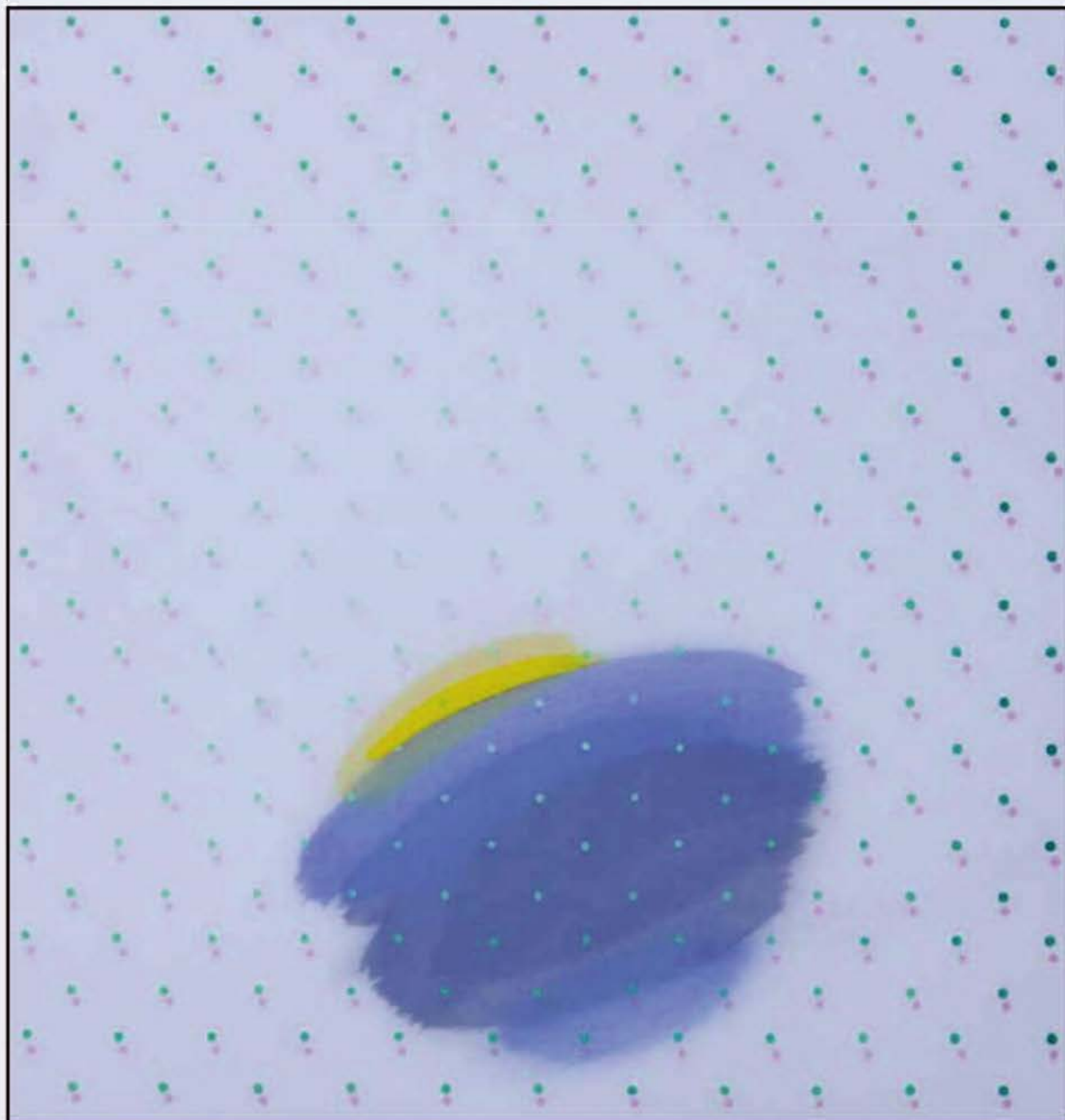


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# Changes in the teaching and learning caused of the COVID-19 pandemic

