ONLINE TEACHING AND DISTANCE LEARNING DURING THE COVID-19 PANDEMIC AND ITS EFFECTS ON STUDENT ACHIEVEMENTS IN HIGHER EDUCATION

Vladimir Kuzmanovic

Faculty of Mathematics, University of Belgrade, Studentski trg 16, Belgrade, Serbia

Abstract

The COVID-19 pandemic had a major impact on all aspects of life, including teaching courses at college level. Mandatory social distancing and imposed limits on the number of people in enclosed spaces forced many colleges to transform the courses they teach into online courses. Distance learning became the norm for the students and teachers as well. Global health crisis, online teaching, distance learning, isolation and limited teacher-student interaction may lead to the decline in student motivation and their achievements. In the online environment, the teachers are faced with a challenge of how to motivate the students, how to actively include them in the teaching process and decrease their feeling of isolation as well as finding various ways to keep the teacher-student interaction at a high level. In this paper I will explore the effects the COVID-19 pandemic had on teaching the undergraduate course of Operating Systems at the Faculty of Mathematics, University of Belgrade. I will also present the teaching methodology and all the equipment and software tools used in teaching the course online. Furthermore, student results on the final exam during the pandemic will be compared to those in the previous years. Finally, I will analyze the benefits and drawbacks of the presented approach in teaching, as well as a few possible solutions to the problems that arise in online teaching.

Keywords: *online teaching, distance learning, programming teaching methodology*

1. INTRODUCTION

The outbreak of the new corona virus in December 2019 in Wuhan, China, has become an international health crisis by March 2020 when the WHO declared a worldwide pandemic. The pandemic had a significant impact on every aspect of our life [1]. Economy, business, industry, healthcare, education and almost every social activity of a modern society was and still is severely affected by the pandemic. Mandatory lockdowns, imposed quarantine and social distancing have derailed educational systems all around the world from their usual operations. This has caused schools, colleges and universities to remain closed for an indefinite period of time and forced millions of students and teachers to change their daily habits and adapt to the new circumstances [2,3].

Educational systems and institutions around the world are focused on resolving challenges caused by the pandemic and creating various strategies to address this and any future crisis. The strategies are aimed at making the educational system functional and easily adaptable to new difficulties it may face in the future [4]. Many educational systems have integrated the Internet and its technologies into the educational process and thus shifted the entire teaching and learning process online [5]. This overnight shift to a new teaching process has caused considerable physical, mental and financial challenges to teachers as well as to students. Possibly inadequate digital competencies, insufficient pedagogical knowledge for teaching courses online and various infrastructural problems can also affect the already challenged teaching process [6]. Availability and affordability of the Internet connection and digital gadgets, difficulties in getting familiar with online tools easily, the discomfort of not getting a face-to-face-interaction, problems in conducting practical classes and feeling of isolation also pose significant problems that need to be overcome in order to make the online teaching process functional [7-9].

Another important aspect of online teaching and learning is the way it is perceived. Many people favor online learning due to its temporal and spacial independence, easily accessible and diversified learning materials and comparatively lower costs compared to institution based learning [10-12]. Before the COVID-19 pandemic online distance learning was preferred by those students who could not go to

schools or colleges due to their busy schedules, but now online teaching and learning became prevalent. Many educational institutions agree that online distance education has become an important alternative to the traditional classroom based teaching and learning process. Ministries of education in many countries now provide remote learning resources for students while schools and colleges are closed.

In this paper I will explore the effects the COVID-19 pandemic had on teaching the undergraduate course of Operating Systems at the Faculty of Mathematics, University of Belgrade. Section two of the paper presents the teaching methodology and all the equipment and software tools used in teaching the course online. The next section compares the result of the final exam during the pandemic with the results in the previous years. Section four discusses the benefits and drawbacks of the presented approach in teaching as well as a few possible solutions to the problems that arise in online teaching. Finally, the last section draws conclusions about the effects of the pandemic on student achievements and presents a few ideas for future work.

2. TEACHING METHODOLOGY

Distance learning is a planned teaching-learning process that presupposes physical distance and possibly temporal distance. Online distance teaching-learning uses internet as a physical layer for teacher-student interaction. Using the internet as a medium of interaction makes it possible for students to learn at their own pace, whenever and wherever they want. This flexibility leads to possible low student attendance during online classes, low teacher-student interaction, low feedback and finally low motivation and low level of academic achievements.

For distance learning to be efficient, it is necessary to use strategies that are quite different from transforming the content used by the teacher in traditional face-to-face classes and placing them on the internet in a static form – usually pdf documents, presentations etc. Also, it is very important to achieve a very high level of teacher-student interaction during and after classes in order to asses the students' motivation and get feedback on their progress. Developing strategies that achieve collaboration between students may decrease their feeling of isolation in an online learning environment and increase their motivation. In an online teaching environment it is important to diversify learning materials and adapt them to learning styles the students have developed. Each person learns in a different way: some like to read text, some like to watch videos, others like to see images, others like to see a mix of text and images etc.

