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Online Delivery of Discussion-Oriented Postsecondary Classes during Critical Health Scenarios, Educating Responsible Computer Scientists towards Improved Societal Trust in Artificial Intelligence

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Abstract

This paper discusses how upper year postsecondary computer science students being educated on social responsibility and AI ethics may benefit from online options for delivery of classes, within discussion-based courses. We reflect on the relationship between empathy, AI social responsibility and online learning, including insights provided by published work on these topics. We draw insights from a course offered in Spring 2022, where students had the opportunity to experience both in-person and online classes, when being educated on social implications of computing. Included are a few recommendations for future efforts to support online classes during times of critical health scenarios.

Keywords

Online Learning, Postsecondary, Social Responsibility

1. Introduction

In Spring 2022, a discussion-oriented upper year course for computer science undergraduates at a university in Canada provided opportunities for students to experience both online classes and in-person classes. At this time, the World Health Organization considered Covid-19 to be a worldwide pandemic (World Health Organization, 2020). Students were asked to reflect on the differing modes of delivery and their relative benefits and disadvantages. This was done

both through survey polls during an online class on ethical responsibility of computer scientists and with a component of the final assignment for the term (a written essay). We report on some of the opinions that circulated at that time.

Our key observations include the following:

1) Students greatly preferred being able to avoid face to face contact with in-person classes, for times when the spread of disease was significant.

2) From their experiences with online classes that were focused on discussion of the topic of the week, guided by the instructor, anchored in readings of the week, the students concluded that the course would function well if circumstances required it to be online only.

3) Some students saw the value in including some classes which were delivered in person, in order to enable greater opportunities for supporting new and ongoing social relationships.

4) Some students saw the value of supporting an entirely online offering of the course, to promote inclusion of those for whom in-person attendance was a challenge or for whom online was simply a strong preference.

The subject matter of the course was the social implications of computing. As such, the students were focused throughout the term on such relevant issues as: the digital divide (so recognizing the need to care about segments of society that were disadvantaged in some way) and the ethics of computer science and AI (realizing that one's personal preferences for operating should not prevent more generous attitudes towards the greater social good, recognizing the need for fair and unbiased solutions that are released to the public).

In this paper we describe the course and its requirements, as well as the computing infrastructure used to support online delivery. We then explore in specific detail the final assignment in the course, which required students to examine the two extreme options for postsecondary education in the 21st century, online vs in-person, in order to reflect on the relative benefits and concerns of these choices. We gained insights into some of the inherent preferences of students for the course if Covid had not been a concern. We also learned of some challenges to be addressed in order for online delivery to be successful. We outline some of the more interesting suggestions that were made during the term and provide additional reflection on what may be best, for the future.

One exercise in this course during the term (run as a kind of Town Hall) required small teams of students to assume opposing positions, composing written position papers posted on a newsgroup for the class to see, followed by oral presentations to the class, responding to audience queries; afterwards, those on the opposing teams were asked to gather and produce a joint statement, posted to a class newsgroup, revealing where they felt the best opportunity for common ground would lie. We explain how a Town Hall on Postsecondary Education helped to frame the discussion of the students regarding online learning. We also use the Town Hall component of the course in order to illustrate our key conclusions. Some of the more valuable commentary provided by the students is revealed and forms the basis for our final reflection towards recommended next

steps with postsecondary teaching in the time of Covid. The perspective of some of the course's teaching assistants is also integrated, towards our concluding remarks.

We observe that many postsecondary establishments are promoting in-person classes due to their belief that this would be the primary preference of the student body (Drea, 2021). This has been promoted, regardless of the state of spread of Covid. We hypothesize that some of the conclusions offered to date have been formed with a view to courses where instructors are lecturing and students are primarily listening, interjecting with commentary on an infrequent basis. A discussion-oriented class necessarily involves considerably more transmission of speech (Dhaniyala, 2020) (which has both increased health challenges and related concerns with being heard properly through masks (Spitzer, 2020), when these are advised as a safety precaution). The course in question during Spring 2022 also had twenty percent of the course grade dependent on class participation. While there were allowances to excuse those unable to attend due to illness, at least some students concluded that having an entirely online option would greatly assist in fairly supporting participation from everyone.

Our conclusions tease apart the parameters which make certain postsecondary courses ideally suited to online delivery and why, and then where challenges may exist for other kinds of course material. As a backdrop for this discussion we also summarize some existing research on postsecondary education in the time of Covid, pointing out that some of this analysis is more directly aimed at a lecture-style delivery and for courses that do not specifically focus on instilling empathy for others and the theme of social responsibility.

The paper is organized as follows. We first provide some clarification of the discussion-oriented computer science course that is in focus for our exposition on online delivery during Covid. We then present reflection on the modes of delivery used, from the perspective of the students, instructor and teaching assistants. Following this, we delve into the topics of empathy, AI responsibility and online learning, both as experienced in the course in question and as studied more generally by researchers. The ending of the paper highlights primary recommendations and conclusions, offering suggestions for the future for online delivery of courses during healthcare challenges. Final remarks emphasize the very special role served by educating students on responsible artificial intelligence and include a look ahead to online delivery beyond the Covid pandemic.

2. Outline of Course in Focus for Our Discussion

The Spring 2022 term consisted of 12 weeks of classes. The course was split into two sections, one at 8:30 am and one at 9:30 am, meeting three times a week for one hour each time. Each section had roughly 50 students. Nine of the dates were used to run the Town Hall exercise, with a different issue in focus on each of these dates. Most the remaining classes were open discussions on a topic of week, where students were expected to read specific papers on that topic prior to

coming to class; these were all identified in a course timetable. One of the Town Hall topics was listed as being run online; the others were organized to be in-person activities. For a few of the weeks that term, the discussion of the topic of the day was arranged to be online only. In the section with Teaching Assistant reflection, below, we explain further the technology that was used for the modes of delivery, and some areas of concern with this.

The course was intended to educate upper year computer science students on the impact of computerization on society. In addition to class discussion and presentations, students also completed written essays or short-answer reflections on the topics of the week, as part of their learning experience and assessment.

2.1. Town Hall on Postsecondary Education

Although each time the course is offered the instructor has the latitude to cover different subtopics of interest, the question of whether postsecondary education could be successful as e-learning is one topic that has been included in the course curriculum for more than 15 years, in the Town Hall format. One side of the discussion contended that appearing in person to be educated was no longer necessary; the other claimed that this was still essential in order to be an effective learning experience. For the Spring 2022 offering of the course, this Town Hall had different presenters in each of the two sections and thus somewhat different conclusions about where a common ground might lie between the opposing views.

