International Journal of Research in E-learning
Vol. 9 (1), 2023, pp. 1–26

DOI 10.31261/IJREL.2023.9.1.04

Karol Hęclik
Rzeszow University of Technology, Poland
https://orcid.org/0000-0003-4304-8162

Lucjan Dobrowolski
Rzeszow University of Technology, Poland
https://orcid.org/0000-0001-7738-176X

Marcin Jaromin
Rzeszow University of Technology, Poland
https://orcid.org/0000-0002-7256-7271

Iwona Zarzyka
Rzeszow University of Technology, Poland
https://orcid.org/0000-0001-6780-3308

A Practical Test of Distance Learning During the COVID-19 Lockdown

Abstract

The article describes the authors' experience of distance learning at Rzeszow University of Technology during COVID-19 lockdown. The problems associated with the didactics in the pandemic period were discussed. They concerned hardware, software, and teaching rooms. Technical and organisational issues were discussed. The aspect of student involvement in the distance learning process and the learning outcomes achieved by the students was also addressed. Finally, the conclusions that emerged from this stage of work with students were presented, as well as suggestions related to the improvement of the distance learning process for the future.

K e y w o r d s: e-learning, distance learning, COVID-19, lockdown

1. Introduction

1.1. General information

The transition of education in Poland, and thereby universities, into a distance learning mode was forced by a government decision. The period began in April 2020 and lasted until June 2021. Thus, the lockdown comprised three semesters of study for universities. In this article, the authors focused on distance learning carried out at the Faculty of Chemistry in Rzeszow University of Technology (RUT), which is a medium-sized technical university in the country, located in the southeastern region of Poland. The university includes 7 faculties: *The Faculty of Chemistry, The Faculty of Civil and Environmental Engineering and Architecture, The Faculty of Electrical and Computer Engineering, The Faculty of Management, The Faculty of Mathematics and Applied Physics, The Faculty of Mechanical Engineering and Aeronautics, and The Faculty of Mechanics and Technology*.

The education of students at the Faculty of Chemistry is carried out in a two-degree mode: the first degree – engineering and the second degree – master's. Four courses were available to students in the undergraduate program: biotechnology, chemical technology, chemical and process engineering, and pharmaceutical engineering. Second-degree studies are provided in two courses: biotechnology and chemical technology. Our students participate in activities such as lectures, exercises, laboratories, and projects. Lectures and exercises are conducted in classrooms equipped with screen projectors, visualizers and traditional blackboards. For core subjects such as mathematics, physics, statistics, and general chemistry, where lecture group sizes are large (>70 people), lectures are held in lecture classrooms, while laboratory exercises (10–15 people) in subjects such as general chemistry, organic chemistry, biology, et al. are conducted in typical chemical or biological laboratories. In addition to these, there are laboratory classes and projects that are conducted in computer labs (e.g.: computer science, statistics, technical mechanics and mechanical engineering, etc.).

During the COVID-19 lockdown in the Department of Chemistry, we educated students in all the courses mentioned. The university authorities followed the decision of the country's authorities and, at the time of the lockdown, announced that all didactics would be conducted online. This meant the complete introduction of e-learning throughout the university for all types of classes. Academics had the choice of teaching from the university's rooms or from home. The students, on the other hand, were to be in their homes. Computers, of course, became necessary for the communication and transmission of teaching content to students. These computers were to be equipped with the appropriate software. This applied to both the computers of university teachers and the computers of students.

The two-year lockdown allowed both academics and university authorities to gain practical experience regarding distance learning. However, the question arises, "Has remote teaching worked well as a form of teaching at the university during the blockade?" This problem is complex. Obtaining an answer requires analysis from several different points of view. In order to carry it out, the authors decided to divide the problem into simpler components. They singled out the following questions:

Q1: Do universities have the facilities required for distance learning?

Q2: Do universities have the equipment needed to conduct distance learning classes?

Q3: Do universities have the software necessary to conduct distance learning classes?

Q4: Are teachers comfortable with operating distance learning equipment?

Q5: Are teachers comfortable with distance learning software?

Q6: Are students more likely to participate in distance learning activities?

Q7: Are students more active during distance learning?

Q8: Are students more comfortable in acquiring knowledge during distance learning?

Q9: Do students perform better during the remote learning process than they do with face-to-face teaching?

In the following content of the article, the authors analyze the various issues contained in the questions and try to find answers to these questions.

1.2. Phases of distance learning

During the lockdown, two phases of distance learning could be clearly distinguished:

- 1st phase – summer semester of the academic year 2019/2020,
- 2nd phase – academic year 2020/2021.

The first phase could be called a „period of storm and stress" or a „temporary transient state". It was caused by the sudden movement to full-scale distance learning for which the universities in Poland were not fully prepared. There was a shortage of equipment, software, and classrooms. As a result, most of the universities experienced some difficulties and turmoil, but they were managed fairly quickly. This sudden and unexpected situation unleashed a lot of creativity among academics. They introduced elements of distance learning without having guidelines, so it was quite diverse: from conducting live classes and broadcasting on the channel of a streaming platform, through instant messaging for synchronous communication such as Teams, Zoom, or asynchronous communication on various chat rooms or social networks, and finally exchanging emails with students. Undoubtedly, the form of these classes largely depended on the ability to use modern information technology in education, in other words, on the knowledge of e-learning techniques. And here, the e-learning training courses organized for employees in 2014–2018 (developed and conducted by prof. Barbara Dębska and the authors of this publication) proved to be an unquestionable asset.

The second phase was a period of relatively stable teaching but with limited effectiveness for the Faculty of Chemistry. This stage was stable because the preceding summer holiday period gave universities time to equip themselves with hardware and software and improve their teaching organization. In addition, university authorities and academics already had some experience from the first phase. So, they had already roughly figured out what needed to be improved in distance learning. Unfortunately, despite the stability of the online teaching process, its efficiency was definitely worse than before the lockdown period. However, it should be emphasized that this was due to reasons beyond the control of university staff. In the range of classes taught in the university's departments, a significant share is taken by practical classes, conducted in studios and laboratories. Such activities cannot be effectively carried out in the distance mode. At the time of the university's transition to the distance learning mode (i.e., at the very beginning of the first phase), it was decided that laboratory classes would be conducted in a limited way, with the help of materials prepared by academic teachers and assisted by technical staff. These details are described in later sections of this article.

2. Premises used during activities

2.1. Rooms used by teachers

At the beginning of the lockdown at the Faculty of Chemistry in RUT, i.e., in the 1st phase, classes were mostly implemented asynchronously, i.e., in the e-learning service, teachers uploaded materials in the form of PDF files, presentations, videos, etc. Students were obliged to download them and study their content. Tests and exams were held remotely. However, some teachers conducted classes (lectures and exercises) in a synchronic manner, using publicly available communication media (social networks, chat rooms, etc.).

