

# Teaching Control during the COVID-19 Pandemic

J.L. Guzmán<sup>1\*</sup>, K. Žáková<sup>2</sup>, I.K. Craig<sup>3</sup>, T. Hägglund<sup>4</sup>,  
D.E. Rivera<sup>5</sup>, J.E. Normey-Rico<sup>6</sup>, P. Moura-Oliveira<sup>7</sup>,  
L. Wang<sup>8</sup>, A. Serbezov<sup>9</sup>, T. Sato<sup>10</sup>, and M. Beschi<sup>11</sup>

<sup>1</sup> *University of Almería, Spain, (e-mail: joseluis.guzman@ual.es);*  
<sup>2</sup> *Slovak University of Technology in Bratislava, Slovakia;* <sup>3</sup> *University of Pretoria, South Africa;* <sup>4</sup> *Lund University, Sweden;* <sup>5</sup> *Arizona State University, USA;* <sup>6</sup> *University of Florianopolis, Brazil;* <sup>7</sup> *UTAD University, Portugal;* <sup>8</sup> *RMIT University, Australia;* <sup>9</sup> *Rose-Hulman Institute of Technology, USA;* <sup>10</sup> *University of Hyogo, Japan;*  
<sup>11</sup> *University of Brescia, Italy.*

**Abstract:** This paper aims to analyze some different solutions that were adopted in control education activities during the pandemic. The authors of this paper are educators in the control education field from different countries on all the continents, who have developed a questionnaire with the idea of collecting data about the COVID-19 pandemic impact on the control education activities. The main objective is to study the diverse alternatives that were used worldwide to perform the online educational activities during that period, such as methodologies, tools, learning management systems (LMS), theoretical exercises, laboratory experiments, types of exams, simulators, software for online lecturing, etc. As a result, comparisons between pre- and during-pandemic educational resources and methods are performed, where useful ideas and discussions are given for the control education community.

Copyright © 2022 The Authors. This is an open access article under the CC BY-NC-ND license (<https://creativecommons.org/licenses/by-nc-nd/4.0/>)

**Keywords:** control education, online teaching, pandemic, learning.

## 1. INTRODUCTION

The COVID-19 pandemic has revolutionized our society in every way, socially, economically and in terms of health (McKibbin and Fernando, 2020; Trougakos et al., 2020; Xiong et al., 2020). Everyone accepts that our lives have changed somehow after it. There are of course many negative issues and situations around the pandemic that we will never forget and that will stay with us for a long time. However, there are also many other positive aspects and variations in our style of life that could be important to keep and to exploit. This is the attitude that the authors of this work would like to transmit from a general point of view, and particularly from an educational perspective: analyze what we have learned because of the pandemic in the field of control education, and preserve what we can positively use in the future (Burke and Arslan, 2020).

Clearly, teaching and learning processes were highly affected during the pandemic at all levels (elementary school, high school, university, ...), where teachers and students had to adapt suddenly to new ways of education (Schleicher, 2020; Burgess and Sievertsen, 2020; Marinoni et al., 2020; Tarkar, 2020). Technology became the main protagonist, where any type of digital resources started to be spread out worldwide. Many education centers were used to work with digital solutions and online platforms as support to education before the pandemic. However, many others had to learn from scratch and adapt their teaching methodologies to the digital world. So, most teachers in the world had to modify their teaching style and look for

new solutions based on online lectures, remote activities, video recording, online polls, web-based methodologies (Williamson et al., 2020), etc.

All those changes were important in most of the disciplines, but the impact was larger in those disciplines with a high practical component, as it is the engineering studies case. In engineering, exercises and experiments in laboratories are a fundamental part of the learning process. Moreover, theoretical lectures are usually mixed with practical exercises and simulations to be discussed with students face-to-face. Thus, during the pandemic period, it was not possible to perform all these teaching tasks in classrooms or in laboratories, and new solutions were required (Jamalpur et al., 2021).

The control engineering field is one example of an engineering topic where important changes were performed not only for practical lectures, but also for theoretical ones. Therefore, this paper is a joint work among lecturers of the control education field around the world, where the idea is to analyze the methodologies, tools, solutions and platforms used in control education before, during, and after the pandemic. In cooperation with IFAC Technical Committee 9.4 on Control Education, we all prepared and discussed a general questionnaire to collect data and opinions about the teaching experiences in control education during the pandemic. This questionnaire was distributed worldwide and this manuscript summarizes the obtained results.

