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Online teaching of practical classes under the Covid-19 restrictions

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ARTICLE INFO

Keywords:
Education
Covid-19
Online teaching
Home lab
Remote laboratories

ABSTRACT

COVID-19 pandemic and its restrictions bring new challenges to all aspects and phases of higher education. At universities, new remote formats have been developed and deployed for lectures and laboratory exercises. This article addresses challenges and introduces the new experience with lectures and laboratory classes during the pandemic time at the Department of Measurement of the Czech Technical University in Prague, Faculty of Electrical Engineering. Based on the student survey of more than 250 students describes the possibilities of how to adapt the lectures during the lockdown. The article also introduces the Home Lab, a tool developed in the department that helps in distance teaching practical electronic classes. Home Lab includes two parts with functional groups, a Laboratory Experimental Device and a System of Measurement Instruments. The article also shows the opportunity for suitable remote exercises and variants of circuits that can be easily assembled and measured using Software Defined Instrument based on various microcontrollers. A detailed description of all How from the teaching software-oriented courses. At the end of the article, practical knowledge and an experience from distance teaching during a three-semester lockdown are shared.

1. Introduction

The COVID-19 Pandemic has dramatically changed teaching at many universities. It is still unclear how long the measures will last, and there is no uniform guidance to help universities quickly transition to a new, full-fledged form of teaching. This situation is particularly challenging for technical universities with large amounts of practical activities and laboratory exercises initially, as they have had to set up a stable, full-fledged online learning system quickly. Everything that had previously been done in face-to-face form, from the actual lectures, seminars, practical demonstrations, and laboratory exercises to written tests and oral exams, had to be converted into digital form, not to mention all the legal and administrative processes behind [1-5].

A significant advantage of universities is that the vast majority of them already have extensive experience in delivering online education and have a range of tools that can be used for this purpose. However, a transition from face-to-face to distance learning requires a rethinking of the concept of the organization of teaching and the provision of a number of related activities, especially in the areas of communication, planning of learning activities, and selection of appropriate methods and tools [6,7].

The Pandemic brings new challenges for universities:

- Sustaining quality: the long duration of the Pandemic - entering graduates spent half of their studies in distance learning in the case of undergraduate programs. In the case of the master’s program, the situation is even worse - three of the four semesters were spent online. Will these graduates become good engineers? [8,9].
- Social aspects: Building own network of contacts (classmates, roommates) is a big part of higher education [10]. How is this traditional process affected in a situation where many students spend a large part of their studies with their parents?
- Staff: rapid transformation is demanding on human resources. Technical universities have a clear advantage over, e.g., humanities-oriented universities in dealing with the digital environment and distance learning tools [11]. However, even some teachers in technical universities may be less comfortable with digital tools, and it is best to see if they need help or someone to consult. Being cooped up at home can be isolating and deepen the fear of dealing with a global crisis. Regular checking in on their feelings of anxiety is as important

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https://doi.org/10.1016/j.measens.2022.100378
Received 23 February 2022; Received in revised form 3 May 2022; Accepted 9 May 2022
Available online 13 May 2022
2665-9174/© 2022 CTU in Prague. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
as checking in on ongoing learning. What tools can lecturers use to ensure continuity of learning and transfer of teaching from the university to home?

- **Tools**: Various tools are available to help, many of them free or licensed by the university. Therefore, it may be tempting to try to use everything. However, students have asked in their regular semester feedback to limit the number of tools, apps, and platforms to not become overwhelmed. If possible, only a few online tools should be used.

- **Privacy**: if the tool is designed to work with the Internet, it must be covered by privacy: videoconferencing introduces teachers and students into their homes, so it is important to consider privacy. Blurring the video background is very appropriate if the tool supports it. In addition, teachers should dress as if they are attending a university and expect students to do the same. Online teaching is also a very appropriate opportunity to review digital etiquette.

- **Share experiences**: it is important to share experiences quickly not only through scholarly channels such as journals or conferences but also to use tools such as social networks to share insights, advantages, and disadvantages of the approach being tested, tools, trials, etc. [12].

All these challenges need to be addressed. This paper presents experiences from distance lectures, teaching laboratory exercises, and software-oriented exercises at the Department of Measurement, Faculty of Electrical Engineering, CTU in Prague.

2. Distant teaching

During the Pandemic, lectures and laboratory classes were changed dramatically [13]. This article focuses mainly on practical laboratory exercises and software-oriented courses and shows the adjustment of lectures during and even after the Pandemic.

