

Article

Challenges Regarding Scientific Transcription in Virtual Office Hours

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Abstract: Mathematics teachers face great difficulties during virtual communication with their students, mainly because scientific and technical subjects use a great many mathematical symbols, abstract objects and a wide variety of technical nomenclatures that are not directly represented on the keyboards of computers, tablets or other communication devices. This paper aims to facilitate oral and written communication between teachers and students in mathematics subjects. In this regard, we describe realistic procedures for use in virtual office hours. We analyse different methods that combine the use of computers, tablets, webcams and an institutional video lecture system. The improvement in oral and written communication will have a positive effect on academic performance and decrease the dropout rate in distance learning courses, because the students feel more closely accompanied in their learning.

Keywords: scientific transcription; virtual office hours; mathematics education



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1. Introduction

One of the greatest difficulties for the teaching community in scientific and technical subjects is the way in which they communicate their discipline to distance learning students. This is crucial in the case of courses that are carried out entirely online, which are very common nowadays. Each year there are more courses of this type on offer, as most universities do not want to be left out of this new scenario and are strongly committed to this modality. They offer Massive Online Open Courses, as well as regular training (degrees and postgraduate courses) online. For example, more than 11,400 free courses can be accessed at <https://mooc.es/> (accessed on 10 January 2021). The Massachusetts Institute of Technology offered distance learning in 33 different academic disciplines in 2017, via the MITx Courses Platform; today these disciplines offer more than 400 courses [1]. Harvard University has approximately 360,000 non-US students taking distance education courses [2]. In addition, the Edx Educational and Learning Platform founded by Harvard and MIT in 2012, currently offers over 3000 courses with approximately 20 million students. Over 120 institutions are part of a prestigious cast of Edx partners [3].

The abundance of symbols in mathematics-related subjects is an obstacle to the flow of written communication: Signs are not limited to the letters of our alphabet, but include diagrams, arrows, graphics and special characters, which are not easy to produce using a conventional computer keyboard (see [4,5]). Almost all students, and many teachers, are unaware of the existence of word processors with equation editors that are efficient (in terms of speed and precision). While many office systems—such as Microsoft Office, OpenOffice from the Apache Foundation, or LibreOffice from The Document Foundation—include word processors that offer the possibility of composing mathematical equations, these are very limited, simply allowing the user to “drag and drop” from a list of signs (such as fractions, powers, matrices, integrals, etc.). On the other hand, there are other specialised word processors, such as L^AT_EX distributions [6,7], which produce high-quality

graphics and symbols, but whose learning curve is slow. For inexperienced users, it is difficult to create formulas in a real-time conversation (see [8–10]).

Asynchronous office hours (i.e., where the student asks for help at a given time and the teacher responds at a later time) presents a simpler situation than synchronous office hour sessions. In the case of asynchronous office hours, the student can use paper and pencil, then take a photograph of the written note with a tablet or mobile telephone, and send it to the teacher by email or via the Virtual Learning Environment (VLE). In turn, the teacher can either reply in the same way or write the text using his or her computer. There are several possibilities:

- Editing the text with a word processor, as we have mentioned above, and attaching the resulting document (in PDF, DOC, DOCX or ODT format) to the email or uploading it to the VLE.
- Editing the text directly in the VLE. Environments based on the Moodle platform allow the messages in the forums to be edited in this way. An example is shown in Figure 1, where a student asks for a formula, using an intuitive but incorrect syntax, the teacher replies using the \LaTeX language in the message and the forum interprets the code properly and displays the formula perfectly. That is why it should be indicated in the reply that the message needs to be read in the virtual environment, since the \LaTeX code is not interpreted correctly in the email notification (and therefore the formula is not displayed). Another way of managing these messages is the one used by Universitat Oberta de Catalunya, which has implemented an equation editor in its email interface to allow equations to be edited directly in emails [10].

