety (adapted from Calvo & D'Mello, 2010). Appendix A summarizes the survey constructs we examined, the survey statements or questions, and the specific rating scale.

3.3.2 *Registrar data*: We obtained sociodemographic information for students who completed the surveys, including student sex, ethnicity, and first-generation college status. In addition, we retrieved students' grades by course and semester for the spring 2019 semester (i.e., regular in-person), the spring 2020 semester (i.e., emergency online) and the spring 2021 semester (i.e., sustainable online).

Letter grades were retrieved on a scale from F to A+ and converted into a numerical scale from 0 (F) to 4.3 (A+). According to the university's policy, students who receive an Incomplete (INC) were considered as having failed the course (F). S (Satisfactory) and U (Unsatisfactory) (i.e., S/U) grades were not assigned a specific numerical value and were not included in the analysis of the grade point averages. Overall, we excluded 147 students from the grades analysis due to S/U grades, which resulted in the final enrolled student sample (N = 2375).

There was an increase in students opting for the S/U grading basis in the emergency online semester compared to the regular in-person and sustainable online semesters. During the spring 2020 semester, the university allowed students to opt for S/U grades instead of letter grades, and 15% of the students in our sample (N = 133) opted for S/U grades. For comparison, in spring 2019 and spring 2021 semesters, 1.1% (N = 8) and 0.7% (N = 6) of the students in our sample, respectively, opted for S/U grades. During emergency online learning, male students were significantly more likely to opt for S/U grading than female students (18.5% vs. 11.5%; $X^2 = 6.92$, p = .009). Continuing-generation college students were not significantly more likely to opt for S/U grading than first-generation college students (15.1% vs. 14.1%; $X^2 = 0.01$, p = .900). Ethnic-minority students more than twice as likely to opt for S/U grading than their majority group peers (29% vs. 13.9%; $X^2 = 9.22$, p = .002).

3.4. Procedure and analysis

We obtained approval for the study protocol from the institutional review board before commencing data collection and all students provided informed consent at the start of the survey. We used surveys to compare student experiences in the first transition to emergency online instruction in spring 2020 with online instruction a year later in spring 2021. The surveys were distributed by course instructors via a hyperlink to a Qualtrics survey, a web-based surveying platform. The survey was framed to students as part of a research project to examine the learning experience in the course, and they received extra credit for completing the survey. After the spring 2021 semester had ended, we retrieved demographic and grade data from the university registrar for three semesters (i.e., spring 2019, spring 2020 and spring 2021).

We performed descriptive and explanatory analysis in IBM-SPSS and R. Missing data were handled using mean imputation within the same semester, which is a valid approach when less than 5% of the data is missing, as is the case in the current study (Little et al., 2014).

4. Results

4.1. Student grades

The first research question focused on how student grades changed during the emergency online semester and sustainable online semester, relative to a regular in-person semester. Fig. 1 shows average grades for all students in our sample and for specific groups of students (i.e., female and male students, first-generation college students and their continuing-generation peers, and ethnic-minority students and their majority group peers).

The average course grade was significantly higher during emergency online learning compared to both regular in-person learning ($t_{(1531)} = 8.78$, $p < .001$) and sustainable online learning ($t_{(1595)} = 8.09$, $p < .001$). The average course grade during sustainable online learning returned to the same level as during in-person learning ($t_{(1616)} = 0.14$, $p = .891$). The elevated average grade during emergency online learning may be partly explained by the university's lenient grading policy during emergency online learning and students opting for S/U grades instead of letter grades if they anticipate a low grade.

Nonetheless, while the small gap in the average grades between male and female students and first-generation college students and continuing-generation college students remained steady over the three semesters, a significant grade gap appeared for ethnic-minority students during sustainable online learning. The pre-existing ethnic-minority achievement gap in the regular in-person semester of about 0.25 grade points ($t_{(775)} = -2.92$, $p = .004$) decreased during the emergency online semester, rendering the gap statistically insignificant ($t_{(754)} = -1.64$, $p = .101$). However, this gap widened substantially to nearly 0.75 grade points during sustainable online learning ($t_{(839)} = -9.95$, $p < .001$). Thus, the achievement gap for ethnic-minority students significantly widened going from regular in-person learning to sustainable online learning.