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## Abstract

Educational process, especially higher education was generally based on classical model of learning till 2020. This model includes table and presentations for teaching, and exams conducted in a classroom. This model was also used at “Goce Delcev” University of Shtip, Macedonia. Then, with rapid development of digital and IT tools for testing, e-testing in that classical model was introduced and included partly, only on some level of the educational process. Teaching was performed face to face in classrooms, but the way of testing was changed. Instead of classical exam on paper, students have an e-test on computer using Moodle 2 platform. The testing was performed in a classroom. Now, according to the situation with Coronavirus disease (COVID-19), all the process of teaching and testing are changed and switched to online performing using Microsoft team’s platform.

In this paper, in order to determine whether online learning affects students' knowledge, we will statistically analyze the results of the first and second partial exam for the subject Mathematics for the students from first academic year, where: the first exam was taken when the exams were performed in a classroom and the second one when the testing was online (via Microsoft Teams). Tested students were from Faculty of Natural and Technical science at University “Goce Delcev”– Stip.

## CCS Concepts

- *Education* • *Mathematics* • *Teaching methodology*

**Keywords:** *e-learning, e-teaching, COVID-19, exams, testing.*



## 1 Introduction

Education is a powerful agent of change, and improves health and livelihoods, contributes to social stability and drives long-term economic growth. Education is the main development tool in the social chain of each country. Without education, but also with poorly conceived and managed education, there will be no progress and development and also, no bright future for the country. Future and survival of each country greatly depends and relay on education. The better the education is conceived, implemented, and managed, the country development is higher and in the right direction. However, education is living matter, it needs to be changed. Is not something that is defined once, and that can last forever. It's a process that needs to be constantly changed and developed facing of time challenges, the size of human and technical resources in the country itself. Because no country is isolated from the other countries around it, its education should follow and adapt to the educational processes of the neighboring countries, the countries in the region, and globally in the world.

In 2020, the coronavirus COVID-19 outbreak disrupted all aspects of life around the globe. All Governments have followed a common goal of reducing the spread of coronavirus by implementing measures that limit social contact. As in any other sector, the COVID-19 pandemic affected education in many ways and the process of education in the whole world was dramatically changed. COVID-19 had a serious impact on students, teachers, professors, and educational organizations around the world. This pandemic caused schools, colleges, and universities in whole world to shut down their campuses. At the beginning it was thought that it would be short temporary situation and the teaching process was stopped. However, for short time many education institutions, switched from face-to-face to online teaching and quickly moved conventional education to distance and virtual learning. All countries in the world began to look for new ways to implement distance education. Fortunately, there is a huge range of modern tools available to face the challenge of distance learning imposed by the COVID-19 pandemic. Quick and sustainable changes for home learning was required. At the same time, the teaching and learning process had to be equally effective. However, online teaching is not simply adding audio to a PowerPoint presentation: it requires thorough training, adaptation of the content to the tool used, and multi-faceted investment, among other things [1-5].

This kind of sudden and disruptive shift from classical to remote education varied by size, governance models, and disciplinary differences. Computers and other mobile devices were the most used for this type of education and became an indispensable tool in the educational process. The digitalization of education had to happen quickly and immediately. There was no time to delay and test computer platforms remotely [2].

Schools around the world have begun to use different distance learning platforms depending on their rating of good and useful. Even before pandemic, technologies have changed the traditional way of education to the modern way of learning including technology-based learning through websites, learning portals, video conferencing, YouTube, mobile apps, and thousand types of free available websites for blended learning tools. However, the total shift to online mode has raised many queries on the quality of education and the entire education system in each country, during this pandemic was and still is global distance learning test [4].

Each subject, including mathematics, faced the same challenges. Many questions were asked without specific answers related to distance learning mathematics, especially about the success

of the realization of the teaching problems and the acquisition of knowledge by the students. This shift in practice has provided an opportunity to reconsider how technology use in mathematics education can be utilized to improve student engagement. Academics and students were forced to work from home using computers or mobile devices. Good thing was that computers were not a novelty in the learning process of mathematics and were used mostly for geometric visualization in the teaching process, as well as for numerical calculations [6].