2.2. End of Term Reflection

By the end of the term, students had experienced several Town Hall encounters. In order to promote active participation in these classes, students were asked to reflect on their enjoyment of this component of the course for their final assignment. They were then tasked with offering specific commentary on the Town Hall concerning E-Learning for Postsecondary courses (and how technology enables this option for teaching). We were interested in learning which of the two opposing views they tended to side with. This group of students was especially well positioned to comment, having experienced both modes of delivery that term (in-person and online).

3. Observations and Discussion from Course Reflection on Modes of Delivery

3.1. Survey Results and Discussion

Prior to the end of year discussion on the varying modes of delivery, a class much earlier in the term that was delivered online conducted polls for students to reflect on whether this particular course should be run online if health concerns were significant and also whether this course was one which could succeed if it were offered online. It was quite telling that this survey was conducted in a class devoted to the topic of Ethical Behaviour of Computer Scientists. The spe-

cific questions asked were:

- Would this course succeed if it had to be online?
- Would you prefer this course to be entirely online if the pandemic continues?
- Would you prefer this course to be entirely online if where were no pandemic?
- Would you prefer this course to be entirely in person?
- Would you prefer this course to have both online, in person?

We learned that 79 percent of the students polled felt that the course would succeed if it had to be online, 70 percent preferred this course to be entirely online if the pandemic continued, 55 percent preferred the course to be entirely online if no pandemic, about 58 percent preferred the course to be entirely in person and 65 percent preferred the course to be both online and in person. The most enlightening conclusions were that the course as constituted could function well online and that there was some reticence to meeting in person during Covid, even though having some in-person classes seemed to be desirable to most students.

3.2. Online vs. In-Person Options

The feedback provided by students when asked about their views on online vs. in-person learning for postsecondary at end of term revealed a few common themes.

One conclusion is that online delivery provides valued protection against contracting Covid. Without the requirement of being in close contact with peers, regardless of the protocols at the time regarding the wearing of masks, students at least have options to distance themselves from others, when online. Student opinions expressed this view as helping to be online if there are time conflicts or illness; health and convenience benefits of being online; Covid and living far away making in-person classes very difficult; a safer environment provided online; online classes being more flexible for health; and accessibility options made available to students when online. From these observations, students then extended their thinking to also comment on being able to attend classes while looking after family members; improved opportunities for time management; avoiding a commute; less stress and better overall mental health when in-person not required; far more productive start to the day (since the class times were early in the morning); and the empathetic comment that we should be allowing equal opportunities for all students, regardless of their personal difficulties.

The course was arranged so that students who were experiencing illness were asked to inform us and to stay away from class. A newsgroup was consistently available which allowed students to provide commentary on the readings of the week, outside the class setting. This was the environment in which the students were being educated and from which their viewpoints regarding online learning were expressed. One observation as well was that at the time that this course was offered, students had been required to learn exclusively online for a couple of the

terms since the pandemic first appeared. While this likely caused several students to wish for increased opportunities to attend in person, this also provided students with additional insights into the challenges faced by their community with respect to protection of their health.

In this course, students were consistently being asked to reflect on the use of computers today within society, the possible benefits and the areas of concern. Although the final assignment did not explicitly invite commentary on the role of online connections in today's business environment, one observation raised by many was that enabling opportunities for online discussions would be very productive, towards providing experiential learning for tomorrow's technical workforce. Impressions raised here included: the fact that computer science jobs function well online and there are expectations for this community to stay up to date with new technologies, with a view by some that there is a real opportunity at the moment to explore how virtual reality technology can be used to simulate in-person experiences, towards improved work environments. There has been a rise of remote work (Phillips, 2020), increased use of virtual presentations (Hacker et al., 2020) and a need to keep employees attentive (Daniels et al., 2022) in order for these experiences to be productive. Promoting more online education for upper year computer scientists thus allows this generation to be well-positioned to thrive in the 21st century workforce. Additionally, tomorrow's tech leaders are provided with first-hand opportunities to gain insights into the requirements for designing the kind of new technology required for all of us to benefit from online communities. This includes novel directions for collaborative groupwork systems (Chakma et al., 2021). We had a discussion one week on the effect of the pandemic on society and explicitly reflected on how computing infrastructure has to be kept robust; continuing the effort to enable valued support for today's global online connections is an important social responsibility for computer science professionals.

While there appear to be important reasons for supporting online delivery of discussion-oriented courses with respect to safety and equal opportunity, as well as to enable a breeding ground for the development of valued technology for tomorrow's workforces, there are also practicalities which must inform decisions about educating postsecondary students. Reflection on the in-person experience yielded particular insights. One issue with the course in Spring 2022 was the fact that the classes were scheduled at 8:30 and 9:30 am. Saving time travelling to the university (requiring an even-earlier start to the day) was one real consideration. The timeslots for our courses are only decided a couple of months before the term starts, so that teaching decisions about the mode of delivery need to allow for all scenarios. Another factor was the reality of the in-person classes, with masks and some ingrained effort for distancing; for some students this posed challenges in being able to effectively hear all of the comments being made by peers, thus favouring instead an online opportunity.

In order for the online classes to run smoothly, other practical considerations arose. The classes where discussion took place online-only in this course used

the video conferencing platform Zoom (with support of chat and breakout rooms). One key concern was the fact that most students opted to keep their cameras off during the virtual classes which ran discussion of the top of the week. Initially, cameras there was no strict requirement for cameras to be on, in order to be as supportive as possible of differing personal challenges for attending (with some students really being ill but still joining the class) and to align with some of the course's central themes of allowing for more privacy in today's computerized world. At one point, it became clear that cameras being on would foster a far more personable, social experience for the class, and would bring us closer to the in-person community that at least some students desired. But when invited to turn cameras on, even with the class where this was to take place having some explicit advertising the week prior, the response rate for cameras on when the class arose was very low. When asked to reflect on the value of online learning for postsecondary discussion-oriented courses, several students explicitly commented that requiring cameras to be on would have greatly improved the experience. We reflect further on this aspect of online for postsecondary education in the recommendations section of this paper.

Other challenges arose for those online classes where discussion with students was organized in a way that asked for initial brainstorming conducted in small breakout rooms (with random placement of students). This style of learning was the arrangement in place for those classes aimed most at eliciting entirely novel proposals, created by the students. This was done for instance for one class where the topic was examining the origins of gender imbalance in computer science, with ideas on how to improve this balance in the future; this was also done when reflecting on benefits and drawbacks of video games and effects on youth. Having breakout rooms online offered very valued protection during the time of the pandemic (where in-person small group gatherings would have had very little chance for distancing for safety) and the really inventive ideas coming out of these classes made these particular classes especially enjoyable to students. But some comments made afterwards suggested that certain breakout rooms were far more productive than others. While the aim was to avoid impositions on students as they expressed their true thoughts, some modest monitoring of the groups by instructors may have assisted; this point is visited in the recommendations section of this paper.

