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Towards a Cloud-Based University Accelerated By the Pandemic

Carlos Delgado Kloos

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0003-4093-3705*

Carlos Alario-Hoyos

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0002-3082-0814*

Carmen Fernández-Panadero

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0003-4855-29237*

Pedro J. Muñoz-Merino

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0002-2552-4674*

Iria Estévez-Ayres

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0002-1047-5398*

Mario Muñoz-Organero

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0003-4199-2002*

María Blanca Ibáñez

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0003-2612-4207*

Pedro Manuel Moreno-Marcos

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0003-0835-1414*

Boni García

*Dept. Telematic Engineering
Universidad Carlos III de Madrid
E-28911 Leganés (Madrid), Spain
ORCID: 0000-0003-1808-8410*

Abstract—The coronavirus pandemic has accelerated the digital transformation of society, and in particular of university teaching. Professors who were reluctant or unwilling to take advantage of what digital technologies offered suddenly were forced to teach with technologies. In this paper, we describe teaching during the two main phases during the pandemic at Universidad Carlos III de Madrid (UC3M): the first phase during the complete lockdown and the second where students were allowed on campus with limitations. We also explain how the investment done during these two phases influences teaching in the future and how digital cloud-based technologies promote active learning at the university.

Keywords—digital transformation, digital education, cloud-based teaching, active learning, coronavirus pandemic.

I. INTRODUCTION

Universities have been promoting the use of digital technologies to improve teaching and learning for many years. There have been many initiatives, local and global. If we restrict to the present century, we can mention first the OpenCourseWare initiative, which was started at MIT in 2002 and then went global. The Khan Academy, shortly after that, was another proof that technologies were ripe for an agile production of digital educational content. The MOOC (Massive Open Online Course) revolution with a starting period around 2010 was another big push for education globally. MOOC technologies could also be used on campus in the form of SPOCs (Small Private Online Courses). The flipped classroom model that existed before made more sense, since videos and quizzes could be produced easily. Universities also had many internal initiatives to promote

teaching innovation. But then in March 2020 the pandemic came and forced all universities to emergency online teaching.

In this paper, we are going to report on the efforts carried out at Universidad Carlos III de Madrid (UC3M) towards digital education before the pandemic (section II), on the time with emergency online teaching in the spring semester of 2020 (section III), on the adapted teaching with limited presence in the academic year 2020/21 (section IV), and finally on how we see the future on the basis of an experiential and active hybrid cloud-based education (section V).¹

II. OLD NORMAL AT UC3M

The teaching model at UC3M since the adoption of the Bologna model consists basically in having in each course half of the time with lectures in large groups and half of the time in seminars in small sections. Labs are added where applicable. The large lecture groups include at most 120 students and the small seminar groups host at most 40 students. In parallel to the normal face-to-face teaching activities, a number of different initiatives were launched in order to promote alternative pedagogies and the creation of audiovisual material. Let's present them in list form:

- Teaching innovation projects have been promoted since 2003. These are educational projects proposed bottom-up by faculty. Typically, they involve 4 or 5 faculty members. Every year around 100 such projects are proposed and 80-90% approved for execution.
- OCW (OpenCourseWare): OCW courses started at UC3M in 2008 (ocw.uc3m.es). Since then, more than

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250 courses have been created with more than 500.000 visits yearly.

- 0 courses: 0 courses are refresher courses for incoming students that are taken before the semester starts. In August 2012 they were held in part online with the help of the Khan Academy platform (which was open source at the time) and content created by our faculty in the format required by this platform. (www.uc3m.es/grado/cursos-cero)
- MOOCs (Massive Open Online Courses): UC3M joined the MOOC platforms MiríadaX (miriadax.net) in December 2012 and edX (edx.org) in March 2013. Since then, annual calls have been launched for faculty to prepare MOOCs and more than 1 million learners have registered for these courses. This has promoted the creation of audiovisual educational material by the faculty with the help of the UTEID (Unidad de Tecnología Educativa e Innovación Docente – Educational Technology and Teaching Innovation Unit) created then.
- SPOCs (Small Private Online Courses): The next step followed automatically. The professors who had made MOOCs wanted to use their material in the regular courses. Other professors however preferred to start with SPOCs in their classes and then go out to the world with MOOCs. Be it one way or another, the call for SPOCs was included in the annual calls and an Open edX installation was created locally (spoc.uc3m.es). Some professors used the content as a complement and others to change the pedagogy and flip the classroom.
- Extension courses: Then MOOC-like courses were started to being used for many other purposes, such as continuing education. They were neither courses marketed as MOOCs nor for regular courses. Therefore, a new Open edX server was installed (extension.uc3m.es)
- Engagement apps: Several professors had been using engagement apps such as Kahoot! [17] or Mentimeter [20] independently. In the spring semester 2019/20 a trial period was launched to have one university-wide app. The app chosen was Wooclap [18], which was integrated into our standard LMS Moodle.