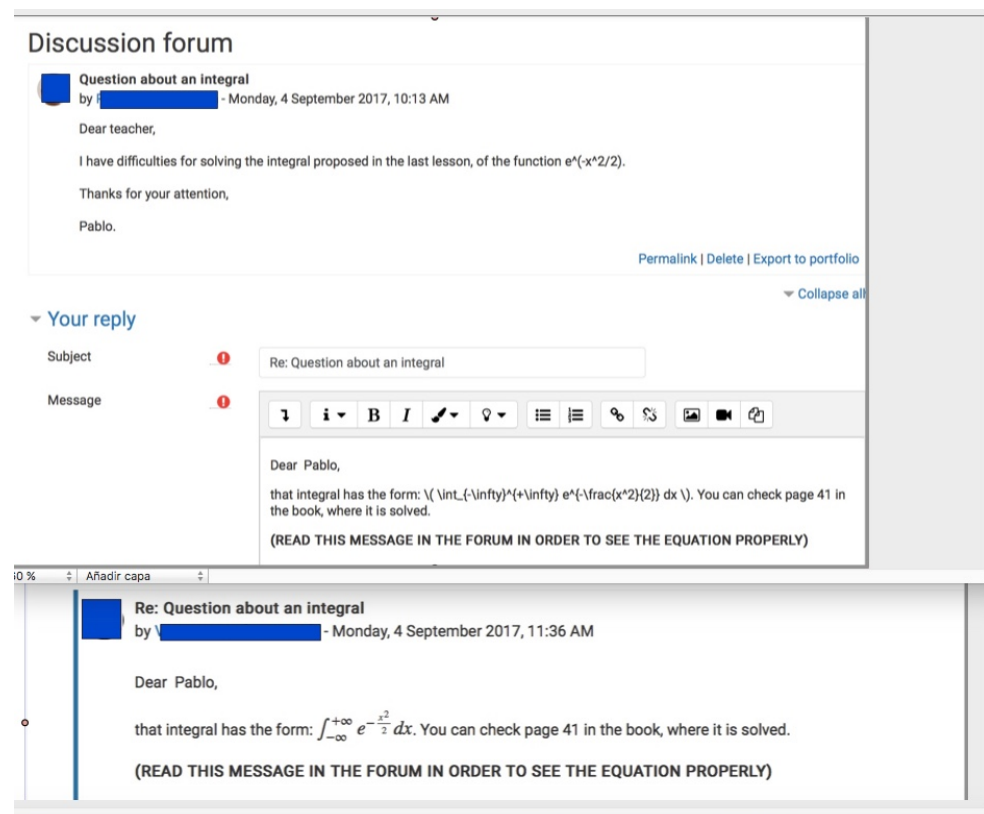


Figure 1. Communication through a Virtual Learning Environment (VLE) forum by using \LaTeX commands. In the upper part the editing part is shown, while in the lower part the effect that the \LaTeX compiler produces on the written code appears.

In synchronous communications, explanations must travel “live”. In this case, in order to achieve fluid communications, we need a device that captures analogical signals and transforms them into digital signals, so that they can travel between the two terminals.

Therefore, the minimum technological requirements that both terminals must share are a broadband Internet connection and a moderately powerful computer. There is an additional requirement, which is imperative for the teacher and highly recommended for the learner, in order to allow the mathematical writing to flow between them: A touchscreen device equipped with a precision stylus to produce readable text.

The motivation behind this research was the creation of a distance education group within the Master's Degree in Computational Mathematics offered by Universitat Jaume I of Castellón (see [11,12]). After the first few years, the teachers noticed that, despite keeping the virtual learning environments up to date with the materials and planned activities, many of the students in that group dropped out of the course (50% of students), while the face-to-face group maintained a rate of 25%. We conjectured that office hours face-to-face was the essential difference between the two types of students, so efforts were made to find the ideal conditions under which to replicate conventional face-to-face office hours with these students. In this regard, a study analysing dropout rates by [13] can be consulted.

Herewith we present and analyse different computer tools that are designed to avoid the difficulty of editing scientific symbols using conventional word processors, which are not very manageable for new users and that detract from fluid communications.

2. Communication Based on a Computer + Webcam (Or a Smartphone)

The basic computer equipment required is a computer with a webcam, microphone and speakers. The process is to establish communication by videoconference, which in this case will always be possible given the equipment described and the existence of popular applications such as Skype, Microsoft Teams, Google Meet, etc. During communication, the way to treat scientific symbols without additional devices involves focusing the webcam on a paper document or whiteboard, where the teacher will write his or her explanations, and the student will be able to see it on his or her monitor (see Figure 2). The process can be repeated in reverse when the student wants to represent symbolic objects.