There were differing opinions about whether opportunities to join the discussion of the topic of the day improved or were less welcoming, with online classes. One observation was that the attendance for online classes was much better, yielding a more varied and valuable exchange of perspectives. Others felt it easier to contribute, when invited to do so; in-person classes required raising one's hand, being chosen (or being told that they would soon be chosen) whereas all hands raised, in a Zoom call were definitely registered with the instructor leading the class. For those with social anxiety the online environment was more welcoming. On the other hand, some students joining online with cameras off found it easier to be distracted, in their home environment. Many enjoyed the

physical presence as a stronger social community, enabling direct friendships to be fostered. Some also felt that seeing the facial expressions and hearing the general laughter in person encouraged them to join in the conversation, more often. In the recommendations section we suggest a step forward to provide the online environment with a greater sense of peer engagement.

The Town Hall component of the course was one with arguably the greatest opportunity for acquiring a feel for "community", as it was meant to simulate a public gathering. This is why the course attempted to run these particular classes in person, from the start of term. However, when the extent of illness is too great, it is difficult to continue to run these classes as well (speakers who are ill being requested to remain at a distance, audience members who would like to listen but are unwell simply losing out on the opportunity). We felt from the start that trying to stream these particular classes would be challenging: for one, there might be only a tiny audience left in person if the option were given (and enabling that valued social community would be compromised). Another issue was adopting the best technology so that hybrid delivery was seamless. We reflect further on this topic in the section of the paper devoted to insights gained by teaching assistants. Suffice to say that for those who felt allowing both online and in-person classes to run during the term would be desirable, the reality was that, on the basis of health concerns alone, this wasn't always feasible.

This course typically includes at least a couple of guest lecturers. With online delivery, we were able to listen to a experts discussing eclectic and interesting topics (support for technology in rural areas, the current needs of older adults online), both coming in from a very far distance where in-person travel would have been prohibitive. Some students explicitly endorsed the continuation of online opportunities to benefit from learning from international luminaries.

The fact that during one of these guest lectures there was a massive technology fail within the province of course didn't help; this simply confirms that online does require properly functioning supportive networking, as a companion concern. What happened for that lecture was that many students, the instructor and the speaker were able to attend without any issues; others who had wanted to be online were unable to. While the guest speakers did inject a healthy complement of exchange with students, leading to discussion and participation, the lecture style, with slides, lends itself to some recording for posterity. This suggests other recommendations in support of effective online postsecondary classes, explained in more detail towards the end of this paper.

4. Teaching Assistant Perspective and Commentary on Technical Component

Teaching assistants were able to observe, first hand, the dynamics, engagement and functioning of those classes devoted to running the Town Hall exercises. A class devoted to discussing whether to Limit the Use of Intelligent Software was held early in the term and run entirely in person. The teaching assistants observed that the question-answering portion of this class had a natural flow, with

additional participation progressing effectively, as students noticed other classmates who were offering to pose a query to the teams.

Prior to this, one Town Hall on the important topic of Responsibility for Displaced Workers was run entirely online. The teaching assistant charged with assessing the value of the participation from each student in the class observed that the engagement in the online Town Hall was slightly easier to manage than in person because participants could "raise their hand" on Zoom and form a virtual queue. The student charged with grading the presenters that day, ensuring that there were sufficient questions from the audience as part of their task, noticed perhaps a bit more reticence from students to pose follow-up queries. In general, however, the conclusions of the teaching assistants who were running this class was that the format was successful, the presenters were heard effectively and the students who formed the audience still had good opportunities to demonstrate their skill in thinking on their feet, to react to the comments from the teams.

While the intention was to run all of the Town Halls scheduled during the last month of the term as in-person exercises (indicating that the class could proceed, as long as the teams on each side had at least one healthy presenter to talk on that day), the number of exceptional cases grew, and we migrated to a hybrid mode of delivery. There were a few different choices for running this technology and the teaching assistants progressed from one option to another. In both cases, the students (including the presenters) could attend the Town Hall session in person or via a Zoom link. Students attending in person were encouraged to also join the Zoom link from the classroom. On the day of the Town Hall, the Zoom meeting was projected on two screens in the classroom through a teaching assistant's laptop, and to prevent any echoing, all students on the Zoom were instructed to mute themselves. The in-person presenters in the audience spoke through the dedicated laptop, and students in the audience who were in person either spoke through the device they used to connect to the Zoom session or the teaching assistant's laptop. The first hybrid session received an overall positive response from the students; however, there were a couple of issues pertaining to the lack of an electronic speaker in class and the reluctance of some in-person audience members to walk all the way to the teaching assistant's laptop to ask a question. So, in the subsequent hybrid sessions, a microphone was used to amplify the laptop's output during the presentation, and the same microphone was passed to the audience members in class. For our course in particular, the teaching assistants had to make fairly quick decisions about the technology to be used, as they were responding to an evolving scenario of concerns with student health. In retrospect, alternative methods for enabling students to be at the class either from the classroom or at home could have been attempted, as well.

One Town Hall with hybrid delivery was on the topic of how to address Digital Misinformation. The teaching assistant in charge of running that Town Hall and judging the value of the presentations felt that this particular class was smoother than other hybrid sessions. They recalled that both groups acknowledged the spread of misinformation as a concern. Each side also recommended

solutions including enforcing legislative rules to counter the behavioral algorithms of social media platforms. The fact that all these arguments were remembered by the teaching assistant several months after the class in question lends support to the claim that the talks were sufficiently clear and engaging.

That being said, the other teaching assistant, tasked with evaluating class participation, had additional recollections of the experience. Establishing proper two-way communication between everyone in the classroom and everyone who joined remotely was difficult technically in part because not all students in the classroom had a laptop; so, this was not entirely a truly online town hall. They remember as well that when students had to ask questions, coming to the front of the class, often these questions had to be repeated or they were misunderstood. All of this resulted in slightly lower participation (in terms of the number of questions and quality of the subsequent discussion).

5. Empathy as a Factor in Considering Online Learning

We begin with a few comments on how empathy was an undercurrent in the course that we are describing in this paper. One of the earliest open discussions in the class was on the topic of the pandemic, and where challenges were introduced for society due to the increased dependence on technology for daily operations. We reflected on which segments of society were most disadvantaged and on a topic that this particular group of students were especially well-positioned to discuss, the shortcomings of the technology being used. This was perhaps the first opportunity for the class to immerse themselves in caring about the lives of those around them. We have already mentioned a topic of ethical behaviour of computer scientists that was introduced as a hands-on thinking exercise, reflecting on how to act in a series of fictitious scenarios. There were varied opinions on how to divide one's loyalties to one's employer and to the users of their software products, when there might be troubling effects of the technology being launched. But once more, consideration of how others may be feeling was front and centre.