In the 2nd phase, four classrooms were prepared and equipped with newly purchased equipment and software for distance learning for teachers. The equipment in the aforementioned rooms was periodically checked by designated persons for proper operation (some of the authors of publication included). Some teachers conducted distance lectures in the prepared rooms, while others conducted them from their staff rooms in the university buildings. However, a significant number of teachers conducted distance learning from home. At the beginning of this phase, among the group of teachers who declared that they would be conducting classes in the teaching room of the university building, there were voices for support persons to assist during their classes. Specifically, this would involve the lecturer conducting the class traditionally on the blackboard and the attendant filming the lecturer live, keeping an eye on the quality of the video and the sound system. These requests were dismissed as unrealistic as the technical staff of the classrooms were only two people who also taught their classes. On the other hand, technical staff of faculty are not trained in the use of multimedia equipment to handle this task.

2.2. Rooms used by students

Unfortunately, the authors are not aware of detailed data on the rooms used by students during online learning, since no one recorded such information during both phases. Nevertheless, at the time of the introduction of the lockdown at the Faculty of Chemistry in RUT:

- in the first month of distance learning, some students declared that they were attending classes while living in dormitories and lodgings,
- after the first month (owing to decisions made by the country's authorities), students declared that they attended classes from home.

Quantitative data are not available; the authors only have feedback from online conversations with students. It was very common for teachers to hear noises transmitted from student computers when students joined remote classes (e.g., sounds of hushed conversations, cries of small children, noises coming from the kitchen, barking dogs, and even sounds of renovations). Given the restrictions imposed by the country's authorities (lockdown), it can be assumed that the vast majority of students attended classes in their own homes.

3. Equipment used for distance learning

3.1. Equipment of dedicated teaching rooms

After the experience of the first phase, teachers and faculty authorities came to the conclusion that conducting classes such as lectures and classes in subjects that require the presentation of graphic content on the fly, for example, such as biochemistry or organic chemistry, where the teacher presents certain content on the blackboard (chemical structures, mechanisms of chemical reactions, etc.), cannot be done using an ordinary computer. To make the classes useful to the students, the teacher has to use an additional peripheral device, as it is impossible to draw effectively and efficiently with a computer mouse. That is why the faculty authorities decided to purchase two graphic tablets with a screen. Also, some of the homeroom teachers have purchased such devices.

The first two rooms prepared at the Faculty of Chemistry in RUT for distance learning were equipped with the following equipment:

- laptop: 3.5 GHz processor frequency, 16 GB RAM, USB 3.0 ports, USB C ports,
- monitor: 21", HDMI,
- graphics tablet: 16" (LCD screen, wireless pen, USB, HDMI),
- mouse: wireless
- media HUB: 4 x USB 3.0, 2 x HDMI, 1 x LAN,
- HD digital camera with built-in microphone (USB),
- headphones communicating via USB and Bluetooth (equipped with a switch),
- visualizer – digital camera mounted on a movable arm (USB).

The rooms listed were prepared for teachers who needed a graphics tablet for their classes but did not have a suitable room and tablet at home. In addition, the prepared rooms took the burden of hardware and software configuration off their shoulders. Each teacher brought only his or her own files and notes with him or her, and launched the ready-made set, and began classes. The equipment was periodically checked to make sure that it was ready for use.

The graphics tablets purchased were models with built-in LCD screens. Each such tablet required two signal cables to be connected to the computer for proper operation: USB, which transmitted the position of the tablet pen, and HDMI, which transmitted the image from the computer to the tablet. The models used were characterized by very low drawing delays, that is, from the moment the pen docks the tablet surface until the virtual ink mark appears on the tablet screen (< 500 ms). In fact, the delays were imperceptible to the user, which is especially important for live drawing.

The other two rooms prepared at the Faculty of Chemistry in RUT for distance learning were equipped with the following equipment:

- desktop: 3.0 GHz processor frequency, 8 GB RAM, USB 3.0 ports,
- monitor: 21", HDMI,
- mouse: wire, USB
- HD digital camera with built-in microphone (USB),
- visualizer – digital camera mounted on a movable arm (USB).

These rooms were prepared for those teachers who did not need graphic tablets for their classes and preferred to use a visualizer instead. Visualizers were prepared as could be shared online: printed materials (books) or notes, written or drawn on paper on the fly, or show small objects (such as small laboratory equipment).

3.2. Equipment used by teachers in office rooms

Teachers used both: desktop and laptop computers in their staff rooms. In addition, managers of some departments purchased video cameras from the funds allocated for didactics. These were HD webcams, which also come standard with a microphone. The cameras were purchased for those employees who intended to use desktop computers (laptops are now equipped with a camera and microphone as standard). As mentioned earlier, a small number of academics purchased graphics tablets from funds allocated for didactics. Some of these purchased tablets were models without a screen (cheaper than those with a screen).

3.3. Equipment used by teachers at home

Academic teachers conducting remote classes from home overwhelmingly used their own private equipment. Again, this included desktop computers as well as laptops. A small number of teachers purchased computer equipment (computer, monitor, graphics tablet, camera, microphone) with private funds. Unfortunately, the authors do not have figures on the share of each category of equipment. Graphics tablets equipped with an LCD screen were very popular. This made it immeasurably easier for teachers, who had to convey complex sign content (e.g., symbols) and graphics (chemical structures, etc.) during lectures and classes.

3.4. Equipment used by students

In this case, the authors do not have detailed data on the equipment used by the students. However, the following picture emerges from the fragmentary feedback that is reaching academics (including the authors):

- the majority of students used laptops, which are standard equipped with a digital camera and microphone (they are placed in the flap that constitutes the screen),
- students using desktop computers equipped themselves with digital cameras on their own or using cell phones (smartphones) as cameras,
- a small percentage of students also used cell phones (smartphones) in place of a computer,
- lack of any feedback that students used graphics tablets.

4. Software used by teachers

4.1. Software used in lectures and classes

Teachers used Windows-based computers to conduct remote classes. These were versions: 7, 8 (including 8.1) and 10. There were some people who used computers running MacOS X or Linux. Communication between teachers and students took place both synchronously (live) and asynchronously. The Zoom program was used for synchronous communication (audio and video transmission) between teachers and students at the beginning of Phase I. The Teams program was also available as part of the MS Office 365 software, for which the RUT has a license. However, at the beginning of Phase I, not all employees were familiar with it. Lecture and class content was made available through these programs.

The content of the lectures was mostly prepared in the form of presentations. PowerPoint was used mainly to prepare the presentations. Few teachers used Impress from the LibreOffice suite. Individuals presented the content prepared in Word or Acrobat Reader (content exported to PDF). The presentations included graphic objects such as chemical structures, spectra (spectroscopy), chromatograms, charts, graphs, diagrams, technical drawings, and photographs. Chemical structures were prepared in AccelrysDraw or ChemSketch. Diagrams came from Excel, Origin, or Calc (from the LibreOffice suite). Diagrams and schematics were prepared using PowerPoint tools or embedded as objects prepared in Visio or Draw (from LibreOffice suite).