Figure 2. Communication based on a computer and webcam.

This type of communication is not the most efficient, because certain negative circumstances may affect communication: Inadequate lighting, low resolution, poor choice of webcam position or sound problems. All this can impede clear communication between

the sender and receiver. Obviously, this means is rudimentary. The reason for including it is that it could be of interest to students or institutions with low budgets.

The most popular Internet video conferencing software to date is Skype, while Google Meet is similar software that belongs to the universe of free applications and web tools from Google Inc., which are available to anyone who has a Gmail account. Both can be used on a computer or any other mobile device and provide a window of communication between teacher and student (or a group of students).

The characteristics of this type of communication are as follows:

- The voice remains the essential element of communication.
- A Skype or Meet connection is needed to transfer the images captured by the webcam.
- The webcam is usually focused on the person or people involved in the communication. However, there are other configurations, which may be more useful in some cases:
 - Focusing on a real notebook or slate where the teacher goes about writing and explaining and the student will see what is being written and listen to the teacher's comments. In this case, the student should be able to interact with the teacher. In this way, it is entirely possible to reproduce a conventional meeting to solve doubts in office hours.
 - A combination of the following elements: Reproduction of the teacher's computer screen, accompanied by the corresponding explanation. This configuration allows the teacher to explain how specific scientific software programs are used, showing step-by-step instructions and looking directly at the effect they produce.

On the other hand, a similar communication tool is using a smartphone. Perhaps this type of communication is the most affordable and popular for students, and therefore should not be declined. In this case, the steps to follow are the following:

- Open a videoconference session.
- Open the same video call on the smartphone.
- Focus the camera of the smartphone either on a blackboard (see Figure 3) or on a sheet of paper located on the desk (see Figure 4).
- Add users through an invitation.
- Proceed to the student-tutor interaction.



Figure 3. Office hours through videoconferencing using traditional whiteboard. On the left, the teacher answers the students' questions by focusing on the blackboard with the smartphone's camera, while the student follows the explanations (right side) with his computer.

In case of any partner having difficulties using Skype or Meet, there are other free websites that would perform the same function. One of them, very popular and of acceptable quality, is the website Whereby [14], that admits free subscription for a videoconference room with up to four participants.



Figure 4. Office hours through videoconferencing using the smartphone by focusing on a piece of paper.

3. Communication Using a Personal Computer and Tablet

An improvement of the situation described in the previous section is the digitisation of the teacher's handwriting using a touchscreen device. These devices, together with the right software, provide clear results and an efficient way of managing written notes (screens) that can be reused in office hours of other students, or saved and made available in the course's VLE. Over time, technology has advanced so that tablets can now capture manual writing very accurately; the Wacom brand (see [15]) is the ultimate exponent. These tablets are connected to the computer via a USB port, and they include software that enables many possibilities: Handwritten notes, artistic drawings, etc.

The most economical tablets have a disadvantage: No trace of the pointer is left as it slides across the surface, although the magnetic tip translates the stroke to the computer screen. The user needs a period of adaptation to acquire the skill of writing on the tablet while looking at the result on the screen. To simply retouch the images or text of an already edited presentation (underline or circle words, draw arrows to join ideas, etc.), this type of tablet is sufficient, but not for manual writing, especially if the writing contains small letters, such as subscripts.

Higher-range Wacom tablets have a screen where the user can see the strokes as they are written and can write with total ease. However, these tablets rival the multi-faceted tablets with the Android or iOS (Apple) operating systems that, for a similar price, can capture writing and additionally allow the user to browse the internet, which—thanks to cloud technologies—make it possible to perform tasks such as the edition of office texts, calculations and many others, without the need to install software. For this reason they are uncompetitive from an economic point of view. However, it should be emphasised that the vast majority of today's tablets (with the aforementioned operating systems) do not allow precise writing: All of them allow the user to scribble with a fingertip or a rubber-tipped pencil, but a special touch technology is needed to capture writing down to the smallest detail, as mathematical writing requires. Unfortunately, the market is not clear about this technical specification, and customers who are interested in accurate writing have to go to stores to test the devices and make sure they have that capability. For example, until the launch of Apple's iPad Pro, earlier models of iPad did not achieve precise writing. This was satisfactory, but far from perfect, and could only be done using a special pointer—from

a foreign brand such as Adonit Jot (see [16])—with a plastic disc at the tip. The iPad Pro features an Apple stylus (optional) that provides a perfect writing experience. Similarly, some Samsung tablets (the Note models) with the Android operating system have screens with a double capacity: One that recognises finger contact and another that recognises the magnetic field of the tablet's own pointer (called an S Pen). Some note-taking applications use that double layer to make the writing experience comfortable and accurate.