As a robustness check for differential self-selection into the grading basis, we imputed S/U grades with two different values to probe the robustness of the observed achievement gap (Maier et al., 2016; Manly & Wells, 2015). We found that the achievement gap between ethnic-minority and non-ethnic-minority students in sustainable online learning was still significant if S/U grades were imputed with either the semester average grade ($t(839) = -4.05$, $p < .001$) or with 'A' grades ($t(839) = -4.02$, $p < .001$).

4.2. Students' learning, social, and affective experiences

We examined all measures of students' learning, social, and affective experiences and performed a *t*-test for independent samples to compare them in the two periods of interest (Table 3). As expected, many of these student experience constructs are correlated with grades in each semester (see correlation table in Appendix B).

We found that student learning experiences generally improved during sustainable online learning relative to emergency online learning. Students perceived their overall experience to be better, the courses to be more organized, and their learning in the course to be more active and engaged. However, students' self-efficacy decreased during sustainable online learning.

To examine students' social experience, we asked how often during class they discussed something with friends (active peers), how many fellow students they felt comfortable asking for help during the course (number of peers) and examined their sense of belonging.
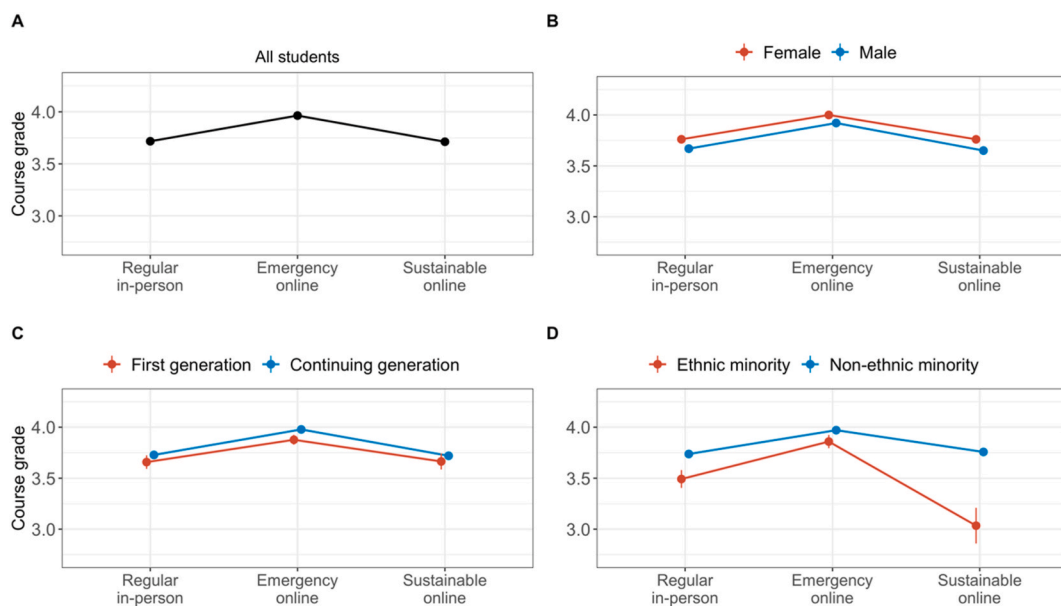

Fig. 1. Changes in grades moving from regular in-person to emergency and sustainable online semesters by student group ($N = 2375$). Error bars indicate one standard error around the mean.

Table 3

Mean scores, standard deviations (SD), and *t*-test statistics with *p*-values for independent samples of student experience during emergency and sustainable online learning ($N = 1290$).

