Research Article

PERFORMANCE OF STUDENTS ON THE EXAMS DURING COVID-19 PANDEMIC

1, *Dr. Mirna Udovičić and 2Dr. Deniz Durmus

1University Sarajevo School of Science and Technology, Bosnia and Herzegovina
2International University of Sarajevo, Bosniaa nd Herzegovina

Abstract

The studies related to the effectiveness of teaching delivery are considered very important in science. Nowadays, the professors have an option to replace the traditional learning with virtual platforms where they can place all their materials. A main aim of this paper is to show effectiveness of teaching during a period of the COVID-19 pandemic, especially for the logical subjects such as mathematics. A percentage of the students who passed the mathematics courses at the SSST University in Sarajevo was taken as an indicator for effectively conducted teaching. Considering our analysis of a situation at the SSST, we showed that the difference between a pass rate of Computer Science students at exams before or after theCovid-19 pandemic and a pass rate during the pandemic was statistically significant.

Keywords: Online teaching, Efficiency, Student exam, Covid-19 pandemic.

INTRODUCTION

Since the whole world was affected by the COVID-19 pandemic recently, in a sector of the higher education some crucial changes were made. More precisely, the traditional type of teaching in the classroom was substituted by online teaching by virtual platforms. There exist many advantages, but also disadvantages of this change. The advantages are saving a lot of resources and time, while the disadvantages are mostly related to the efficiency and quality of teaching. It is known that we can express the efficiency through some parameters of passing the exams, attending classes and through average grades in subjects. The creation of a new knowledge is an important factor of the national economy. The studies that are measuring the effectiveness of teaching delivery are considered very useful in science.[1] The process of higher education reform in Europe, which has been ongoing since the 90s, is significant because it foresees the formation of a common space in which higher education systems in different European countries will be mutually compatible. A study that was related to a distance language learning claims that the online language courses could be just as effective as live language courses, in case they are organized well.[2] Note that this conclusion was made only for teaching the language courses. The question that we often pose is can this statement be the same if we compare some of the subjects that need to study the logical tasks, like all the mathematics courses. Nowadays, it is possible that we replace traditional learning with virtual platforms where we can place all our materials. So, we can see that the virtual platform has become a substitution for the classroom. However, in order for this method to be successful, a certain amount of a self-discipline is needed.[5] This is where a gap between the virtual platform and teaching in a classroom arises; the advantage of the classroom is that it allows monitoring the student's progress and work. In this case the students can be motivated by the fact that their work and effort will be carefully monitored.

*Corresponding Author: *Dr. Mirna Udovičić,*
University Sarajevo School of Science and Technology,
Bosnia and Herzegovina.

On the other hand, the distance learning certainly has a lot of positive effects when we are talking about the fact that the students can save a lot of their time. We need also to mention technological obstacles, the unavailability of the Internet for all the students. In the literature, there are much more works that talk about negative consequences of the online teaching compared to those that are talking about positive effects related to the effectiveness of this way of teaching. A traditional form of teaching makes a communication easier, while the implementation of teaching virtually represents a real challenge for achieving a good communication between professors and students. These problems are directly related to the effectiveness of teaching and its measurement. It is known that the education system in many countries was considered ineffective even before the pandemic. The aim of this paper is to show the effectiveness of teaching during the period of COVID-19 pandemic, especially for the subjects that contain logical tasks, such as the mathematics. The courses for which the effectiveness of teaching will be monitored are the mathematics courses Calculus and Discrete Mathematics, which are the compulsory subjects for Computer Science studies at the SSST University in Sarajevo. The percentage of the students who passed these courses was taken as an indicator for effectively conducted teaching. A similar research was done in Serbia and the results were presented in a paper[3]. Namely, the efficiency is expressed as a measure that is showing us how well resources are used. The subject Mathematics in Engineering Management was taken into consideration in[3], which represent a compulsory subject in the first year, at the Faculty of Mechanical Engineering in Niš. The MS Teams virtual platform was used for teaching. The mathematics subject was chosen for the reason that in order to conduct mathematics classes, it is necessary to do tasks that require the presence of the professor and solving tasks on the blackboard. When a Covid-19 pandemic was at the beginning stage, this way of conducting classes was made impossible; so it was interesting to present how students coped with this subject in this "new reality caused by the crisis situation". The numerical values showed that a percentage of students who passed the exam in the school year 2019/2020 was 52%, while a number of students who passed the exam in the school year

