An Interdisciplinary Study of Perceptions, Efficacy, and Adaptation in Pandemic Pedagogy Supported by the Institutional Data Lake

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Abstract

The COVID-19 pandemic forced a sudden shift to online learning in Physics and Chemistry in Singapore. As restrictions eased, researchers explored its impact through interviews with instructors and analysis of student data made available through a data lake managed by the National University of Singapore's Institute for Applied Learning Sciences and Educational Technology. Interviews focused on instructor adaptation and beliefs about online teaching, while the data investigated student perceptions and changes in teaching efficacy pre- and post-pandemic.

Keywords

Institutional Data Lake, Academic Analytics, Interdisciplinary Research, Online Education, Interviews, Data Lake houses for Higher Education, Pandemic Pedagogy

Introduction

The COVID-19 pandemic, with its enforced school closures and travel bans, has redefined normalcy, forcing parents to juggle homeschooling and work while families grapple with isolation and severed connections. Imposed restrictions like safe distancing and non-essential workplace closures have profoundly impacted daily routines, leading to increased anxiety, financial hardship, and strained relationships[1,2]. Many schools had adopted remote teaching via online platforms in place of physical classes as a stopgap measure to minimize any disruption to students learning[3,4]. As the pandemic situation improves[5]. numerous countries have lifted the COVID-19 restrictions and physical interactions are once again allowed[6]. For schools and institutes of higher learning, even though operations have largely returned to normalcy, there are a lot of lessons that educators can learn from when teaching during the pandemic period[7]. These experiences could be valuable as not only would it enable educators to prepare for similar events that could once again disrupt face-to-face teaching that educators could take for granted.

To reflect on how the COVID-19 pandemic have impacted teaching and learning, the research team in this report conducted interviews with physics and chemistry course instructors to garner (i) their perspectives on how they conducted teaching and assessments during the pandemic, (ii) their views on online education, and (iii) their view on the support given by the university. In addition, to understand

how students were affected by the transition to online learning during the pandemic, the researchers also examined students' course feedback retrieved from a data lake managed by the National University of Singapore's Institute for Applied Learning Sciences and Educational Technology (ADL) to investigate how the shift to online learning have affected students' perception of the conduct of the courses as well as the educators' teaching efficacy.

Literature Review

About the NUS ALSET Data Lake

According to Zagan and Danubianu, Data Lake is a storage place for data – both structured and unstructured, a resource containing raw data that can be retrieved, disseminated, and analyzed[8]. Managed as a data lake designed strictly to support research uses, the ADL aggregates data from across campus into a centralized repository which can then be queried by researchers[9]. The ADL makes available a de-identified version of the data collected by the university and its researchers that are related to education and student learning. The data include course and program enrolment histories, basic demographic information, as well as course feedback submissions provided by students at the end of the semester[10,11]. During the enrolment process, NUS students provide their consent to allow the university to make use of their personal data and other data collected by the institution according to the NUS Personal Data Notice for Students. Research uses are included in the policy listing of approved purposes. In accordance with the university's research guidelines, an anonymized version of the data is available through the ADL for research uses. In addition to these demographic data, the ADL also makes available usage data and activity logs related to students' use of university's learning management system.[10,12,13] Data made available through the ADL are used by the university's faculty for educational analytics research purposes[9]. Using data repository to conduct educational analytics is not new. For instance, Open University has a Virtual Learning Environment (VLE) that collects data such students' interaction with the VLE, students pass rate, and students' satisfaction. Holmes et. al used those data to investigate the common learning patterns among the learning designs identified, how those data differ across the learning designs, and which learning design patterns would have the greatest impact in improving students' learning outcomes[14]. Given the sensitive nature of the data, research ethics approval from the Learning Analytics Committee on Ethics, a Departmental Ethics Review Committee (LACE-DERC)) was obtained before accessing the data provided through the ADL[15].