	Construct	Emergency online $N = 698$ Mean (SD)	Sustainable online $N = 592$ Mean (SD)	Difference *t*-test	*p* value
Learning experience	Experience	2.79 (0.88)	3.27 (0.70)	$t = 10.61$	$p < .001$
	Organized	2.87 (0.90)	3.17 (0.81)	$t = 6.25$	$p < .001$
	Clarity	3.17 (0.77)	3.20 (0.77)	$t = 0.68$	$p = .496$
	Skills	3.14 (0.87)	3.13 (0.92)	$t = -0.23$	$p = .818$
	Engaged learning	2.68 (0.89)	2.80 (0.76)	$t = 2.65$	$p = .008$
	Active learning	0.37 (1.70)	1.51 (1.32)	$t = 13.25$	$p < .001$
	Difficulty	-0.21 (1.32)	-0.21 (1.40)	$t = 0.05$	$p = .996$
	Fall behind	0.25 (1.02)	0.34 (1.15)	$t = 1.48$	$p = .138$
	Self-efficacy	1.25 (1.12)	1.13 (1.04)	$t = -1.99$	$p = .047$
Social experience	Active peers	1.74 (1.19)	2.01 (1.05)	$t = 4.23$	$p < .001$
	Number of peers	3.74 (3.57)	2.68 (2.04)	$t = -6.37$	$p < .001$
	Belonging	1.28 (1.02)	1.23 (0.95)	$t = -0.98$	$p = .329$
Affective experience	Concentration	3.35 (0.97)	3.15 (1.00)	$t = -3.68$	$p < .001$
	Boredom	1.66 (0.90)	1.57 (0.89)	$t = -1.94$	$p = .052$
	Frustration	2.31 (1.16)	2.16 (1.26)	$t = -2.23$	$p = .026$
	Confusion	2.09 (1.04)	2.03 (1.11)	$t = -1.05$	$p = .293$
	Anxiety	1.64 (1.27)	1.69 (1.35)	$t = 0.80$	$p = .425$

Students reported that they had more opportunities to discuss the course materials with their peers during sustainable online learning than emergency online learning, but the number of peers they felt comfortable reaching out to dropped significantly. Their sense of belonging remained relatively stable moving from emergency to sustainable online learning.

For students' affective experience, we found that the transition from emergency to sustainable online learning resulted in a drop in both concentration and frustration, but no significant changes in anxiety, boredom, and confusion.

4.3. Experiences outcomes by students' identity-based groups

We examined gaps in learning, social, and affective experiences between female and male students, first-generation relative to continuing-generation college students, and ethnic-minority students and their majority group peers.

First, during emergency online learning, female students reported significantly lower self-efficacy ($t_{(687)} = -4.87, p < .001$) and belonging ($t_{(687)} = -2.67, p = .008$), as well as higher frustration ($t_{(687)} = 2.85, p = .005$), confusion ($t_{(687)} = 4.57, p < .001$), anxiety ($t_{(687)} = 4.45, p < .001$), course difficulty ($t_{(687)} = 2.29, p = .022$), and more social interaction with peers ($t_{(687)} = 2.11, p = .035$). There were no significant changes in the magnitude of gender gaps from emergency to sustainable online learning (all sex-by-semester interactions: $p > .05$). During sustainable online learning, female students still reported lower self-efficacy ($t_{(589)} = .$

$-3.99, p < .001$), as well as higher frustration ($t_{(589)} = 3.07, p = .002$), confusion ($t_{(589)} = 3.85, p < .001$), anxiety ($t_{(687)} = 3.14, p = .002$), and course difficulty ($t_{(589)} = 2.59, p = .010$). While the gender gap in belonging was not significant during sustainable online learning, female students were significantly more engaged with the learning process than males ($t_{(589)} = 2.49, p = .013$).

Second, during emergency online learning, there were not statistically significant gap between first- and continuing-generation college students and there were no significant changes in the magnitude of first-generation status gaps from emergency to sustainable online learning (all first-generation-by-semester interactions: $p > .05$). During sustainable online learning, first-generation students reported lower self-efficacy ($t_{(590)} = -3.17, p = .002$) but also more acquired skills ($t_{(590)} = 2.15, p = .032$) than continuing-generation students.

Third, during emergency online learning, ethnic-minority students reported a worse learning experience ($t_{(696)} = -2.26, p = .024$), less belonging ($t_{(696)} = -1.98, p = .048$), less collaboration with peers ($t_{(696)} = -2.14, p = .032$), and a harder time catching up after falling behind ($t_{(696)} = -2.08, p = .038$) compared to ethnic-majority students. There were no significant changes in the magnitude of ethnic-minority status gaps from emergency to sustainable online learning (all minority-by-semester interactions: $p > .05$). During sustainable online learning, ethnic-minority students still reported less belonging ($t_{(590)} = -3.85, p < .001$), but also more frustration ($t_{(590)} = 3.28, p = .001$), confusion ($t_{(590)} = 2.21, p = .027$), and anxiety ($t_{(590)} = 2.69, p = .007$) compared to ethnic-majority students.