The topic of Artificial Intelligence had a showcased role within the course as well. Early in the term, the students were tasked with imagining how AI Ethics could best be taught to upper year computer science students; some very creative ideas were proposed, including role playing exercises. At a later date, the Town Hall on Artificial Intelligence arose and allowed students to revisit their earlier reactions to both Ethics and to AI, in considering whether it was possible or necessary to impose specific restrictions on the use of AI today. This entire exercise was an important step forward in imagining how trust in the use of Artificial Intelligence can be sustained. As such, we began a continuum of thinking from empathy to the broader concern of social responsibility. Throughout the course, the students were challenged to not only identify areas of concern but also to propose concrete recommendations for new actions and agendas, in order to enable positive change for society. As computer scientists, they were able to out-

line detailed suggestions for how the technology should be designed and run. Since the students in the course could one day become either the designers of this artificial intelligence technology or those running their own organizations, using AI to drive decision-making, the greater appreciation for dilemmas surrounding this topic helped to enlighten students about the need for trust in technology, as well.

Although our course had specific opportunities to be empathetic, it is important to note that researchers have observed more general changes in attitudes of caring from students subsequent to the onset of the pandemic. According to a study by Baiano et al., (2022) university students demonstrated improved affective (emotional) empathy one year after the initial outbreak of the pandemic (2022). This trait has been associated with greater compliance to lockdown measures such as social distancing, mask-wearing, and sheltering-in-place (Petrocchi et al., 2021; Karnaze et al., 2022). The study also found evidence of improved cognitive empathy—the ability to take the perspective of others—compared to pre-pandemic times (Baiano et al., 2022). Cognitive empathy has been associated with more rational evaluation of situations, lower levels of depression, and higher self-esteem (Green et al., 2018). Both cognitive and affective empathy are related to mindfulness, a protective factor from worry and anxiety during the COVID-19 outbreak (Baiano et al., 2022). These results suggest that increases in empathy may have yielded the important benefit of assisting individuals in coping with difficult times during the pandemic.

The role of online experiences in enabling more empathetic responses has also been studied at greater length as well. While empathy towards others enhances individual resilience amid anxiety, so does experiencing empathy from others (Afroogh et al., 2021). A study of pandemic social media use revealed that among those with high levels of anxiety, those who experienced greater social support online felt increased empathy, whereas those without social support did not experience significant changes in empathy (Qin et al., 2022). Given the ability of empathy to mitigate the harms of negative emotions, this suggests that online social support may help individuals handle anxiety in a healthy manner. The perception of emotional support is also enhanced by the dissemination of health information on social media (Zhao et al., 2021; Chung et al., 2021). As such, online technologies can be leveraged to extend both informational and emotional support to those distressed by COVID-19, increasing their experience of empathy and enhancing resilience.

In the Conclusions section of the paper we comment further on how the promotion of empathy within discussion-based courses contributes to the perceived value from online teaching.

A number of recent references also reveal the tremendous effort coming from the artificial intelligence community to support positive outcomes for society during the time of Covid. As noted in an AAAS report, the pandemic provided a unique opportunity to prove that AI could be harnessed for the benefit of all humanity (Harrus, 2021). Indeed, numerous AI applications have been created

towards a wide range of societally beneficial goals.

For instance, AI algorithms have been used in government-deployed contact tracing applications to help determine individual infection likelihood (Ahmed et al., 2020). They have also been used to integrate disparate data sources into large-scale COVID surveillance models, which may predict viral spread, simulate the effects of mass gatherings, and anticipate resource allocations required to support affected communities (Arora et al., 2021). Beyond population-level applications, AI has been applied to the diagnosis and treatment of COVID-19. AI-based models have been used to identify the virus in medical images and blood samples, often with greater accuracy than human analysis (Garg et al., 2020; Abbasi et al., 2022; Brinati et al., 2020). Multiple studies have also examined the use of AI in vaccine and treatment development (Zhu et al., 2021), noting the ability of these algorithms to screen millions of possibilities in a short time (Carpenter et al., 2018).

Knowledge sharing and communication have been other key aspects of pandemic life which have potential for improvement by AI, especially natural language processing. For instance, AI-powered chatbots have increasingly been suggested as ways to address public questions about COVID (Miner et al., 2020) and deliver telehealth appointments (Bharti et al., 2020), while the AI-powered, web-based COVID-19 Open Research Dataset aggregates COVID-related research for use by academics and the public worldwide (Condon, 2020). The detection and removal of harmful pandemic-related misinformation is another avenue through which AI applications currently yield social benefits (Ahmad et al., 2022). Overall, the field of AI has risen to the challenge posed by COVID-19 and demonstrated the ability of AI to enhance human wellbeing.

This supporting research on the increased profile of artificial intelligence during time of Covid serves to demonstrate that including a focus on this subfield of computer science in our particular course also had added value for the students. In our Conclusions, we provide final insights into this aspect of the teaching for our course, as well.

The students in this course had heightened awareness of the importance of being socially responsible computer scientists, along with several opportunities to become acquainted with what researchers in AI were attempting to achieve for society (as a specific case of what the path to being more empathetic and caring of others might look like, within our profession). Taken together with attitudes from the students that were supportive of online learning suggests that the environment was especially well suited for encouraging students to desire the protection of all vulnerable groups.

6. Related Work on Postsecondary Education during Covid

This paper reveals several reasons why online delivery may function very well for a discussion-oriented course for upper year students in computer science, one that has a suitable undercurrent of social responsibility. Related work on postsecondary teaching broadens our view.

Studies of postsecondary online learning during the pandemic have revealed varying outcomes for students in different environments. Previous research has identified the following major influences on student satisfaction: faculty-to-student and student-to-student interaction (Omar et al., 2021a), student self-sufficiency and proactiveness, ease of use of online learning platforms, student perceptions of course usefulness (Pham et al., 2021), and opportunities for engagement with course material in thought-provoking ways (Casanova & Paguia, 2022). In turn, student perceptions of course usefulness, also known as task value, are influenced by a student's sense of belonging in the academic environment (Han & Rideout, 2022).

