# COVID-19 Response and Its Aftermath: Experience in Introducing Online Learning Technologies to Diverse Teaching Staff

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**Abstract.** The paper is devoted to the experience of developing an online educational system at Volgograd State Technical University. We describe the process of the abrupt transition to online learning during the COVID-19 pandemic and the following process of merging online and on-site learning. The paper discusses how the university's online educational environment was formed and how its staff adapted. We describe the technical, didactic, and organizational measures which resulted in the growing popularity of the online learning environment and other e-learning tools. The online learning environment was created by connecting the existing information system 1C.University with the online learning management system Moodle. The 1C.University software stores the organizational information about the students, their enrollments, teachers, courses, curricula, etc. The custom module that connects 1C.University and Moodle LMS allows keeping student enrollment in the electronic courses up to date and creating additional services for students and teaching staff. The developed education and information electronic environment of the university hosts more than 16 000 online courses. Many courses contain educational videos and interactive learning elements.

**Keywords:** online learning · technology acceptance · electronic information and educational environment · Moodle

## 1 Introduction

Online learning—a method of supporting on-site classes and a kind of correspondence learning—has a long history. The University of Phoenix began offering online degrees as early as 1989. But, despite many achievements, including developing Massive Open Online Courses and Intelligent Tutoring systems, most of the pedagogical staff in traditional educational institutions still needed to be convinced about online learning. COVID-19 pandemics and relevant quarantine measures gave a powerful impetus to the implementation of online learning

The reported study was funded by VSTU, project number 60/438-22.

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O. Gervasi et al. (Eds.): ICCSA 2023 Workshops, LNCS 14104, pp. 507–524, 2023.
https://doi.org/10.1007/978-3-031-37105-9_34

all around the world [16,20]. Many educational institutions suddenly faced the necessity to move their classes online, which forced the quick adoption of the new form of learning with all its difficulties and problems [14]. However, the same events helped widen the usage of e-learning methods and environments when the initial problems were overcome.

Today, e-learning services and platforms are used for teaching students on all levels of education, professional training and retraining, and adult education. They went beyond a mere medium between a teacher and a learner and became a separate scientific and professional field. The leading world universities actively study and implement e-learning technologies and share open online resources and courses. Developing, implementing, and supporting electronic educational software became a new trend in the IT industry.

E-learning can be considered a complex system with the following basic parts (subsystems):

1. Software and tools for organization and support of educational process;
2. Software and systems for control of learning process, grading, and assessments;
3. Software and systems for organizing interactions of departments of an educational institution for supporting the learning process, including technical support;
4. Software and systems supporting learning analytic and decision-making about the learning process, allowing to get an overall picture of the learning process and increasing its efficiency.

The E-learning process generates a lot of data in the form of the digital learning footprint of each participant of the learning process that can be analyzed. It allows controlling online and on-site classes of each teacher, students' attendance of classes, and the amount of time spent studying the electronic learning materials, gathering and grading assignments, automatic test grading, operative demonstration of the current course grade, and so on, which students, teachers, and university management staff value.

Back in 2020, when educational institutions abruptly had to move their classes online because of the quarantine, many smaller institutions did not have experience in online learning and ready solutions and tools for that [5]. Learning-process participants on all levels of education used the software and solutions they knew. They were used to - or, at least, had easy access to, often without an effort to unify and structurize this new, for them, way of learning. Different teachers in the same institutions often used different tools: for example, some teachers used Skype, others used Zoom, yet others used software messengers or file servers [2]. The institutions encountered the problems like the lack of professional skills in e-learning (and general information and media technologies) among the teaching staff, inadequate communication equipment with low bandwidth that cannot support the stream of e-learning for all the students and teachers at once, and the lack of server space and computing power to keep it all running [4].

These problems were solved with time. New servers were bought; internet bandwidth was enhanced to the level where it could support the workload of fully online classes. Teachers and tutors underwent professional training and developed their electronic materials. When the quarantine ended, many educational of them decided to use this experience and the e-learning tools they learned to support their learning process in class and during homework. Management and the staff of departments that worked on the transition to e-learning encountered new problems, which were deeper [8,11] and required more effort to search, e.g., the following problems:

1. Systematic integration of the learning management systems and educational tools with existing information systems storing administrative data about students and staff.
2. Maintaining the institution's electronic library, integrating it with the learning management system, and enhancing the university's library with seamless access to external digital libraries.
3. Creating a secure platform for qualitative and quantitative grading of online students, including developing electronic question and learning-problem banks and implementing proctoring systems.
4. Creating remote-access laboratories (virtual or giving access to actual physical equipment), which can replace attendance of on-site laboratories [17,19];
5. Learning-process analysis aimed at identifying hidden opportunities, finding and predicting students' needs, and predicting demand for online courses to maximize the efficiency of the supported online courses and increase competitiveness in the educational service market.