Teachers used PowerPoint and Whiteboard mainly, for activities requiring drawing (e.g., chemical structures and reactions) or writing mathematical expressions. The whiteboard built into the Teams program was used less frequently. The popularity of PowerPoint or Whiteboard is due to the fact that they allow easy and quite convenient use of a graphics tablet and more intuitive operation. This is much more convenient than the whiteboard built into the Teams program. The authors received feedback from teachers in the Faculty of Chemistry, who declared that these programs were much more convenient than the whiteboard built into the *Teams* program.

Laboratory activities were limited to video recording of laboratory experiments. Some videos were supplemented with voiceover commentary.

The classes held in computer labs were conducted remotely. Some of the software used in such classes was open source or freeware. However, a good portion was commercial software.

4.2. Software used during computer lab classes

Laboratory classes using computers were implemented to a limited extent due to the lack of student access to these specialized programs requiring a domain-supervised installation and running, which was impossible on student private computers. This was due to the license granted to the university by the manufacturer of such software. Examples include Microcal Origin or the MS Office suite (Excel, PowerPoint, Word). Commercial software, usually used in computer labs, available to students at home, are, for example: Matlab, Statistica, AccelrysDraw, ChemSketch, and Visual Studio. So, these programs have been used in remote teaching. On the other hand, some commercial programs were able to be replaced by open source programs. Details are given in Table 1.

Table 1
Summary of sample subjects and software used by the authors in distance learning (computer labs)

No.	Course	Software	License
1	packages of application software	LibreOffice Calc	open source
		Matlab	commercial
2	experimental methodology	Statistica	commercial
3	statistical processes control		
4	statistics and results elaboration		
5	computer science	LibreOffice Draw	open source
		LibreOffice Impress	open source
		AccelrysDraw	commercial (free version)
		ChemSketch	commercial (free version)
		NetBeans	open source
		GIMP	open source
		SharpDevelop	open source
		Visual Studio	commercial (CE[1] version)
6	fundaments of programming	CodeBlocks	open source
		Visual Studio	commercial (CE version)

For the implementation of distance learning classes on the subject of packages of application software, an initial attempt was made to use Excel in a version that runs in a web browser (MS Office 365). However, due to the fact that it is a very

[1] CE = Community Edition – software available free of charge to schoolchildren, students and hobbyists.

poor version, it was quickly abandoned (after first lesson) and replaced with Calc from the LibreOffice suite.

4.3. E-learning platform and communicators

During distance learning, coordination between teachers and students and mutual communication became a necessity. On this purpose, the Moodle learning management system, already running on the RUT servers, the Teams program (within MS Office 365), the USOS, system and (to a limited extent) traditional email were used.

The origins of e-learning at the Rzeszow University of Technology can be traced back to 2004, when the Faculty of Chemistry obtained Center of Excellence status (Dębska, Dobrowolski, Jaromin, & Hęclik, 2020). Then, the Center for Distance Education (CDE) began to operate on the faculty. The establishment of CDE was closely connected with the COMODEC project (Fifth Framework Program of the European Union). It was initiated by prof. Barbara Dębska. CDE became one of the tasks carried out by the staff of the Department of Computer Chemistry under WORK PACKAGE 3: Computer-aided Information Retrieval from Chemical Databases. From the funds earmarked for this project, an IBM Lotus LMS educational platform was purchased, on the basis of which a teaching portal was built, subsequently made available to students through a (now defunct) website: www.e-chemia.pl. With the funds available from the COMODEC project, it was also possible to purchase equipment and build a computer lab suitable for remote learning. The portal pages included online teaching materials, which took the form of:

- lecture handouts that can be used by students when they need them, such as preparing for an exercise, test, or exam,
- interactive calculation exercises designed in such a way that the student can change the data, and the computer supervises each step in the calculation and explains the mistakes made by the student,
- instructions for laboratories containing a description of the exercise, a simulation of its course, a description of how to process the results and a test to verify the student's preparation for the test, and
- lessons that expand the scope of the material taught with additional content, allowing personalized learning pathways for different groups of students.

Through the portal pages, teaching materials were made available to support education in both chemistry and chemical informatics. The database of the portal was constantly expanded, both in terms of the number of courses (bioinformatics, methodology of the experimental work) and their content. Among others, applications were developed: modelling the operation of measuring devices (e.g. spectrometers (Dębska, Guzowska-Świder, & Hęclik K, 2013)), simulating the course of laboratory exercises, following and supervising the interactive way in which students solve computational tasks in the field of chemometrics, explaining the work of complex computer tools (a tutorial of the Statistica program, or a tutorial of the CLC Sequence Viewer program for analyzing, comparing and presenting genetic sequences), as well as teaching student-chemists the basics of programming in Pascal and C/C++ and using the acquired skills to solve, for example, chemical engineering tasks. According to the draft structure of the portal www.e-chemia.pl, its development was achieved not only by expanding the database of teaching materials but also by the fact that some of the portal's teaching material resources were created on the Moodle platform. Although IBM Lotus LMS was a commercial platform, Moodle is made available under an open source license. In addition, not only is it used in the process of self-learning, but it is also possible to conduct research on the teaching process carried out remotely using it. Throughout the years of CDE operation, professor Barbara Dębska has led and actively participated in the development of the www.e-chemia.pl portal.

In 2013, a strategy for the computerization of the RUT was developed and continued until 2020. The implementation elements of e-learning into the university's didactics was one of the tasks planned but it required the construction of a virtual campus. This was achieved thanks to the efforts of prof. B. Dębska. The e-Learning Center was established. The launch of the RUT's learning platform took place in 2014, and since then prof. B. Dębska has served as the rector's representative for e-learning. The staff of The Department of Computer Chemistry began transferring teaching materials from the www.e-chemia.pl portal to the new e-learning portal. In that year, a training program on e-learning was prepared for university teaching staff. It was developed by Prof. B. Dębska and the authors of this publication. Between 2014 and 2018, 25 training courses were implemented with a total of 185 participants (22% of all university teachers). Since 2014, the Moodle platform has been used all the time by university teachers and students.

During the COVID-19 lockdown, the e-learning platform was primarily used to make teaching content available to students by university teachers and also to notify students of course details. The content available on the platform is arranged hierarchically. Each faculty has a separate section, which is divided into degree programs (1st – BSc, 2nd – MSc) and, subsequently, into courses. During the lockdown, the Faculty of Chemistry educated the following students:

- 1st degree in the courses: biotechnology, chemical technology, chemical and process engineering, and pharmaceutical engineering
- 2nd degree in the courses: biotechnology, chemical technology, chemical and process engineering.