Before the pandemic, digital technology use in mathematics classes mainly was generally considered as inconsistent in quality, quantity, and effectiveness (OECD 2016). Although there was some positive experience about digital technology as an educational imperative (Bower 2017), there were still many questions regarding how and when it should be used, and whether its use transformed and improved student experiences of mathematics education. The educational crisis caused by the pandemic resulted in educators being forced to fully rely on digital technology as the prime teaching and learning resource regardless of their existing technology-related beliefs and practices. This situation forced quickly change, which can be viewed as an opportunity for significant shifts to occur in how mathematics educators use technology in future face-to-face, online and blended classroom teaching [6-8].

Mathematical programs such as Mathematica and MatLab were and still are indispensable for learning and practicing mathematics [9-20]. But, also the pandemic COVID - 19 faced mathematics with new challenges that could not be compared to anything previously used [21], [22].

Mathematics had to adapt to new times and new distance learning platforms such as Microsoft Teams, Zoom, Skype... Previous concepts for learning and conducting teaching with all its specifics, especially the basic mathematical goal of solving tasks using a green board and chalk were no longer possible to use. Main advantages in the e-teaching and e-learning were saved time and money for traveling to work and back. One of the main disadvantages was the large access to materials, as well as the possibility of cheating on exams.

Although the adoption of distance learning is key to ensure the continuity of education following the physical closure of schools, students are, on average, likely to experience a learning loss during the lockdown.

Physical school closure and the adoption of distance education may negatively affect students' learning through four main reasons: less time spent in learning, stress symptoms, a change in the way students interact, and lack of learning motivation. However, the remote schooling is fundamental to ensure the continuity of learning in situations where in-person classes are suspended.

Very important task in the learning process is assessment or autonomous learning, that is challenging without the direct supervision of teachers. These tasks arise the questions how to ensure the assessment's adequacy to correctly measure students' progress; how can teachers compare students' results if they differ from previous years? On one hand, if students achieve higher scores than in previous years, this could be linked with cheating in online exams or with changes in the format of the evaluation tools. On the other hand, lower grades could also be caused by the evaluation format change or be attributable to autonomous learning as a less effective teaching method.

In order to determine whether online learning affects students' knowledge, we are making statistically analyze of the results from first and second partial exam for the subject Mathematics. This analysis covers first academic year students, from Faculty of Natural and Technical science at University “Goce Delcev”– Stip.

The tested students took the first exam in in a classroom and the second one when the testing was online (via Microsoft Teams).

## **2 The response of the West Balkan and Macedonian education systems in pandemic**

The influence of the COVID 19 pandemic to the education, mainly comes because of the closed schools and transition of the “normal” learning to the distance learning. The closing of the schools impacts to 91% of the students in the world, especially the students in poor families. Depending on the governance model, faculties and departments at some institutions have had their own approaches. Disciplines that require lab work, practical experience, and external collaboration were more difficult to teach remotely. Similarly, to the other countries in the world, the countries in the West Balkan including our country closed their primary and secondary schools at the beginning of the pandemic, the period 9-13 March 2020. In order to have continuity in the teaching and learning, while the schools are closed, all the countries include different ways for teaching and distance learning in emergency. These new steps and standards for distance learning covers series of mechanisms for teaching: TV and radio presentations, resources at some webpages, online classes etc. Most of the countries choose combination of methods. Most of the countries in the region used TV presentations and lessons and in order to offer more presentations must cut the time for presentation and the number of subjects in schools. The teachers weren't prepared to use the new platforms and to use the resources, successfully, [23]. The countries must make changes in the school calendars, to adapt the holiday days and to provide information technologies for the students. Despite the fast action across the region, school closures and less effective forms of distance learning will inevitably lead to learning losses and increase inequality. The transition to large-scale online learning is very difficult because it is very complex even in the best of circumstances. In a pandemic, the transition to distance learning in an emergency was suddenly done, [24].

