Computer Education in the Age of COVID-19

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COVID-19 has been devastating across the globe, forcing profound changes in most human interactions. Through an informal survey of numerous educators worldwide, we explore some of the disease's effects on the education community and how the online delivery of educational materials can meet these challenges.

As many in the world continue to suffer from the devastating effects of the COVID-19 pandemic, solutions are continuously being sought for dealing with its consequences and the need to reduce opportunities for infection. Stores of all kinds have adapted by encouraging social distancing, requiring face masks, installing Plexiglas partitions in front of cashiers, and implementing myriad alternate measures, including metering the number of customers and enacting curbside pick up, home delivery, etc. Fortunately (if the word can be used in light of the catastrophic dimension of these events), the pandemic has come at a time when Internet connections are well established, countless applications of data processing and exchange are available, and many tools are available for effective communications among multiple participants in widely distributed areas of the world. This has enabled a number of office-based activities to be efficiently off-loaded to the homes of office workers.

In between these two extremes, establishments of higher learning have been faced with the same dilemma with which businesses worldwide have dealt: how to continue operating when workers and customers experience difficult and strained relations because of necessary safety measures. The problem is particularly acute for educators, who have long relied upon face-to-face interactions and interpersonal feedback to tailor the delivery of high-quality knowledge.

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We have therefore endeavored to find out how our colleague educators in computer science and engineering have approached this dramatic situation, what fruit their efforts have borne, and what support (or resistance) they have met with the student population, their own colleagues, and their administration. Indeed, most universities and schools worldwide have had to quickly retool and turn to long-distance education to continue fulfilling their educational mission when faced with the pandemic emergency and the resulting stay-at-home orders. This has caused many teething problems, from needing to educate instructors, to deciding how lab classes could be handled, all the way to designing secure environments for exams. It is thus the goal of this column to describe the reactions of educators globally. We offer a small sample of how our international colleagues have dealt with the crisis, what they regret, how they will improve; in short, they relate their experiences to the community, perhaps providing some guidance to us all for the future.

THE SURVEY

We contacted a small sample of colleagues from a number of countries around the world and presented them with the a set of 10 questions.

Question 1

What classes did you teach during the pandemic (undergraduate/graduate/lab)? How many students?

We received reports for 24 computer science and engineering-related classes for 10–400 graduate and undergraduate classes from 14 universities in nine countries, including the United States, United Kingdom, Brazil, Russia, Australia, Spain, Japan, China, Taiwan, and Iran in addition to a report for 18,000 classes for 50,000 undergraduate and graduate students from Waseda University, Japan.

Question 2

Did any one topic lend itself better/worse to remote teaching?

Most respondents (with some exceptions) are satisfied with online teaching, and there appears to be no specific topic for which online teaching presents any disadvantages. On the contrary, a number of respondents felt that it allowed the students to better concentrate. Some even cited programming courses as easier to manage online. On the negative side, some people deplored the obvious lack of teacher–student interaction. Lab classes can also take advantage of many online teaching platforms with recording or playback functions, which allow the students to review difficult steps or verify procedures beforehand.

Question 3

What tools did you use? How much ramp-up effort was needed? What kind of support did your home institution provide? What kind would you have liked?

The following tools were reportedly used:

› learning management systems (LMSs): Moodle, Canvas, etc.
› plagiarism detection: iThenticate, Turnitin, Ejudge, etc.
› on-demand video creation and/or delivery, including
  • massive open online courses, YouTube, etc.
  • for self-on-demand video content creation in professors' homes and content delivery: Panopto, Contents Creation Studio, Open Broadcaster Software with a Vimeo platform, etc.
  • for assisted content creation on campus and content delivery, Millvi, etc. were utilized
› for real-time online lectures and meetings with recording: Zoom, Blackboard Collaborate, Microsoft Teams, Cisco Webex, Google Meet, Skype, Tencent Meeting, Rain Classroom, Jitsi, etc.; most universities provided enough licenses for faculty members and staff

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› reporting and analytics for LMSs: IntelliBoard, etc.
› smartphone scanner generating PDFs for handwritten answers: Microsoft Office Lens, etc.
› exam proctors.

Universities offered the following support to prepare and operate online classes:

› "Teaching Anywhere" sites for teachers, providing information on how to prepare and operate online education with the lecturers' experiences during classes
› webinars to explain how to prepare online lectures, including on-demand video lectures and real-time online lectures (these were very helpful to educators who had not used network meeting systems or prepared on-demand

video materials from their homes)

› "Learning Anywhere" sites for students, offering information on how to prepare and receive online lectures, including the prevention of server overload as a result of simultaneous logins in the morning and after lunch.