In the survey preparation, we understand that educational activities are organized in different manner in each university and in each country. On the other hand, we also understand that education for undergraduate and post-graduate students are different, and thus, we suggested to fill out the questionnaire combining the experience from both perspectives. Hence, the proposed questions were formulated from a generic point of view to cover lecturing, laboratory tasks, exercises, homework, exams, and so on. In this way, the questionnaire can be filled out from a global perspective according to the experience of each teacher.

We strongly believe that this information can be very useful for the whole control education community and that it can help all of us to learn from each others.

## 2. THE QUESTIONNAIRE

The structure of the survey was developed in different blocks of questions. First, basic questions about the country and affiliations of the participants were required. Afterwards, the groups of questions were specifically oriented to determine the tools, methods, activities, exams, and other resources used before, during and after the pandemic.

The first block was dedicated to knowing the tools and resources used before and during the pandemic with the following group of questions:

- What tools/platforms did you use before the pandemic situation came?
    - blackboard/whiteboard and chalk/pen.
    - Powerpoint-like presentations.
    - laboratory experiments.
    - experimenting with “home kits”.
    - remote experimentation.
    - interactive examples via web interface.
    - online polls.
    - discussion forums.
    - LMS Moodle.
    - university information system.
    - MS Teams.
    - Google Classroom.
    - YouTube videos.
    - own video recordings.
    - others (providing other ideas).
  - What tools did you use during online teaching?
    - pre-recorded lectures (asynchronous lecturing).
    - online live lectures (with any kind of synchronous feedback).
    - “virtual blackboard/whiteboard” (hand writing distributed via Internet).
    - Powerpoint-like presentations.
    - practical experimenting with “home kits”.
    - remote experimentation.
    - interactive examples via web interface.
    - online polls.
    - chat.
    - discussion forums.
    - YouTube videos.
    - video recordings (complementary materials).
    - others (providing other ideas).
- Then, the interest was moved on the LMS and the software tools used for online lecturing with the next questions:
- What LMS (if any) did you use for online teaching or videoconferencing as support to teaching activities?
    - LMS Moodle.
    - Canvas LMS.
    - university information system.
    - MS Teams.
    - Google Meet.
    - Google Classroom.
    - Zoom.
    - Cisco Webex.
    - Discord.
    - video streaming via YouTube.
    - video streaming via Twitch.
    - other
- Afterwards, the focus was on the students’ motivation and the different ways to perform online exams:
- What methods did you use to keep students engaged and motivated?
    - projects and open-ended assignments presented to the entire class or submitted as a short video.
    - daily/weekly quizzes that count toward the course grade.
    - games that do not count towards the course grade.
    - additional take-home or virtual lab assignments.
    - mini-competitions among the students in the class (for example, tune a controller).
    - other.
  - How did you perform the exams?
    - multiple choice test.
    - short live interviews with students.
    - written exams that students upload to a platform once they finished.
    - complex project containing various tasks.
    - other.
- Finally, the interest was focused on the methodologies and resources to be kept after the pandemic:
- Do you think that after the pandemic will you return to the teaching activities in the same way as it was before?
    - yes
    - maybe
    - no
  - What activities would you like to retain in teaching after the pandemic?
    - pre-recorded lectures (asynchronous lecturing).
    - online live lectures (with any kind of synchronous feedback).
    - “virtual blackboard/whiteboard” (hand writing distributed via Internet).
    - Powerpoint-like presentations.
    - practical experimenting with “home kits”.
    - remote experimentation.
    - interactive examples via web interface.
    - online polls.
    - chat.
    - discussion forum.
    - YouTube videos.
    - own video recordings.