Under these circumstances, the written communication between teacher and student can occur in several ways:

- Tablet → Computer → Videoconferencing (see Figure 5): The screen of the tablet is “mirrored” as a window on the teacher’s computer screen, which is shared with the student during the video conference.
 - Tablet:
 - * The teacher needs a note-taking app that can handle and store several pages, so that the notes can be revisited. Examples of free apps of this kind are: Penultimate [17] for iOS and Squid [18] for Android.
 - * Apple devices have Airplay, a built-in protocol for broadcasting their screen to other devices, such as a computer or television. Android devices can use the free application Mirroring360 Sender Basic [19] or other options such as those explained in [20,21].
 - Computer:
 - * In order to receive the signal from the tablet, the recipient needs either an Apple TV receiver or software such as Mirroring360, which is relatively inexpensive (see [19,20]). The tablet is mirrored on the computer screen.
 - * Video Conferencing software (Skype or Google Meet) makes it possible to switch between the webcam image and the desktop (the full screen or any of its opened windows), so that the conversation can move dynamically from the picture of the teacher to the handwritten explanations or computer explanations.
- Tablet → Internet browser: There are websites whose content is a blank canvas on which visitors can write. These sites are helpful when they are used with touchscreen devices. An example of a free website is A Web Whiteboard [22]. This site allows the user to save the final written content as an image file in PNG format and share the temporary URL with collaborators in order to enable them to see and write on the same board. Other similar websites offer storage and management of the generated whiteboards in the cloud, but they all require a paid subscription. Another free Google App with the same functionality is Google Jamboard [23].
- Teacher tablet → Student tablet (see Figure 6): When both teacher and student use the same type of device, they can interact on a shared document through a specific app (see [24]).



Figure 5. Communication between teacher and student via videoconferencing by using a tablet and computer.

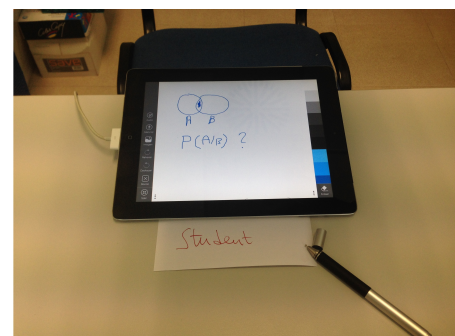
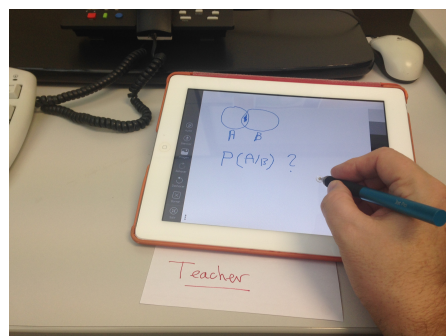


Figure 6. Communication between teacher and student via tablets.

4. Institutional Video Lectures

The best tool for reducing the student's need for office hours is recording video lectures. If video lectures are made available to students publicly (on a site like YouTube) or privately (on the Moodle platform, the VLE in the case of our institution), students can overcome a few of the difficulties of the learning process by themselves: Missing a specific detail, following complex arguments, etc. Video lectures can be played back repeatedly until the student finally understands. Otherwise, office hours are required.

One way to record teacher office hours from the computer is to use specific software, such as Camtasia [25], with a commercial license, or aTube Catcher [26] and CamStudio [27], with a free license. It is enough for the desktop to contain the image of a whiteboard (as discussed in Section 3), where the teacher writes, and a pre-recorded video is achieved.

Another way to produce videos is to take advantage of the tools available on the Internet. The website YouTube allows live streaming and recording from a computer desktop or from a mobile telephone or tablet. Once recorded, the video can be edited online with the utilities provided by the website itself [28].