Online learning is a prospective field of development for traditional learning institutions. In the modern world, when people have to keep learning their whole lives to be efficient workers, this way of learning opens new opportunities for educational institutions and people who consider buying their products.

## 2 Related Works

Responding to the COVID-19 pandemic, different universities adopted online learning platforms and general-purpose online communication tools their staff was most acquainted with: the required speed of the response did not leave enough time to prepare staff for new challenges. Later, these solutions were improved or replaced by institution-wide solutions: some educational institutions developed their own tools, while most of them used standardized learning tools. Many reported their progress in implementing COVID-19 response and adopting e-learning platforms in research papers and articles.

Financial University (Moscow) used the Microsoft Teams platform to hold most of its online lectures, practice lessons, and other online activities. The platform allowed teachers and students to use presentations and demonstrate different software on their screens while videoconferencing. During the quarantine in 2020, they also used Microsoft Skype for Business to hold staff meetings

and Zoom for some of their video conferences. The students received assignments in the University's LMS and Microsoft OneNote. Studying information systems in accounting and banking implies practicing using real banking and accounting software. Financial University used Microsoft RemoteApp solutions to allow each student access to remote laboratories with installed commercial-grade software [10], which can be considered establishing an online laboratory with remote access.

In universities of the Kurdistan region of Iraq, the survey of students and teachers about using online learning after COVID-19 showed the following. About 35.6% of survey participants used learning management systems (e.g., Moodle, Google Classroom, Edmodo, or Adobe Captivate Prime) for online learning after the COVID-19 outbreak; 21.6% of participants used mobile messengers (e.g., Viber, WhatsApp, Telegram, Messenger, WeChat) for online learning; while 9.2% of respondents used online classroom applications (e.g., Newrow Smart, Blackboard Collaborate). 33,6% of the survey participants used web-conference and webinar platforms (e.g., Zoom Meetings, Google Meet) [12].

A survey of students (78.5% of participants) and teachers (21.5% of participants) of 65 higher-education institutions in Ukraine (the most active participating institutions were the National University of Aviation and its Summer Academy, Kyiv National Trade and Economic University, Volyn National University named after Lesya Ukrainka, National Technical University named after Igor Sikorsky, and Odesa Agrarian University) had shown active usage of online learning platforms Zoom (88.3% of participants) and Classroom (85.3% of participants). Innovative using of these online platforms improved the students' learning gains. The respondents also used software and tools like YouTube (49.5%), LMS Moodle (47.3%), Microsoft Teams (35.7%), Skype (32.9%), Microsoft one note (12%), Coursera (7.7%), Kahoot (7,6%), etc. [25].

A study conducted in Indonesia with 26 teachers from higher-education institutions in Sumatra, Java, Borneo, and Sulawesi showed similar results. Teachers and students often used learning management systems during the COVID-19 pandemic; Google Class and Edmodo were the most commonly used systems. They also used videoconferencing services Zoom and Skype. One of the unusual findings was that learning management systems hosted by institutions were less attractive for teachers than videoconferencing services [13]. That was likely caused by the lack of skills to develop online learning materials and the significant effort necessary to create necessary online data for using learning management systems.

Universities in Pakistan have also actively transferred their pedagogical and educational activities to the virtual environment. Most universities developed effective online learning systems and switched to online learning. Projects, group work, lessons, and study guides were posted in online learning systems. Teachers have used various tools for virtual classes. Zoom, Google Meet, Microsoft Teams, Webex, and other software applications were used for study and work [18].

## 3 Online Learning Technologies in VSTU

The timeline of implementing online learning technologies in VSTU is presented in Table 1.