2020/21 was 51% .[3] The difference between the year before the pandemic (2019/20) and the year during the pandemic (2020/21) was 1%. So, a general conclusion was that if we took the percent of students who passed the course as a parameter, the teaching of mathematics online at the Faculty of Mechanical Engineering in Niš was conducted effectively. Even before the COVID-19 pandemic, there existed an initiative to modernize the teaching process in the countries of our region. One example was the Singidunum University in Serbia. The following subjects of the Faculty of Informatics and Computer Science: Mathematics, Discrete mathematics and Probability and statistics in the school year 2010/2011 have been analyzed in [4]. More precisely, the three different groups of students were observed. The first group consisted of students who were listening to the lessons traditionally, through lectures and laboratory exercises in the classroom. The second group also was listening one part of the lessons traditionally, while they had the additional online exercises organized. More precisely, a combination of two methods was organized for them. The third group of students attended the classes and exercises online. Considering the exams, they were organized in person in the classrooms for all the students. One of the parameters for the analysis was a motivation, which was observed through the presence of classes, i.e. platforms, while the other was an average grade, which was observed in mutual correlation through the different methods of teaching. Related to a motivation of the students, the results of the analysis showed that there existed the difference in the attendance according to the teaching method and a conclusion was that the combined method showed the best results. Note that the results on the colloquiums and exams indicate that a motivation, or equivalently the attendance, was not decisive, although it was an important factor for passing the exams. The three previously described groups of the students were compared according to their achieved results. The observed parameters were the mean score, or equivalently the arithmetic mean and the variance. So, the resulting numerical values presented in a table [4] showed that the second group of students who combined both methods had the highest average grade of 7.42 and the smallest value of a variance equal 0.32. The Moodle learning platform was chosen for the implementation of mathematics online teaching.[4] Its main advantage from the teacher's point of view is the possibility of full interaction with students. Also, some of additional filters were installed that enabled the creation of TeX notation, on the basis of which it was possible to create online mathematical records. A name of mathematical software designed for student education is Wiris. A software contains several interactive modules for drawing and creating the mathematical notations.

Theoretical overview in Bosnia and Herzegovina

Considering a situation in Bosnia and Herzegovina, the decline in the quality of teaching in the online model was often discussed, but there were no measurable indicators or major research on this topic. At the very beginning of a pandemic, a question of the digital knowledge and skills that teachers and professors possessed so that a lesson could be designed and fully implemented was posed. The development of digital competences among teachers and professors is prioritized through various networks for the improvement of educational practices at the level of the European Union, such as eTwinning, whose desk also operates at the level of Bosnia and Herzegovina. Earlier educational research, such as PISA, showed that the majority of schools in Bosnia and Herzegovina

did not have a sufficient number of digital devices for teaching. According to the PISA 2018 Report for BiH, only 32% of the schools included in the research had a sufficient number of devices for teaching, of which 56% have satisfactory availability of software that improves the teaching and learning process. The transition to the online model was met by the unpreparedness for all actors involved in a high school education, especially for the parents and students who could not provide digital devices or a stable Internet connection for teaching in the same capacity. A situation did not improve much in a period of the Covid-19 pandemic. According to the results of the UNICEF research [10], the learning outcomes in the two pandemic school years are estimated to be significantly weaker compared to previous years. As many as 82.9% of the teachers and 72.5% of the surveyed representatives of the school administration estimate that there has been a significant decline in mastering educational outcomes in critical two school years. This especially relates to marginalized groups of children who had difficult access to quality inclusive education, which caused additional educational inequalities. In a Report on the evaluation of online classes during the pandemic created by the parents and students in BiH, for the period from March to June 2020, it was stated that "close to a quarter of the parents surveyed (22.9%) stated that their children used mobile phones exclusively for work" or that 5.3% of the children from the surveyed sample waited for their parents to return from work in order to use their smartphones, while an additional 27.8% of the children, according to their parents' statements, shared the digital equipment with brothers and sisters. So, such working conditions made it difficult to access digital web tools and different programs on which tasks were set, but also limited teachers to create content in which the online teaching would really be connected with the strengthening of all digital competences. Considering a situation at the Universities and higher education, practically every second teacher (48.5%) stated that the achievements were significantly lower. In the Guidelines for conducting online classes in the Canton of Sarajevo, a recommendation was issued for the use of the Microsoft Office365 and the Google for Education platforms, as well as the Moodle, Edmodo and Class Dojo platforms, as safe and reliable from the aspect of protecting the personal data of the students and teachers. In online educational community, classes were mostly conducted by video call via the Google Meet platform, which does not require an additional subscription, or via Zoom, which has the limited time for free access. However, unpreparedness or inadequate equipment with digital devices often turned online classes in a video call into classic, frontal work in which teachers present the teaching unit, while the real involvement of students in monitoring the lessons was questionable. At the University of SSST in Sarajevo, a Zoom was used for the video calls, while a virtual blackboard was used for all the mathematics courses.