Conducting the interview with Faculty

Conducting interviews with research participants is a common method of data collection in social sciences as it enables the interviewees to share valuable information such as their experiences and emotions on a given topic[16]. Even though interviews are usually conducted in social sciences studies, researchers in the field of natural sciences have also employed interviews as part of the data collection procedures in their research. For instance, Ivanjek et al. conducted both a semi-structured interviews with 16 physics students from five universities across Europe[17]. The interview was conducted online, as asked about their perspective on various topics such as feelings towards online courses, their attitude towards synchronous and asynchronous teaching, and comparing between physical teaching and online teaching[17]. To ascertain how COVID-19 pandemic have on students' and teachers' perspective of their learning and teaching experience, Broad et. al conducted a study by using surveys, focus group discussions, and interviews with undergraduate students and staff from the University of Leicester's Chemistry Department[18]. Some of the themes that were discussed with the research participants during the interview include their understanding of the blended learning model, their opinions of how the university has done in transiting to blended learning, and how appropriate were the changes made to the examination styles[18]. In terms of scope of research participants, Chan et. al took it further by conducting a sequential mixed method research with two Asia-Pacific medical schools in Hong Kong to ascertain medical teachers' experience with remote teaching during the pandemic[19]. In

that study, Chan et. al conducted an online survey with 139 medical teachers from the two medical schools. The results of the survey were then used to develop interview questions to be asked to the 13 interviewees within the same two medical schools either through a face-to-face interview or via a Zoom meeting[19].

Although there have been multitude of studies which involves conducting interviews with research participants either within the same departments, or between two institutes of same field of study to ascertain the impact of the shift to online learning on students' and educators' learning and teaching experience, there are very few studies done that combined both inter-faculty interviews and educational analytics using data collected from a data lake. Thus, this study aims to bridge this gap to gain more insights on how the shift to online learning during the COVID-19 pandemic affects both learning and teaching experience of students and educators.

Research Methodology

Both qualitative and quantitative data were collected in this study. Quantitative data in the form of students' course feedback were collected from the ADL. For qualitative data, one-to-one interview was conducted with the course instructors to ascertain their perception as well as challenges faced when conducting online classes. The researchers felt that doing a one-to-one interview with the course instructors rather than conducting a focus group discussion would enable the interviewees to share their thoughts better. This sentiment was supported by Ryan, Coughlan, and Cronin where they mentioned that conducting an individual interview could enable interviewers to collect in-depth data as it allows interviewees to share their perceptions, understanding, and experiences on a given subject matter[20]. In addition, findings by Kruger et al. indicates during one-to-one interviews, interviewees were more likely to share their personal opinions and emotions with the interviewers compared to interviews done in a focus group session[21]. Kruger et al. opined that the nature of the individual interviews provided some psychological safety to share some of the more sensitive topics[21]. In the similar vein, Powell, Single, and Lloyd felt that focus group consisting of strangers rather than friends will be less likely to promote a conducive environment for the participants to share their perspective candidly[22]. Taking the literatures into account, as well as the nature of the information that would be shared by the research participants, the researchers opted to do a one-to-one interview to help build a comfortable environment to allow the participants to share their perspective freely.

For the course feedback, they are a series of questionnaires (shown in Table 1) consisting of 5-point Likert scale rating as well as open-ended questions which students are invited to complete towards the end of the semester before the final examinations. These questionnaires help to gather information on students' learning experience by measuring students' perception of the course in general, as well as their opinion on the teaching effectiveness of the course instructor[23]. This feedback would help course instructors to improve on their teaching as well as the content taught for the future batch of students. For this study, only data related to courses that were taught by course instructors who agreed to participate in the interview were obtained from the ADL for analysis.

Table 1. Questions asked in the course feedback conducted towards the end of the semester.