Influences on student academic achievement in online courses often fall along the same thematic lines as the aforementioned factors of satisfaction, particularly as satisfaction itself is a predictor of achievement (Omar et al., 2021a). Better academic results, such as a higher GPA, are associated with task value among first-year students (Han & Rideout, 2022). They are also associated with a greater sense of belonging, the perception of empathetic faculty members, comfort with asking questions and participating in class (Han & Rideout, 2022), past experience with online learning (Ashida & Ishizaka, 2022), and student engagement (Omar et al., 2021a). This last factor is particularly relevant to the online learning environment, as students have frequently reported feeling less engaged and motivated in online courses (Simonova et al., 2021; Kelly, 2022).

This past research pointing to frustration with the lack of engagement in online learning was primarily focused on lecture-based, instructor-centered settings where students were only given brief invitations to ask a question or think of a comment (Simonova et al., 2021; Kelly, 2022). Two recent studies have shown the possible value of integrating more discussion between students into these environments. Yang (2021) carefully assembles student data from a private university setting for a course on language, and while they observed some hesitation among students to engage in discussion, the author also determined that greater academic success was achieved by those who participated more often on the online forum. Omar et al. (2021b) report on a course where groupwork was a significant component and suggest that meaningful connection between coursework and real-world applications would lead to greater student satisfaction during online discussion. Engagement levels and satisfaction may differ in online courses that are instead primarily discussion-oriented, given the importance of mutual, immediate, and direct student-instructor interaction for establishing a high-quality online learning experience (Mohammed et al., 2022); more frequent opportunities to critically examine course topics are of significant value.

There is indeed a different dynamic in courses that migrated online where the instructor would have been delivering a lecture, and there would be a good deal of silence from the students, save for asking the instructor an occasional clarifying question. During their final reflection on modes of delivery for postsecondary, students in our course also weighed in on best practices for other classes

they had experienced that were not discussion-oriented. Some pointed out the value of being able to play and reply the lecture, at their own pace. Others missed the opportunity to interrupt the instructor, when the class was not being run in real-time.

We can gain further insights into the value of online teaching by broadening the scope of our study to other kinds of postsecondary courses. Some past research which concluded that online delivery had been successful was either for professional disciplines such as dentistry (Zheng et al., 2021) or for graduate-level seminar-based courses (Omar et al., 2021a; Casanova & Paguia, 2022) which were more heavily focused on having students present existing research. Some graduate students mentioned social coping strategies for handling pandemic-related stress, such as communicating with peers through technology, engaging with their own students, and finding adequate time to connect with others for emotional support (Kee, 2021). This aligns with the aforementioned findings which show positive correlations between social interaction and student wellbeing, collaboration, and achievement (Omar et al., 2021a). Students themselves often become aware of this relationship over time (Han & Rideout, 2022). Some found even find it easier to seek help and ask questions in the online format, as typing questions in a chat during an online class felt less intimidating than speaking out loud in a face-to-face classroom (Zhang et al., 2022; Zheng et al., 2021). Finally, a few studies of graduate-level courses showed that student acquisition of course content was comparable to content acquisition in the equivalent in-person offerings from before the pandemic (Ashida & Ishizaka, 2022; Zheng et al., 2021).

The work surveyed above which found that online delivery has been quite successful for professional disciplines such as dentistry (Zheng et al., 2021) or for graduate-level seminar-based courses, which were heavily focused on having students present existing research (Omar et al., 2021a) is quite insightful. The success of these courses connects well to the experience in our class because the same requirement of very active participation from students is expected in all of these environments. This leads us to some additional commentary in our conclusions about the dynamic between teacher and students in postsecondary classes and how this is an influence on the value of online delivery.

7. Reflection and Conclusion: Key Summaries and Insights

We conclude that the promotion of empathy in our course during the pandemic was one element that likely factored into support for online learning; that AIers are increasingly considering how their research can deliver social value at times of critical need (and that there is a responsibility for doing so) serves to heighten the sensitivity of upper year computer science students who are being educated about the implications of their discipline. When exploring in greater detail the literature about postsecondary courses during the time of Covid, we conclude that even if online wasn't always successful, research to date has not focused well enough on issues for courses that are discussion-based. It is perhaps not suffi-

ciently clear whether the theme of desiring face to face contact with peers would be equally relevant for courses that are not simply lecture-based. We suggest that with increased opportunity in courses to experience empathy, students may still emerge with greater buy-in for online teaching options. In the Recommendations section, we propose some steps for enabling some contact with peers, while still maintaining care for the safety of others.

A summary of our remaining key insights is as follows:

- online is needed at times;
- online is supported, especially for discussion and by responsible students;
- entirely online with cameras on seems ideal (camera component);
- brief appearances by instructors in online breakout rooms may assist;
- consider making use of the additional functionality of the online platform;
- alternate arrangements for technology failures should be anticipated;
- time of the course may be a factor for preferences of teaching method.
- at times of considerable illness, trying to support in-person options with hybrid classes may introduce new challenges that reduce the learning experience.

As a final nod to the power of artificial intelligence to inform the sensitivities of students in postsecondary computer science, we note that social welfare functions are studied within several artificial intelligence subfields, such as designing multiagent systems. There is debate about whether solutions should embrace utilitarian principles of the greatest good for everyone or egalitarian edicts of investment in repairing imbalances with the community of agents. It seems that alternatives such as these may permeate as well decisions for methods of delivery for courses during the time of Covid.

7.1. Companion Conclusions from a Student in the Course

While writing this paper to report our observations and conclusions, drawing from the experiences we had during the Spring 2022 term with this course, we sought to integrate as well some final reactions from the direct viewpoint of a student. The perspectives of the teacher and the learner, in combination, have been a common theme in this exposition. One student coauthor on this paper provided the following valued perspective about why online learning may be well supported by the class. They point out that not only were the students in the course upper year computer science students but also that many also had as well experience in industry, through a Co-op program at our university. This means that they already obtained significant exposure to online systems for handing in assignments, office hours with teaching assistants where screens were shared in order to debug assignments and also connecting to servers remotely in order to hand in those assignments. And many of them had engaged in virtual meetings with colleagues at work as well, resulting in additional comfort levels with connecting at a distance. As such, their viewpoints were likely different from students who were only in their first or second year of study.

The personal opinion of this student about the classes that were totally online and the Town Hall that ended up being hybrid also revealed additional insights into quality assurance improvements for the course. In a sufficiently large class, such as ours, the ability for the instructor to notice all the hands that were raised during discussion was in fact facilitated by the features supporting this, in Zoom. And while running an entire Town Hall online was effective, migrating to a system where some students were in class while others joined virtually provided an entirely different environment, to navigate. Engaging with a speaker who is in the class, while you are online introduces a novel, challenging dynamic, for instance. Added to this are the difficulties in properly hearing all the speakers. Online, with captioning enabled for those with disabilities, would enable a much more inclusive experience.