Each course contains a range of courses that correspond to the taught subjects (modules). The course is managed by a coordinator. He/she is responsible for creating and configuring the course. He/she can provide materials for didactics, or he/she can delegate this to the subject teachers assigned to the course.

During the period of remote teaching, the following were placed in the course: lecture presentations, files with assignments, instructions for classes, and videos of laboratory classes. In addition, tests and quizzes were created in the course to verify the knowledge of the students, acting as remote tests and exams. A small number of teachers used Zoom and also the Forms module, available on the Teams platform, to conduct tests and exams.

4.4. Training in the use of hardware and software

A training course on how to use the e-learning portal was already organized for academics in the first phase of distance learning. It included: registration, logging in, setting up and configuring the course, posting content in various formats, and creating tests and quizzes. It was conducted by one of the authors. In the course of conducting it, it turned out to be very necessary, as many people had never used the platform or did so rarely[2]. In particular, the most difficult part was the preparation of tests and quizzes to replace test and exams (at least in some subjects). Several such training sessions were held.

In addition, instructions for creating tests and quizzes containing screenshots with explanations were prepared by one of the authors. These were in the form of PDF files which were placed on the main page of the portal so that they would be visible as soon as any teacher logged in.

4.5. Evaluation of work with hardware and software

The Moodle e-learning platform, installed on the RUT server and administered by the university staff, performed very well, operating practically without malfunction and allowing for quick and convenient content sharing and communication with students, as well as conducting colloquia and exams. Similarly, the USOS and Zoom software also worked smoothly.

The Teams application was evaluated very differently by teachers: better or worse. In the initial period, some important functionality for the university was not available, such as downloading student attendance lists during lessons. Another problem was the cases of faulty uploading of the view of the shared program window. This manifested itself as a view of a black or grey rectangle where

[2] Details of the training courses conducted among the staff of Rzeszow University of Technology (including the Faculty of Chemistry) were published at the conference: *Dębska B., Dobrowolski L., Hęclik K., Jaromin M., Organization of training for academic teachers by the e-Learning Center of the Rzeszów University of Technology, XVIII Virtual University conference 2018 (Knowledge and teaching in the face of the idea of transhumanism), Warszawa 20–21 June 2018*.

the shared program window should be visible. These problems were originally reported by students to the teachers. This problem arose when working with ChemSketch, which was used extensively by chemists. Another inconvenience was that the number of simultaneously visible images of people connected in a single session was limited to 9 (later increased to 12). Originally, the *Teams* program was created to implement meetings of small groups of employees in large corporations. The requirements of corporate employees are different from those of education. It might be necessary to conduct a detailed study of the ergonomics of this program among students and teachers[3]. However, this issue is beyond the subject of this article. The authors have received signals from university teachers that it is inadequately adapted for university teaching. In comparison, the authors rate the *Zoom* program as better designed, more responsive and ergonomic.

The ergonomics and functionality of the *Forms* module (a module of the *Teams* application) was evaluated differently by teachers. Unfortunately, due to the difficulties of the lockdown as well as its low usage rate, no research was conducted on the ergonomics of this module. Nevertheless, it is important to remember that, as with *Teams*, the capabilities of the *Forms* module are due to its purpose – it is a module for corporations and not education.

However, the biggest disadvantage of solutions such as *Teams* and *Forms* is that these are services hosted on the server of a private entity, additionally located in the jurisdiction of a foreign country. The university (authorities, teachers, technical staff) does not have full access to this service and the data stored there. In addition, these data may be accessed by people who perhaps should not have them. It is important to remember that corporations very often disregard the provisions of the General Data Protection Regulation (GDPR). Many times in the past, due to poor server security, carelessness of corporate employees, or their dishonesty, data has been leaked. The problem is compounded by the fact that not only the university does not have lever age over the corporation, but also the Polish government. EU bodies have also had difficulties in the past enforcing compliance by foreign (non-European) corporations.

The software used during the computerized laboratory classes, listed in Table 1, worked flawlessly. This is hardly surprising in view of the fact that it has been tested many times. Students have also used it in the past on their computers at home. Difficulties occasionally occurred. Generally, this was due to poor knowledge of some students of how to use the program. These problems were solved continuously by the teachers teaching the classes.

[3] This topic is quite broad and would involve research at the intersection of software ergonomics and software development methodology.

5. Work with students

5.1. Conducting the lectures

In the 1st phase, in most cases, the lectures were prepared as PDF files (less often PowerPoint or Word) and uploaded to the university's e-learning platform.

In the 2nd phase, the situation was already stabilized and academics had developed some ways to deal with distance learning. Before the start of the academic year, courses were prepared on the e-learning portal. Gradually, the content of the lectures was to be uploaded to them, after each meeting was completed. According to university authorities' guidelines, lectures were conducted online. The presenters either used only presentations or lectured in a mixed manner, i.e. presentation interspersed with content drawn or written on the screen and explained on the fly. For example, lectures in the spectroscopic methods of analysis course were conducted using presentations, as it is difficult to draw on the screen (or blackboard) the spectra that were created by the apparatus. On the other hand, lectures in organic chemistry were conducted in a mixed way, i.e. the lecturer presented the content from the presentation, then went into detail using a tablet and drawing program. During lectures, students were not allowed to share content. However, they could make comments using microphones or via chat. However, not all lecturers allowed the use of microphones. Nevertheless, the backchannel sometimes proved necessary, such as when there were momentary lapses in video and audio transmission or when there were questions from students. During lectures, only some lecturers turned on the cameras. Unfortunately, the authors do not have detailed statistical data on this issue. On the other hand, students generally had their cameras turned off during lectures and often turned off their microphones as well. In such a situation, it was difficult for the teacher to determine how many students were actually attending the lecture and how many only had their computer equipment on but were absent.

5.2. Conducting the classes

In 1st phase, classes were conducted similarly to lectures. However, in 2nd phase, the exercises were already conducted online. Teachers conducting the following classes:

- displayed files with pre-prepared content of exercises and tasks,
- conveyed information by writing or drawing (chemistry, math, etc.) using:
  - a graphics tablet – in PowerPoint or Whiteborad,
  - a visualizer – on paper,
- "drew" structures in ChemSketch or AccelrysDraw,
- "drew" diagrams in PowerPoint, Draw, or Visio.

During the exercises, students were required to turn on their cameras and microphones. Students were also allowed to share the content of their screens and were occasionally asked to respond. In such cases, the student was required to share the program window in which he/she presented his/her solution to the task. In the case of chemical structures (and reaction mechanisms, in particular), students had a more difficult situation than the teacher because of the lack of a tablet. Nevertheless, they were slower but very good at writing down chemical structures or calculations with the mouse.

5.3. Conducting the laboratory classes

Laboratory classes at the Faculty of Chemistry take two forms. The first type is the classic classes in a chemical or biological laboratory, which depends on the field of study (chemical technology or biotechnology). The second type is classes in the computer lab. In this case, students work with software. In the case of classic laboratory classes, academics recorded a video of an experiment on a given topic if technically feasible. Sometimes, technical staff (lab technicians) were called in to help perform the experiment or record the experiment. During or after the recording, the teacher described in voice the activities performed. The recording was copied to a computer and then uploaded to an e-learning platform for the relevant course.