The purpose of all these initiatives was to promote a culture at the faculty to create educational multimedia content and interactive quizzes. This culture change and the support unit put in place have been immensely useful when the pandemic stroke.

III. EMERGENCY ONLINE TEACHING

On 10 March 2020, the Government of the Region of Madrid published a decree that suspended face-to-face educational activity at all levels, including the university level starting on 11 March. This implied an emergency situation overnight. Initially, the suspension would last only 15 days, but then it was extended for the rest of the semester.

During an emergency, one has to act promptly. There is no time for long-lasting plans. Three main decisions were taken. One was to continue all lectures and seminars online at the scheduled times synchronously using a videoconference platform. A second one was to implement an emergency

training program for the pedagogical use of such a platform. The third one was to establish an agile communication channel with faculty and staff.

On the first decision, we clearly decided that we opted for the synchronous mode of teaching a class. A lecture was not to be replaced by some material be it textual or audiovisual given to the students. There could be complementary documents or multimedia content for the students in the same as it was possible before. We valued the importance of synchronously teaching a class with the possibility for students to pose questions and for professors to implement active teaching methods. At the university, we were already using two videoconferencing solutions: Blackboard Collaborate Ultra and Google Hangouts Meet (that was later rebranded as Google Meet). We decided to make Blackboard Collaborate Ultra become the default system for all classes because it had many of the features needed for regular class development. It was already integrated with our Learning Management System, Moodle, so that for each course section the corresponding students were allowed to follow the class online. For other uses, such as meetings or office hours, Google Meet offered the best functionality because of its integration with Google Calendar. We should mention here that our main ICT services (email, drive, etc.) are powered by Google through GSuite for Education (now Google Workspace). Google Meet also served as a backup system in case of problems with Blackboard Collaborate and for some exams. In fact, at some moment, although Blackboard was exponentially incrementing their cloud to respond to the increasing usage, this backup option became important. It was only once and for a short time, but it happened.

Although many professors had advanced experience in using online videoconferencing tools and engagement apps in class, it was clear that not all faculty had the same level of mastery. Therefore, the second decision of devising a training program was equally important. On the precise day of 11 March, we communicated an emergency training program for bringing faculty up to speed for teaching online. The program was carried out from Thursday 12 March till Tuesday 17 March, four days of training that allowed the normal schedule of classes to continue one week after the suspension of in-person teaching. We designed a rather flexible training scheme that required no registration and allowed to follow the training as often as desired. The training itself was carried out on Blackboard Collaborate Ultra and therefore it was like teaching by example. We had one instructor teaching and several additional staff responding to a myriad of questions through the chat. There was such hunger to learn all the different features available. The training was followed by 1,525 faculty members, which with a total number of 2,000 faculty members, implied quite a large percentage (some of them are not teaching in the spring semester). The main training during these four days in March was about the educational use of the videoconferencing system and the advanced use of our LMS Moodle and in particular of the assessment features.

Figure 1 shows the evolution of the sessions launched every day and the total and unique attendance every day. Quite impressive how the whole university moved online overnight. You can see the rise starting on 18 March and even higher usage in the weeks after that, reaching over 22.000 unique daily attendees on 30 March.

Fig. 1. Sessions launched and daily attendance during March 2020

Several other rounds of training sessions had to be set up later on:

- Before the final exams to prepare for this challenge. The Respondus Lockdown browser was acquired, and specific training had to be given.
- In June/July and also in September additional training sessions were organized to prepare for the following academic year. Some faculty members who only teach in the fall semester needed to receive the basic training provided in March and therefore it was repeated. Furthermore, additional methodological and technical content needed to be presented. More about this in the next section.

The third decision in the early days of March 2020 was to maintain agile communication with all stakeholders. At a moment like this, many questions come up. To respond to this challenge, two main actions were taken. One was to set up a helpdesk through a unified email box managed by a group of staff members with different backgrounds. The other one was to deploy a website that contained all relevant information at each moment.