METHODOLOGY

During our analysis of a situation at the SSST, we applied the following statistical methods: t test, proportion test and z statistics test. We showed that the difference between a pass rate of CS students at exams before or after aCOVID-19 pandemic and a pass rate during pandemic was statistically significant. We also showed that a difference between a number of A marks was significant. More precisely, we concluded that online teaching of mathematics affected more the students who wanted to get a mark A, than those who only

wanted to pass the exam. Related to the average exam grade, it was decreased significantly during the pandemic, which was expected.

RESULTS OF STUDENT EXAMS

We used the dataset for the exams of the SSST University that are available through a system called SPACE in our research. The student's marks of the two first year mathematics courses, Calculus and Discrete Mathematics, from the first and the second semester respectively, were analysed. We took a sample of 26 students of the first year of Computer Science in a school year 2019/2020. This group listened Calculus in winter semester, while they listened Discrete Mathematics in a spring semester. We also took a sample of 28 students who listened Discrete Mathematics in spring 2018/2019 and a sample of 45 students who listened Calculus in winter 2020/21during the pandemic. The marks obtained during the year before the pandemic and during the pandemic were statistically compared.

Now we set up the first hypothesis.

H1: The difference between a pass rate of the 1st year CS students at the mathematics exams before the COVID-19 pandemic and the pass rate during the pandemic is statistically significant

We used the t test and a proportion test in order to check the hypothesis. The results are presented in a table below.

Table 1. Statistics of examination

Exam	Pass rate before COVID-19	Pass rate during COVID-19
Calculus	73	55.5
Discrete Mathematics	64	54

Since the obtained results of t-testing showed the difference at the levels 10% and 5%, we can conclude that a hypothesis H1 is true for a given significance level of 0.05. So, the difference between a pass rate of CS students at exams before a COVID-19 pandemic and the pass rate during the pandemic is statistically significant. Note that a proportion test is also showing the difference only at level 10%. A conclusion is that t test is more appropriate for our data set. Our next step is to analyze and compare the results after the COVID-19 pandemic and during the first pandemic year. Note that we took the last three school years including 2024/25 as a sample. The reason is that our aim was to have a larger sample and obtain more precise result. We have chosen to investigate one course, Discrete mathematics. The results are presented in a *Table 3*.

Since the obtained results of the proportion test showed the difference at the levels 10% and 5%, we can conclude that there exists a significant difference for this course. In order to verify our obtained results, we also compared a pass rate for this subject in the periods before and after the pandemic. An obtained p value was 0.091, which showed no difference at the level 5%. The only conclusion was that the students managed to improve they exam scores for Discrete mathematics in the last three years.

When we want to compare the numbers of the highest marks, we set up our second hypothesis.

H2: The difference between the rate of A level marks of the 1st year CS students at the mathematics exams before the COVID-19 pandemic and a rate of A level marks during the pandemic is statistically significant

Table 2. Results of testing

	t test	Proportion test
t value/ z value	3.00	1.458
p value	0.0421	0.072

Table 3. Results of a proportion test

Exam	Pass rate during COVID-19	Pass rate after COVID-19	z value	p value
Discrete Mathematics	54	77.82	2.194	0.014

We used the t test in order to check the hypothesis. The obtained results are presented in a *Table 5*.

Table 4. Statistics of examination

Exam	Rate of A before COVID-19	Rate of A during COVID-19
Calculus	23.4	14
Discrete Mathematics	21	17

Table 5. Results of t testing

	t test
t value	3.487
p value	0.036

Notice that we obtained a smaller p value in the *Table 5*, when we were testing the difference of A level marks. So, we can conclude that online teaching of mathematics affected more the students who wanted to get the highest mark, than those who only wanted to pass the exam. Since mathematics is the abstract subject and most of the professors had no experience with online teaching at the beginning of a pandemic, this was expected.