5. Discussion

5.1. Summary of results

In this study, we examined how major changes to learning modalities during the COVID-19 pandemic impacted college student experiences and grades. Based on our theoretical lens that views crisis as opportunity for change, our research goal was to reflect on the recent disruptions to current practices, identify areas for improvement, and to seek positive, sustainable change. We compared the first transition to emergency online instruction in spring 2020 to the sustainable online instruction a year later in spring 2021. We examined

student grades and experiences, aiming to identify the opportunities and takeaways for online instruction in higher education and described challenges for specific socio-demographic groups to address following the COVID-19 crisis. Based on our findings, we discuss the lasting effects of the pandemic and portray the opportunities and challenges of online instruction in higher education.

Our analysis of student grades over the two-year period revealed that all groups of students achieved higher grades during emergency online learning. We assume that grades were higher during this semester due to the updated university-wide grade policy during the emergency online semester (i.e., allowing students to opt for S/U grades) as well as changes in course assessment (i.e., instructors dropped tests and projects). The S/U policy, alongside the changed assessment process, may explain the decreased achievement gap between different groups of students, particularly for ethnic-minority students. However, the widened achievement gap for ethnic-minority students moving from regular in-person learning to sustainable online learning is cause for concern. This gap increased despite higher rates of S/U grades among ethnic-minority students compared to their majority group peers during emergency online learning, and despite more course planning and institutional support in sustainable online learning.

5.2. Implications for theory

These findings contribute to the body of evidence that online instruction might negatively affect students' achievements, particularly students with lower prior GPA (Bettinger & Loeb., 2017; Xu & Jaggars, 2014) and ethnic-minority students (Harackiewicz et al., 2014; Harris et al., 2020; Xu & Jaggars, 2014). Achievement gaps tend to be larger for ethnic-minority undergraduate students enrolled in introductory STEM courses (Theobald et al., 2020). Our findings further demonstrate a growing grade gap for ethnic-minority students following the pandemic crisis. These gaps represent an urgent issue to address, as they contribute to widening inequalities in higher education.

The widened gaps might be caused by the stressors and challenges that ethnic-minority students faced during the pandemic (Brancaccio-Taras et al., 2021; Istenič, 2021). This speaks to the challenges of using online learning as the only instructional modality for students who may be less familiar with it and who have a less robust support system (Lagier, 2003; Richardson, 2012, 2015). This could also indicate student burnout or loss of motivation during a prolonged period of online learning (Barratt & Duran, 2021; Gonzalez-Ramirez et al., 2021). Our study emphasizes that ethnic-minority students might need a stronger safety net to support their educational needs during times of crisis, and efforts should be made to create more inclusive online environments addressing those needs. The findings further highlight the need to monitor achievement gaps, especially for ethnic-minority students, over time to examine whether they increase or decrease as we move on from the height of the pandemic.

Our findings regarding students' experiences showed that they had mixed experiences (learning, social and affective) moving from emergency to sustainable online learning. Some learning and social experiences improved over time while others did not. Overall, students had better learning experience during sustainable online learning, and they perceived courses to be more active and engaging. These findings somehow supported our initial assumption that student learning would evolve over time, as students became more experienced and comfortable with the new instructional methods and learned how to navigate online instruction (Benito et al., 2021; Hajjej et al., 2021). Spring 2021 (i.e., sustainable online) was the third semester of online instruction for some students. Therefore, students' online learning readiness might have improved, leading to a more positive learning experience (Joosten & Cusatis, 2020; Tang et al., 2021). The improved learning experience during sustainable online learning could also indicate the improved quality of the courses and the institutional planning (Zerihun et al., 2012).

However, some aspects of student learning and affective experiences did not improve from one semester to the next (Alon et al., 2021). Therefore, it seems that the efforts to improve courses and create a more sustainable framework for online instruction might have not been sufficient from the students' perspective. Students' perceptions are not an objective measurement of course quality, but they can reflect learners' unattended needs (Nguyen et al., 2017; Rienties & Toetenel, 2016).