Student feedback on course survey	Student feedback on teaching survey
C1: What is your overall opinion of the course? 5: Very good 4: Good 3: Average 2: Poor 1: Very Poor	**T1**: The teacher has enhanced my thinking ability: 5: Strongly agree 4: Agree 3: Neutral 2: Disagree 1: Strongly disagree

C2: The grade that I am most likely to get in the course is: 5: A 4: B 3: C 2: D 1: F	**T2**: The teacher provided timely and useful feedback: 5: Strongly agree 4: Agree 3: Neutral 2: Disagree 1: Strongly disagree
C3: I rate this course as: 5: Very difficult 4: Difficult 3: Average 2: Easy 1: Very easy	**T3**: The teacher has increased my interest in the subject: 5: Strongly agree 4: Agree 3: Neutral 2: Disagree 1: Strongly disagree
C4: What I like about the course:	**T4**: What are the instructor's strengths?
C5**:** What I do not like about the course:	**T5**: What improvements would you suggest to the instructor?

Institutional Approval from Multiple Authorities

Approvals from relevant authorities need to be sought before the study can be conducted. As this research involves the study of course instructors from both the Department of Chemistry, and the Department of Physics, approvals from both Heads of Department (HOD) were required. Once both HOD had assented to the conduct of the research, approval to access the ADL was requested and was granted by ALSET and the Provost's Office.

Methods

Recruitment of Research Participants

Potential course instructors were first shortlisted using LumiNUS based on the following inclusion criteria: (1) they must be course instructors for either Department of Chemistry or Department of Physics, and (2) they must have taught the same course for the minimum of five consecutive academic years – three consecutive academic years before the COVID-19 pandemic period (AY2017-2018, AY2018-2019, and AY2019-2020), and two consecutive academic years during the pandemic period (AY2020-2021, and AY2021-2022). The second inclusion criteria would enable the researchers to compare data across the years while mitigating the difference in teaching styles among the course instructors.

Using course information available on LumiNUS, the researchers shortlisted 18 course instructors that fulfilled the inclusion criteria. The researchers then sent an email to the shortlisted course instructors to invite them to participate in the study. Two weeks later, another follow-up email was sent to those who did not respond to the previous email. At the end of the recruitment period, eight course instructors (labelled in the data as Instructors A-H) agreed to participate in the study. The researchers briefed each of the course instructors on the purposes in this study as well as how their data provided by them will be protected. The researchers also sought and obtained informed consent from all eight course instructors pertaining to the use of their data for this research.

Conduct of interview with interviewees

The researchers curated a set of open-ended interview questions which enabled the interviewer to ask follow-up queries to further clarify what the interviewees shared[24]. These curated questions aim to get insights on how course instructors conducted their teaching before and during the pandemic, their preferred mode of teaching, and their opinions of online teaching. The full list of questions can be found in the Supporting Information. The curated interview questions can be classified into two main themes: (1) adaptation of teaching methods to online learning, and (2) perceptions of efficacy of online teaching.

The one-to-one interview was conducted by one of the researchers (MXP) with each of the eight course instructors either through Zoom conferencing software or via face-to-face at the preference of each interviewee. Each interview session lasted between 25—45 minutes. To mitigate the effect of social desirability bias[24]. the interviewer reiterated that their privacy will be protected and that there are no right or wrong answers to the questions asked during the interview. The interviewer also requested to record the conversation using a voice recorder during the interview for transcription and data analysis purposes only. Three of the interviewees acceded to this request while the interviewer took down detailed notes for the remaining five interviewees who declined to have the conversation recorded.

Obtaining quantitative data from ADL

After the interviews for the eight course instructors were completed, the researcher (MXP) proceeded to obtain course feedback data from the ADL. Each course is taught once – either semester 1 or semester 2 – in a single academic year. As some course instructors taught more than one course, and other courses were taught by more than one course instructors within the same academic years, course feedback from nine courses were obtained from the ADL. Each of these nine courses was given a pseudocode of C00X where X is an integer from one to nine. However, as both NUS Department of Chemistry and Department of Physics traditionally have lower cohort size compared to other faculties, some of these nine courses would have very low enrolment rate. As a result, these courses would also have a relatively low student response rate for the course feedback. Thus, the researchers set up the criteria that the minimum total amount of feedback collected for each course should be 30. Three courses (C004, C007, and C008) did not attain this requirement and were therefore left out during the data analysis.