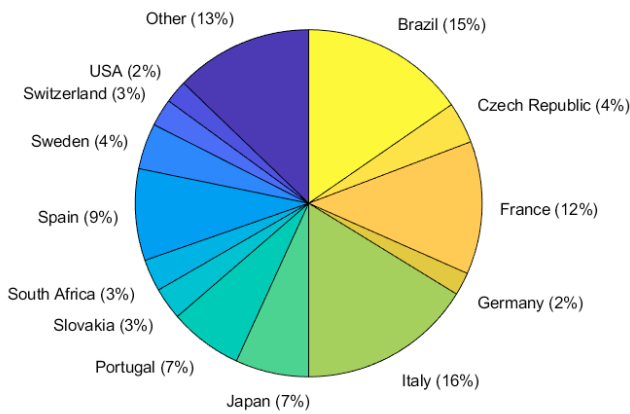


Fig. 1. Distribution of questionnaire answers among countries

- others (providing other ideas).
- What do you think are the main advantages and disadvantages of online lecturing with respect to traditional in-person lectures?
  - Online instructions allow teacher to do better lecturing.
  - Students have been more responsible because of online instructions.
  - Motivation of the students during online instructions is low.
  - It is more difficult for students to ask questions to the teacher during the lecture.
  - It is useful for students if they can watch again the recorded lectures.
  - Students pay less attention during the lectures as they have the chance to watch them again.
  - For the teacher, it is more difficult to engage students.
  - It is useful for inclusivity (for example for people with specific learning disorders).

Notice that the idea was to develop a simple and easy questionnaire with the aim of collecting as many responses as possible. For that reason, we designed a short group of questions to avoid having a very tedious questionnaire. There are of course many other questions with a deeper pedagogical perspective that could be asked in future works, but this topic is out of the scope of this paper. The following section summarizes and discusses the results obtained from the collected data.

### 3. RESULTS AND ANALYSIS

Until January 7, 2022 the questionnaire was filled by 234 individuals from 29 countries. The detailed distribution among countries is shown in Figures 1 and 2. Figure 1 shows countries where the questionnaire was completed at least by 2% of the total participants. Countries with smaller number of respondents are covered by the joint name “Other” that is shown in more details in Figure 2.

As a first result, our interest was focused on knowing what tools/platforms/resources lectures used before the

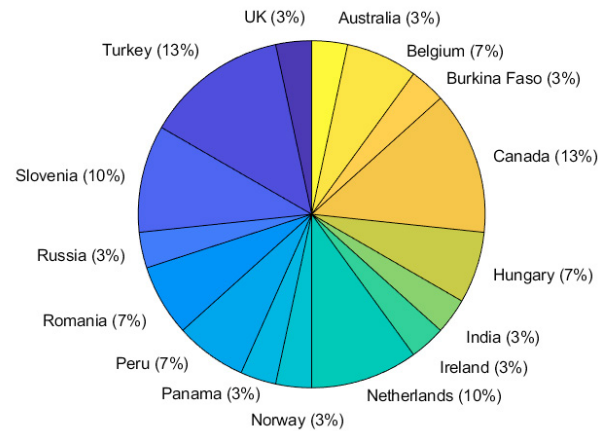


Fig. 2. Distribution of questionnaire answers among countries that are covered in Fig. 1 by the name “Other”

pandemic situation came. Figure 3 shows the obtained results about the most often used tools. Moreover, some other material out of our proposals was provided by the participants, obtaining the following ideas:

- examples and simulation in MATLAB<sup>®</sup>/Simulink<sup>®</sup>,
- own (standalone) demonstration tools,
- textbooks,
- computer exercises,
- own audio recordings,
- Git,
- Facebook study groups.

These answers were compared with the situation when lectures were taught online during the pandemic. Although at first glance it might seem that the blackboard with chalk and whiteboard with pen will not be used in such conditions, the opposite was true. People started to use “virtual blackboard/whiteboard”, i.e. handwriting distributed via Internet. In spite of this, as it is evident from Figure 3, the blackboard/whiteboard and Powerpoint-like presentations were partially substituted by the tools that are more appropriate for online teaching. The big increase in own video recordings was due to the use of prerecorded lectures (asynchronous lecturing) that started to be quite popular. Furthermore, from the extra comments, we also obtain examples based on interactive sessions with screen sharing or using classical communication tools such as cellphone or email.

The pandemic period also brought higher use of LMS. Figure 4 shows that approximately two years ago Moodle was the most common LMS. COVID-19 enabled widening of MS Teams and partially also of Google Classroom. The increase of MS Teams is very relevant. An important issue remarked by the responses was that the selection of the LMS was mostly done by the institution and educators rarely use other platforms.