Students' social experience improved with the transition to sustainable online learning. They reported more opportunities to interact with peers and discuss course materials during class time. This indicates an improvement because interacting with peers is likely to increase student satisfaction and indicative of a better support system for the course (Dumford & Miller, 2018; Lee et al., 2011; Turk et al., 2022). This is particularly important during a crisis such as the COVID-19 pandemic, as peer support might help students overcome challenges (Tang et al., 2021). That said, in the long run, online learning seemed to harm the number of students' social interactions. We found that over time, students reported a lower number of peers whom they felt comfortable asking for help. These findings suggest that facilitating meaningful peer interaction is more challenging during online instruction (Lee et al., 2021; Sjølie et al., 2022). Instructors should actively encourage students to interact during and after class by incorporating collaborative activities (i.e., peer work, think-pair-share, group projects) and class discussions (Tang et al., 2021; Turk et al., 2022).

Our examination of the experiences of historically underrepresented groups of students in STEM courses revealed some lasting effects of the pandemic. Moving to sustainable online learning, female students and first-generation college students reported lower self-efficacy and ethnic-minority students reported less belonging. Female students and ethnic-minority students also reported a worse affective experience, including more frustration, confusion, and anxiety. Many studies have reported lower self-efficacy for female students and first-generation college students (Clabaugh et al., 2021; Deng et al., 2021; Tang et al., 2021; Zahrae-Afellat & Alipour, 2021), as well as less belonging for ethnic-minority students (Huerta & Fishman, 2014). Our findings contribute novel insight into the lasting effects of the pandemic, particularly for identity-based groups of students, and emphasize a need for more supportive online learning environments (Lee et al., 2022).

Transitioning to online instruction is a challenging task even for experienced instructors (Alon et al., 2021; Lee et al., 2022; Tang et al., 2021); hence, higher education institutions should offer additional support and training for instructors, particularly those with less experience with online pedagogy and instruction (Edmunds et al., 2021; Kim & Bonk, 2006; Moore et al., 2011). Moving beyond

the pandemic and incorporating a sustainable mode of online learning in higher education demands that institutions and instructors invest time, effort, and resources to overcome the challenges of online instruction and create a more inclusive learning environment (Lee et al., 2022; Zhao et al., 2021).

In this study, our main objective was to deepen the understanding of the transition from in-person to emergency and sustainable online learning during the COVID-19 crisis. Overall, this research makes significant contributions to the field of online learning in higher education for various reasons. Primarily, we offer a unique perspective by examining the challenges and opportunities that emerged from the sudden shift to emergency online learning, as well as the subsequent transition to sustainable online learning. By perceiving the crisis as an opportunity for change, we investigate the positive aspects that have emerged from the pandemic and gain valuable insights into how different modes of instruction can be enhanced. Previous studies on the transition to emergency online learning in higher education have primarily focused on the implications for student achievement and well-being during the emergency learning period. However, our study delves into a relatively unexplored area by examining online learning in the semesters following the initial transition.

Furthermore, our longitudinal analysis shed light on the changes in achievement gaps and experiences between ethnic minority students and their peers, highlighting the need to address educational equity in online learning environments. By identifying these disparities and observing their evolution, we contribute to a better understanding of how to design and implement sustainable online learning practices that ensure equal opportunities for all students, especially those from ethnic minority backgrounds. These insights hold significant relevance not only in the immediate context of the COVID-19 crisis but also in the long term, as online learning continues to play a crucial role in higher education. As online learning becomes increasingly prevalent, our insights and recommendations become pertinent for decision-makers and practitioners who aim to create effective and equitable online learning experiences for all students. Thus, our research informs the design of more effective online learning approaches moving forward, thereby advancing the field.

5.3. Implications for practice

Our study offers several implications, both at the institutional and instructor levels. At the institutional level, there is a need to improve the support system for instructors and students engaged in online learning. It is essential to strengthen the institutional infrastructure and offer trainings for instructors, particularly those who need to construct an online course for the first time or who are not familiar with online teaching practice and pedagogy (Dumford & Miller, 2018; Scherer et al., 2021). Trainings should address the pedagogical aspects of online instruction, teaching instructors how to build a sustainable and effective online course and apply best practices. They can also benefit from guidance on how to create inclusive and supportive class environments that address minority students' needs (Neuwirth et al., 2021) and learn about the importance of peer interaction in online courses (Alon et al., 2023; Turk et al., 2022).