The computer-based classes were held in a slightly different format. Before class, students familiarized themselves with the topic of the meeting by reviewing the instructions posted in the corresponding course on the e-learning platform, just as previous classes had done during full-time study. If necessary, as described in the instructions, the students downloaded the relevant software from the university server (commercial software) or from an open source server. The installation method was described in a separate manual. In some classes, students also downloaded data files to their computers, which they then worked on during the course. After establishing a connection through an instant messenger (Teams or Zoom), students ran the software provided for work during a particular meeting. During these activities, they were also required to turn on their cameras and microphones. They also had the opportunity to share the content of their screens. The instructor explained on an ongoing basis how to perform specific operations, operate the program or obtain certain results. During the class, students were called on to respond. The students were required to share the program window in which they presented their results or demonstrated how to perform certain operations. In addition, recordings (screen sessions) showing the operation of programs and solving specific tasks were prepared for some subjects. An example is the recordings for the subject of application software packages prepared by one of the authors, concerning the operation of a spreadsheet (Excel, LibreOffice Calc) and Matlab. The recordings were accompanied by data files with solutions.

5.4. Execution of tests and exams

Tests and exams were implemented in two ways. The first was similar to those conducted during classroom instruction. The students solved the assignments by writing on pieces of paper. During the writing process, they were required to turn on cameras and microphones and position them in such a way that the lecturer could monitor them. The time for writing the colloquium was predetermined by the teacher. Students were informed about the technical details in the classes before verifying their knowledge. Additionally, the information was communicated to them by a university e-mail. Before the established time, the recorded solutions were photographed (smartphone) or scanned (scanner) by them and sent via university email to the teacher's email inbox. Alternatively, a variant was also used, whereby photographs or scans of the course were uploaded to an e-learning portal, where each student has their own account.

The second way to verify student learning results was through the use of tests and quizzes posted on the e-learning portal. The teacher prepared the relevant quiz in the course in advance. He/she configured it, i.e. the start and end date and time, the way the answers were given, etc. Then he/she included a set of questions in text (or graphic) form. The questions could be single or multiple choice. As in the first case, students were notified in advance about the colloquium or exam and its mode, via USOS or university email. If, during the course of the test or quiz, the student exceeded the allowed time, the server automatically interrupted the quiz, scoring the student, those answers that were given by the student. Immediately after the quiz was over, each participant could check the result of the quiz and review their answers and see which, if any, were incorrect.

The first way of verifying learning outcomes (i.e., photographing the solution sheet) has the disadvantage of being prone to potential abuse by students. Unfortunately, for some subjects, it is not technically feasible to perform them with a test or quiz. Organic chemistry is an example. It is not possible to prepare a reliable colloquium or exam on this subject using a quiz. Such verification requires drawing chemical structures or reaction mechanisms. Even if such software existed, the student would first have to learn how to use it at least in a good degree to be able to write (or rather draw?) the solutions in time.

Unfortunately, the second way of verification is also prone to abuse by students. The reason is that the student is sitting in front of the computer at home. Thus, the teacher has no way of verifying that the student is not using a third party acting as a prompoter. However, this method has the advantage that the student does not have to photograph or scan his/her work and send it as a file (attachment) by email or post it on the portal. The results are already there. The second advantage is that as soon as it is completed, the results are automatically graded by the software, so the student knows their grade right away. Another plus is that there is no question that the evaluation is subjective. Unfortunately, automation has the disadvantage that the student does not answer the question him/herself but chooses an answer within a certain pool. So to some extent, some students may guess the answer without actually having knowledge.

Attention should be paid to abuses on the part of teachers who, unable to fully control students during the verification of learning outcomes, shortened the duration of a test or exam time absurdly. By shortening the duration, they wanted to force the students to prepare as well as possible and prevent them from using their notes. Unfortunately, excessive shortening of the duration of revision resulted in enormous stress among students, which often demotivated them. Because they thought, why bother trying and rushing if they still will not physically manage to write everything despite being well prepared.

Another burden was the automatic end time of the test or quiz and the unreliability of electronic equipment, the Internet connection. Students were burdened with a great deal of stress as to whether everything would work properly and whether they would be able to scan and upload their work in time, whether the Internet connection would be stable, and whether they would be able to be logged into the relevant portal throughout the verification period, which was a prerequisite for participation.

5.5. Coordination of the distance learning process

As mentioned earlier, the teaching process was coordinated using an e-learning platform, among other things. In the case of the work of academic teachers on the platform, some negative habits and routines have become apparent. A considerable number of subjects are taught by several people. For example, for half a semester a lecture is given by Professor A, and then, by Professor B, or a lecture is given by Professor A, classes by Doctor B, and laboratory classes by Doctors D and E. In the expected case, one course should be created with a name like the subject being taught. However, in many cases, not a single course taught cooperatively was created, but several different courses, often having additional phrases in their names. Examples of such course names are:

- "Basics of something XX/YY–ZZ>BasOfSth, Winter Term 2021/22, Laboratory, group no. 1",
- "Some materials. Laboratory exercises led by Prof. A… B… for group no. 2–5",
- "Subject with a long name IVCX – lecture FINAL TEST".

The problem was acute, as about half of all courses created within the department were called this way. This creates some confusion in the portal and can make it difficult for students to use it.

5.6. Students' preparation for classes

During the lockdown, the requirements for students' preparation for the courses changed slightly. In the 2nd phase, these requirements were openly stated in the courses posted on the e-learning portal. The first difference was that students did not have to come to lab classes equipped with personal protective equipment (lab coat, goggles, gloves). However, they should still be prepared to practice the lecture content. The second difference was in the classes conducted with software, i.e. those that were conducted in the computer lab before the lockdown. Students were required to pre-install software on their home computers (this applied to the software described in Section 4.2. Software used during computer lab classes). The access to this software and how to install it was given in advance in the instructions posted on the e-learning platform. In addition, they should: (a) be in a separate room and (b) have a personal computer running. In most cases, students were prepared correctly. Nevertheless, sometimes there were single cases when:

- the student did not install the software in advance, despite the fact that the others in the group had done so (the instructions for the class were posted in advance in the corresponding course on the e-learning portal), thereby causing delay for the others in the group,
- the student wanted to participate in a computer lab class using a smartphone and being on the go (bus), where the class was about a program running on a personal computer,
- a student reported a problem with the installation of the software, in a situation where he/she had a laptop computer with an incompatible operating system, which he/she did not notify the teacher in advance,
- students disconnected from the current instant messaging session, with most cases generally reconnecting quickly (up to 5 minutes), reporting internet connection problems in the chat (which was very often true, though not always).