For the helpdesk, the email address uc3mdigital@uc3m.es was set up as a unique destination for all issues related to how the teaching should proceed. The management of this email box was delegated to a number of staff members. They would label the inquiries according to the topic and respond. In this way, the workload was shared, and all had access to questions and responses. When appropriate, requests were forwarded to other services.

Specific webpages organized under <http://uc3m.digital> were the other destination of the information. The information was organized by stakeholders: for staff, students, and faculty. This website included infographics to highlight the most relevant messages to convey, a FAQ, guidelines for teaching/learning and assessment, tool guides, the status of external cloud-based tools, and references to additional material. During the semester, many institutions issued many documents of different kinds. Some were recommendations, some instructions that had to be followed. It was necessary to analyze all this information and decide what applied to the university.

The exam calendar and the classroom assignment for the exams are always defined well ahead of time. When it was decided to make the exams online, several challenges came up. One was to prevent plagiarism, but then there were others of organizational nature. Each of the schools made the room assignment for the exams independently of one another. But

when moving the exams online, there is one global resource to allocate, namely the computing resources. And these were not infinite. So, it was necessary to determine what was the maximum number of concurrent students the system could manage, and how many could start simultaneously. At the same time, the technicians started to finetune the system to increment these numbers as much as possible. General coordination was needed as well as the definition of (shorter) timeslots for longer days. Due to this work, there were no disruptions during the exams. Also, no intruders came into the network due to the reinforcement of the firewalls.

In summary, during the summer semester of 2020, the strategy was: early reaction, clear instructions, relevant training, and agile communication. Many faculty members expressed their appreciation of what had been achieved. Looking back, however, this was the easy part. A greater challenge lied ahead. How to organize instruction in a mixed way?

IV. TEACHING WITH LIMITED PRESENCE

Starting September 2020, students could go back to campus, but in a limited way. Students in class had to use a mask and be 1.5 m away from each other. This reduced the effective capacity of lecture halls and seminar rooms between 30% and 70%, depending on the concrete rooms and whether they had fixed or movable furniture. Overall, this meant an effective reduction of seats from 16,500 to 7,500 for undergrad students.

What to do with the students that would not fit every day? To analyze the situation well, we need to fix the terminology. Talking about mixed or hybrid teaching does not clarify well what is meant. We envisage two main options:

- DS - Division by students. By this, we mean that some students follow the classes in person (onsite) and some online at the same time. All classes are taught in the same way, independently of the type of class, whether they are lectures or seminars.
- DC - Division by class types. By this, we mean that some class types are taught onsite and some online. All students have the same experience. Typically, lectures would be taught online and seminars (and labs) would be taught onsite.

DS (Division by Students) (see Figure 2) has an organizational advantage. The same schedule could be followed as in previous years. However, it has implications on the technology needed in the classrooms and on the cognitive load of the professor, who has to serve two kinds of students, the ones onsite and the one online.

Fig. 2. Division by Students

DC (Division by Class types) (see Figure 3) does not require any technological equipment in classrooms. It is also conceptually much simpler for the professor. However, it implies much larger organizational work. First, it implies measuring classroom by classroom to determine the exact capacity of each room. Since lectures were held online, the big lecture halls could be used for seminars with distanced students. Nevertheless, this implied a larger number of seminar sections (groups) with fewer students each and therefore more teaching load for faculty. On the other hand, lectures could hold more students than the maximum capacity of physical lecture halls.

Fig. 3. Division by Class types

These two, DS and DC, are the two main options. Other options are possible as well, such as division by course (some courses/subjects totally online and some totally onsite) or even by year (e.g., freshmen and seniors onsite and sophomores and juniors online). Combinations of all these options are also possible.

The main decision taken was to apply essentially DS for master programs and DC for undergraduate programs (with notable exceptions). Master programs have normally fewer students, and whenever possible onsite teaching was sought. The DC setting is very flexible and therefore very convenient for master students. This meant that equipment was installed in classrooms for master programs. These were Smart Technologies Podium 624 interactive monitors, such as the one shown in Figure 4. We believe that it is better to replace the standard blackboard on the wall with an interactive monitor and use shared board applications than to install cameras to stream the image of the professor writing on the blackboard. In this way, we take advantage of the collaboration features available in the board applications on the cloud.