2.1. Lectures

There are many possibilities for offering online lectures to students [14–18]. Many universities offer online lectures and teaching classes. However, it never happened before the whole semester/year had to be taught online without any personal contacts or consultation for all students. From our experience and as a result of student surveys, the best way to offer the lectures is to record the lecture in advance to provide an opportunity to watch the video before the scheduled time so that the students can prepare their questions or topic for discussion. Afterward, the lecturer will be available for remote consultation at all participants’ initially scheduled lecture time. The survey of more than 250 students of bachelor’s and master’s degree programs reveals the power of choice to watch a pre-recorded lecture and use it as a study material. One of the survey questions was: “Was the opportunity for you to watch a pre-recorded lecture a benefit?” the results are shown in Fig. 1.

The lecture can be recorded in the class when the lecturer uses the whiteboard and is recorded via camera or if there is no possibility to attend the university (i.e., lockdown or quarantine), a recorded presentation in suitable software (i.e., MS PowerPoint or similar), where tools like a pointer, marker or drawing, and other features are available, could be used. The crucial benefit, especially for students in a first-year grade, is the possibility to play the recorded lecture multiple times to better understand the problematics, in particular before the final exam.

Another important aspect is that the lecturer has to be available online at the scheduled time to ‘live’ and discuss all the problems raised through the watched lecture with the lecturer. The results from the survey for the question: “Was the opportunity for you to discuss a lecture with the lecturer online in the scheduled time a benefit?” show the importance of the availability of the lecturer (Fig. 2).

All these findings have to be considered in improving distance lectures, not only at the universities. In addition, the offered recorded lectures can also be used during contact classes as a supplement for students who need to repeat the problem or could not attend the lecture. This proved to be an essential aspect and an excellent complement to contact lectures as feedback from the students in the first semester after the COVID-19 pandemic lockdown. Now, all the lectures are available on the youtube channel of the department.

2.2. Seminars/laboratory exercises

Most laboratory exercises and experiments are not suitable for direct transformation to distance learning. From our experience, a quick solution is to make laboratories as a set of short movies where students watch the video, make notes and then send the laboratory report to the teacher. The pros are that the students can watch the video before the class and consult everything with the tutor.

The cons of this solution are the minimal student interaction. A better solution is to develop new or modified labs suitable for distance learning.

Another way to solve the substitution of practical laboratory teaching in distance form is to use the Home Lab. It is based on the knowledge that several experiments in basic electronics and sensors correspond to a model with two functional groups. The first group consists of an

![Fig. 1. The result of the student survey on the importance of pre-recorded lectures importance.](image-url)

![Fig. 2. The result of the student survey of the lecturer availability.](image-url)
The Department of Measurement of the Czech Technical University in Prague, Faculty of Electrical Engineering, has developed such improvised measurement instruments for several years. The measurement instruments are based on powerful STM32 microcontrollers. The microcontroller with its peripherals (ADC, DAC, comparators, counters) serves as the front end of the improvised device. Since all functions are software implemented or only using the peripherals on the microcontroller chip without the use of other external circuits, we refer to this solution as Software Defined Instrument - SDI. For availability, a PC with a USB interface, which every student has at home, is used for power supply, SDI control, and display of its results, Fig. 4.

These SDIs have been used at the Department of Measurement for teaching for several years.

It is primarily used for solving individual student projects and in classes focused on practical teachings, such as electronics basics courses for students in the first semester or motivational courses for high school students. Thanks to this, there was enough experience with SDI, which for students in the first semester or motivational courses for high school students in the first semester or motivational courses for high school students focused on practical teachings, such as electronics basics courses teaching for several years.

Alternatively, the design of the experiment can be modified to the improvised devices that are sufficient - for example, not to measure the response of the RC integrator with a time constant of 1 ms, but to use a circuit with a time constant of 1 ms.

Only basic measurement instruments such as oscilloscope, multimeter, voltage source, and generator are used for such experiments. These devices may not provide the top-class parameters for many experiments and can often be replaced by improvised device solutions. The Department of Measurement of the Czech Technical University in Prague, Faculty of Electrical Engineering, has developed such improvised measurement instruments for several years. The measurement instruments are based on powerful STM32 microcontrollers. The microcontroller with its peripherals (ADC, DAC, comparators, counters) serves as the front end of the improvised device. Since all functions are software implemented or only using the peripherals on the microcontroller chip without the use of other external circuits, we refer to this solution as Software Defined Instrument - SDI. For availability, a PC with a USB interface, which every student has at home, is used for power supply, SDI control, and display of its results, Fig. 4.