Some of these opinions are very helpful in reinforcing the conclusions that we have independently chosen to summarize. But as we move on from our conclusions to our proposed recommendations and how to take steps forward in the section below, we will draw further inspiration from some of this reflection.

7.2. Perspectives on Delivering Lecture-Based Postsecondary Courses

While the focus of this paper has been on delivering an upper year postsecondary course that is discussion-based, perspectives on factors that arise in more lecture-based courses are also of value to reflect upon, to deepen our appreciation of the differing needs for the teaching our course.

Student commentary on this topic included some discomfort with software used to avoid cheating on exams, held online; the dullness of recorded video lectures; the desire to avoid Zoom fatigue through the scheduling and spacing of online classes. Specific suggestions to make such online courses more effective included student check-ins as part of the course requirement; paying more attention to first year students, who may need initial in-person connection to build up social circles, before becoming more resilient in online settings. There was a concession that one benefit of online lectures was the flexibility to pause and re-watch, if recorded. And there was also the observation that certain lab-based classes might simply have to take place in person, with proper precautions. We expand our final recommendations just briefly to acknowledge these additional challenges to education during the time of Covid.

8. Recommendations

In the Conclusions section we had several observations which lend themselves to concrete recommendations, for instructors of online postsecondary course during times of healthcare challenges. These point the way to possible future research on how best to succeed with online delivery.

1) Find a way to have cameras on during class

We have reported that several students felt that this would have resulted in an

improved social experience, to compensate for not being face to face with their peers. There is still a challenge. Students may opt out unless there is a penalty for doing so (e.g. impact on their class participation grade). It seems too harsh to consider doing this. Perhaps steps that are more in line with positive reinforcement can be tried.

2) Adjusting the time of day for the course

At many universities, the timeslots chosen for a course are determined by the Registrar's office, though trying to take into consideration the preferences of instructors to some extent. Over the years, we have found that morning classes are more conducive to active participation. We hypothesize that if the timeslots were not so early, there may have been somewhat more objection to avoiding in-person delivery. The extent to which there are considerable health challenges will still matter, however. In times of dramatic concern, starting classes slightly later might be the ideal path to an excellent online communal discussion.

3) Instructors doing brief inspections of online breakout rooms

We commented that some students felt that their breakout rooms did not have sufficiently fair or active brainstorming. This inequality among groups, for group thinking could still be the case when launched during in-person classes. Circulating just briefly from group to group, so as not to compromise the open exchange of ideas, seems to be an ideal avenue for encouraging students to be operating in a more functional manner.

4) Consider alternatives to hybrid delivery for classes with presentations

While our own experience was limited to what was attempted for the technology that linked those in class and those at a distance, it seems clear that hybrid delivery detracts from the learning experience for classes with student presentations. One option worth pursuing is to decide that classes will be online only, providing sufficient advanced notice for speakers and audience to be prepared. We observed some positives for the supporting in person delivery for the Town Hall exercises with respect to eye contact and chances to make friends. Pragmatically, at end of term, enabling all students to complete their required work is a consideration. There is a true challenge in deciding how to gauge the level of illness and the need for moving online. (This is not to say that effort and judgment cannot be brought to bear here). We recommend making some of the cosmetic improvements to the online experience in 1) 2) 3) above and then attempting an entirely online course, to see whether the social experience, overall, can be a better one. We also recommend introducing other, explicit opportunities for students to "gather" with new friends and acquaintances as part of the course requirements.

5) Consider enriching the learning experience with guest speakers

During times of health challenges, guest speakers may be quite supportive of appearing at a distance. Online learning at any time seems ideally suited for integrating the perspectives of others in other countries.

6) Leverage the additional functionality of the online platform

Both students and teaching assistants valued the use of the icons that show

hands being raised, as one example of what may be valuable. While our course did not make much use of the chat feature of Zoom, this is another function that may inspire additional education experiences.

7) Continue to imagine the use of new technology to enhance the learning

Some students suggested that virtual reality may assist students in obtaining a more immersive and rewarding educational experience online. This is but one avenue for leveraging technology to improve student satisfaction. Especially for upper year computer science students, such options should be explored, but perhaps in a pilot study before integrating into the course itself in any given term. Anticipating alternate options for technology as backups to failures may be of some value as well, though country-wide incidents are rare. Technical experts on campus may be sources of insights for backups.

8) Know your community and continue to find ways of being attuned to this

As pointed out by the reflection of our student coauthor, the previous and ongoing current experiences of those enrolled in the course may well end up providing additional support for the teaching method of delivering online. Instructors should always pause to think about the intended learners in the course and their relationship to the proposed pedagogy.

9) Consider lessons learned from courses that are not discussion-based

As also pointed out by the student coauthor, those experiencing your course may also be attending other classes that are more lecture-based and thus the experiences from these environments may still play some role on the attitudes of students within your discussion-oriented course. Lessons learned about how to be more engaging, in any environment, should be in focus.

10) Consider fostering an inclusive environment, where empathy and responsibility towards others play a more active role

Even though these elements were natural inclusions in a course with our subject matter, we believe that all instructors can begin to see benefits from promoting a more caring attitude towards everyone in the class. We have seen entire societal shifts in adjusting attitudes towards others, during the time of Covid, according to papers that we surveyed. This suggests opportunities for building on these new-found behaviours.

9. Final Words

Responsible AI is a current direction within the field that encourages AI researchers to be invested in core issues of fairness, trust and well-reasoned decisions about usage of AI systems. In educating tomorrow's computer scientists, many of whom may go on to become AI professionals in industry or academia (according to a recent survey of career paths for computer science (Zweben & Bizot, 2022)), it is important to instill an investment in responsible attitudes regarding the field and its technology. A course such as ours devotes considerable attention to increasing awareness of ethical concerns for computer science, in

general, as well.

Our current reflection on the experiences within the course suggests that students being educated in this topic area may emerge with a greater commitment to responsible behaviour. While we can see that AI has much to offer in supporting assistance to society during the time of Covid, realizing the value of being more empathetic, in general, towards other individuals within our own circles may be a valued side-effect of this education. If this is the case, then greater support for continued online education on the part of the student population may emerge, regardless of differing personal preferences.

We saw this pattern of thought in several of the responses provided from the end-of-term commentary about the course. Students who specifically discussed the challenges that certain subgroups of their peers might face (focusing less on themselves) provided us with some insights into this important increase of empathy. (One of the most telling observations was that those in lower socioeconomic classes will benefit, avoiding housing and travel expenses, if able to continue to learn online from their current location). We also feel that when the topic of Covid is placed front and centre, for students who are facing their own personal challenges, more support for online delivery of classes can also be seen. In the course, the first long essay required of the students in term asked for commentary on computers and work, and while the assignment did not specifically require reflection on the new demands on computer science with respect to work, due to Covid, about ninety percent of the students in the course chose to mention Covid in the very first paragraph of their essays. This indicates that the pandemic, at least at that point in time, early June 2022, occupied an important part of the student consciousness.