**Table 1.** Timeline of implementing online learning in VSTU.

| Time | Activities |
|---|---|
| 2017 | Creation of the university's electronic information and education environment (EIEE) |
| Summer 2018 | Beginning of yearly surveys of students, teachers, and employers regarding the quality of the educational process |
| March 2020 | Emergency mass generation of online courses in EIEE and filling them with content |
| March–December 2020 | Teacher raining in using EIEE and videoconferencing systems |
| July 2020 | The Department of Automation of Educational Activities was created |
| September 2020 | Transition to the EIEE 2.0 platform connected to the 1C.University information system. Appointment of employees responsible for EIEE at departments and faculties |
| September 2020 | Beginning of automatic checks of the EIEE for empty courses and inactive users (twice per year) |
| December 2020 | Approval of the e-course template for basic educational programs |
| January 2021 | Training of teachers with advanced training courses begins |
| November 2021 | Annual competition "The best online course belonging to basic educational programs at the university's EIEE" |

### 3.1 Online Learning in VSTU Before 2020

According to the Federal State Educational Standards, Volgograd State Technical University (VSTU) implemented Electronic Information-Educational Environment (EIEE) years before the spring of 2020. The environment provided access to curricula, course (module) and internship programs, electronic textbooks, and learning material referenced in the course (internship) programs; it allowed students creating their electronic portfolio, including saving their course projects and grades. When undergraduate and graduate curricula include courses using e-learning technologies, the environment must also provide features like building an electronic educational footprint of the learning process, storing the results of exams and the graduate projects and theses, holding online classes and exams which are codified in the curricula for learning programs taught using e-learning tools, and communication between the participants of the learning process using the Internet, including synchronous and asynchronous communication.

EIEE function is supported by educational institution's equipment and staff's (both teaching staff and supporting staff) skills in information-communication technologies (ICT); its use is regulated by the federal law [1].

To conform with these legal regulations, VSTU implemented EIEE and provided teachers access to it. However, it did not gain popularity: teachers were very conservative towards using it in their learning process except in some departments of the Faculty of Electronics and Computing. In December 2019, the average number of unique EIEE users was only 73 people per day. The main cause was the low level of development of digital competencies among university teachers and the significant amount of work required to move part of their courses online. Video conferencing tools were used rarely. By 2020, VSTU's teaching staff contained over 800 teachers, only 13% of them young (see Table 2).

**Table 2.** Age categories of Volgograd State Technical University teachers.

| Age group | Teachers in 2020 | Teachers in 2022 |
|---|---|---|
| Under 35 years | 13% | 15% |
| 35–55 years | 49% | 47% |
| Over 55 years | 38% | 38% |

According to surveys, 16% of the university's teachers did not even know what Learning Management Systems and Massive Open Online Courses (MOOCs) are. About 65% of teachers have never been trained in MOOCs. 31% of the respondents stated that they are firmly against creating online courses in EIEE.

### 3.2 Emergencies Measures at Spring 2020

With the advance of the COVID-19 pandemic in the spring of 2020, educational organizations all around the world suddenly had to switch the bulk of their learning process to a remote (primarily online) form. Only a small percentage of universities were fully ready for that transition. VSTU had to solve several problems urgently:

1. creation of online courses in EIEE for all the courses (modules, internships)currently taught in the university;
2. training teachers in e-learning technologies (ELT);
3. teaching students e-learning technologies;
4. control of the learning process in the new form;
5. finding and supporting hardware and software for teachers and students.

A creative team was assembled from employees of the educational-methodological department, teachers of the department "Software for automated systems" and students majoring in Software Engineering to solve the first task. In a week, this team collected the necessary reference data. It developed a set of SQL scripts that prepared information for the Moodle authentication and enrollment plugins External Database and automatically created almost 5 000 online courses with about 1 000 teachers and 14 000 students enrolled in them.

Then it was necessary to teach teachers and professors to develop and publish content in online courses and use video conferencing services to hold online

classes. To solve this problem, several of the most experienced teachers filmed tutorial videos that were widely distributed in EIEE. A group of volunteers was assembled from the students of the Faculty of Electronics and Computing; they helped teachers to install software and trained older teachers in using information-communication technologies.

Most of the students already had a higher level of development of digital competencies than teachers. For them, tutorial videos were filmed about using EIEE and video conferencing services. At that time, no single solution for video conferencing was accepted at the university. Most of the teachers used Zoom or Discord.