However, for undergraduate studies, we had to find a uniform way to comply with the spacing limitations. We opted for having lectures online and seminars and labs onsite. For seminars and labs, personal proximity is more important. You cannot have some students onsite and some online. Nevertheless, you can perfectly have all students online for lectures. It was found that the student interaction worked better with the online chat tool in Blackboard Collaborate Ultra than in person.

Fig. 4. Teacher podium. The upper monitor is for videoconferencing. The lower monitor is an interactive one, namely Smart Technologies Podium 624

Equipment was bought for lending to professors so that they could give their undergraduate lectures online (from their offices or their homes). These were Wacom interactive monitors. The objective here is to install these monitors in the lecture halls for undergraduate studies once the pandemic is over. In this way, the investment made is fully taken advantage of in the future.

V. TEACHING AND LEARNING IN THE NEW NORMAL

How do we foresee university teaching to be when the pandemic is over? Some professors who did not value digital tools for education at all suddenly were forced to use them. And they found some interesting advantages. The same applies to remote work in general.

The new normal is not going to be like the old normal. It will be blended and hybrid. It will take advantage of the affordances of the face-to-face context and the ones of the digital context.

The cloud appears as a new communication space. Professors and students interact onsite but also additionally through the cloud even if they are in the same room. It is important to distinguish online from remote. Remote instruction requires online tools, but you can use online tools also in the classroom.

For remote instruction, cloud collaboration is key. Here we see two main components to start with: the visual interaction between professors and students (A) and the collaboration on the materials (C). But additionally, there is the informal interaction (B) that is equally important for the university experience. Let's analyze these three topics in more detail:

- A. Videoconferencing
- B. Virtual networking
- C. Cloud-based boards

A. Videoconferencing

We have seen how standard videoconference tools that were designed for meetings have been used for lectures and seminars. Multiple tools exist: Blackboard Collaborate Ultra [1], Google Meet [2], Microsoft Teams [3], Big Blue Button [4], Bluejeans [5], Jitsi Meet [6], Cisco Webex [7], GoToMeeting [8], Amazon Chime [9], and especially Zoom [10] that has seen an explosion in adoption. During the recent months, some of these tools have been seeing an addition of features on different fronts:

1) Image

The image would show a person with its background. Initially, there was no possibility to directly change the background, only indirectly through applications that create a virtual camera, like ChromaCam [11] or SnapCamera [12]. ChromaCam can detect the border of the person and the background and change the background. SnapCamera can do even more and add Augmented Reality resources. If one wants to add several sources to the image, such as including slides for the presentation of a virtual board on top of the image of the person, one can use OBS [13]. OBS is used by gamers to stream while they play e-games. Scenes with several sources can be defined, which can be changed with ease. OBS generates a virtual camera that can be input to any videoconferencing tool. It is a very flexible tool. There are now other tools with less flexibility but a simpler interface, like mmhmm [14], that allows to combine the presenter's image, a freely chosen background, and some slides or videos with educational content.

More recently, some videoconferencing tools have been including blurred and virtual backgrounds (predefined or uploadable ones), making the other applications unnecessary. Google Meet actually uses machine learning to determine the border between the person and the background.

2) Audio

One might think that there is not much to say about audio. But there are also interesting developments here. First, some applications, such as Google Meet, can cancel out noise that is not a voice. This is useful to filter out typing or background noise.

Then there are applications, such as High Fidelity [15] that provide spatial audio: the voice from a person on the left part of the image comes from the left. It gives a much more immersive experience and helps to understand better, especially if several people are speaking simultaneously.

The conversion from speech to text and text to speech has improved very much lately. Some applications generate the transcript of what the speaker is saying automatically. It could also be translated to another language on the fly. Applications such as PowerPoint and videoconferencing tools offer closed captions in several languages.

Editing recordings has also become easier. Applications such as Descript [16] transcribe the audio to the corresponding text. But then what you can do is edit the text and the audio will follow. If you delete a word in the text, the word is eliminated from the audio. If you replace a word with another one in the text, it is also replaced in the audio. The audio for the new word is generated automatically with the voice of the speaker. AI-generated voice clones that are used to create deep-fakes become handy when editing video.