Results

Interview with Course Instructors

The qualitative interview data was analysed with the help of the General Inductive approach[25]. Using this approach, the researchers analysed the data by reading the interview transcripts carefully to find common themes and concepts. To derive these themes and concepts, a six-step process from Braun and Clark was adopted[26]. The six-step processes are:

1) Familiarizing oneself with the data
2) Generating initial codes
3) Searching for themes
4) Reviewing themes
5) Defining and naming themes
6) Producing the report

After analysing the data, the researchers generated both open and axial codes. Open codes summarize the quotes from the raw data while axial coding further categorizes the open codes. In the third step of the three-stage process, themes and selective codes were identified.

Before the start of the COVID-19 pandemic, all eight course instructors conducted their class in-person. Only one course instructor (Instructor H) had some experience with conducting flipped classroom. In the case of Instructor H, they conducted all their classes in-person and recorded and uploaded the lecture sessions to LumiNUS for the small number of students who could not attend the lecture, allowing these students to watch the videos on their free time.

During the pandemic period, six course instructors conducted their classes synchronously using the Zoom conferencing software. They shared that during the online teaching sessions, they taught the class in the same manner as though they are teaching in in-person session. Two other course instructors (Instructors B and G) taught their classes asynchronously conducting flipped classroom. In

this flipped classroom format, both Instructors B and G uploaded their pre-recorded lectures videos online for their students to watch in their free time before attending the synchronous tutorial sessions conducted on Zoom.

Six course instructors preferred to conduct their classes in a physical classroom while the remaining two course instructors indicated no preferences in teaching online or in-person. The most common reasons cited by these six course instructors are that students tend to pay less attention in online classes and appeared more distracted, and the instructors also perceived lower students' participation during online classes. Table 2 summarizes all the reasons these six course instructors provided for their preference in teaching in-person, as well as some representative quotes given by the instructors during the interview. For the remaining two course instructors, they felt that both online teaching and in-person teaching are equally effective in educating students. However, these two course instructors also noted that if COVID-19 pandemic did not occur, they would have returned to giving in-person classes as this was the de facto method of instruction.

Table 2. Reasons some course instructors preferred teaching in-person.

Why course instructors prefer teaching in-person	Representative quotes	Number of responses[a] (*N*=6)
Students pay less attention/are more distracted online	"Online, it's very easy for them to get distracted. The majority of people are like that, it's just human nature."	3
	In-person, it's easier to establish communication with the students and to keep them focused.	
Difficult to get feedback from students	"Teaching in-person gives me the ability to see the students' facial expression and how they respond to my lecture. The feedback on whether they are following is an advantage."	2
	"when I teach in-person, I can gauge students' understanding from their expressions and address any issues immediately."	
Lower student participation	"Students don't participate. They don't turn on their videos (webcam). Hardly anybody participates in discussion."	3
Students tend to skip online lessons	"I record my lectures and upload them, but this encourages students to skip class."	2

Despite most course instructors indicating a preference for in-person teaching and they had the option to continue applying this mode of instruction since their class size was below 50, only one instructor has returned to teaching in the physical settings. When asked by the interviewers why they continued to conduct online classes even if they had the choice, many of the interviewees cited "health" reasons as the main reason as they are aware of the potential health risks involved if conducting physical lessons. Table 3 summarizes the reasons provided by the course instructors for continuing to conduct online classes.

Table 3. Reasons some course instructors continued to teach online.

Reasons for continuing to teach online	Representative quote	Number of responses[b] (*N*=8)
Health reasons	"I was more comfortable teaching on Zoom because of COVID danger."	3
	"Many people were getting medical exemptions and health warnings. We would not be able to get all students in class all the time."	
Students opt for the online option when it is available	"We are encouraged to do hybrid if class is in-person. But almost all students opted for the Zoom option."	2
	"The rules keep changing… Maybe the next day everything has to go online. Until they have clear set rules, I will still go online because it is more certain for the students."	
University/Government Policy	"A lot of it depends on the University – what's the stance on how to approach the post-COVID environment? If the university were not so worried (about) COVID anymore, then I would do it in-person. So, I think it's more policy."	2
Convenience	"Teaching hybrid is too troublesome."	1

[b]There were only 8 qualitative responses that could be coded into the four categories of reasons.