### 3.3 Systematization of EIEE in 2020–2021

In July 2020, the Department of Automation of Educational Activities (AEAD) was created at VSTU. It became responsible for the functioning and development of the university's EIEE. Its responsibilities included developing software to connect the university's information system 1C.University with the LMS Moodle, which was used to support the learning process, organize training of the teaching staff, and prepare administrative measures to promote online learning technologies and evaluate their development at the university.

**Developed Software.** Given the tight deadlines – the first version of the software was developed in just a week – it could not be used to maintain education in the subsequent academic years. So, in time for the next academic year, that began on September 1st 2020, a new application was developed that could provide persistent control over course generation and student and teacher enrollments. The main goal of that application was to connect the university's administrative software 1C.University, which stored information about students, their academic majors and minors, curricula, courses, and teachers who taught them to the Moodle LMS. As it required changing the identification of courses, it was decided to launch a new platform, EIEE 2.0, allowing teachers to import their courses' content from the old platform. The new application consisted of two parts:

1. a *set of SQL plugins* captured university-specific code parts, generating tables of online courses, student groups, and group enrollments;
2. the *Moodle enrollment plugin PoasDatabase*, and extended version of the basic External Database plugin that mostly contained generalized code, not tied to the peculiarities of the learning process at a particular institution.

One of the essential design decisions was determining the exact conditions for creating separate online courses. Students in Russia choose their academic major when enrolling in a higher-education institution, and the relevant curriculum determines which courses they must pass each semester. So common courses with the same names can differ significantly depending on the student's academic major: e.g., a Physics course taught for students majoring in different branches

of mechanical engineering is different from a Physics course for future chemists, IT specialists, and managers. Also, courses with many enrolled students can be divided among several lecturers; in this case, not all the lecturers teach the same. Some long courses take several semesters to complete, with different topics for each semester. So we decided to create separate online courses if at least one of the following parameters was different:

- level of education (e.g., undergraduate, graduate);
- semester number;
- academic major;
- kind of learning (e.g., on-site, correspondence, evening, shortened);
- course name;
- lecturer.

If a lecturer wants to use the same online course to teach students from different academic majors or kinds of learning, or two lecturers want to share their materials in a common course, they can use Moodle Course Meta-link functionality to link students enrolled in one online course to the other course.

One of the problems the development team encountered was that VSTU had not employed the scheduling capabilities of the 1C.University system, so the system's database did not contain information about lecturers responsible for different courses in a direct form. It was a serious problem because a big, university-wide course could be taught by several lecturers who adapted their courses to the academic majors of the students they taught. The only place where this information could be found was the module to print grade sheets which lecturers have to fill twice a semester so that faculty staff could track students' progress during the semester. So it was decided to generate online courses based on the grade sheets, which allowed faculty members control over the time of online course creation (i.e., they can be created in advance if the lecturer asks for it).

As students select their academic major at enrollment and their curricula specify exactly which courses they should take each semester (except elective courses), students at VSTU mostly learn in stable groups. So the developed software makes heavy usage of Moodle cohorts (global groups): students are enrolled in courses as groups, not individually. That required enhancing the standard External Database plugin to add automatic cohort enrollment from the external database. We also created bigger cohorts (e.g., combining all students of a certain level of education belonging to a particular academic major or faculty), which allowed heads of learning departments and deans of faculties mass mailing to groups of students.

Another problem that our software-development team solved was dealing with enrolled students who failed their final exams. At VSTU, students are given a grace period to complete the courses they were not able to complete in time; these students had to be enrolled in their previous courses individually, not as a part of the group. So we developed separate software that monitored exam scores, created lists of students in the grace periods, and kept them enrolled in the courses.

The main Moodle installation of the university's EIEE[1] is connected to a smaller Moodle installation[2], supported by "Software for automated systems" department. That second installation hosts innovative learning plugins developed by "Software for automated systems" department:

- assignment module PoasAssignment allows students to select and solve individual variants of assignments distributed using different strategies, which helps avoid cheating;
- Preg question type, which lets teachers specify open answers as regular expressions and can hint next correct character and next correct token in the training mode [21];
- CorrectWriting question type which analyses the sequence of tokens in the answer and reports misplaced, missing, and extraneous tokens [22];
- Supervised block, which opens access to summative and exam quizzes only when the teacher holds classes.

They are used in online courses teaching programming and English as a foreign language.

The developed Moodle plugin PoasDatabase is released under General Public License and can be accessed via its repository site[3]. We plan to submit it to Moodle plugin database once it is made fully compliant with Moodle coding guidelines.