In order for the video to have a more motivating effect on the student (so that it is not just a "voiceover" that accompanies the marks that appear on the board), it is important

for the teacher to use the computer webcam to display his or her image in a corner of the screen. This can be achieved in several ways: It is automatic when sharing screen in Skype or Google Meet calls, and it can also be obtained through the popular free media playback software VLC [29], which allows such a window to be created using the following menu options:

1. Medium > Open capture device (choose webcam)
2. Video > Always above all
3. View > Minimum interface

By placing the window in one corner, the experience is much closer to face-to-face learning, especially if the student knows the teacher personally. It is important to involve the student emotionally, which is certainly the best way to help them in their learning using the mechanisms that their brain uses for this purpose [30]. It has been proven, especially during recent decades, that new technologies not only result in new educational methodologies [31], but are also very useful for applying the good practices of traditional methodologies to students who were not able to attend on-site classes: New technological means, intelligently combined with contrasted traditional methodologies.

In the case of our institution, a great deal was invested in technological means between 2005 and 2010, and practically all the classrooms are equipped with multimedia tables with the appropriate software and hardware (the computers are constantly updated and have a touchscreen, and there is a video projector). A considerable number of these classrooms (about 40, see [32]) have a high-resolution camcorder installed on the ceiling, with 4 preset positions (see Figure 7). Every teacher can record the daily in-class lecture by following a few simple steps:

1. Select from:
 - (a) PC desktop: It takes the desktop image.
 - (b) Camera: It takes the video camera image from the classroom ceiling.
 - (c) PIP: A switch that enables or disables the overlay of the ceiling camera image in a corner of the desktop.
2. If “Camera” or “PIP” are chosen, the teacher must select one of four preset camera positions, which will focus on:
 - (a) The chair where the teacher usually sits in order to use the computer.
 - (b) The lectern, where a touchscreen monitor with an accurate stylus is installed, which controls the computer.
 - (c) A close-up of the blackboard.
 - (d) A general view of the blackboard.
3. Press the “Save” button to start recording.
4. Press the “Stop” button to stop recording.

After stopping the recording, the video file is transferred via FTP to the remote video server, where the video processing starts and, in a few minutes, the video file is privately available for the teacher. It can be viewed, edited online, deleted and marked as publishable. If published, it can be accessed from any Internet browser by simply using the URL, which is usually linked within the Moodle page.

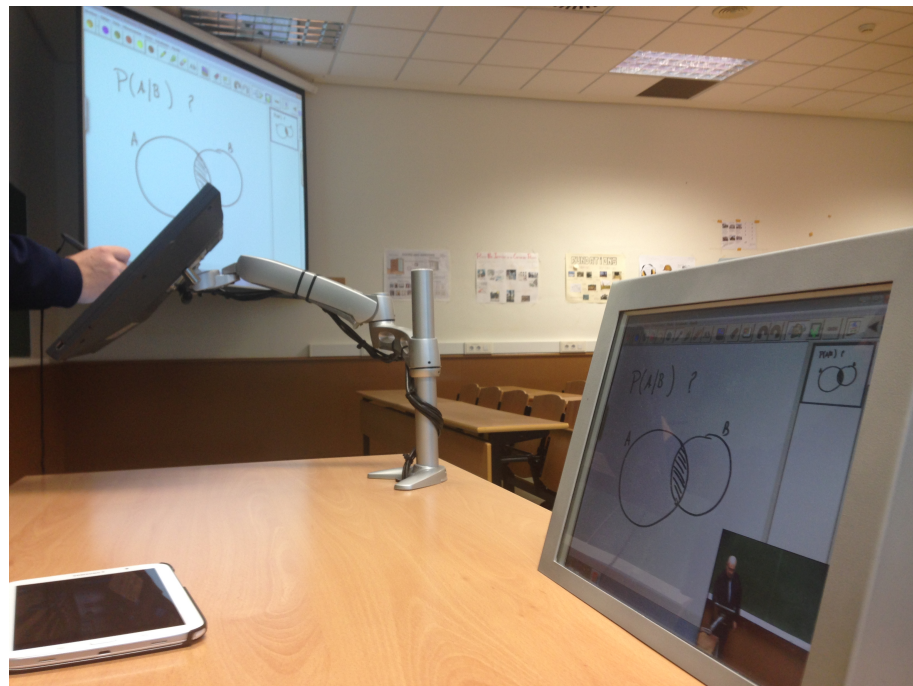


Figure 7. Communication by using an institutional videoconference.