However, LMS solutions only facilitate sharing of teaching materials and presentations, testing or administration of courses and students. In most cases, they do not allow synchronous online teaching where students can also ask questions. For this reason, a large number of teachers were

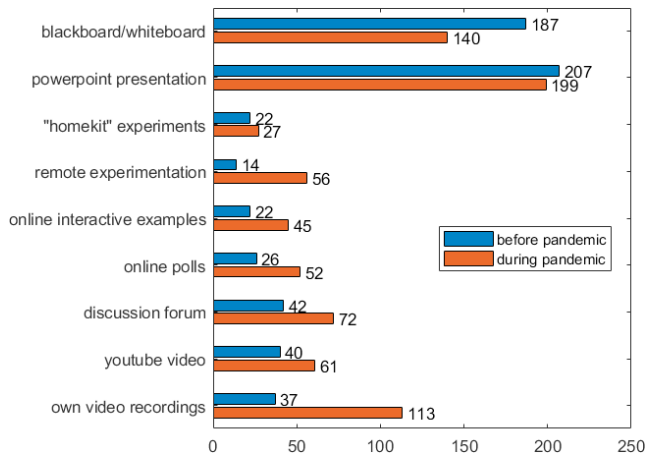


Fig. 3. Overview of different tools used before and during pandemic

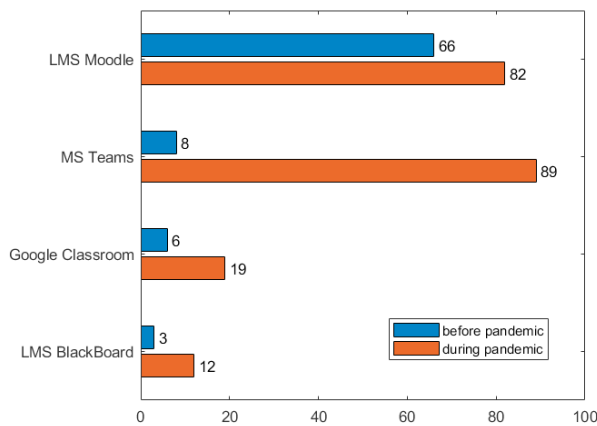


Fig. 4. Overview of the most used LMS before and during pandemic

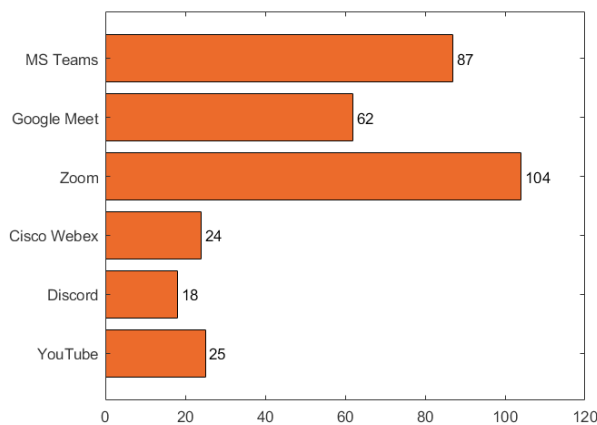


Fig. 5. Overview of the most used software for online lecturing

looking for online streaming opportunities. As can be seen from Figure 5, several software solutions were used for this purpose. Zoom, MS Teams, and Google Meet were the most often used.

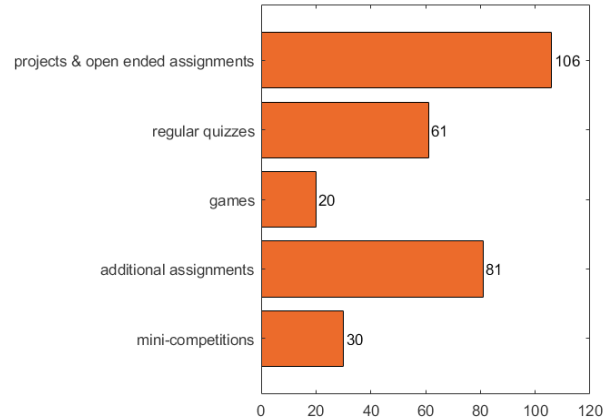


Fig. 6. Overview of methods used for engaging and motivating students

Since teaching via the Internet requires the use of other ways of attracting students, we were interested in methods that teachers used to keep students engaged and motivated. Figure 6 shows the questionnaire replies, where it is observed that for motivation purposes, teachers mostly used various forms of assignments: projects, open-ended assignments, additional take-home assignments, regular quizzes (online or offline), competitions, or games. Moreover, the following examples were also given by the questionnaire participants:

- practical experiments,
- encouragement to create discussion sessions among schoolmates,
- quizzes,
- polls,
- exercises and simulations in MATLAB<sup>®</sup>/Simulink<sup>®</sup>,
- more frequent communication via email,
- splitting seminar into shorter time slots with smaller number of students.

One respondent mentioned that normally students found jokes enjoyable, but together with this answer there come also several comments saying not to try it online because it is a disaster if you don't hear or see the smiling audience.

Of course, during online teaching it is also necessary to do exams and evaluation activities. The feedback results for this question are summarized in Figure 7. In most cases, students needed to write the exam on paper, then scan and to upload to a platform after the exam is finished. Computer-based multiple choice tests were the second choice. These possibilities were followed by complex projects containing various tasks and short live interviews with students. In a few cases, it was possible to accomplish traditional face-to-face exams. Other ways also provided in the responses were:

- test with calculated questions in Moodle,
- oral exam via MS Teams,
- time restricted project with individual parameters,
- MATLAB Grader<sup>®</sup>,
- stack quizzes/questions in Moodle.

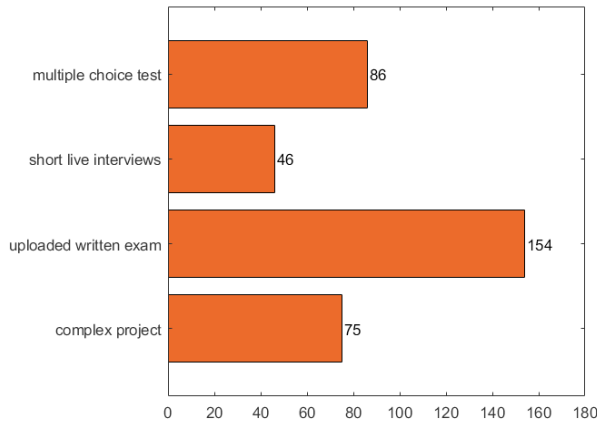


Fig. 7. Overview of methods for exam realisation

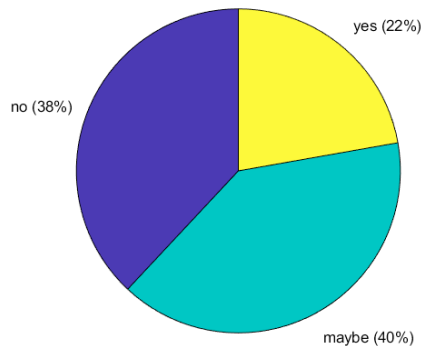


Fig. 8. Answers to the question “Do you think that after the pandemic will you return to the teaching activities in the same way as it was before?”

An interesting discussion ensued among the respondents. In some cases, when exams were done by hand and uploaded to a platform, students were required to have their remote video-camera switched on to be supervised by the lectures. It was interesting to know that in many universities, this option was not allowed because of privacy reasons. Actually, it was also forbidden to talk with students during online lectures. However, don't we (as lectures) see the students' faces and what they are doing in person when they perform an exam in a classroom? So, why is it not allowed to require the same for online situations? This question opens an interesting discussion about the quality of distance evaluation.

Probably, everyone is interested in whether, when all the waves of the pandemic end, we will be able to return to the previous way of life and with the same teaching activities. Figure 8 shows that just 22% of respondents (i.e. less than one quarter) think that it will be in the same way as before. The rest of respondents agree or partially agree that it will be not the same.