**Training of Teaching Staff.** At first, teachers and professors of VSTU had significant difficulties filling the online courses generated for them with educational content. To solve that problem, the team governing the transition to online learning developed professional training courses "Organization of teacher's educational activities with the help of tools of university's electronic information and educational environment". Many teachers wanted to study these courses at once, and the registration for courses was immediately filled out for the following year. The course covered the main methods of work in the EIEE, which were necessary for developing online courses and using them in the learning process; they were explained in detail so that the teachers could start using the acquired knowledge immediately. The template online course was created to help teachers satisfy the basic requirements to the online courses they developed; teachers could import elements of the template course into their courses.

The template course includes the following required course elements:

1. News forum (news is published only by teaching staff);
2. General forum (all course participants can participate in discussions);
3. Online consultation with students (the teacher sets the date and time for each group when synchronous online communication takes place);

[1] https://eos2.vstu.ru.
[2] https://edu.vstu.ru.
[3] https://bitbucket.org/oasychev/moodle-plugins-poasdatabase/src/master/.

4. General information for course participants (the course program (module, internship), templates for the documents produced by students (title pages, laboratory work protocols, etc.), a list or links to recommended literature and other documents used in the learning process;
5. The course educational content (can be filled before the start of the semester or during it);
6. Mid-semester exams (including the necessary materials to prepare for them);
7. Survey of the course quality (anonymous survey for course participants to evaluate the course effect and quality);
8. The results of students' learning in the course (student grades on a 100-point scale).

Of course, an online course for this training program was also created: it served both as an example and training grounds where teachers could see how their students will experience different elements of online learning. The teachers who participated in the training program especially appreciated video lectures about online learning which they could watch anytime. It was important because many of them could only attend some of the synchronous classes because of their teaching schedule. Access to the online course remained open to the participants after completion of training; according to the Moodle usage statistics, the materials in that course were accessed actively when teachers needed to review the materials after a long break in their usage (e.g., before starting creating online course materials for the next semester). 97% of teachers who participated in training returned to review the material later.

In general, the teachers who completed the training course began to use the EIEE features a lot more actively; after mastering the digital skills, they became creative while developing their online courses. Later, the team developed an advanced training course "Improving the professional competencies of a teacher by using ICT in the context of the implementation of the Federal Education Standards of Higher Education", during which participants learned to record video lectures, edit them by video editor, working with virtual whiteboards and, post the prepared videos to their courses in the EIEE. That made the learning process much more engaging and accessible and increased the learning material's clarity. Even when the university returned to holding in-person classes, video lectures remained in high demand because they allowed students who could not participate in the in-person lecture fully master the topic. They also make online courses more accessible in case of another sudden transition to purely online learning.

Three advanced teacher-training programs in digital competencies were developed between the fall of 2020 and the end of 2022. Four hundred sixty-three people underwent the training and received certificates of professional development. The first program was devoted to working with the university's EIEE and MS Teams video conferencing service. The second program was created to train advanced EIEE users to work with video (MOVAVI[4]) and various interactive

[4] https://www.movavi.ru/.

elements in EIEE and virtual boards (IDROO[5], JAMBOARD [3]). The third program was devoted to the automated generation of didactic and methodological documentation.

**Administrative Measures.** Every department and faculty of the university was required to appoint a designated person responsible for interactions with the environment to organize communications between teachers and the staff implementing EIEE and avoid getting the EIEE staff overwhelmed by trivial questions and requests. These teachers underwent advanced training and could answer most of their peers' questions and perform simple requests (like adding tutors to the courses); they received additional capabilities in the EIEE sections devoted to their departments (faculties) by assigning a special role in Moodle role system. Heads of departments and faculty deans were also assigned a special role at their department (faculties) level to control their subordinates.

The people responsible for the implementation of the EIEE in their departments have the following responsibilities:

1. Adding additional teachers (tutors) in online courses.
2. Assistance in organizing the training of the department staff in using EIEE.
3. Distribution to the department staff passwords and logins to EIEE, institutional e-mails, Office 365 (MS Teams) accounts, etc.
4. Quickly and effectively learn to work with the software used in the university to automate learning.
5. Advising teachers in creating and usage of online learning courses.
6. Collecting questions and requests regarding EIEE from the department staff and communication with the AEAD specialists concerning the requests they cannot perform themselves.