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The Home Lab model is based on the student assembling LEX on a solderless prototyping board (called breadboard), part of a supplied set of materials, and assembled according to the instructions. It uses SDI and a PC with a USB for the measurement, which also powers the whole experiment. Thanks to the use of a PC, the student can share the screen of its SDI, e.g., oscilloscope (see Fig. 5), with the lecturer remotely to discuss and present the experiment results or consult the problem that occurred during the experiment.

It even proved to be an advantage compared to a situation where a student had a real digital oscilloscope, where the screen was difficult to share with the lecturer.

Two versions of the SDI were used for distance teaching. The first version uses a ready-made Nucleo module with the STM32F303RE microcontroller, which implements the functions of an oscilloscope with sampling frequency $f_s = 4$ MS/s, function generator, counter, PWM generator, voltmeter, adjustable voltage source, and logic analyzer up to 12 MS/s. The second “low cost” version is used if there is a high risk of damage to a microcontroller in case of a student’s mistake. It is based on a single chip-SDI circuit microcontroller STM32F042F6P6, Fig. 6.

It includes an oscilloscope with sampling frequency $f_s = 600$ kS/s, PWM generator, counter, logic analyzer up to 8 MS/s, voltmeter, and a simple FFT analyzer.

During the Pandemic, the home lab model was successfully practically verified during distance learning in three subjects with more than 150 students. Some students applied to borrow SDI not only for the class but also to verify the results in other individual projects such as a diploma or bachelor thesis. More details about Home Lab can be found on the homepage [https://leo.fel.cvut.cz/](https://leo.fel.cvut.cz/).

### 2.3. Programming exercises

Software-oriented teaching online experience is described based on the observations during the Computer Networks course, where more than 150 students enrolled. Participants are bachelor’s degree students in the second semester. As a part of the class, students implement several network programming tasks (Socket Programming in C/C++). The general task is transferring the binary file (e.g., picture) between students using the User Datagram Protocol (UDP) protocol. As a rule, one student programs a sender side, and the second student codes a receiver side. The goal of individual tasks is to practice Automatic Repeat Request (ARQ) methods and data protection codes.

During the typical semester, students work step by step on three tasks. The first one is about developing an unprotected file transmission application to demonstrate its weaknesses and become familiar with Socket Programming. The second task employed Stop-and-wait ARQ, CRC error detection on a packet level, and file integrity check by a hash function. The efficiency of the Stop-and-wait protocol is experimentally evaluated (participants use a network delay simulation tool). The third assignment replaces Stop-and-wait by Selective Repeat algorithm. Also, a student should prove understanding of the relation between Round Trip Time (RTT) and window size on communication speed. Programming exercises themselves are suitable for distance learning by nature. However, several problems remained previously unsolved.

Under normal conditions, lessons are held in a computer laboratory. Workstations are connected to the same IP network, and, thus, computers are directly accessible for incoming UDP connections. Under Covid-19 restrictions, students are located at various places with various internet connections, and public IP addresses are unusual. The challenge was how to interconnect students. Deployment of a virtual private network (VPN) technology could be the key. Requirements: The VPN should be easy to set up, especially on the client (student) side, reliable, and multplatform client availability since students use all three common platforms (Windows, Linux, and macOS). SoftEther VPN Project (https://www.softether.org) was chosen as a quick solution to resume teaching. Time showed it was a good choice, and with some adjustments and server hardware upgrades, it remains a permanent solution. Windows users use the SoftEther VPN client with its communication protocol. The rest use L2TP over IPSec supported by various devices and VPN clients. The evolution of network configuration is depicted in Fig. 7.

Another problem was the task evaluation [20]. During normal conditions, evaluating individual tasks consists of demonstrating the
program function and a short interview with a lecturer. In this case, we prefer live interaction with a lecturer instead of deploying some automated system. The idea was to preserve the original style. Fortunately, modern video conferencing platforms can create conditions close to living evaluation during the class. Beyond standard video calls, screen sharing is required for program demonstration. The interaction (talk) with the teacher is appreciated by students more than during normal conditions.