As the pandemic also resulted in difficulty in conducting examinations due to the implementation of COVID-19 restrictions, the course instructors were asked what changes they have made to their examinations. Table 4 below summarizes the changes that they adopted in their course assessments.

Table 4. Changes that instructors have made for their examinations during the pandemic.

Changes in the conduct of examination	Representative quote	Number of responses[c] (*N*=7)
Status quo/Sticking to in-person examinations	"It's essentially the same because I managed to have face-to-face exams throughout covid. There is no difference in what I have done"	2
Online examinations conducted but no change in the examination format	"Online examination, students submit onto LumiNUS. Same types of questions were asked."	2
Online examinations but changes were made in the format	"There used to be a written component, right now it's all MCQ (Multiple Choice Questions)"	2
Reduce weightage	"I decreased the weightage of the final examinations because I sensed that average or below average students might learn less. I also received unclear or ambiguous signals that the weightage of the final examinations should be lower for online classes."	1

[c]One of the eight instructors decided to do away with the final examinations completely. Thus, the number is less than 8.

Finally, the course instructors were asked about the support that was provided by the university in helping them in transiting to online learning during the pandemic. Table 5 summarizes the support that the university had provided to them.

Table 5. Support that university provided to course instructors in helping them conducting online teaching, as well as areas in which they hope university could provide more support in.

Support given by university	Representative quote	Number of responses (*N*=8)
Technological infrastructure	"The platforms that we used for recording like LumiNUS or Zoom."	4
	"You already have the infrastructure in place. LumiNUS was already there. You can do quizzes online."	
Conduct of examinations	"We are given a lot of instructions on how to conduct online examinations."	4
Training/Equipping	"They have conducted workshops to make sure it become very friendly to us."	3
	"Emails about some good functions on LumiNUS, how to do class polls etc."	
Technical Support	"CIT (NUS Centre for Information Technology) helped me a lot. Last lecture, there were some glitches, and the Zoom lecture did not come out (no output). I approached them and they immediately helped."	1
Equipment	"At the department level, quite a few lecturers requested for tablet, and the university supported them."	1

More Support Needed	Representative quote	
More tailored training and equipping	"It is not obvious if blended learning works for a Physics lecture at Level 3 (third year undergraduate level), for example."	2
Technical Support	"Pre-recorded lectures are difficult. Who is going to do it?"	2

Course Feedback

Upon obtaining the students' course feedback for the five academic years as mentioned in the preceding section, the researchers grouped the data into two categories – feedback that were given prior to the pandemic (called "Before COVID"), and feedback given during the pandemic (called "After COVID"). For each course, the means, and standard deviations of the rating for all Likert items were calculated and grouped according to the academic years.

A two-tailed Welch's t-test at 10% level of significance was conducted for each course to determine if the difference between the mean Likert scores for Before COVID and After COVID were significant. The result of the Welch's t-test is shown in Table 6 below.

From Table 6, negative values imply that the mean Likert rating for After COVID is lower than Before COVID. Numbers that are in bold give the corresponding p-value that is less than 0.1.

Table 6. Results of the Welch's t-test. The numbers bolded represent values whose corresponding p-value is less than 0.1.

Survey Questions	Modules					
	C001	C002	C003	C005	C006	C009
C1	-0.16	1.03	-0.44	**3.18**	**-3.32**	-0.57

C2	0.28	-0.84	0.58	-0.53	-0.90	0.32
C3	0.29	**-1.84**	0.51	0.79	-0.35	-0.05
T1	0.19	0.05	0.06	**1.85**	**-2.57**	-0.17
T2	**1.66**	0.61	0.04	**2.89**	**-2.35**	0.17
T3	0.21	0.48	0.40	**2.60**	**-1.97**	-0.90

Discussion

Instructors prefer in-person teaching

Most course instructors interviewed indicated that they preferred in-person teaching compared to online teaching. Many of them felt that students are more likely to be distracted during online classes, and the authors hypothesized that this distraction could arise due to students multitasking online such as texting their friends while attending the online classes. Indeed, numerous literatures have revealed that students are often distracted during remote learning[27–30]. Some of the common sources of distraction includes sending online messages[31], checking notifications[32], as well as distractions from noisy environments[33]. In addition, students often did not turn on their webcam during online synchronous classes due to myriad of reasons such as being self-conscious about their appearance, and privacy[34,35]. As a result, many of the course instructors interviewed expressed their frustrations in not being able to see their students' facial expressions to gauge their level of attention.