The people responsible for the implementation of the EIEE in their faculties have the following responsibilities:

1. Assistance in detecting and fixing data errors in the learning-process data stored in 1C.University, including interacting with other structural divisions.
2. Coordination of the activities of the staff responsible for the EIEE in the faculty's departments.
3. Distribution to the faculty, students, and staff passwords and logins to EIEE, institutional e-mails, Office 365 (MS Teams) accounts, etc.
4. Assistance in organizing training in online learning and learning analytics for faculty members.
5. Collecting questions and requests regarding EIEE from the faculty students and communication with the AEAD specialists concerning the requests they cannot perform themselves.
6. Quickly and effectively learn to work with the software used in the university to automate learning.

[5] https://app.idroo.com/.

Heads of structural divisions have access to all the courses of their structural division. They have read-only access to course content, including assignments, chats, forums, and event logs. That allowed them to control the learning process in their divisions without directly interfering in the learning process. In December 2020, the university's rector officially approved the procedure for the development of online courses at the university's EIEE. The course template was introduced, and lecturers were required to fill all their courses with learning content. AEAD staff periodically performs an automatic check of the EIEE, detecting empty courses and users who have not logged into the system for a month or more. Every year, the university surveys of students, teachers, and employers to assess the quality of the educational process. The results of checking courses and surveys of education quality are distributed to the heads of structural divisions, who can take informed actions based on it. Currently, the AEAD staff is working on a system for assessing the quality of course content at the university's EIEE.

Volgograd State Technical University has been holding a staff contest "The best online course in basic educational programs at the university's EIEE" in order to motivate teachers to create quality, interesting, modern online courses; to identify, support and distribute successful practical experience of university staff in using online learning; to popularize the improvement of course content; to increase competence and professional skills of the staff in creating and implementing educational courses in EIEE, and also to encourage the innovation among the employees involved in the processes of modernization of the university's activities in the development of online courses. The courses are evaluated by the following criteria.

1. Compliance of the online course structure with the "Procedure for creating online courses in the EIEE of the VSTU", approved by order of the rector. The course must contain a scanned copy of the approved course program, forums, didactic content, materials for mid-semester exams, quality assessment survey, and final grades for the previous year. The relevance and availability of the indicated bibliographic sources.
2. Quality and completeness of online-course content. Compliance with didactic content to the approved course program.
3. Completeness and quality of the bank of test questions. Correctness of questions and variety of the question types used. The number of tests to test students' knowledge.
4. Variety of used course elements and variety of their settings.
5. Availability of teacher-created video materials, their quality, and total duration of videos in the course.
6. Organization of teamwork among students (usage of the "Workshop" Moodle activity module; dividing students into teams to perform learning tasks, etc.).
7. Usage of interactive learning elements (Moodle "Lesson" activity module, virtual whiteboards, etc.);
8. Clarity and accessibility of the material (the course materials are presented in understandable terms for the target audience, saturated with illustrative

material (tables, figures, etc.), well structured, main ideas and conclusions are highlighted).

A professional jury is formed to judge the contest. It evaluates each submitted online course according to the criteria described above. The winners receive a monetary reward. University teachers can access the winning courses to learn and adopt best practices. The contest dynamics show a significant increase in the quality and variety of course content. Having mastered the EIEE tools, the course authors introduce creative components; they switch from links to publicly available materials to creating their own engaging videos; the usage of interactive elements also increased. All that contributes to achieving the primary goal of the online educational process—increasing students' interest and engagement in learning their chosen profession, which ultimately makes it possible for the university to prepare professionals who like their job.

## 4 Evaluation of the Results

### 4.1 Method

Since 2018, the university has been conducting internal assessments of the quality of education every year by surveying students, teachers, and employers. The questionnaire for teachers includes at least 27 questions. Some of them are dedicated to e-learning technologies. We analyzed answers to these questions (see Table 3) to evaluate the effects of implementing the EIEE and providing training in e-learning. 316 teachers participated in the survey in 2018, 261—in 2020, 257—in 2021, 436—in 2022.

The number of unique users in EIEE was calculated using a special query to the LMS Moodle database. For the calculation, the average value of the number of unique users for each day of the month was taken.