As an additional data point, we note that the following additional support to cope with COVID-19 was provided at Waseda University:

› free lending of Wi-Fi routers and PCs to students with financial issues stemming from the pandemic

› specially discounted ¥1 smartphones with tethering functionality and one-year free data communication for all students, faculty members, and staff who needed to reduce home network bandwidth problems

› negotiation with major smartphone companies for the purpose of discounting data communication fees for all students in Japan during the spring semester

› access to a help desk for faculty and students to prepare, operate, and/or participate in online classes from their homes. The help desks were operated by using "home-based call center systems" so that staff and teaching assistants (TAs). could answer from their own homes.

The University of California, Irvine (UCI) also proactively assisted in the transition:

› online classes for the lecturers and TAs prior to the quarter; these classes were aimed at lecturers with content creation and delivery, website design, etc.

and will continue through the summer.

› special attention was given to configuring our Zoom licenses to minimize the chances of security problems.

Question 4

If this became a permanent model of teaching, do you feel you would end up spending more or less time in your teaching activities? In other words, once the ramp-up period is gone, will this be more or less efficient for the educator?

There appears to be no consensus on this issue: some feel that they can be more efficient and that the difficulties experienced in these early days will serve as an investment that will pay off in the future. However, there is one caveat in that this investment should not come at the detriment of flexibility, which is particularly important in any technical discipline. Others see online teaching as a temporary fix and look forward to resuming face-to-face interactions. They fear that graduates will be missing some important part of the educational experience, which may result in a weaker class of graduated students. This means that particular attention should be given to connecting the classes into a meaningful body of knowledge and skills. Also, everybody recognizes that the initial preparation effort is significant.

Question 5

If you had a lab class, how did you deal with the social-distancing requirements?

Some respondents reported that online labs in the computer science field could be performed by using university servers and public cloud systems. This has been relatively easy, compared with other fields.

For the future, if labs must be held on campus, plans are made to use not only ordinary labs but also classrooms (since many would be vacant), which would mean dividing a lab class into smaller subgroups, thereby respecting social-distancing guidelines.

Question 6

What specific difficulties did you encounter? Were any of these difficulties due to "local" conditions? Were any of these problems related to security (think Zoom "bombing")?

Security issues, Zoom bombing, and adaptation to new tools appear to have been early teething problems, which were quickly resolved. The biggest problems were indeed related to mastering the technology. Connectivity appeared to be uneven: some foreign students experienced difficulties connecting to their home university, and educators had a harder time measuring their engagement in the topics taught. Furthermore, within some developing countries, Internet bandwidth sometimes could not support the demand of an online class. Also, one respondent alluded to those students who live at home and had to share their Internet access (and sometimes equipment) with other family members: this is certainly a consideration that should be given by the educators. Some institutions asked students to turn their cameras off during lectures for privacy considerations. Amusingly, one colleague reported being "bombed" by his children during a lecture. A simple lock on the door solved this.

Question 7

In terms of tests and exams, did you require physical proctoring from a trusted source? Did you secure the assistance from a testing center? Perhaps you used a long-distance testing system?

Proctoring and usage of test centers often seen in U.S. universities have not been used in other countries. Take home-type exams, projects, or open-book exams were used to avoid the need for proctoring. When watching students during handwritten exams, institutions in some countries required one or two cameras to show the student's face, the surrounding environment, or the entire person as well as microphones to record surrounding sounds.

Question 8

Some universities opted for a pass/no pass grading scale at the end of the quarter/semester. If yours was one, can you comment on the process?

The answers to this question were inconclusive, perhaps due to the character of the question. No strong preference emerged, but indeed, many universities adopted a pass/no pass grading system. As a point of note, UCI allowed its students to take any class, even if required for the degree, to be taken pass/no pass during the spring 2020 quarter. The decision was left up to the students.

Question 9

Do you see the student experience as having been enhanced or diminished by the online teaching of specific classes? For instance, I have had reports that students are less apathetic and make use of the professors' office hours more regularly (rather than bunching all their questions for right before the tests).

Most universities reported that online classes utilizing real-time teaching using network meeting systems with recording and on-demand video teaching were better than or no different than in-person classes. Some universities said students' understanding of the subject was improved because of self-paced learning, including playback speeds and repeated playbacks for difficult topics, allowing for more questions in real-time classes with chats and "raising hands" tool features.

One university reported that students watched videos just before the exams in on-demand video lectures. Another university said that students studied at an ordinary time rather than before the exam with on-line real-time lectures. One colleague, however, noticed fewer students during remote office hours than during in-person office hours. In summary, most felt that the online classes effectively improved the quality of education.

Question 10

How about on the whole? Is this an opportunity for or a threat to the traditional concept of university education? It has been reported that many (U.S.) parents have balked at spending high tuition costs for their children to merely "watch a screen" day in and day out. Many have said that the university social experience is an indispensable educational tool to provide individual growth for future professionals. What would replace it? Are there any hybrid models on the horizon?