In writing this paper, we have learned a lot about the value of online classes during critical health challenges. But we have learned as well about the benefits that students can gain when proper care and consideration is given to encouraging active participation and motivating learners to be truly supportive of the virtual classroom. As such, we feel that online delivery of postsecondary education holds important promise in the future, regardless of how the health challenges in our lives continue to evolve.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Abbasi, W. A., Abbas, S. A., & Andleeb, S. (2022). COVIDX: Computer-Aided Diagnosis of COVID-19 and Its Severity Prediction with Raw Digital Chest X-Ray Scans. *Quantitative Biology, 10,* 208-220. https://doi.org/10.15302/J-QB-021-0278

Afroogh, S., Esmalian, A., Donaldson, J. P., & Mostafavi, A. (2021). Empathic Design in Engineering Education and Practice: An Approach for Achieving Inclusive and Effective Community Resilience. *Sustainability, 13, 4060.*

https://doi.org/10.3390/su13074060

Ahmad, T., Lazarte, E. A. A., & Mirjalili, S. (2022). A Systematic Literature Review on Fake News in the COVID-19 Pandemic: Can AI Propose a Solution? *Applied Sciences, 12,* Article No. 12727. https://doi.org/10.3390/app122412727

Ahmed, N., Michelin, R. A., Xue, W., Ruj, S., Malaney, R., Kanhere, S. S. et al. (2020). A Survey of COVID-19 Contact Tracing Apps. *IEEE Access, 8,* 134577-134601. https://doi.org/10.1109/ACCESS.2020.3010226

Arora, G., Joshi, J., Mandal, R. S., Shrivastava, N., Virmani, R., & Sethi, T. (2021). Artificial Intelligence in Surveillance, Diagnosis, Drug Discovery and Vaccine Development against COVID-19. *Pathogens, 10,* Article No. 1048. https://doi.org/10.3390/pathogens10081048

Ashida, A., & Ishizaka, H. (2022). Effects of Changing from on-Site to Online Distance Classes on Graduate Students' Help-Seeking: Lessons for Sustainable Teaching and Learning from the COVID-19 Pandemic. *Asia Pacific Education Review, 23,* 653-667. https://doi.org/10.1007/s12564-022-09783-4

Baiano, C., Raimo, G., Zappullo, I., Marra, M., Cecere, R., Trojano, L., & Conson, M. (2022). Empathy through the Pandemic: Changes of Different Emphatic Dimensions during the COVID-19 Outbreak. *International Journal of Environmental Research and Public Health, 19,* 2435. https://doi.org/10.3390/ijerph19042435

Bharti, U., Bajaj, D., Batra, H., Lalit, S., Lalit, S., & Gangwani, A. (2020). Medbot: Conversational Artificial Intelligence Powered Chatbot for Delivering Tele-Health after COVID-19. In *2020 5th International Conference on Communication and Electronics Systems* (pp. 870-875). IEEE. https://doi.org/10.1109/ICCES48766.2020.9137944

Brinati, D., Campagner, A., Ferrari, D., Locatelli, M., Banfi, G., & Cabitza, F. (2020). Detection of COVID-19 Infection from Routine Blood Exams with Machine Learning: A Feasibility Study. *Journal of Medical Systems, 44,* Article No. 135. https://doi.org/10.1007/s10916-020-01597-4

Carpenter, K. A., Cohen, D. S., Jarrell, J. T., & Huang, X. (2018). Deep Learning and Virtual Drug Screening. *Future Medicinal Chemistry, 10,* 2557-2567. https://doi.org/10.4155/fmc-2018-0314

Casanova, V. S., & Paguia, W. M. (2022). Expectations, Experiences, and Satisfaction of the Graduate Students with Distance Online Learning Environment in OMSC Graduate School during the Covid-19 Pandemic. *Journal of Practical Studies in Education, 3,* 14-22. https://doi.org/10.46809/jpse.v3i1.39

Chakma, U., Li, B., & Kabuhung, G. (2021). Creating Online Metacognitive Spaces: Graduate Research Writing during the COVID-19 Pandemic. *Issues in Educational Research, 31,* 37-55. https://search.informit.org/doi/10.3316/informit.748747335200300

Chung, S., Kim, E., & Houston, J. B. (2021). Perceived Online Social Support for Parkinson's Disease Patients: The Role of Support Type, Uncertainty, Contentment, and Psychological Quality of Life. *Communication Quarterly, 69,* 259-279. https://doi.org/10.1080/01463373.2021.1940232

Condon, S. (2020). *White House Leads Effort to Publish COVID-19 Open Research Data Set.* ZDNET. https://www.zdnet.com/article/white-house-leads-effort-to-publish-covid-19-open-research-data-set/

Daniels, R. A., Miller, L. A., Mian, M. Z., & Black, S. (2022). One size Does NOT Fit All: Understanding Differences in Perceived Organizational Support during the COVID-19 Pandemic. *Business and Society Review, 127,* 193-222. https://doi.org/10.1111/basr.12256

Dhaniyala, S. (2020). *When COVID-19 Superspreaders Are Talking, Where You Sit in the Room Matters.* The Conversation.
https://theconversation.com/when-covid-19-superspreaders-are-talking-where-you-sit-in-the-room-matters-145966

Drea, J. (2021). *Online? In Person? The Power of Letting Students Choose.* Harvard Business Publishing.
https://hbsp.harvard.edu/inspiring-minds/online-in-person-the-power-of-letting-students-choose

Garg, T., Garg, M., Mahela, O. P., & Garg, A. R. (2020). Convolutional Neural Networks with Transfer Learning for Recognition of COVID-19: A Comparative Study of Different Approaches. *AI, 1,* 586-606. https://doi.org/10.3390/ai1040034

Green, L. M., Missotten, L., Tone, E. B., & Luyckx, K. (2018). Empathy, Depressive Symptoms, and Self-Esteem in Adolescence: The Moderating Role of the Mother-Adolescent Relationship. *Journal of Child and Family Studies, 27,* 3964-3974.
https://doi.org/10.1007/s10826-018-1216-z

Hacker, J., Vom Brocke, J., Handali, J., Otto, M., & Schneider, J. (2020). Virtually in This Together—How Web-Conferencing Systems Enabled a New Virtual Togetherness during the COVID-19 Crisis. *European Journal of Information Systems, 29,* 563-584.
https://doi.org/10.1080/0960085X.2020.1814680