Another common reason cited by the course instructors for preferring to teach in-person was that students tend to participate less during online classes. The course instructors mentioned that students hardly turn on their webcam and participate in class discussions. According to Garrison's Community of Inquiry Framework, to have a conducive educational experience for students, three presences – Social Presence, Cognitive Presence, and Teaching Presence – must exist[36]. Social Presence – the ability for the learning community to establish themselves as a fellow human being by projecting their own personalities[36] – is usually negatively affected in online classes as students find it difficult to interact with their peers[37]. As a result, this could lead to a reduction in motivation among students, which could possibly lead to them not wanting to participate actively in class[38].

Online teaching as pandemic pedagogy

Although many of the course instructors expressed their preference for in-person teaching, many of them continued to teach online despite being able to conduct face-to-face teaching. The primary reason cited by the course instructors for continuing online teaching as the pandemic pedagogical approach is "health". It is understandable that course instructors are aware of the health risks involved as back in 2021 – 2022 when this study was conducted, Singapore was still in the relative early stages of vaccinating citizens against COVID-19 as the first vaccine batches of vaccine from Pfizer-Biotech, and Moderna, arrived in the country[39,40]. Thus, it is understandable that the course instructors were wary about the health risks involved if the course instructors continued using in-person teaching. In addition, early in the pandemic period, Singapore took on a more cautious approach in stemming the spread of the coronavirus by advising the population to quarantine themselves should they come into close contact with people infected with the virus[41,42]. This means that if anyone living together with the students got infected with the virus, the said student must isolate themselves and not go out. Thus, to minimize any disruptions to the class and prevent anyone from missing out on the lessons, course instructors would have to do online teaching even though their class size met the criteria set by the university to do in-person teaching.

Changes in Assessments

Besides shifting teaching to online, course instructors also had to change the way they conduct their assessments. Out of the eight course instructors interviewed, one of the instructors (Instructor F) did away with assessments completely and replaced it with an essay on a given topic which students were to write about. Seven other instructors continued to incorporate assessments in their course. Two of the course instructors did not make any change to the way they conduct their assessments and continued to do in-person tests.

Four other course instructors interviewed conducted the assessments online. Even though all four instructors conducted the online assessments by uploading the examination questions onto LumiNUS at a specific timing and did the proctoring via Zoom, there are some differences in the assessment format. For instance, Instructors B and H felt that conducting online examinations may make proctoring difficult which may affect the integrity of the examination's conduct. Thus, they made some changes to the conduct of the assessment such as changing all question format to multiple choice question format and randomizing the order of those questions for each student, to making their assessment an open-book test respectively. For Instructor H, even though they adopted an open-book test where students could access any reference books they wish, questions that were being asked in the assessment could no longer be answered by memorizing facts. Instead, students had to employ higher order thinking skills using the materials from the reference books, thus making their assessments more challenging. The strategy of incorporating higher-order thinking questions was similar to one of the suggestions made by the members from the Association of Pacific Rim Universities (APRU) where they promoted asking open-ended questions that discourage students from regurgitating facts that they have learnt[43]. These higher-order thinking questions will force students to apply, analyse, and evaluate course materials learnt – cognitive domains which sits in the higher hierarchy of the bloom's taxonomy[44]. These cognitive domains may help students to boost critical thinking and reinforce the skills that were acquired previously in class[45,46], this may even help students in knowledge retention. Instructors A and D did not make any changes to the assessment format even though they have conducted them online.