3) Interaction

Even in lectures, the interaction of students is very important, and more in other kinds of educational events, like seminars. The video of the professor speaking is not enough. Therefore, many videoconferencing tools have been including textual chat components both for chatting throughout the presentation and for the Q&A (question and answer) session at the end. Some tools even allow to upvote questions, so that the speaker answers them first. Professors report that the interaction is more intense in online lectures than in face-to-face ones. It is clear, there is a lower entry barrier to posing questions online than onsite.

The conversation can also be initiated by the speaker or assistant, either through components for polls integrated into the videoconferencing tool or by using outside tools. Dozens of tools exist for this purpose, such as Kahoot! [17], Wooclap [18], Socrative [19], or Mentimeter [20] to mention a few. These are equally valid for onsite or online classes. They are also useful for hybrid classes.

4) Management

Class for Zoom [21] provides some interesting possibilities in terms of combination of views. For instance, it is possible to have the teacher and teaching assistants or presenting students in key positions on the screen so that they are distinguished from the rest, and to have student views with specific orderings (alphabetical, hand-raising, engagement, feedback). It is also possible to combine the teacher with content-based background, to sit students together in a virtual lecture hall (see Figure 5), or to add the images of remote students to one of students in class for hybrid settings. There is a special procedure to authenticate students so that no incoming people can enter the class. It is also possible to view the students' desktops and even to get a report whether they have the app as the active window. A student dashboard presents additional information. All these features provide a much richer experience from an educational point of view both for the teacher and the students.

Fig. 5. Example of the virtual desk view with all the participants seated. The original background is removed from all participants and a row of seats added. This image is from Microsoft Teams, where it is called 'together mode', but the feature is also available in Class for Zoom.

This provides a transition from videoconferencing tools that are designed for meetings to ones that are more appropriate for education. Due to the investment that is presently carried out, we are convinced that many more such initiatives will come up.

B. Virtual Networking

Videoconferencing tools normally only support the scheduled formal interaction in class. However, some newer tools support spontaneous informal interaction as well. Applications like Wonder (formerly Yotribe) [22], Gatherly [23], Gather.town [24], Rally [25], Remo [26], inSpace [27], Remotion [28] or Minglr [29] offer support for this. You can typically see a plane where nodes representing different users can freely move (Fig. 6). The background can be changed to a few preset images or to an image that is uploaded. The nodes have the name, picture, or even live image of the person they represent. Once nodes come close to each other on the plane, a videoconference starts automatically. In some applications, the places to meet are fixed, such as tables with 4 or 6 seats, or they are lists, or they can be any place on the plane.

Fig. 6. Example of the use of Wonder: the 4 nodes have come together and a bubble was formed launching a videoconference with the 4 participants.

Other applications give more value to the virtual environment. Rather than having a plane where the representatives of the persons can be seen, there is a 3D environment with avatars representing the persons. An example of this is the iLRN virtual campus [30]. The context is richer, but the interaction is typically limited to text or audio.

C. Shared Cloud-Based Boards and Documents

The cloud can be used to host a virtual board that can be shared online. It can be used by professors as they would normally do with a blackboard or whiteboard or as a collaborative board where students with or without a professor can construct something together (see Figure 7).

Fig. 7. Example of the use of Google Jamboard

You can scribble with your handwriting, but you can include boxes with typed text and also include some geometric figures such as boxes, circles, and arrows. Let us distinguish three kinds of shared board applications (see Figure 8):

- General shared boards. Boards for handwriting, geometric figures, and text.

- Boards specialized in diagrams. Boards that concentrate on geometric figures in order to draw diagrams. Handwriting is not possible.
- Shared documents. Applications specialized in text. It can be strings organized in lines (text documents) or numbers organized in tabular form (spreadsheets).

Fig. 8. Classification of shared boards

1) General Boards

There are many applications for general boards. Jamboard [31] by Google, shown in Figure 7, is one such application that runs in a web browser or on iOS and Android smartphone apps. Jamboard is also the name of a physical board that runs this software. Microsoft has Whiteboard [32] as a standalone Windows app or for the web browser or iOS smartphones. And then there are many others: Stormboard [33], Conceptboard [34], Sketchboard [35], Limnu [36], and many more. Some are open source such as OpenBoard [37] and some with only payment options such as Mural [38]. Some have many features, such as Miro [39], and some are quite simple, such as Whiteboard Fox [40] or AWW (A Web Whiteboard) [41]. Some include additional features in the application, such as text or video chat or templates and frames, and others prefer to integrate with other applications, such as Slack. Be it one way or another, these board applications on the cloud make the classical blackboard very weak in terms of expression possibilities.