### 4.2 Results

Currently, EIEE attained high popularity in the university. According to the results of the internal evaluation of education quality, 83% of teachers rate the functioning of EIEE as "good" and "excellent". Less than 1% of them indicated that they do not know the concepts of e-learning and massive open online courses. The average number of MOOCs a VSTU teacher passed successfully is 2. Less than 1% of teachers expressed the desire to use only in-person learning. Most teachers are willing to incorporate online courses in their teaching practice to some extent. Despite the already large number of trained teachers, 78% of them consider it necessary to improve their competence in online learning technologies. 45% of the teachers want to master new tools for educational activities (development of Internet sites, virtual quests, etc.).

Per university regulations, the teaching staff must fill online courses in the university's EIEE with content. A separate document regulating the structure of the course has been developed. For two years now, a university-wide contest of online courses belonging to basic educational programs has been held at

**Table 3.** Survey of teachers.

| Question | Scale of measurement |
|---|---|
| Do you know what a Learning Management System (LMS) and Massive Open Online Course (MOOC) are? | yes/no |
| Are you willing to create electronic courses, including video lectures, text lecture notes, virtual laboratories, assignments for homework, tests and final exams? | 4-point Likert scale |
| Please rate the quality of the EIEE functioning | 4-point Likert scale |
| How many MOOCs did you completed (receiving certificate, credential, or diploma)? | number of courses |
| Are you willing to use the features of EIEE in your educational activities in the future? | 8-point Likert scale |
| Do you need to improve your skills in the field of online learning technologies? | 5-point Likert scale |

VSTU. New digital services for EIEE are being developed and implemented to facilitate the learning process. In 2022, two massive open online courses were developed at VSTU. All this contributes to the popularity of the EIEE. In 2022, the average number of unique users per day was 2 330 (see Fig. 1). It can be seen that the number of users was very low before the COVID-19 lockdowns; it increased to the maximum during the distance-only learning period, then lowered when the learning became blended (lectures were held online, seminars and laboratory works on-site) and the university returned to fully on-site lessons. Still, it remained sufficiently higher than in pre-COVID-19 time because many teachers and students liked to use the online learning environment. The peaks of user activity occur during exam periods at the end of each semester (December, January, May, June); the highest user activity was registered during the winter exams of 2020–2021 academic year. These exams were held online according to local regulations. The lowest activity was in September, when students began to learn after long summer vacations. In the last year, the difference between the highest and lowest activity decreased because teachers began to use online learning courses in their everyday learning activities.

## 5 Discussion

Universities that effectively developed the digital transformation strategy of the educational process before the COVID-19 pandemic were relatively calm in switching to e-learning in 2020. However, most educational institutions faced a similar set of problems. These include:

1. Lack of necessary personal technical means for students and teachers;
2. No internet or its low bandwidth;
3. Lack of necessary digital competencies, usually among teachers;

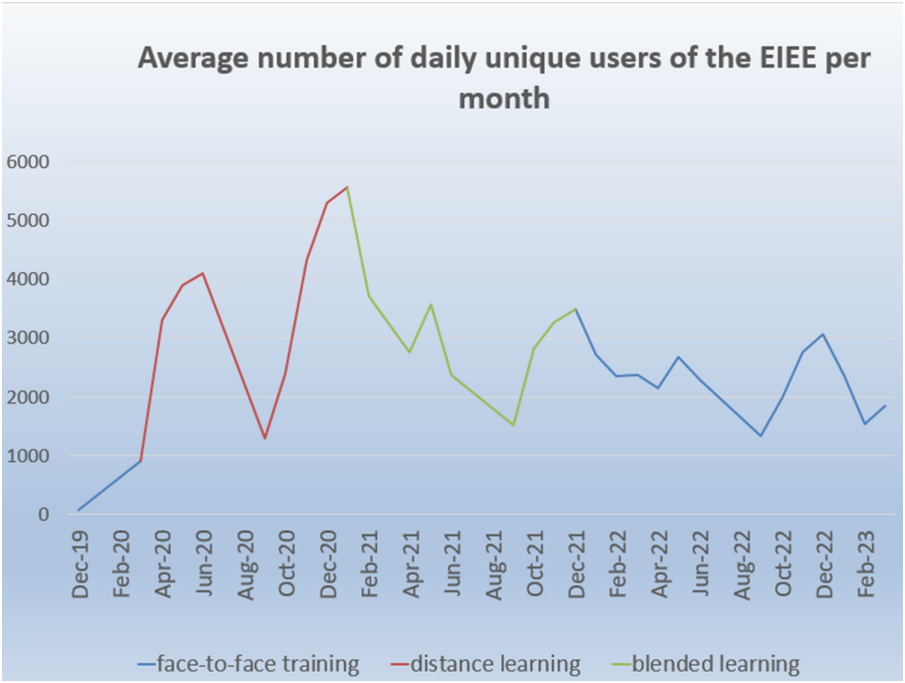


**Fig. 1.** Average number of unique users.

4. Lack of necessary software from universities and the ability to provide it for personal use for students and teachers;
5. Fear of new learning technologies.