In Figure 3, we compared the tools that were used before and during the pandemic. Since we cannot expect that

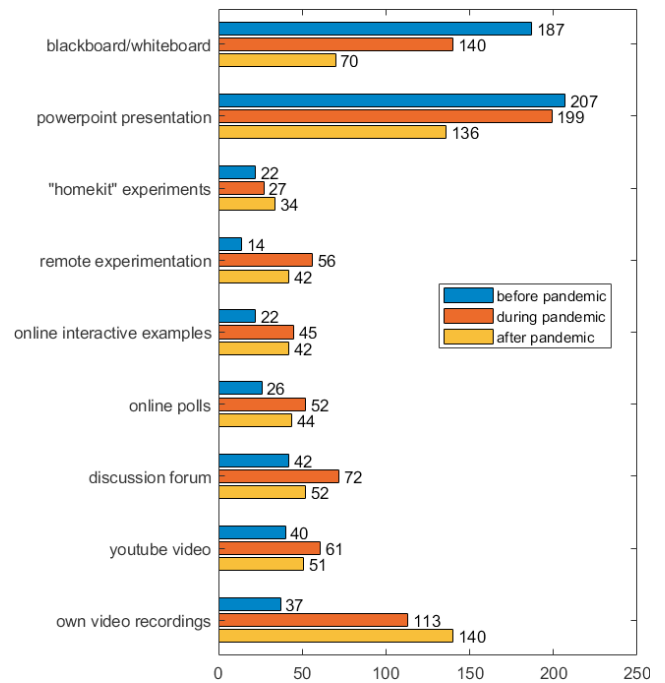


Fig. 9. Overview of tools used before, during and after pandemic

education will be the same as before, we wanted to know what we can expect in the future. Therefore, colleagues were asked which activities they would like to retain in teaching after the pandemic. Figure 9 enhances this study and compares the obtained answers to the expansion of tools that were used up to now. Regarding the use of blackboard/whiteboard, it is necessary to say that we were asking about the use of “virtual blackboard/whiteboard” that was used during online teaching. The increase in the item “own video recordings” was due to the fact that it actually includes two video forms - own videos (51 answers), but also pre-recorded lectures (109 answers). The most surprising result was the decrease of the use of Powerpoint-like presentations. All other online tools were as expected - reduced use in comparison to the pandemic period but the increased use in comparison to the period before COVID-19. In addition, some teachers would like to keep the recording of lectures to be later available to students for individual study.

Finally, Figure 10 shows the opinion about some statements related to the advantages or disadvantages of online teaching. As observed, most of the respondents agree that online teaching is most difficult for students and teachers. For students because they lose motivation and attention, being more difficult for them to ask questions and follow the lecture evolution. There is a general concern that being in front of a computer all the time opens many possibilities for distraction. For teachers, it is more difficult to keep the attention of students and get them to participate. Most of us agreed that face-to-face teaching provides live feedback from students which is impossible to observe in online teaching. So, most of us think that online teaching is not a good solution for education from a global point of view. However, some advantages were observed. For instance, to record the lectures can be useful for students to watch and revise the contents again. Also, to create video material

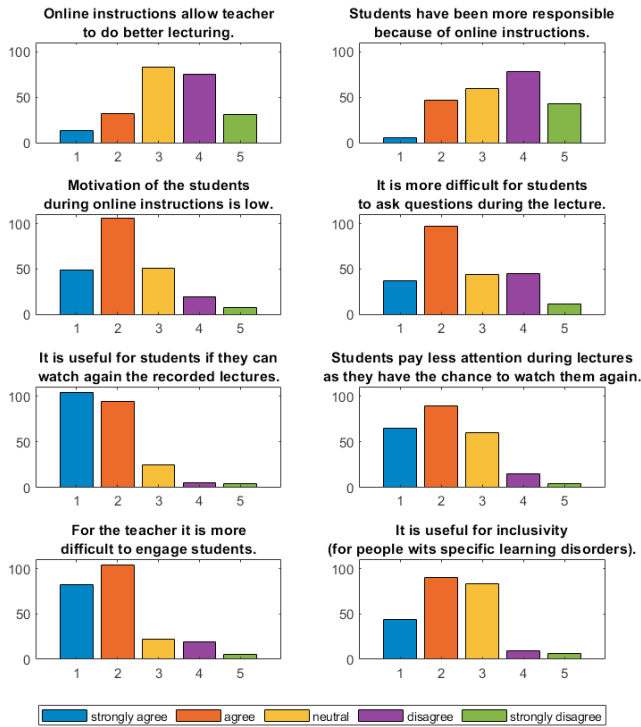


Fig. 10. Main advantages/disadvantages of online lecturing with respect to traditional in-person lectures