2) Boards for Diagrams

Whereas general boards are very flexible in what you can draw, specialized ones allow working faster for what they are optimized. Google Drawings [42] is Google's diagramming software for creating collaboratively all kinds of diagrams, such as organizational charts, flowcharts, concept maps, etc. The diagrams can be downloaded in several formats or inserted in Google documents. Diagrams.net [43] is free and open-source software that is available for Windows, macOS, Linux, ChromeOS. But it also works in a browser and integrates well with Google Workspace, Office 365, and other apps. There are many more. Here are a few more: Invision Freehand [44], Microsoft Visio [45], Lucidchart [46], or Gliffy [47].

Some applications specialize even more, say for Mind maps or Concept maps: Bubbl.us [48], Coggle [49], or Mindmeister [50]. This specialization allows drawing much faster since the app has knowledge of the type of diagrams drawn.

3) Shared Documents

Shared documents like Google Docs [51] are also "places to meet" on the cloud, in this case, to write documents collaboratively. They can be considered as shared boards specialized on text strings organized in lines. Multiple versions that are sent by email are things of the past. People meet on the cloud to write documents collaboratively, be it

synchronously or asynchronously. History and commenting functions help further.

If instead of strings in lines, we need text (often numbers, but not only) organized in tabular form, we are talking about spreadsheets that also can live on the cloud. It is Google Sheets [52] in the case of the suite of Google Workspace [53]. And if we want to optimize for presentations, we need Google Slides [54]. Note that Google Slides can on the one hand be used to create a presentation collaboratively. Matt Miller [55] has numerous applications on how to use this possibility in an educational context. For instance, each student draws one slide for a given task. On the other hand, the slides can be presented by the teacher in class, and the students can follow the presentation on their devices. Interaction features such as polls and questions are also integrated into the tool, which makes the class more interactive. In the first case, the cloud supported the creation of the slides, in the second, the presentation.

Of course, Windows Office tools, such as Word, Excel, PowerPoint, and more, have “traveled” from the desktop to the cloud for collaboration through their 365 counterparts [56]. The same applies to Apple iCloud tools Pages, Numbers, and Keynote [57].

Apart from the tools from the big players, there are other ones that are interesting as well, for instance, Etherpad [58]. Etherpad is an open-source project. You can set your own server for document collaboration. There are additionally some institutions that provide their servers free of charge. Perusall [59] is basically a social e-reader. After uploading documents, open educational resources, or books by major publishers, students can comment and engage in a conversation around the text. This participatory interaction on the class materials helps to understand the content much better.

VI. A HYBRID FUTURE IN EDUCATION

Be it through general or specialized shared boards and documents, and virtual formal and informal meetings, part of the action is moving online. The question is not whether onsite or online is better, because each of the two spaces has advantages and disadvantages, the question is how to combine the two spaces to achieve the best learning experience.

Two trends come together and match very nicely. On the one hand, the need for constructive teaching and active learning. On the other hand, the use of technologies to support hybrid cloud-based education. The cloud is a space that supports active education very well.

The change to hybrid education is necessary, but this change has to be managed well. Pedagogy is needed here as well and lots of support and professional development programs for faculty and staff. Institutional reorganization is due to support the change like we have done with the creation of UC3M Digital and the realignment of the units included in it.

However, there is an additional difficulty when trying to define a future setting: the speed at which technological innovations take place. The already close-to-exponential growth is being incremented even further by the tremendous investment made by companies to take advantage of the opportunities brought by the pandemic. Advances in synthetic speech generation, deep learning, high-speed networks, new

materials, and in many more areas, will allow doing things that are barely imaginable today.

VII. CONCLUSION

In [60], the final report of the Online Education Policy Initiative at MIT, the authors express four recommendations. The document is from 2016, but very applicable to the times we are living through presently [61, 62]:

- Recommendation 1: Increase interdisciplinary collaboration across fields of research in Higher Education, using an integrated research agenda.
- Recommendation 2: Promote online as an important facilitator in Higher Education.
- Recommendation 3: Support the expanding profession of the “Learning Engineer”.
- Recommendation 4: Foster institutional and organizational change in Higher Education to implement these reforms.

Here we want to stress that we have implemented recommendations 2 and 4 at our university.

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