Most of the respondents used the word *complement* in responding to this question: online/remote teaching should be a complement to face-to-face interaction. It is a good approach in these times of emergency, but it will continue to provide advantages in the future: students can avoid long commute times (a prevalent problem in large metropolises), have access to a larger library of courses if those courses can be shared between educational institutions, and learn at their own pace (recording lectures is a tremendous benefit, which has been recognized by all).

At the same time, it is felt that face-to-face interaction will remain an essential component of university education. It will be the "spirit" and the "personality" imparted by each institution in its educational mission and provide the "glue" between all the bits of knowledge that can be gleaned from online teaching. Incidentally, the rigid quarter/semester format may be revised in favor of a more flexible approach, which could see topics divided into logical "modules."

This article reports on what has only been a necessarily small and incomplete snapshot of reactions to COVID-19 throughout the world. A more thorough study would have included many more representatives from a larger number of countries, from different backgrounds (for example, small specialized institutions versus large, multidisciplinary universities), etc. We know that such studies are currently being undertaken, and we look forward to the additional information they will provide. However, for the moment, our observations seem to confirm that our colleagues have weathered the COVID-19 storm well and that important lessons have been learned with respect to how to continue, what has worked best, and the future, at large, of online education.

We also hope that this quick online education report from nine countries coping with COVID-19 in the spring of 2020 will be useful for worldwide educational institutions in preparing online or hybrid education in the coming

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semesters or quarters. We assert that one of the essential factors to effectively provide online education during this difficult period is a collaboration among faculty members, students, and staff in addition to providing appropriate tools and communication technology.

As a footnote of sorts, we note the RheSYS project, which analyzes how organizations have coped with and adapted to the COVID-19 crisis, considering in particular how certain institutions have been able to capitalize on the crisis as a transformative opportunity for accelerated, technology-driven change while others have instead sought a return to a precrisis operating model. Also, the COVID-19 Museum (http://covid-19.museum/) links various and diverse digital collections and offers the use of data sciences to explore, highlight, and more generally extract knowledge from collections. ◼
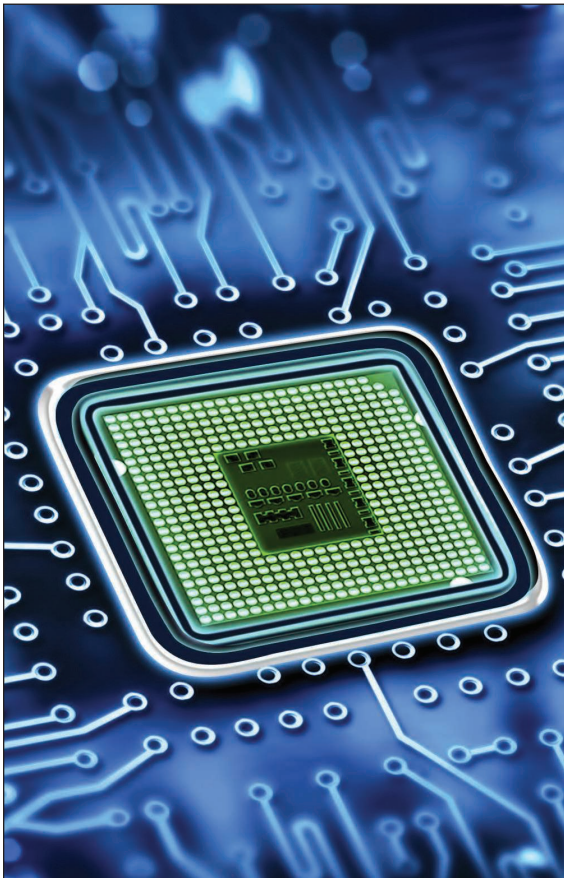
colleagues who responded to the questionnaire presented in this article: Eduard Ayguade (Universitat Politecnica de Catalunya, Barcelona, Spain), Christophe Cérin (Université Sorbonne Paris Nord, France), Jeremy Gibbon (Oxford University, United Kingdom), Alfredo Goldman (Universidade de São Paulo, Brazil), Michael Green (University of California, Irvine), Sun-Yuan Hsieh (National Cheng Kung University, Taiwan), Keqiu Li (Tianjin University, China), Alba Melo (Universidade de Brasilia), Ali Movaghar (Sharif University of Technology, Tehran, Iran), Weisong Shi (Wayne State University, Detroit, Michigan), Jidong Zhai (Tsinghua University, Beijing, China), and Albert Zomaya (University of Sydney, Australia) as well as Arutyun Avetisyan, Sergey Gaissaryan, Efim Grinkrug, Vartan Padaryan, and Irina Dudina (all from the Ivannikov Institute for System Programming of the Russian Academy of Sciences, Moscow). Several others helped but asked that their names not be included. To all: although we could not include all of your remarks, your input to this article was invaluable.

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