During the winter semester of 2021 situation allows return to on-site teaching with certain limitations and countermeasures. Preventive or forced quarantines still require the employment of online teaching solutions. Methods of teaching programming exercises online presented in this section were used to complement the traditional classroom approach. The VPN server is deployed as permanent teaching support to help students develop and test their network applications outside the classroom, regardless of the Pandemic. The described online evaluation method was used in case of a teacher or student quarantine. Probably the

![GUI of the SDI software on STM32F042F6P6.](image1)

![Single chip-SDI circuit microcontroller STM32F042F6P6 and LEX.](image2)

![Network setup adjustment for distance learning.](image3)
best experience gained during the pandemic period is the suitability of consultation of network programming tasks using an online video conferencing platform. The outline is that students share their screen with a problem – code snippet, error message, network log, etc. The lecturer can very effectively navigate students to understand and fix the problem. If necessary lecturer can send a code fragment using the chat function. This approach is more efficient than e-mail consultation and more frequently than one-to-one consultation.

The experience with online learning of software-oriented courses can be summarized as follows. In our specific condition, with tasks designed to assume that students’ computers are connected to a local area network (LAN), an additional technical solution - VPN had to be deployed. Modern video conferencing platforms are very suitable for consultation or evaluating software-oriented courses. Presented solutions have proven themselves and are incorporated permanently into our classes.

2.4. Projects

In classical teaching, most courses end with an individual project. It would seem that this was not possible at the time of the COVID-19. However, in some practically oriented courses, the opposite is true. It turned out that individual projects could be effectively solved even in the times of COVID-19 and distance teaching. At the end of the semester, students solved individual projects in distance learning, similar to standard teaching, thanks to the Home Lab distributed by post to the students’ homes. These projects involved using the STM32F042 microcontroller, SDI, and Home Lab in various experimental cases. These projects involved various reaction testers, robotic toys, or smart home applications like an acoustic alarm clock with remote control by mobile phone via WiFi or automatic watering of flowers.

Nevertheless, it can also include some interesting, unusual project assignments designed by students themselves; processor-controlled laser pointer for activating cat movement at home (projection of moving light trails on the floor), muscle activities monitor including improvised electrocardiograph, game steering wheel with accelerometer or a hamster movement activity monitor. An example of two individual projects is in Figs. 8–11.

Figs. 8 and 9 show muscle activities monitor include improvised electrocardiograph based on Home Lab and a recorded signal by SDI of a student’s Electrocardiograph.

Another example of an individual project is a processor-controlled laser pointer for activating cat movement at home (Fig. 10). The students use a Home Lab and SDI and a 3D printer to manufacture a holder of two servos and a laser pointer, Fig. 11. The movement of the laser is realized by employing two servo motors, one of which moves along the horizontal axis and the other vertically. A home 3D printer ensures the base of the servomotors.

In-home project realization showed some remarkable facts. Suppose projects were solved by classical contact teaching in the laboratory. In that case, the broad stocks of materials are available to all students, and they could operatively change the requirements for components depending on the status of the project. However, during distance teaching, these forced students to plan more carefully what components are available or can be ordered regard to the delivery time of the online shops. Moreover, some students have a 3D printer at home, and it can be used to manufacture mechanical components in a project, which includes not only electronics but also mechanics. To sum it up, the individual projects during the Pandemic revealed much greater independence of students; there was nobody to help them at home; the projects were more time-consuming since most of the problems were solved only by students; on the other hand, it shows greater teaching efficiency, students learned a lot thanks to this independence.

3. SDI and its methods and uses

As mentioned in chapter 2.2., the SDI has been developed at the Department of Measurement for several years. The need for oscilloscope instruments that students could use to solve individual projects in subjects during the study motivated the team to create an inexpensive oscilloscope-type instrument. At the beginning of the development, an effort to achieve the best possible parameters leads to the Nucleo F303 board with a powerful STM32F030R processor. It contains several peripherals suitable for the implementation of such devices. It has 4x ADC, with sampling rate up to 2 MS/s, 2x DAC with sampling rate up to 2 Ms/s, an operational amplifier, analog comparators, SRAM 80 kByte suitable for storing data sampled from ADC, and data for a signal generation using DAC. This was the first version of the LEO device (https://leo.fel.cvut.cz/), developed as a part of the diploma thesis [21] with top parameters, see Fig. 12.

The instrument is available in two variants. The basic version contains an oscilloscope, an arbitrary function generator, a voltmeter, and a programmable voltage source. The advanced version also contains a counter and a three-channel PWM generator with the possibility of duty cycle modulation. At the time of distance teaching, LEO found employment in master’s degree classes (individual projects) and an undergraduate degree program (in the field of microprocessor classes).