At that moment several companies provided opportunities to use their software products free of charge, which helped a lot. Many platforms have made access to their online courses free. That made immersion in e-learning technologies more accessible and comfortable. The experience gained by universities over the past three years cannot go unnoticed. Students and teachers have found many positive aspects of using e-learning technologies. Personal communication cannot be completely replaced. However, some students are able to master educational programs completely in a remote format at a convenient time and an appropriate pace. The growing account of full e-learning programs in universities confirms this fact. Even with classical in-person teaching, teachers actively began to use new methods and tools (mastered during the COVID-19 pandemic), which made the educational process more interesting for students. The lack of necessary equipment or stable internet in remote areas where students live is sometimes an unsolvable problem. However, with combined learning models, online learning can be successfully developed and improved while addressing inequalities [9]. The lack of live communication can be compensated by video conferencing and chatting. According to [23], the video conferencing feature can be used in online

learning to facilitate effective communication and interaction between students and teachers. Discussion forums are a common tool among learners [12]. Using this tool, students can interact, view, and discuss course materials; it encourages students to share, discuss, and process their thoughts and think critically [7,15]. Therefore, despite the absence of a teacher, students feel his presence when using discussion forums. Online learning makes higher education more accessible to a wider range of people as it creates educational opportunities which are free from temporal and geographic constraints [24].

While VSTU came little prepared to the beginning of the COVID-10 lockdowns, which prompted some emergency measures, the university's management opted for developing a centralized online learning environment based on the powerful Moodle LMS and training the teaching staff. This required more effort but produced better results than the strategy relying on non-specialized, well-known software that some universtities adopted (e.g., see [6]). The learning process of VSTU has undergone significant changes during the implementation of EIEE because the pandemic forced the pedagogical community to study and adopt e-learning methods. Many young teachers prefer online teaching as a regular method, while middle-aged and old-aged teachers prefer in-person learning. Even though most of the university teachers are over 55 years old, many teachers have become fascinated with the use of interactive tools and are actively using them now. That engages students in the learning process and increases their motivation in general.

## 6 Conclusion

The COVID-19 pandemic forced many educational institutions and their teaching staff to consider using online learning tools. Volgograd State Technical University created the Department of Automation of Educational Activities (AEAD) in June 2020. The department's responsibilities include the development and maintenance of the university's electronic information and educational environment (EIEE), training teachers in online learning technologies, and implementing new digital services into the learning process. All the educational departments and faculties elected members responsible for implementing online learning, who work in collaboration with the AEAD staff. The online learning process is based on the Moodle LMS, which was integrated with the university's administrative information system based on 1C.University software to maintaining relevant information about currently taught courses and students enrolled in them.

Much has been done to motivate teachers to use EIEE more actively in the educational process. Local regulations were developed with uniform requirements for the structure of courses and for the obligation to fill them with educational content. Reminder courses are regularly held to form and develop digital competencies among teachers. A competition of online courses with financial rewards for winners and prize-winners is being held. New digital services are being developed; new elements are added to the EIEE to facilitate the teacher's work. Despite the relatively high assessment of the quality of the EIEE by teachers,

the quality of the course content still needs to be higher. The fact that the availability of a high-quality online course today is not part of a teacher's job contract and is not considered during competitive selection for a position, unlike articles and textbooks authored by the teacher, for example, also has a negative effect. Nevertheless, the high-quality content of the EIEE affects the motivation for learning and the student body's retention. Therefore, creating an automatic system for checking the quality of content is one of the priorities of the AEAD for further development of educational software.

**Acknowledgements.** We want to express our thanks to Yaroslav Kamennov and Mikhail Denisov for participating in the implementation of software deployed in the university's electronic information and education environment.

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