6. Summary

Answers concerning Q1, Q2:

Summarizing the distance learning period, it should be noted than in the case of dedicated rooms and staff rooms, the university did well. Also as for the equipment used by teachers, there were no difficulties in the second stage of the blockade. Occasional problems with hardware and software at the Faculty, were resolved on an ongoing basis by the authors (there were fewer than 10 such problems during the entire lockdown).

Answers concerning Q3:

As for the analysis of the hypothesis that universities are well-equipped with software for remote classes, this issue should be divided into four groups, according to the types of software:

(a) basic, i.e. operating system,

(b) synchronous communication (online messaging),

(c) content exchange (e-learning platforms),

(d) daily work (editors of various types, engineering calculations, etc.).

Ad. (a) The first group of software is the system for desktop computers. The vast majority of this is Windows (ok. 98%). It completely meets the needs of both teachers and students. The only caveat is the system's automatic updates, which can sometimes cause chaos and disorganization, as they cannot be easily blocked. In the case of the other systems, i.e. Linux and MacOS X, it is worse. The former is not suitable for everyday desktop work. The authors have been following the development of this system for many years (i.e. since 1999). The obstacle is its architecture and the habits and design decisions of the programmers who decide on its development. The main emphasis while working with this system is on the command line (called also: terminal, console)[4]. MacOS X, on the other hand, is much more expensive than a typical personal computer, including Windows in the price of the computer. However, the most acute thing is that both of these systems mostly lack the appropriate versions of the software used by students at our faculty.

Ad. (b) The second group is online communicators, capable of transmitting video and audio simultaneously. What is there is basically enough (e.g., Zoom) or is of lower[5] quality (MS Teams). This is particularly acute on computer equipment that has been used for several years (it is difficult to require a student to purchase very powerful, expensive equipment). Another acute problem is that these programs are not tailored to the needs of universities. The first is a general-purpose communicator, basically for home users. The second is designed for corporate users. Both of these groups have very different needs from students and teachers (Wea, Dua Kuki, 2021). Moreover, in both cases the communication is

---

4 This way of working is not suitable for desktop systems. Instead, it is suitable for servers administered remotely.

5 Software quality is related to features such as ergonomics (e.g., poor features, unintuitive GUI), responsiveness (e.g., slow response to user actions), crashworthiness (e.g., hangs), system resource requirements (e.g., high CPU load, high RAM usage), installation difficulty (e.g., need to install various virtual machines, interpreters, third-party libraries). The problem of low-quality software is related, among other things, to the tools used to produce the software, the knowledge and experience of the programmers developing the software, design assumptions, etc. The production of software by a large company does not automatically imply its high quality. Very often corporations buy beta-phase software projects from start-ups and under-invest in their development. In addition, software developed using scripting languages has higher CPU power requirements and consumes more RAM than programs compiled into machine code. This is unfortunately the case with the *MS Teams* program.

supervised by corporations – they are the ones who own and administer the servers. These problems are noticed, analyzed and discussed in the academic community (Ślósarz, 2020). In the case of the Teams program, there is another issue of the technology used. A conglomeration of HTML, CSS and JavaScript solutions is sufficient for web development but not for server and desktop applications[6] (Pereira, Couto, Ribeiro, Rua, Cunha, Fernandes, Saraiva, 2017). In addition, the communication server[7] should run on the university's computers (servers). Unfortunately, despite the passage of several years, it is clear that corporations will not create a communicator that meets the needs of universities, because they have no profit in it. On the other hand, the open source movement is incapable of creating ergonomic, intuitive-to-use and well-equipped software (negative examples include: Linux desktop version (Tashkinov, 2023), GIMP, Inscape, CMake, Python, R). Developing such software requires a large effort from a team of programmers who expect to be paid lavishly (rightly so), a determined project manager who will ensure that the software being developed is user-friendly and the user manual is comprehensive. Many open source projects show a chronic lack of: documentation, decent manuals and years of technical support. One should not be surprised, it costs a lot of effort finally. Another well-known affliction of many open source projects is that their developers stop being interested in the project after 2–5 years. Bored, they start a new project, shinier and promising more fame. As you can see, we will still have to wait for good communication software for universities.

Ad. (c) The portal used by our university should be evaluated positively, even though it is open source software, too. Admittedly, Moodle is not very user-friendly for those who install and administer it (IT specialists) but it is useful enough (ergonomic) for students and teachers. From the point of view the lockdown period, it should be evaluated positively.

Ad. (d) As for programs for daily work here is basically fine. Either you can use open source (LibreOffice) or freeware applications (ChemSketch, AccelrysDraw) or commercial ones available for students (Statistica, Matlab).

Summarizing points a–d, it should be said that our department is not badly equipped with software, and the weak point is synchronous communication. However, this is not our university fault. Improving this situation is beyond the reach of the universities.

[6] Developing software using node.js technology and the Electron library is quite fashionable nowadays and, moreover, allows corporations to slightly reduce the cost of producing such software. However, the end-user loses out, as the quality of such software is inferior compared to programs developed with classic tools. Most of the client (desktop) software was and still is developed using languages compiled to machine code (e.g. C++) and using extensive libraries (e.g. Boost, Qt, VCL). Unfortunately, this approach requires higher financial resources and an incomparably better educated and professionally experienced staff (programmers).

[7] Server has two meanings: (I) program and (II) – computer. The authors mean both, i.e. software as a service, running on computers in the university's server room.

Answers concerning Q4:

In most cases, teachers coped well with operating the equipment (computer, camera, microphone, graphics tablet). The few who had difficulty understanding the use of multimedia computer peripherals were trained and coped with the requirements of distance learning at a later stage. It can be unequivocally stated that teachers have managed quite well in this case. It should also be borne in mind that the percentage of technology laggards will decrease significantly in the years to come as multimedia peripherals are becoming more widely available, just because only because their prices are lowering.

Answers concerning Q5:

Again, most teachers have done well with the software. Those few, as in the case of hardware, were trained either in groups or individually (rarer situations) (Forde, Obrien, 2022). A much bigger problem turned out to be the cooperation of teachers using the e-learning platform, as described in Section 5.5. Teachers using such practices forgot that the e-learning portal exists primarily for the benefit of students. An overabundance of fragmented courses with strange names causes students to feel lost, which detracts them from the effectiveness of teaching. Meanwhile, the platform is supposed to help them. Perhaps the remedy for such practices would be to encourage students to report such irregularities/deficiencies to the person in charge (the dean's attorney/rector) could intervene with the teacher who introduced the chaos. Currently, the problem of portal clutter has diminished and only about 1/3 of the faculty's courses are disjointed. Nevertheless, the problem still exists and needs to be solved. So from the point of view of handling the software, the teachers did well. On the other hand, their work on the e-learning platform needs to be corrected.