Support provided by the University

When asked about the support provided by the university to help them ease the transition to online teaching, most of the course instructors interviewed cited the university's technological infrastructure as adequate. The course instructors particularly praised the functionalities in LumiNUS such as ability to conduct quizzes and support for multimedia as one of the important features that helped them to transit to online teaching easily. Another support that the course instructors frequently cited was the university's support in helping them to conduct their assessments. Course instructors were appreciative of the university's proactiveness in sharing with the instructors some of the various strategies and tips on conducting online examinations. However, some course instructors felt that the university could have provided more tailored support in helping course instructors in teaching their curriculum. For instance, two course instructors were not sure if blended learning was appropriate for teaching third year physics courses. Other course instructors felt that pre-recorded lectures were difficult to do.

Overall students' feedback

As shown in Table 6, most courses had no significant differences between the students' perception of the course as well as teaching efficacy before and after the pandemic. However, C006 experienced a statistically significant decrease in students' opinion of the course (C1) as well as poorer perception of the instructor's overall teaching efficacy (T1 – T3) during the pandemic despite the course instructor perceiving a higher student participation online. For this course, the course instructor conducted flipped classroom by uploading pre-recorded lecture videos online and conducted tutorials synchronously during the first academic year since the start of the pandemic. In the following academic year, the same course instructor converted all their classes to synchronous online teaching via Zoom and insisted their students to turn on their webcam during the session. The researchers could not explain why this change

would result in adverse effects on the overall course opinion, as well as the teaching feedback. Furthermore, the researchers were skeptical if insisting students to turn on their webcam alone would cause students to give negative ratings for the course feedback.

C005 experienced a statistically significant improvement for the mean students' overall opinion of the course (C1), as well as for all aspects of the course instructor's teaching efficacy (T1 – T3). This course places a strong emphasis on students' participation by making it 40% of the overall course grade. The course promotes students' participation by first dividing the student population into different groups. Each group was then tasked to present on the research paper or topic during the synchronous online session on Zoom to the other groups. Like a peer review, each of the non-presenting groups would then ask the presenting group questions or provide critique. The course instructor noted that even though a minority of students were actively asking questions, there seemed to be some increase in the students' level of engagement compared to other sessions when the instructor was teaching didactically. The researchers posit that through the incorporation of active peer discussion in the form of class presentation and peer review during the online session, this helped to foster a learning community and enable the students to check their understanding, coming up with new ideas, as well as self-reflection[47,48]. These would in turn increase students' motivation and could lead to higher perceived teaching efficacy as well as improved students' overall course opinion[49].

Limitations of the study

One limitation of this study is that for the students' course feedback, the researchers did not analyze the qualitative feedback given by students. Analyzing the students' qualitative comments would have enabled the researchers to gain better insights on students' emotions and feelings regarding a particular course. These insights would then help the researchers to explain why C006 experienced a statistically significant decrease in students' course opinion as well as instructor's teaching efficacy during the pandemic.

Conclusions

The researchers conducted interviews with the course instructors from the Physics and Chemistry Departments to garner their perspectives on how they had adapted to online teaching, and their opinions on online teaching. Furthermore, the researchers also made use of the university's data lake to analyse students' course feedback. While instructors expressed a preference for in-person teaching, prioritizing safety when class sizes exceeded the limit reveals the complex factors influencing their online teaching choices. Students generally maintained positive perceptions of courses and instructors during the shift, with two exceptions demonstrating statistically significant changes. This suggests that online learning can be effective when tailored to specific contexts and challenges. The data lake, beyond offering valuable insights into instructors' experiences, provided a unique window into student adaptation, revealing hidden trends and potential areas for further investigation. This study demonstrates the importance of the application of the institutional educational data lake in understanding the complexities of online learning, paving the way for future evidence-based research and development of effective teaching, and learning strategies.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Learning and Analytics Committee on Ethics (protocol codeL2021-09-01, a departmental ethics review committee endorsed by the National University of Singapore's Institutional review Board and approved on the 11 November 2021).

Conflict of Interest Statements

The authors declare no conflicts of interests.

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