Another important angle to address is the effect of the university's grade policy on students' achievements. Our study showed that the S/U grade policy during emergency online learning decreased achievement gaps and increased average grades for all groups of students. This finding has implications for selecting grades policies. On the one hand, universities could change their grades policy for introductory courses to the S/U system, as allowing students to opt for non-letter grades seems to reduce existing achievement gaps for ethnic-minority students in introductory STEM courses. This can provide them with a better starting point in their academic studies (Theobald et al., 2020). However, it is important to take into consideration that S/U grades might also prevent policy makers and instructors from identifying and addressing achievement gaps that could harm students' academic progress.

At the instructional level, we suggest that instructors who teach online courses monitor their students' grades and experiences throughout the semester and identify signs of struggle and knowledge gaps. This could be done by utilizing a student survey that could help instructors and institutions assessing and monitoring potential challenges among students. Instructors might also consider applying interventions found useful for enhancing student engagement and self-efficacy in contexts of online instruction, such as plan-making or value-relevance interventions (Kizilcec et al., 2020). For example, in the value-relevance intervention, students are asked to reflect on their values and write about how mastering the course content contributes to what they value. Instructors could also incorporate synchronous sessions as part of an online course. While these are hard to schedule and less flexible for students and instructors (Kim et al., 2005; Muthuprasad et al., 2021), synchronous meetings may help instructors become more engaged with students (Jaggars & Xu, 2016), address their concerns, and promote peer interaction (Hrastinski, 2008).

5.4. Limitations

Our study has several limitations. First, student-reported experiences might present a biased picture of their learning experience (Deslauriers et al., 2019). Further studies might consider using additional tools to collect data, such as classroom observations, instructor reports, interviews, and experience sampling. Second, the number of ethnic-minority students and first-generation college students in our sample was relatively small, which limits the generalizability of our findings and calls for more longitudinal research on student experiences and grade gaps during online instruction in the pandemic. Third, our study focused on four information science courses and the results may generalize to other disciplines. While information science is considered an interdisciplinary field within STEM education, each field may have unique characteristics that impact student experiences and achievements. We call for future research to examine how our findings generalize to other fields in higher education. In addition, our survey measures do not provide an explanation for the causes of the widened achievement gap among minority students in sustainable online learning. Further studies could use interviews or targeted measures to identify explanations for these gaps. Lastly, the study is situated in the context of a major

pandemic that is still ongoing and the long-term effects on students' educational outcomes are still to be determined. Future research should revisit our findings beyond the context of the pandemic to examine how the observed patterns evolve over time.

6. Conclusion

While the outbreak of COVID-19 has caused a major disruption in the higher education system, it has generated room for instructors and institutions to reflect on existing practices, identify room for improvement, and take advantage of the new practices that are introduced. Through the theoretical lens of crisis as an opportunity for change, our findings point to several opportunities seized by instructors and other higher education stakeholders. The transition from emergency to sustainable online learning allowed the university to improve their support system and infrastructure. Our study suggests that despite the improved learning and social experiences among students, the move to sustainable online learning did not solve several significant challenges and these lingering effects of the pandemic still need to be addressed. The most pressing issue to address appears to be the significantly widened achievement gap for ethnic-minority students moving from in-person learning to sustainable online learning.

Credit author statement

Lilach Alon: Conceptualization, Methodology, Analysis, Writing – original draft, Writing- Reviewing and Editing. SeoYoon Sung: Writing- Reviewing and Editing. JiYong Cho: Analysis, Visualization. Rene Kizilcec: Analysis, Visualization, Supervision.

Declaration of competing interest

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.

Data availability

The data that has been used is confidential.