Higher education institutions in the region were temporarily closed and more than 600,000 students were suddenly transferred classes online to ease campus closures. In general, the capacity of the education system at the tertiary level is much higher, just like access to technology and skills, as well as student autonomy. Hence, classes are held online. Universities in the Western Balkans to maintain teaching relies mainly on video conferencing tools like which are Zoom, Skype, Google Classroom, Microsoft Teams. Instructions and others have been prepared guidelines to help professors move online teaching.

Similarly, because of the pandemic Goce Delcev University starts with hybrid way of teaching and testing of its students. The transfer from teaching in the faculties to the distance teaching was done very fast. The IT skills of the teachers and students facilitate good realization of the teaching process. The university use Microsoft Teams as a platform for e-teaching and e-testing of the students. Also, from the beginning Goce Delcev university have provided electronic systems for facilitation of the students and teachers tasks and obligations. Most of the materials are in the electronic form at the e-library. The students have possibility to download for free and

have the materials in e-form. Also, the system of e-learning was developed many years before the pandemic. This system offers organization of all the subjects as the courses and the teachers organize all their lessons and exercises at it. The system of e-index offers to students' electronic realizations of all administrative obligations and needs. All these electronic systems help for easily overcoming of all the barriers in the pandemic.

In the teaching process, the teachers prepare presentations of their lectures and exercises. All the classes according to the schedule of the faculty were organized in Microsoft Teams. The students were informed all the time for all activities by their e-mails and Microsoft Teams. The classes in mathematics and other similar subjects which require exercises and laboratory exercises also were organized electronically. The teachers have used digital tables in order to provide adequate way for explanations of the exercises. Also, they used videos and many applications Mathematica, MatLab, etc. for better presentations of the material.

The process of assignments was realized through the e-learning system via e-tests, e-quizzes, and via oral presentations and answering of the given questions.

In the addition of this paper we have analyzed the results of the students who have been tested in normal way, before of the pandemic and by e-test in the pandemic period.

### 3 The data analysis

In the paper, we are analyzing the students' results in the subject Mathematics 2 from two partial exams. The first partial exam was performed before the pandemic of Covid 19, on classical way, while the second one was performed online via internet.

The statistics of the results is done in Microsoft Excel. From the descriptive statistical analysis and t-Test, we want to determine whether online teaching affects to the students' knowledge and results. The sample consists of 63 students from technical faculty at University "Goce Delcev" - Stip. The minimum point of the test is 0 and the maximum point is 20.

In descriptive statistics are given information about mean (mean represent the mean scores for the students of the partial exams), standard error of the mean, mode (mode is the most frequently occurring score), median (median is the middle score of a students' target group), standard deviation, sample variance, minimum and maximum obtained points, range (range is distance between the largest and the smallest obtained points from students), and count (the number of tested students from technical faculties).

The descriptive statistics for the standard exam (first partial exam) what was performed before the pandemic of Covid 19 (on classical way) is given in Table 1.

<b>Standard exam</b>	
Mean	4,476190476
Standard Error	0,616323915
Median	5
Mode	0
Standard Deviation	4,891919416

Sample Variance	23,93087558
Kurtosis	-0,161898643
Skewness	0,827799968
Range	17
Minimum	0
Maximum	17
Sum	282
Count	63

Table 1 Descriptive statistics for standard exam

The sample consists of 63 students from technical faculty. Each student can get minimum 0 points and maximum 20 points. The mean the obtained results is 4,48 from standard exam. These results are very bad considering that the maximum number of points is 20. We should also emphasize that 28 out of 63 students gained 0 points. That can be seen from the mode of the sample that is equal to 0 and from the value of median that is equal to 5.

The range between a maximum number of points and minimum number of points is 17. But only one student had good result (17 points). This means that there is a big difference between the gained knowledge of the students. Most of the students did not show any knowledge from the material, and only few students show great results.