Distance learning platforms and learning management systems (LMS) enable all necessary course materials and activities to be grouped and organized in an orderly fashion. Besides organization, using the LMS can greatly increase the teacher-student interaction. Also, the use of various conferencing software, presentation software, blogs, chat forums and many other tools for communication may increase the effectiveness of online teaching-learning process.

The undergraduate course of Operating systems at the Faculty of Mathematics in the 2020/2021 academic year was held during the 12 weeks of the winter semester. The course was held online due to the imposed restrictions on the number of people in closed spaces imposed by the Ministry of Health of Republic of Serbia because of the COVID-19 pandemic. For the course to be held in a quality manner it had to be reorganized and properly adapted to the new circumstances.

Usually, the course of Operating systems is held as a mix of practical exercises demonstrated by the teacher in the classroom and a series of tasks given to students for self-assessment. The students are required to participate in the teaching process by actively discussing the proposed solutions to the presented problems. The equipment necessary in this scenario is a computer with a text editor and a compiler for the chosen programming language, a projector and a black board.

Transforming this approach to distance teaching and maintaining a high level of student-teacher interactions requires extensive use of modern technology and devices. Firstly, it is necessary to make a transition from standard classroom based teaching to online teaching. This requires video conferencing software and broadband internet connection. The Faculty supplied licenses for Cisco Webex

conferencing software which was used throughout the semester for every course activity. The chosen conferencing software enables the teacher to teach classes as audio or video conferences. Also, the software enables easy screen sharing both for the teacher and for the students in real time as well as public and private chat rooms for all participants of the conference video call.

The chosen conferencing software enabled easy transition of the teaching process to the online environment. The classes were held as video conferences where all practical exercises demonstrated by the teacher were broadcasted to students via screen sharing option in the conferencing software itself. This approach made classes highly dynamic because problem solving and coding was displayed to the students step by step in real time and all their questions could be answered immediately due to the classes being held as video conferences. The only difference compared to the standard classroom approach was physical distance between the teacher and the students and the lack of classroom atmosphere. This highly increases the feeling of isolation among students and possibly limits the student feedback which is essential for maintaining a high level of quality in teaching. These effects of online teaching can be reduced by actively including the students in the teaching process and possibly awarding them by giving extra points to those that actively participate during classes. Starting discussions in classes also significantly increases students' feedback and helps in assessing their progress. The classroom atmosphere can also be improved by asking the students to keep their cameras turned on and thus increase social interaction.

If the classes are not based on solving practical exercises, but on explaining fundamental concepts and algorithms from the theory of operating systems, this approach may be insignificant. The problem arises when algorithms and theorems need to be explained or proved. One approach is to perform all explanations by verbally describing the statically shown text in the form of a document or a presentation. This limits the students' interaction and the flexibility of teaching, thus decreasing the critical teacher-student interaction. In such a scenario, besides video conferencing software, a pen tablet and interactive blackboard software are essential tools for quality teaching.

The use of a pen tablet and interactive blackboard software enables a step by step introduction of new topics and step by step proving of theorems with easy emphasizing of important details. Also, the use of pen tablet enables immediate answers to every question students might ask, thus increasing the students' role in the teaching process and helps in keeping the teacher-student interaction at a high level. Wacom pen tablet and OpenBoard blackboard interactive software was used during the course of Operating Systems. OpenBoard software allows for easy handwriting on the virtual blackboard and creation of documents in PDF for further sharing with the students.

Important aspect of online teaching is the quality of materials offered to students for learning as well as easy accessibility. Also, the way those materials are organized may help the students in the learning process. Learning management systems can be used for organizing the materials and monitoring students' progress and asses their interest on certain topics covered in classes. Also, many learning management systems allow teachers to create tasks that students need to fulfill and thus increase teacher-student interaction. Finally, many learning management systems can have a role of a virtual classroom during and after regular classes.

Moodle learning management system was used during the course of Operating systems. Materials were organized in a weekly manner and consisted of three parts. For each week and each group the students had the ability to use the following online materials whenever they wanted:

- Recording of the class – The classes were held as video conferences and each class/conference was recorded from the beginning till the end. After the recording was completed it was shared with the students with the help of cloud services.
- Written lectures – Every class was covered by a written lecture the students can use offline.
- Commented source codes – Every practical problem that was solved during classes was commented in detail and shared with the students. Besides the commented source codes, the codes from classes were also shared with the students for comparison.

- Contents of the blackboard – All explanations and flowcharts were written on the virtual blackboard with the help of a Wacom pen tablet and OpenBoard software. The content of the blackboard was exported to PDF for easier use and shared with the students.