Han, B., & Rideout, C. (2022). Factors Associated with University Students' Development and Success: Insights from Senior Undergraduates. *The Canadian Journal for the Scholarship of Teaching and Learning, 13,* Article 3.
https://doi.org/10.5206/cjsotlrcacea.2022.1.10801

Harrus, I., & Wyndham, J. (2021). *Artificial Intelligence and COVID-19: Applications and Impact Assessment.* AAAS AI Report, American Association for the Advancement of Science.
https://www.aaas.org/sites/default/files/2021-05/AIandCOVID19_2021_FINAL.pdf

Karnaze, M. M., Bellettiere, J., & Bloss, C. S. (2022). Association of Compassion and Empathy with Prosocial Health Behaviors and Attitudes in a Pandemic. *PLOS ONE, 17,* e0271829. https://doi.org/10.1371/journal.pone.0271829

Kee, C. E. (2021). The Impact of COVID-19: Graduate Students' Emotional and Psychological Experiences. *Journal of Human Behavior in the Social Environment, 31,* 476-488. https://doi.org/10.1080/10911359.2020.1855285

Kelly, K. (2022). Building on Students' Perspectives on Moving to Online Learning during the COVID-19 Pandemic. *The Canadian Journal for the Scholarship of Teaching and Learning, 13,* Article 4. https://doi.org/10.5206/cjsotlrcacea.2022.1.10775

Miner, A. S., Laranjo, L., & Kocaballi, A. B. (2020). Chatbots in the Fight against the COVID-19 Pandemic. *NPJ Digital Medicine, 3,* Article No. 65.
https://doi.org/10.1038/s41746-020-0280-0

Mohammed, L. A., Aljaberi, M. A., Amidi, A., Abdulsalam, R., Lin, C.-Y., Hamat, R. A., & Abdallah, A. M. (2022). Exploring Factors Affecting Graduate Students' Satisfaction toward E-Learning in the Era of the COVID-19 Crisis. *European Journal of Investigation in Health, Psychology and Education, 12,* 1121-1142.
https://doi.org/10.3390/ejihpe12080079

Omar, H. A., Ali, E. M., & Belbase, S. (2021a). Graduate Students' Experience and Academic Achievements with Online Learning during COVID-19 Pandemic. *Sustainability, 13,* Article No. 13055. https://doi.org/10.3390/su132313055

Omar, M. K., Hassan, M., Arsad, N. M., Ismail, N., Jamaluddin, R., & Jusoh, R. (2021b) Undergraduates Students' Learning Experience on the Impact of Online Learning dur-

ing Pandemic. *Open Journal of Social Sciences, 9,* 167-184.
https://doi.org/10.4236/jss.2021.99012

Petrocchi, S., Bernardi, S., Malacrida, R., Traber, R., Gabutti, L., & Grignoli, N. (2021). Affective Empathy Predicts Self-Isolation Behaviour Acceptance during Coronavirus Risk Exposure. *Scientific Reports, 11,* 10153.
https://doi.org/10.1038/s41598-021-89504-w

Pham, T. T. T., Le, H. A., & Do, D. T. (2021). The Factors Affecting Students' Online Learning Outcomes during the COVID-19 Pandemic: A Bayesian Exploratory Factor Analysis. *Education Research International, 2021,* Article ID: 2669098.
https://doi.org/10.1155/2021/2669098

Phillips, S. (2020). Working through the Pandemic: Accelerating the Transition to Remote Working. *Business Information Review, 37,* 129-134.
https://doi.org/10.1177/0266382120953087

Qin, X., Yang, F., Jiang, Z., & Zhong, B. (2022). Empathy Not Quarantined: Social Support via Social Media Helps Maintain Empathy During the COVID-19 Pandemic. *Social Media + Society, 8*. https://doi.org/10.1177/20563051221086234

Simonova, I., Faltynkova, L., & Kostolanyova, K. (2021). Students' Reflection on Online Distance Learning: Advantages, Disadvantages, Recommendations. In R. Li, S. K. S. Cheung, C. Iwasaki, L.-F. Kwok, & M. Kageto (Eds.), *Blended Learning: Re-thinking and Re-defining the Learning Process. ICBL 2021. Lecture Notes in Computer Science* (Vol. 12830, pp. 275-286). Springer. https://doi.org/10.1007/978-3-030-80504-3_23

Spitzer, M. (2020). Masked Education? The Benefits and Burdens of Wearing Face Masks in Schools during the Current Corona Pandemic. *Trends in Neuroscience and Education, 20,* Article ID: 100138. https://doi.org/10.1016/j.tine.2020.100138

World Health Organization (2020). *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-11 March 2020.* World Health Organization.

Yang, Y. (2021) A Study on Online Learning Behaviors of the Private University Students Based on SPOC Mode—Take Zhejiang Yuexiu University as an Example. *Open Journal of Modern Linguistics, 11,* 212-225. https://doi.org/10.4236/ojml.2021.112017

Zhang, H., Morris, M., Nurius, P., Mack, K., Brown, J., Kuehn, K., Sefidgar, Y., Xu, X., Riskin, E., Dey, A., & Mankoff, J. (2022). Impact of Online Learning in the Context of COVID-19 on Undergraduates with Disabilities and Mental Health Concerns. *ACM Transactions on Accessible Computing, 15,* Article No. 29.
https://doi.org/10.1145/3538514

Zhao, J. Han, H., Zhong, B., Xie, W., Chen, Y., &Zhi, M. (2021). Health Information on Social Media Helps Mitigate Crohn's Disease Symptoms and Improves Patients' Clinical Course. *Computers in Human Behavior, 115*, 106588.
https://doi.org/10.1016/j.chb.2020.106588

Zheng, M., Bender, D., & Lyon, C. (2021). Online Learning during COVID-19 Produced Equivalent or Better Student Course Performance as Compared with Pre-Pandemic: Empirical Evidence from a School-Wide Comparative Study. *BMC Medical Education, 21*, Article No. 495. https://doi.org/10.1186/s12909-021-02909-z

Zhu, Y., Li, J., & Pang, Z. (2021). Recent Insights for the Emerging COVID-19: Drug Discovery, Therapeutic Options and Vaccine Development. *Asian Journal of Pharmaceutical Sciences, 16,* 4-23. https://doi.org/10.1016/j.ajps.2020.06.001

Zweben, S., & Bizot, B. (2022). 2021 Taulbee Survey: CS Enrollment Grows at All Degree Levels, with Increased Gender Diversity. *Computing Research News, 34,* 1-132.
https://cra.org/crn/wp-content/uploads/sites/7/2022/05/May-22-CRN.pdf