The standard deviation is 4,89 and the sample variance as average square of the means is 23,93. From standard variance, we can conclude that standard deviation is low and that there is no big deviation from mean number of the obtained points.

Descriptive statistics for the online exam (second partial exam) that was performed online is given in Table 2.

<b>Online exam</b>	
Mean	3,253968254
Standard Error	0,487408402
Median	0
Mode	0
Standard Deviation	3,868684256
Sample Variance	14,96671787
Kurtosis	-0,522987486
Skewness	0,798626544
Range	13
Minimum	0
Maximum	13
Sum	205
Count	63

Table 2 Descriptive statistics for online exam

For online exam, the mean of value of the obtained points is 3,24. This result is worse than the mean result of standard exam (the mean is 4,48). In this case, even 32 out of 63 students gained 0 points. The mode and median in this case are 0.

The range between a maximum number of the obtained points and minimum number of points is 13. But only few students have good result (12 or 13 points). Again, the greatest number of the students showed very poor results. The standard deviation is 3,86 and the sample variance as average square of the mean is 14,96. The standard deviation is very low and that is good because there is no big deviation from the mean number of points. But the mean of the point is only 3.

In addition is given frequency distribution of the results. The frequency distribution displays the number of observations within a given interval. The interval size depends on the data being analyzed and the goals of the analyst, but the intervals must be mutually exclusive and exhaustive. Some of the graphs that can be used with frequency distributions are histograms, line charts, bar charts and pie charts. Frequency distributions are typically used within a statistical context. In our example the frequency distribution as the part of descriptive statistics will be present with table and histogram for the standard partial exam (partial exam 1) and for the online exam (partial exam 2), separately. The frequency distribution table for the standard exam of students from technical faculty is given on the Table 3.

<b>Points from Standard exam</b>	<b>Frequency</b>	<b>Percent</b>
from 0 to 5	33	52,38%
from 6 to 10	21	33,33%
from 11 to 15	6	9,52%
from 15 to 20	3	4,76%

Table 3 Frequency Distribution for standard exam

In Table 3 are given frequencies and the percent for intervals with length 5. (from 0 to 5 points, from 6 to 10 points, from 11 to 15 points and from 16 to 20 points). From this table is derived the histogram given with Figure 1.

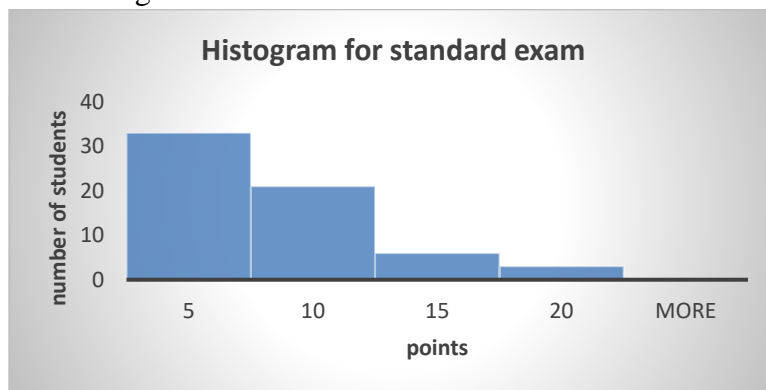


Figure. 1 Histogram for standard exam

The results from Table 3 and Figure 1 shows that the most students obtained the minimum point from 0 to 5 (33 students). 6 to 10 points obtained 21 points. Only, 6 students obtained from 11 to 15 points and 3 students from 16 to 20 points. And from frequency distribution, we can conclude that the result from the first partial exam of the students at technical faculty are very bad.

The frequency distribution table and histogram for the online exam of students from technical faculty are given in Table 4 and Figure 2.