Moodle learning management system was used a central course page where all the materials were available to all the students on the course irrespective of the group they were assigned to. All the groups had access to all the materials and recordings, because live classes cannot be identical in different groups due to different levels of student activity. Student questions are usually different and this diversity may help the students to master the course easier.

3. RESULTS

The course of Operating systems was held during the twelve weeks of the winter semester in the academic year 2020/2021. More than 250 students enrolled in the course and were divided into six groups with 45-50 people in each group. Since the classes were held online and recordings were available to the students, class attendance was not compulsory. This decision had a significant impact on attendance which is shown in figure 1. Also, the figure shows the statistics of usage of the available materials. The values were normalized for easier interpretation on the same graph.

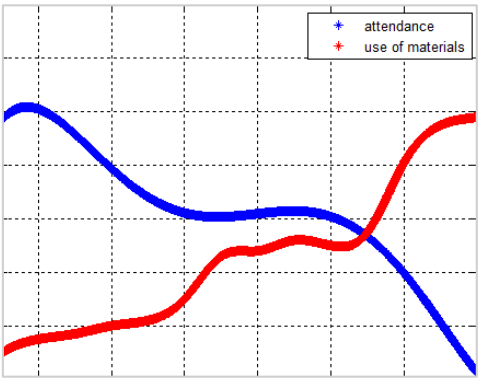

Figure 1. Plot of attendance and use of materials during the semester.

It can be clearly seen that attendance and the use of online materials show a strong negative correlation, i.e. with the decrease of attendance the usage of online materials increases and vice versa. It can also be seen that after week 6 the number of students that show up on classes stabilizes, but the use of online materials continues to grow slowly. This can be explained by the curriculum of the course. After week six the most complex topics in theory of operating systems are demonstrated and even the students who regularly show up on classes refer to the online materials for extra help in mastering the introduced concepts. Also, the usage of online materials exploded prior to and during the exam week when the students intensively prepared for the exam.

At the end of the winter semester, the students could take the final exam at two terms at their own choosing. The first term was at the end of January, and the second was two weeks later in mid-February. The students could take the exam in one of the proposed terms or in both. Table 1 shows the results of the final exam in the past three years.

Term	Students	Passed	Failed	Success Rate (%)	Avg. Score (%)
January 2019	115	91	24	79.13	58.56
February 2019	98	58	40	59.18	51.91
January 2020	136	97	39	71.32	66.92
February 2020	69	53	16	76.81	55.96
January 2021	102	78	24	76.47	69.84
February 2021	60	32	28	53.33	69.94

Table 1. Final exam results in the years 2019, 2020, 2021

Years 2019 and 2020 were regular years with classes being held in the classroom. Year 2021 was the year of the adapted course of Operating systems that was held completely online with no physical contact between the teacher and the students. The table shows comparatively lower number of students who decided to take the exams in both terms in 2021 compared to the non-COVID-19 semesters. Also, the percentage of students who passed the exam in the first terms remains unchanged compared to previous years. The percentage of students who passed the exam in the second term is comparable to the results from the year 2019, but significantly lower than the numbers from 2020. The difference in results in 2020 remains to be analyzed in the future as it may possible be an outlier. The average score accomplished by the students in the year 2021 is stable across both terms and significantly higher than the average score in the previous years. This result was possibly achieved due to the materials available to students being of greater quality and better diversified.

During the entire semester, student attendance was recorded for further analysis. Students who did not attend the course did not receive any penalties and students who attended online classes did not receive any rewards. Combining this data with the exam results and data from figure 1 yields interesting results. The results are displayed in Table 2.

Term	Students	Attended the classes (I)	Did not attend the classes (II)	Passed (I)	Passed (II)	Avg. Score (I)	Avg. Score (II)
January 2021	102	72	30	63	15	75.68	60.15
February 2021	60	35	25	24	8	74.32	63.89

Table 2. Final exam results of students who attended and did not attend the classes

Table 2 shows that the students who attended classes regularly had better results compared to those who relied solely on course materials or attended classes occasionally. Besides having much higher average score on the final exam, the ratio of students who passed the final exam is much higher among the group who attended the classes regularly. This leads to a conclusion that high quality and well diversified course materials combined with class attendance yield much better academic results that any of those teaching components separately.

4. DISCUSSION

The results clearly show that the COVID-19 pandemic had effects on the teaching process as well as student achievements during the course of Operating systems in the winter semester of the academic year 2020/2021. The number of students who took the exam in both terms has decreased by 15-20% compared to the non-pandemic years. Even though the number of students taking the final exam has

decreased, the ratio of students who passed the exam and the ratio of students who failed the exam to the total number of students taking the exam has remained comparable to the previous years. Also, one other key component of the exam results is the average score of the students who passed the exam. The average score of students who passed the exam is stable across both terms which is a significant difference compared to the non-pandemic years. Previous years show drastically lower academic achievements in the second term compared to the first term. Besides being more stable, the average score is also higher in the COVID-19 semester compared to those in the previous years.