5. Conclusions

In this paper we have described several options for managing office hours with distance students in mathematics subjects, and it can be extended to Engineering and Science subjects in general. Different tools and procedures are analysed that make it possible to overcome the difficulty of written communication of mathematical symbols.

It can be seen that the method described in Section 2, based on the use of a computer and webcam, is the most basic, depending on external factors such as good lighting and a suitable placement of the webcam. However, this choice should not be ignored, as it may be the only one available to students or countries with limited resources.

A significant leap in communication involves the use of tablets, which can be used for manual writing, thus making it possible to display mathematical symbols without losing clarity. In Section 3 several procedures are presented, depending on the resources available to teachers and students, either using tablets alone, with the appropriate software or interacting on a website, or complementing the tablet with the computer to explain how software works.

Section 4 describes the case of our institution, which has incorporated the technical means into many classrooms for video recording of classroom lessons. The use of video-classes in the virtual learning environment has allowed students to reduce the need for office hours, thus enhancing autonomous learning.

Since the use of more sophisticated equipment can improve the quality of communication, we must not lose sight of emerging technologies and the latest tools. The area of information and communication technologies is growing at such a rate that today's novel tools can become outdated in a very short time.

Another important aspect to consider is the desirability of establishing a visual link between the teacher and the student during communication, in the different ways described above. It is very positive for the student to see the teacher. In this regard, for example, when recording a session on a virtual whiteboard, showing the image of the teacher giving the explanation in a lower window can enhance the student's perception sense of accompaniment in the learning. Personal contact between teachers and students is considered crucial for optimal academic advancement. The benefits of empathy, body language and sensitivity generated in face-to-face teaching are difficult to emulate remotely. However, due to geographic dispersion, lack of economic resources, or critical situations such as

the Covid-19 pandemic in progress, face-to-face contact cannot occur. In this regard, the current technological revolution in communication devices is very useful in overcoming these shortcomings.

In our opinion, online communications between the teaching staff and the students must be taken very seriously by institutions that offer distance learning in scientific and technical fields and try to ensure that this training is of a high quality. This communication must be accessible, fluid and capable of enhancing interaction. These requirements should not lead to a model based solely on the use of new technologies. The design of a virtual education model should pay special attention to methodological planning and be well thought out [33].

Office hours are fundamental in learning, especially in terms of the student's perception of accompaniment: The feeling that the teachers are concerned largely prevents high dropout rates on these courses [13,34–36]. In addition, these institutions should carry out specific training courses for teachers who will be in charge of online teaching, which should be done before the start of the academic year.

The need to establish fluid communications to resolve students' doubts in distance office hours has been a constant challenge in university departments that teach scientific subjects. This is particularly the case in our department when giving courses to students who cannot attend our on-site classes because of geographic restrictions. Our experience indicates that improving written communications has had a positive effect on the learning process of the subjects involved. We support our analysis with the summary of a small survey collected in the Master's Degree in Computational Mathematics offered by Universitat Jaume I of Castellón:

- Regarding students, the majority of students (63.6%) use institutional video classes and tutorials recorded by the teacher, and consider them very useful. However, their use of tablets and smartphones to communicate with teachers is scarce (9.1%), as well as the use of online collaborative whiteboards (18.2%). Nonetheless, they consider these ICTs tools very useful (63.6%).
- Regarding teachers, a great majority use Skype, and tablets or smartphones to communicate with other teachers in online meetings (81.8%). However, only a few (14.9%) use these devices in teaching tasks, and just a 43% is recording video lectures for their students. In contrast, most of them (85.7%) acknowledge the benefits of an ideal situation where both teachers and students would use tablets with handwriting facilities in their interactions.

Our work shows affordable tools to carry out the use of ICTs that educational actors are willing to use, as we can see in the survey, and whose institutions should encourage and give effective support.

If advanced tablets are not available, a first approach should be the use of a smartphone, focusing on the blackboard or paper (Section 2). Once the use of tablets gets more widespread, teacher/student communication via tablet (Section 3) is more advisable. Finally, it is always recommended to continue with the use of institutional video lectures (Section 4), which are widely accepted and valued.

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