to explain some complicated concepts is a very powerful tool for lectures. Imagine, the typical question that is repeated time after time by students. The recording of a simple video about the solution can be of incredible help to students for better understating, and also to reduce the repetitive tasks for lectures. Moreover, to have tutorial meetings online is a very useful to address individual or group doubts, allowing for bigger availability. On the other hand, all the online solutions have demonstrated to be very beneficial for inclusivity situations for students with specific learning disorders.

#### 4. CONCLUSION

This paper summarizes the opinion of more than 230 educators from almost 30 different countries around the world, about the impact of the COVID-19 pandemic in control engineering education. This study was an initiative of The IFAC Technical Committee on Control Education, who proposed a working group composed by the authors of this manuscript in order to work on it. Then, this working group designed a questionnaire with the idea of collecting data about the technology, methodologies, activities, tools and any other resources used by educators worldwide during the pandemic. As a general conclusion, it was interesting to see that most of the respondents think that we will not teach exactly in the same way as before. Somehow, new tools and methodologies will be kept in our teaching activities in the future. For instance, it was a surprise to see the reduction in the use of Powerpoint-type presentations, and the increase of creating own videos to explain concepts and ideas. The use of remote experiments/tasks is another option that will be kept after the pandemic. Moreover, the tools for online lecturing is for sure now an important part of our new

education activities. In the case of exams, written exercises dominate over other options. This is perhaps because of the mathematical nature of control engineering, which is difficult to evaluate using other alternatives.

We think that this type of study can be very useful for the control education community. To share ideas among us is a very powerful tool to continue learning and improving. Future works are focused on collecting data on more specific topics such as: type of exercises, home kits, laboratory experiments for different levels, self-evaluation activities, etc.

#### ACKNOWLEDGEMENTS

The authors would like to thank all the colleagues who contribute to the survey, as well as Prof. Antonio Visioli as Chair of the IFAC Technical Committee on Control Education for his support.

#### REFERENCES

- Burgess, S. and Sievertsen, H.H. (2020). Schools, skills, and learning: The impact of covid-19 on education. *VoxEu. org*, 1(2).
- Burke, J. and Arslan, G. (2020). Positive education and school psychology during COVID-19 pandemic. *Journal of Positive School Psychology*, 4(2), 137–139.
- Jamalpur, B., Chythanya, K.R., Kumar, K.S., et al. (2021). A comprehensive overview of online education–impact on engineering students during covid-19. *Materials Today: Proceedings*.
- Marinoni, G., Van’t Land, H., and Jensen, T. (2020). The impact of covid-19 on higher education around the world. *IAU Global Survey Report*.
- McKibbin, W. and Fernando, R. (2020). The economic impact of covid-19. In R. Baldwin and B.W. di Mauro (eds.), *Economics in the Time of COVID-19*, 26–45. CEPR Press, London.
- Schleicher, A. (2020). The impact of covid-19 on education insights from education at a glance 2020. Retrieved from *oecd. org website: https://www. oecd. org/education/the-impact-of-covid-19-on-education-insights-education-at-a-glance-2020. pdf*.
- Tarkar, P. (2020). Impact of covid-19 pandemic on education system. *International Journal of Advanced Science and Technology*, 29(9s), 3812–3814.
- Trougakos, J.P., Chawla, N., and McCarthy, J.M. (2020). Working in a pandemic: Exploring the impact of covid-19 health anxiety on work, family, and health outcomes. *Journal of Applied Psychology*, 1234–1245.
- Williamson, B., Eynon, R., and Potter, J. (2020). Pandemic politics, pedagogies and practices: digital technologies and distance education during the coronavirus emergency. *Learning, Media and Technology*, 45(2), 107–114.
- Xiong, J., Lipsitz, O., Nasri, F., Lui, L.M., Gill, H., Phan, L., Chen-Li, D., Jacobucci, M., Ho, R., Majeed, A., et al. (2020). Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of affective disorders*, 55–64.