Answers concerning Q6:

During distance learning, attendance was verified by a list of student accounts visible in the communicator (e.g. Teams), i.e. connections. It could be saved to a file. In the case of lectures, it is difficult to determine whether the students actually attended, or whether only their computer logged into the communicator. For example, a lecture group on the course statistics and results elaboration led by one of the authors had about 110 people. In the case of exercises and computer labs, this was easier to verify because the groups were smaller, students were required to turn on cameras and microphones, and were debriefed. Verification of actual student participation is also difficult to solve because the teacher should be focused on teaching the class. Communication programs usually transmit a limited number of images of participants' faces (e.g., 9 or 12). So the teacher would have to take breaks during the course of teaching to switch the view of these people in the thumbnail list. The more people a group has, the more cumbersome this is. Even if the program could display a large number of thumbnails (e.g., 100), the teacher would still be distracted (reviewing the participants). The question "should the teacher play the role of a controller?" remains an open one. In addition, with a very large number of thumbnails, there is a technical problem of transmitting a large number of video streams to the meeting participants (even if they have limited video resolution). Thus, remote teaching makes it difficult to reliably verify students' attendance in classes, but attendance was slightly higher than during full-time study (i.e., before the lockdown).

Answers concerning Q7:

The activity of the student (engagement) in class can only be assessed for exercise and computer laboratory classes in the same way as for attendance, i.e. by questioning individuals in the group. The authors observed during the classes that most of the students were interested in the classes. If an issue (task, program) caused a problem, they reported it to the teacher. The teacher's involvement in explaining or solving a problem (including a technical software-related one) made the students more willing to cooperate during the class. It should also be mentioned that students during the lockdown were slightly more likely to participate in consultations than their predecessors during full-time study. The consultations were arranged individually by the teacher. Online consultations have the advantage that the student does not lose time getting to the university. On the other hand, the teacher can use his/her free time for consultations beyond those hours that result from his/her work schedule. In particular, if the consultations were held in the evening, the teacher also would not have to spend time commuting to the university. Therefore, the authors notice some increase in student activity during remote classes.

Answers concerning Q8:

The period of distance learning was undoubtedly easier for students. This ease manifests itself in two aspects: time and finances. It goes without saying that these involve getting to the university and back home. This issue also applies to students living in dormitories and hostels. Except that these two cases differ in the proportion of time and financial costs incurred. Distance learning reduces the time it takes commuting students to get to the university and back home. On the other hand, students who live in dormitories or lodgings do not have to bear the costs associated with leasing the premises. With distance learning, both groups can live in their hometowns without wasting commuting time or money to stay near a scholar. Instead, they have to bear the cost of purchasing a computer and software. However, computers become commonplace and are used in households, these costs can theoretically be ignored. The situation becomes more complicated when there are more people in the family (e.g. teenagers) engaged in distance learning. Then parents need to purchase additional computers and software if their children's classes are held at the same time. In such a situation, two cost estimates would have to be made: (a) for hardware and software, and (b) for travel and fees for premises and food during the blockade period. For this purpose, a large number of such cases would have to be analyzed. Collecting such financial data would be quite a technical challenge. However, a cursory analysis of (a) the prices of computers and basic software[8], and (b) adding up the prices of transportation tickets (bus, train) for commuting between 5 and 20 km of the university, as well as the prices of dormitory and lodging fees over a period of 3 semesters, would likely come out in favor of distance learning. Thus, remote learning makes it easier for students to complete their studies (Ciano et al., 2022), but not everywhere. There are still countries where the infrastructure is not sufficiently developed to take full advantage of the possibilities of e-learning (Adzovie et al., 2022), as well as those where young people do not have sufficient skills in the use of hardware and software (Sohil et al., 2022).

Answers concerning Q9:

The last issue, which seems to be the most important of those presented so far, is the effectiveness of the learning process slowed down during the COVID-19 lockdown. However, it is difficult to assess it objectively in the case of the 1st phase, since the teachers (including the authors) were not able to get enough feedback, other than tests conducted through tests and quizzes. Nonetheless, colloquia from this phase generally performed at least as well or slightly better than during classroom learning. The better results may have been due to the limited control opportunities of the students, which some of them probably eagerly took advantage of. There was much more of this feedback in the 2nd phase. However, the grades were similar to those of the 1st phase. The reason may have been the same but in addition, students, like teachers, gained some experience during 1st phase. On the one hand, there may have been abuse during the writing of colloquia or exams, but on the other hand, there may also have been a low-effort learning effect ("there is lower control, so I don't have to make an effort"). In the end, these two opposing effects may have balanced each other out, producing a result similar to those of in-person classes. Unfortunately, these are only speculations. There is no way to verify it because it would require reconducting colloquia and exams in stationary form on the same group of students, right after conducting them in an e-learning form, and then comparing them. Perhaps in the future someone will conduct such studies. It would be very interesting from a sociological and didactic point of view. Thus, the last hypothesis remains unresolved for reasons of constraints: time, financial and technical. Some universities are trying to assess the impact of blockade on the teaching process (Boulos, 2022). There are reports in which measurable losses in the teaching process are found (Patrinos, 2022) as well as those that present

[8] The hardware and software for remote learning can be used for several years without having to replace it with a new one.

opposite conclusions (Abunamous et al., 2022). The discrepancy may be due to the different areas of teaching in each school, which affects the specifics of the classes taught.

In summary, the currently available IT infrastructure (hardware, software) has enabled distance learning for at least a dozen years. There are still problems with slow connections or periodic short breaks in connectivity, but mainly in small localities, significantly distant from large urban centers. Nevertheless, these are increasingly rare cases. Therefore, during the blockade period, it was possible to switch to remote learning mode without major perturbations, albeit not without effort (Cárdenas-Cruz et al., 2022). Unfortunately, the authors conclude that this mode of teaching is less effective and prone to various pathologies in the teaching process. In particular, it is inappropriate for universities training students in natural sciences and technical subjects, where the mastery of laboratory work is important (Dębska, Guzowska-Świder, & Hęclik, 2016). For such universities, the optimal solution seems to be the blended learning method, where lectures, classes, classes in the computer lab, and consultations are held remotely, while laboratory classes and exams are conducted stationary. Moreover, the following also seems important:

- the continuous process of retrofitting the university with appropriate hardware and software,
- continuous training of academic teachers in the use of the same, so that they can effectively and efficiently conduct classes remotely and also,
- convincing university authorities and a large part of academic teachers themselves of the advantages of such a form of teaching.