The next step of our work is to test the difference between the average grades. We set up the third hypothesis:

H3: The difference between the average exam grade of the CS students for the Discrete mathematics after a COVID-19 and the average exam grade during a pandemic is statistically significant

The results of a proportion test are presented in a *Table 6*.

Table 6. Results of a proportion test

Exam	Average grade after Covid19	Average grade during Covid19	Proportion test	p value
Discrete Mathematics	67.88	52.6	2.39	0.0084

Since we obtained a small p value, we can conclude that the hypothesis H3 is true and there is a significant difference at all levels, 10%, 5% and 1%, between the average grades for this course.

We also applied z test to a same previous data set and obtained the following results in a *Table 7*.

The obtained results also confirmed the H3 hypothesis; a p value of a z test is exactly 0.010, while a p value of the previous proportion test is smaller 0.0084, which means that we get a stronger conclusion by the proportion test.

Table 7. Results of z testing

Exam	Average grade after COVID-19	Average grade during COVID-19	z test	p value
Discrete Mathematics	67.88	52.6	2.317	0.010

Our next step was to analyze and compare the midterm results during the pandemic and after it for the same course Discrete mathematics. Note that the midterm exams in a year 2019/20 needed to be organized online at the SSST University because of the very strict measures introduced by the BiH government in that period. Although six different test groups for the mathematics midterm in spring 2019/20 were created, the students managed to cheat and use technologies to improve their results. So, the pass rate at the midterm was 79.1%, while the pass rate for the final exam of a same generation was only 54%. Obviously, the first result is not realistic and it gives us a strong proof that the students were cheating on a midterm. Note that the mathematics midterm exams are well organized in person and several different groups are always prepared for a group of approximately 20 students. We can also consider a sample of midterm results in a period after a Covid-19 pandemic and compare them to the final exam results for each year separately. The results of a proportion test are presented in a *Table 8*. Obviously, only the first row for the pandemic school year is showing the difference at a level 5%, while there is no significant difference for any school year after the Covid-19 pandemic.

Table 8. Comparison between midterm and final exam results

Discrete Mathematics exam: year	Pass rate on midterm	Pass rate on final exam	proportion test z value	P value
2019/20	79.1	54	1.843	0.033
2022/23	77	79.3	0.219	0.412
2023/24	82	82.5	0.038	0.484
2024/25	77.7	66.7	0.736	0.229

RESULTS OF ENTRANCE EXAMS

After analyzing the results of student examination, we decided to also analyze the results that pupils achieved during the entrance examination at the SSST. Namely, every school year the entrance exams at the SSST University (Sarajevo) are organized twice a month in a period from the March until the September. Considering the entrance exams at the CS department, the pupils need to pass the English and Mathematics exam. Since the COVID-19 started in March 2020, the management of the SSST decided to organize all the entrance exams online. We tested the difference between the student results on the mathematics online entrance exam and the results of the 1st year CS students achieved on the Mathematics test organized at the beginning of a school year 2020/21 in the classrooms. It is important to point out that the same lessons from the high school mathematics were tested; also, the same generation was tested.

The results of a statistical analysis are presented in a *Table 9*.

Table 9. Results of t testing

Pass rate online exam	Pass rate exam in classroom	t test	p value
77	42.5	7.181	0.0094
88.8	43.5		

The results from a *Table 9* are showing that a difference between the online entrance exams and the exams organized in the classrooms is statistically significant for all significant levels: 10%, 5% and 1%. Based on a fact that the same high school mathematics topics were tested, we get a strong conclusion that the students were cheating during the online entrance exams. We can see that a previous p value of 0.0094 is much smaller than a p value obtained in a *Table 2* when we were testing the hypothesis H1. So, it is not possible to organize the online exams in future in a classical way using the zoom video calls. Our general conclusion was that the mathematics exams organized online had a negative effect on the education process. Related to the online teaching, the negative effects were less significant. Even more, we can take into a consideration the existing literature from our region. The general conclusion was that, if online lessons were well organized, they are the same effective as the lessons in person organized in the classrooms. Note that a majority to the professors from the SSST University were not prepared for online teaching at the beginning of a pandemic. This fact influenced the student marks significantly. Of course, the quality of this teaching process improved during the past several years. The preparatory mathematics online classes are organized at the SSST and we are receiving a positive student feedback every year.