Higher student achievements can be attributed to extensive use of information technology and cloud services and making the course content available at any place and at any time. Also, the learning materials are better diversified and allow students to employ different learning techniques and thus increase their level of understanding of the introduced topics. The use of learning management system allows the students to have a systematic overview of the available materials as well as the course curriculum. Finally, extensive use of information technologies enables the teacher to have better insight into students' problems in learning as well as their motivation and thus adapt the classes to students' feedback and needs.

Besides student achievements at the end of the course, the quality of classes and a high level of teacher-student interaction are also important. Making attendance not compulsory and enabling students to use the course materials throughout the semester has led to lower attendance, which consequently leads to lower teacher-student interaction with students who decide to rely solely on course materials without attending online classes. This may be the reason for the decrease in number of students taking the final exam, due to their lower confidence and lower motivation compared to those who attended online classes regularly. Students who attended classes regularly had a much higher average score on the final exam compared to those who did not attend classes regularly. Also, the ratio of students who passed the exam to the number of students who took the final exam is significantly higher in the group who regularly attended online classes. This leads to a conclusion that class attendance should probably be compulsory in order to get better student feedback as a teacher and to get a higher quality education as a student, which consequently leads to higher academic achievements.

5. CONCLUSIONS

The course of Operating systems at the Faculty of Mathematics, University of Belgrade, was first held completely online in the winter semester of the academic year 2020/2021 due to the outbreak of the COVID-19 pandemic and imposed limitations on the number of people in closed spaces. The course was thoroughly adapted to ensure high quality of education in the new circumstances. The adaptations ranged from modifying the lectures to the online environment and using video conferencing software as a means of communication to the extensive diversification of the learning materials. Content management system was used as a centralized course page that allowed easy sharing of learning materials and monitoring of students interest in the course topics as well as a means of assessing the students progress during the semester. Also, the results achieved by the students where analyzed and discussed as well as the benefits and drawbacks of the teaching methodology presented in this paper. Finally, conclusions where drawn and possible solutions to the mentioned drawbacks were proposed.

REFERENCES

1. Mackenzie, JS, Smith, DW, 2020, "COVID-19: a novel zoonotic disease caused by coronavirus from ChinaL what we know and what we don't". Microbiology Australia, vol 41, no. 1, pp 45-50.
2. Li, C, Lalani, F, 2020, "The COVID-19 pandemic has changed education forever. This is how", World Economic Forum.

3. Jackson, C, Mangtani, P, Hawker, J, Olowokure, B, Vynnycky, E, 2014, "The effects of school closures on influenza outbreaks and pandemics: systematic review of simulation studies", PLoS ONE, vol 9, no. 5, pp 1-10.
4. Dhawan, S, 2020, "Online learning: A panacea in the time of COVID-19 crisis", Journal of Education Technology Systems, vol 49, no. 1, pp, 5-22.
5. Sun, A, Chen, X, 2020, "Online education and its effective practice: a research review", Journal of Information and Technology Education Research, vol 15, pp. 157-190.
6. Kim, K, Bonk, CJ, 2006, "The future of online teaching and learning in higher education", Educause Quaterly, 22-30.
7. Saghed-Tehrani, M, 2009, "The results of online teaching: a case study", Information System Education Journal, vol 7, no. 42, pp 1-10.
8. Nguyen, T, 2015, "The effectiveness of online learning: beyond no significant difference and future horizons", MERLOT Journal of Online Learning Teaching, vol 11, no. 2, pp 309-319.
9. El-Seoud, MSA, Taj-Eddin, IATF, Seddiek, N, El-Khouly, MM, Nosseir, A, 2014, "E-Learning and students' motivation: a research study on the effect of E-Learning on higher education", International Journal of Emerging Technology Learning, vol 9, no. 4, pp 20-26.
10. Murphy, MPA 2020, "COVID-19 and emergency eLearning: Consequences of the Security Policy", Contemporary Security Policy, vol 41, no. 3, pp. 492-505.
11. Bao, W 2020, "COVID-19 and online teaching in higher education: A case study of Peking University", Human Behavior and Emerging Technologies, vol 2, no. 2, pp 113-115.
12. Basilaia, G, Dgebauadze, M, Kantaria M, Chokhonelidze, G 2020, "Replacing the classic learning form at universities as an immediate response to the COVID-19 virus infection in Georgia", International Journal for Research in Applied Science and Engineering Technology, vol 8, no. 3, 101-108.