Points for online exam	Frequency	Percent
from 0 to 5	42	66,67%
from 6 to 10	18	28,57%
from 11 to 15	3	4,76%
from 15 to 20	0	0%

Table 4 Frequency Distribution for online exam

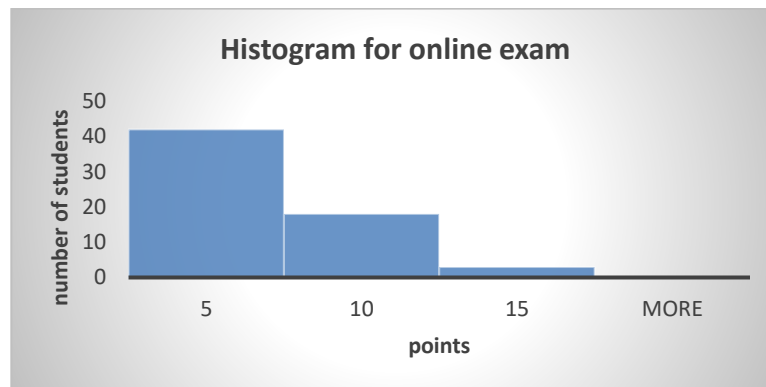


Figure. 2 Histogram for online exam

The results from Table 4 and Figure 2 show that the results from online exam are worse than result from standard exam. And here, the most students obtained the points from 0 to 5 (42 students). 18 students obtained from 6 to 10 points. Only, 3 students obtained from 11 to 15 point and there are no students who obtained from 16 to 20 points.

In order to determine if there is a difference between the average results in the normal test (first partial test) and electronic test (second partial exam), t-Test: Two-Sample Assuming Unequal Variances is performed, like a test that is one of the most widely used and the most widely known statistical test. The first partial exam was performed on classical way and the second partial exam was performed online. For that purpose, we set the following hypotheses:

1.  $H_0: \mu_0 = \mu_1$ 
  - Null hypothesis, there is no difference between the average number of points from standard partial exam and from online partial exam.
2.  $H_0: \mu_0 \neq \mu_1$ 
  - Alternative hypothesis, there is a difference between the average number of points from standard partial exam and from online partial exam.

We examine the stated hypothesis, t-Test. The obtained results are: - The value  $t = 1,980272249$  with 95% confidence interval. The significance level for the t-test is 0.05 and a degree of freedom is 118. Because  $t(118) = 0,1225 < 1,9802$ , we can accept the null hypothesis. This means that is not a significant difference between the average number of points from standard partial exam and from online partial exam.

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Variable 1</i>	<i>Variable 2</i>
Mean	4,476190476	3,253968254
Variance	23,93087558	14,96671787
Observations	63	63
Hypothesized Mean Difference	0	
Df	118	
t Stat	1,555460848	
P(T<=t) one-tail	0,0612572	
t Critical one-tail	1,657869522	
P(T<=t) two-tail	0,1225144	
t Critical two-tail	1,980272249	

Table 5 t-Test for number of points from standard partial exam and online partial exam.

#### 4 Conclusion

From the short research we have done for this paper, it can be concluded that the process of teaching and testing during the pandemic is changed very much. All the education process in the world on all levels: primary, secondary and tertiary has undergone major changes. The digital transformation of education systems in all levels has allowed incorporating a new way for performing teaching–learning system. Pandemic situation showed all the strengths and weaknesses of education systems facing the challenge of digitalization. However, the response of the universities also was appropriate to this situation. The use of the all-digital platforms and digital technology facilitates the education process.

The students' results for Mathematics have shown that the students have almost the same results on the test before pandemic using traditional methods comparing to online learning during pandemic.

In any way, COVID-19 pandemic has prompted innovation and institutional self-examination. The chance of large-scale, long-term changes in educational process is largely dependent on how institution treat pandemic. If they treat COVID-19 as a short-term crisis, then whatever is done to help extend learning when schools are closed will be only temporary. And after educational institutions are reopened, the status quo will be restored. However, the lesson should be learned from this situation is that more attention should be paid to the digitalization of the education system and digital technology and educational platforms must be more included in education in order to develop opportunities for distance learning.



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