Conclusion

When we check the existing literature from a period before the COVID-19 pandemic, the combination of a traditional and online teaching method showed to be the most effective.[4] Considering our analysis of a situation at the SSST, we showed that the difference between a pass rate of CS students at exams before or after the COVID-19 pandemic and the pass rate during the pandemic was statistically significant. We also showed that a difference between a number of A marks was significant. More precisely, based on the obtained p values, we have concluded that online teaching of mathematics affected more the students who wanted to get a mark A, than those who only wanted to pass the exam. Related to the average exam grade, it was decreased significantly during the pandemic, which was expected. Note that a majority of the professors from the SSST University were not prepared for online teaching at a beginning of a pandemic, which directly reflected to the student marks. Especially, we investigated the difficult courses, mathematics courses. Ofcourse, a quality of this teaching process improved during the past several years. The preparatory mathematics online classes are organized at the SSST and we are receiving a positive student feedback every year. Considering the examination of these courses, it was determined that the previously applied online examination method had a negative effect on the education process and it should be avoided in a future.

REFERENCES

1. Ramón Fuentes, Begoña Fuster, Adelaida Lillo-Bañuls, A three-stage DEA model to evaluate learning-teaching technical efficiency: Key performance indicators and contextual variables, Expert Systems with Applications, Volume 48, 89-99, 15 April 2016.
2. Kelly M. Moser, Tianlan Wei, Devon, Brenner Remote teaching during COVID-19: Implications from a national survey of language educators, System, Volume 97, April 2021
3. A. Kitic, M. Radisic, Efikasnost sprovođenja nastave tokom pandemije COVID-19, XXVIII *Skup* TRENDOVI RAZVOJA: "Univerzitetsko obrazovanje za privredu", *Kopaonik,* Paper no. T1.4-1, 2022
4. Jelena Gavrilović, Ivana K. Kovačević, Komparativna analiza primenjenih edukativnih metoda u nastavi matematika, Zbornik radova konferencije ETRAN, Jun 2013
5. Branislava Novaković, Biljana Carić, Online mogućnosti i ograničenja, XXVII Skup TRENDOVI RAZVOJA: "On-line nastava na univerzitetima", Novi Sad, 15 - 18. 02. 2021
6. Fürnkranz J., D.Gamberger, N. Lavra, "Foundations of Rule Learning (Cognitive Technologies)", Springer, 2010.
7. T.N. Basit, S. Tomlinson, "*Social Inclusion and Higher Education*", Plocypress, 2012.
8. Durlach P.J., Lesgold A.M. "Adaptive Technologies for Training and Education", Cambrige, 2012
9. UNICEF (2000). Defining Quality in Education. Paper presented at the International Working Group on Education, Florence, Italy (June, 2000).
10. UNICEF (2021a). Pregledna studija o kvalitetu nastave na daljinu i kombiniranog učenja u osnovnom i srednjem obrazovanju (i ZiTO) u Bosni i Hercegovini tokom pandemije koronavirusa
11. UNICEF (2021b). Pregledna studija o potrebama nastavnika u nastavi na daljinu i kombiniranom učenju u osnovnim i srednjim (i ZiTO) školama u Bosni i Hercegovini tokom pandemije koronavirusa
12. UNICEF EDC (2021). Educators' Digital Competency Framework (Okvir digitalnih kompetencija nastavnika)
13. Anohina, A. Analysis of the terminology used in the field of virtual learning, *Educational Technology & Society* 8(3): 91–102, 2005
14. Simonson S. R., Earl B., Frary, M. Establishing a Framework for Assessing Teaching Effectiveness, *College Teaching* Volume 70: 164 –180, 2021
15. Vieluf, S., Klieme, E. Teaching Effectiveness Revisited Through the Lens of Practice Theories. In: Praetorius, AK., Charalambous, C.Y. (eds) Theorizing Teaching. Springer, 2023
16. Munna A. S., Kalam, A. Teaching and learning process to enhance teaching effectiveness: a literature review, *International Journal of Humanities and Innovation (IJHI)* Vol. 4 No. 1, pp. 1-4, 2021
17. Cabrero R. S., J. Luis Estrada-Chichon, A. Abad-Mancheno, Lidia Manoso-Pacheco, Models on Teaching Effectiveness in Current Scientific Literature, *Education Sciences,* 11(8), 409, 2021
18. Paolini, A. Enhancing Teaching Effectiveness and Student Learning Outcomes, *The Journal of Effective Teaching*, Vol. 15, No.1, 20-33, 2015

****