Concerning using the Nucleo F303RE module, an ELA logic analyzer with a recording length of up to 50k samples and a maximum sampling rate of up to 12 MS/s has been developed. The firmware of the ELA logic analyzer for Nucleo F303, which was created as the diploma thesis [22], cooperates with the well-known PC application sigrok Pulse View, which enables the analysis of protocols, Fig. 13.

Since the LEO project is based on. NET and Windows, not allowing students with Linux operating system to use it, the possibility of using it in the Linux operating system has been addressed in another diploma thesis.

Within the work [23], the project EMBembedded Oscilloscope (EMBO), working in both MS Windows and Linux operating systems, has been created, Fig. 14. It operates with NucleoF030RE and BluePill STM32F103 boards.

During the COVID-19 Pandemic, LEO found employment in an undergraduate degree program where the numbers of students in classes were significant (up to a hundred). It has been challenging to ensure the same instrumentation for all the students. Therefore, the focus has been on a cheaper version of SDI solutions than the Nucleo F303. As part of the diploma thesis [24], a platform with STM32F042 has been created with the Zero eLab Viewer application, which was (in the time before the chip crisis) the cheapest SDI solution with a price under $2. Thanks to this, it was possible to offer SDI based on STM32F042 to each student during distance teaching.

Later, when the chip crisis during the Pandemic hit the market, the availability of the STM32 microprocessors dropped to the minimum; another question arose: How to modify the SDI to apply to commonly available hardware even in a chip shortage. The first solution was modules “Blue Pill” and “Black Pill.” Therefore, the firmware for STM32F103 (which is the core of these modules) was created, and it can work with the same application Zero eLab Viewer. This solution has
some parameters even better than the STM32F042 version. Subsequently, Blue Pill support for EMBO has been developed. The next step is to adapt the SDI to the most used modules with Arduino. There are several versions of various oscilloscope-based applications for the Arduino on the Internet. Still, after verification, they were not designed as a tool with a clear pedagogical purpose but rather as a tool for “geeks.” SDI with an Arduino module with an ATmega 328 microcontroller worked as a voltmeter, pulse generator, counter, oscilloscope, or data logger has also been developed. The SDI for Arduino has been realized as a diploma thesis [25], where the firmware for Arduino – Uno has been developed. The project Ard-eLabViewer contains firmware for the microcontroller. Zero eLab Viewer’s original application creates a simple laboratory instrument such as a voltmeter, data recorder, oscilloscope, pulse generator, and counter. Although the parameters of the SDI are very limited, it turns out that it can be a good tool for getting acquainted with the problem of signal processing and the basics of working with an oscilloscope. An example of an Arduino - Uno SDI Zero eLab Viewer [26] application is in Fig. 15.

Table 1 presents an overview of the SDI processors and their PC applications.

Table 2 shows only the approximate values of the possible parameters of the SDI implementation. The actual parameters depend on the specific version of the firmware implementation with the respective PC application.

In teaching the measurement, the usual approach is that the performance and parameters of the measuring instrument are adapted to the object or process that is being measured and evaluated. The approach must be reversed during the COVID-19 Pandemic and the chip shortage. The experiment has to be adapted to the possibilities of the measuring device. The assumption was not to measure an object or an experiment but to modify the object or the experiment and its conditions adequately measured using SDI with limited parameters. Tasks are being prepared so that even Ard-eLabViewer will suffice with its limited parameters. The main goal of the measurement is not to find out the parameters of an unknown object but to learn how the parameters of the object can be found.

4. Experience

The Pandemic at universities affected mainly courses of practical laboratory teaching. The immediate need to find an alternative way of practical laboratory teaching has led to the massive use of the presented...
SDI method. E.g. in the winter semester of 2020/21, over 90 sets of equipment with electronic components for homework, including Nucleo F32F303RE as SDI, were lent to students in three different subjects. In the summer semester of 2021, students in a single subject received 60 sets of components (breadboard, WiFi module ESP8266, magnetometer, OLED display, microcontroller STM32F042 with module F0-Lab, as in Fig. 4) to allow for laboratory teaching.

The practical learning brought much knowledge. It was possible to have full-fledged lectures only in courses of basic stage study, where no specialized instrumentation for teaching was needed, and it was possible to replace all the instrumentation by Home Lab with SDI. Laboratory teaching in distance form was organized similarly to contact teaching. The only difference was that the students had their Home Lab with SDI and communicated with the teacher and each other through video-communication services (e.g., Microsoft Teams, Google Meet).