References

Abunamous M. O., Boudouaia A., Jebril M., Diafi S., Zreik M., Hartsell T. (Reviewing editor) (2022). The decay of traditional education: A case study under covid-19, *Cogent Education*. doi: 10.1080/2331186X.2022.2082116

Adzovie D. A., Jibril A. B., Hartsell T. (Reviewing editor) (2022). Assessment of the effects of Covid-19 pandemic on the prospects of e-learning in higher learning institutions: The mediating role of academic innovativeness and technological growth, *Cogent Education*. doi: 10.1080/2331186X.2022.2041222

Boulos A. N. (2022). Evaluation of the effectiveness of online education in anatomy for medical students during the COVID-19 pandemic. *Annals of anatomy = Anatomischer Anzeiger : official organ of the Anatomische Gesellschaft*, 244, 151973. doi: 10.1016/j.aanat.2022.151973

Cárdenas-Cruz A., Gómez-Moreno G., Matas-Lara A., Romero-Palacios P. J., Parrilla-Ruiz F. M. (2022). An example of adaptation: experience of virtual clinical skills circuits of internal medicine students at the Faculty of Medicine, University of Granada (Spain) during the COVID-19 pandemic, *Medical Education Online.* doi: 10.1080/10872981.2022.2040191

Ciano, J.D., Acerra, J. & Tang, A. (2022). Development of a remote learning educational model for international Emergency Medicine trainees in the era of COVID-19, *International Journal of Emergency Medicine.* doi:10.1186/s12245-021-00405-1

Dębska B., Dobrowolski L., Jaromin M., & Hęclik K. (2020). Historia i aktualne zadania realizowane przez centrum e-learningu działające w Politechnice Rzeszowskiej [History and current tasks implemented by e-learning center operating in the Rzeszów University of Technology], In B. Galwas (Eds.), *Panorama e-edukacji w Polsce [Survey of e-education in Poland]* (pp. 51–72), Warszawa. doi: 10.17388/wut.2020.0001.okno

Dębska B., Guzowska-Świder B., & Hęclik K. (2013). Chemometrics and spectroscopy problems solving by chemical portal. In *WCCE 2013 – Learning while we are connected* (Vol. 2, pp. 162–172). Toruń: Nicolaus Copernicus University Press. ISBN 978-83-231-3093-2

Dębska B., Guzowska-Świder B., & Hęclik K. (2016). The Benefits of Using Blended-learning Methods in Spectroscopy*, International Journal of Continuing Engineering Education and Life-long Learning*, *Vol. 26, Issue: 2, Special Issue: SI*, 153–167. doi: 10.1504/IJCEELL.2016.076012

Forde C., Obrien A. (2022). A Literature Review of Barriers and Opportunities Presented by Digitally Enhanced Practical Skill Teaching and Learning in Health Science Education, *Medical Education Online*. doi: 10.1080/10872981.2022.2068210

Patrinos H.A.(2022). Learning loss and learning recovery, *Decision, 49*, 183–188. doi: 10.1007/s40622-022-00317-w

Pereira R., Couto M., Ribeiro F., Rua R., Cunha J., Fernandes J.P., Saraiva J. (2017) Energy efficiency across programming languages: how do energy, time, and memory relate?, SLE 2017: Proceedings of the 10th ACM SIGPLAN International Conference on Software Language Engineering, 256–267. doi: 10.1145/3136014.3136031

Sohil F., Sohail M. U., Chapman D. L. (Reviewing editor), (2022). Measuring the impact of COVID-19 on distance learning for educational sustainability, *Cogent Education*. doi: 10.1080/2331186X.2022.2034248

Ślósarz A. (2020), The Moodle community platform versus the Microsoft Teams corporate application. In Eugenia Smyrnova-Trybulska (Eds.), *E-learning, vol. 12: Innovative Educational Technologies, Tools and Methods for E-learning* (pp. 15–28). Katowice–Cieszyn. doi: 10.34916/el.2020.12.02

Tashkinov A. S., Major Linux Problems on the Desktop, 2023 edition, https://itvision.altervista.org/why.linux.is.not.ready.for.the.desktop.current.html [dostęp: 15-01-2023]

Wea K. N., Dua Kuki A. D (2021). Students' Perceptions of Using Microsoft Teams Application in Online Learning During the Covid-19 Pandemic. *Journal of Physics: Conference Series,1842,* 012016. doi: 10.1088/1742-6596/1842/1/012016

Karol Hęclik, Lucjan Dobrowolski, Marcin Jaromin, Iwona Zarzyka

Test praktyczny zdalnego nauczania w trakcie lockdown'u COVID-19

Streszczenie

W artykule opisano doświadczenia autorów z okresu prowadzenia zajęć zdalnych na Wydziale Chemicznym Politechniki Rzeszowskiej w trakcie pandemii COVID-19. W artykule poruszone zostały problemy związane z dydaktyką tego okresu. Dotyczyły one sprzętu, oprogramowania i pomieszczeń dydaktycznych. Omówiono kwestie techniczne oraz organizacyjne. Poruszony został także aspekt zaangażowania studentów w proces nauczania zdalnego oraz osiągniętych przez nich efektów nauczania. Na koniec przedstawiono wnioski, jakie się nasuwają z tego etapu pracy ze studentami, a także propozycje związane z poprawą procesu zdalnego nauczania na przyszłość.

S ł o w a k l u c z o w e: e-learning, zdalne nauczanie, COVID-19, lockdown

Кароль Хенцлик, Люциан Добровольски, Мартин Яромин, Ивона Зажыка

Практический тест дистанционного обучения во время карантина COVID-19

А н н о т а ц и я

В статье описывается опыт авторов в периоде проведения дистанционных занятий на химическом факультете Жешувского Политехнического Института во время карантина, введённого из-за пандемии коронавируса COVID-19. В статье рассматриваются проблемы, связанные с преподаванием в период пандемии. Это касалось оборудования, программного обеспечения и учебных аудиторий. Обсуждаются технические и организационные вопросы. Также обсуждается аспект вовлечения студентов в процесс дистанционного обучения и результаты обучения, которых они достигли. В конце представлены выводы, сделанные по данному этапу работы со студентами, а также предложения, связанные с усовершенствованием процесса дистанционного обучения на перспективу.

К л ю ч е в ы е с л о в а: электронное обучение, дистанционное обучение, COVID-19, изоляция

Karol Hęclik, Lucjan Dobrowolski, Marcin Jaromin, Iwona Zarzyka

Prueba práctica del aprendizaje a distancia durante el confinamiento por COVID-19

R e s u m e n

El artículo describe la experiencia de los autores en el aprendizaje a distancia en la Universidad Politécnica de Rzeszów durante el confinamiento por COVID-19. Se discutieron los problemas asociados a la didáctica sobre el periodo pandémico. Se referían al hardware, el software y las aulas de enseñanza. Se debatieron cuestiones técnicas y organizativas. También se abordó el aspecto de la participación de los alumnos en el proceso de aprendizaje a distancia y los resultados alcanzados por éstos. Por último, se presentaron las conclusiones que surgieron de esta etapa de trabajo con los estudiantes, así como propuestas relacionadas con la mejora del proceso de aprendizaje a distancia para el futuro.

P a l a b r a s c l a v e: e-aprendizaje, aprendizaje a distancia, COVID-19, cierre