Appendix A. Survey measures and response scales used in this study

	Variables	Question/Statement	Reference	Scale
Learning experiences	Experience	How would you describe your experience in this course?	Alon et al. (2021)	0 (poor) to 4 (excellent)
	Organized	How well organized was this course?		0 (poor) to 4 (excellent)
	Clarity	How clear are the learning goals in this course?		0 (poor) to 4 (excellent)
	Skills	Compared to how much you knew about the course topic at the start, how much new knowledge and skills have you learned by taking this course?		0 (not at all) to 4 (a great deal)
	Engaged learning	How often did you synthesize ideas, think critically about the content, and apply the material to unfamiliar topics and problems?		0 (never) to 4 (always)
	Active learning	How active or passive was the learning experience in this course?		−3 (passive) to 3 (active)
	Difficulty	How easy or difficult is the course relative to other courses you have taken at [name of university]?		−3 (difficult) to 3 (easy)
	Fall behind	How easy or difficult is to catch up with the materials in this course after falling behind?		−2 (difficult) to 2 (easy)
	Self-efficacy	How much do you agree or disagree with the following statements? -I believe I will receive an excellent grade in this class - I'm certain I can understand the most difficult material presented in the readings for the course - I'm confident I can do an excellent job on the assignments and tests in this course - I am certain I can master the skills being taught in this class	Pintrich & De Groot, 1990	−3 (strongly disagree) to 3 (strongly agree)
Social experiences	Active peers	How often during class time did you discuss course materials with fellow students?	Alon et al. (2021)	0 (never) to 4 (always)
	Number of peers	How many fellow students in this class do you feel comfortable asking for help with the course?		Integer input field
	Belonging	How much do you agree or disagree with the following statements about (name of the university)? - I think the same way as people who do well in this course - There were times when I felt like an outsider in the course (reversed) - People like me are good at topics covered in this course	Walton and Cohen (2007)	−3 (strongly disagree) to 3 (strongly agree)

(*continued*)

	Variables	Question/Statement	Reference	Scale
		- Sometimes I felt that I did not belong to this course because of comments, actions, or behaviors of my lecture instructors (reversed) - Sometimes I felt that I did not belong to this course because of comments, actions, or behaviors of my section instructors (reversed) - Sometimes I felt that I did not belong to this course because of comments, actions, or behaviors of other students (reversed) - I sometimes worried that my lecture instructors could think I am less capable than other students (reversed) - I sometimes worried that my section instructors could think I am less capable than other students (reversed) - I sometimes worried that other students could think I am less capable (reversed)		
Affective experiences	Concentration Boredom Frustration Confusion Anxiety	How often did you experience each of these emotions during the course?	Calvo & D'Mello, 2010	0 (never) to 5 (always)

Appendix B. Spearman correlation between experiences and achieved grades in emergency and sustainable online learning (N = 1115). [a]

	Variables	Emergency online N=578	*p*-value	Sustainable online N=537	*p*-value
Learning experience	Experience	$r = 0.14$	$p < .001$	$r = 0.15$	$p = .001$
	Organized	$r = 0.14$	$p = .017$	$r = 0.10$	$p = .017$
	Clarity	$r = 0.11$	$p = .005$	$r = 0.06$	$p = .144$
	Skills	$r = 0.05$	$p = .221$	$r = 0.08$	$p = .077$
	Engaged learning	$r = 0.05$	$p = .171$	$r = 0.04$	$p = .295$
	Active learning	$r = 0.03$	$p = .462$	$r = 0.01$	$p = .996$
	Difficulty	$r = 0.11$	$p = .007$	$r = 0.28$	$p < .001$
	Fall behind	$r = 0.19$	$p < .001$	$r = 0.22$	$p < .001$
	Self-efficacy	$r = 0.18$	$p < .001$	$r = 0.24$	$p < .001$
Social experience	Active peers	$r = 0.02$	$p = .692$	$r = -0.02$	$p = .689$
	Number of peers	$r = 0.04$	$p = .369$	$r = 0.10$	$p = .018$
	Belonging	$r = 0.15$	$p < .001$	$r = 0.25$	$p < .001$
Affective experience	Concentration	$r = 0.07$	$p = .072$	$r = 0.09$	$p = .031$
	Boredom	$r = -0.07$	$p = .086$	$r = -0.07$	$p = .095$
	Frustration	$r = -0.15$	$p < .001$	$r = -0.27$	$p < .001$
	Confusion	$r = -0.11$	$p = .006$	$r = -0.26$	$p < .001$
	Anxiety	$r = -0.18$	$p < .001$	$r = -0.29$	$p < .001$

a 175 Students who completed the survey and did not have a matched grade or received S/U grades were omitted from the analysis (emergency online: N = 120; sustainable online: N = 55).

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