A strict regime has been introduced, a mandatory presence at distance lectures, a mandatory camera, and basic instrumentation equipment (e.g., multimeter, tools, breadboard) for work. At the beginning of the exercise, there was always a presence through the camera, followed by checking the theoretical background for the task. Each student had to show the prepared task (connected circuit on a breadboard). During the class, each student had to show the results, share the functionality of the connected circuit by sharing their screen with an SDI (typically an oscilloscope) and then submit a laboratory report to the system. The class should not be greater than ten students to involve and motivate all the students to solve their tasks.

One interesting and unexpected effect of students’ mutual connection and communication manifested itself in distance learning. During distance classes, the students communicate more often and intensively. They cooperate profoundly and share the solving of problems with each other. The fastest ones are done sooner, which motivates the other students to work faster and better. Thanks to SDI screen sharing and mutual communication with the teacher, other students see the results of other colleagues’ laboratory work much better than in standard laboratory teaching. The joint control of students through videoconferencing in distance learning was motivating. Even not-so-talented students have been motivated for greater performance. It can be stated that the exchange of information between students during distance learning was paradoxically better than it is now in contact teaching in the laboratory, where students have a respirator and have to maintain distances. It is better not to speak to reduce the risk of infection.

Practical distance learning placed greater demands on teachers, as distance diagnosis and error analysis possibilities were limited. The student thus functioned as a remote-controlled oscilloscope probe, where the teacher guided the student to measure and diagnose a circuit via the SDI shared screen. The teacher had to learn to predict student errors in incorrect circuit behavior. A typical problem was the exchange of values of resistors with color-coding. Since the teacher knew the range of resistors in the Home Lab, it was easier to estimate the incorrect connection of the component (e.g., the student connected a 10 kΩ resistor instead of a 1 MΩ).

Despite all the problems of distance hands-on teaching using Home Lab and SDI, it also had positive effects, showing the great potential of SDI and its use in contact teaching. During the semester where the contact teaching has been possible, a Home Lab has been lent to students to work in the laboratory with standard instruments. If the task was not completed in class, to continue at home using the SDI device. This turned out positively. Students did not need to go to the laboratories out of the class when designing a programming task. Still, they managed everything at home with SDI oscilloscope LEO with Nucleo STM32F303.

5. Conclusions

The COVID-19 Pandemic suddenly strikes, and universities around the globe have been forced to switch to online teaching to help slow the spread of the disease. At first glance, their transformation can be viewed as straightforward. However, practical realization reveals few remarkable details.

The article pointed out new challenges related to distant teaching and presented the experience with distant lectures during the Pandemic at the Department of Measurement, FEE, CTU in Prague.
It described how to prepare the Lectures and Laboratory classes on practical electronics. Shows practical laboratory experiments using the Home Lab and two possible models with functional groups, a Laboratory Experimental Device and System of Measurement Instruments. A detailed description of all developed SDIs is also present. It is supplemented with the experience of teaching a software-oriented online course with network programming. At the end of the article, practical experience and some bits of advice are shared.

The student survey showed the importance of pre-recorded lectures during the Pandemic and in the post-COVID-19 era. Even though the direct comparison of results achieved by face-to-face and remote teaching modes is not currently available (the syllabus was changed just before the Pandemic situation started), the effectiveness of distance teaching can be illustrated by signs of satisfaction on the part of students and their results, which they achieved with regard to the COVID-19 emergency. The Pandemic brought many difficulties and complications to practical laboratory teaching. In solving these problems, it turned out that in some limited topics, focused mainly on courses in basic studies, it is possible to use other methods that can be used as a supplement to standard laboratory teaching, especially in students’ independent homework and in solving their projects.

CRediT authorship contribution statement

Jakub Svatos: Conceptualization, Validation, Investigation, Writing – original draft, Visualization. Jan Holub: Conceptualization, Writing – review & editing, Supervision. Jan Fischer: Software, Validation, Investigation. Jan Sobotka: Software, Writing – review & editing.
Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors would like to thank all members of the Department of Measurements of FEE CTU in Prague for their patience and support during the Pandemic when much effort had to be spent to ensure high-quality teaching.

The authors would also like to thank STMicroelectronics for the direct support and providing the necessary STM32 processors for SDI and Nucleo F303RE modules.

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