# Analysis of student performances in online and face-to-face learning: A case study from a Bosnian public university

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**Abstract**
In the past three years, the COVID-19 became a global health issue and had huge impact on education. This study investigates and compares the student performances after transition from face-to-face learning environment to online learning environments as a result of the spread of the pandemic. Data is collected from a large Bosnian public university and analyzed using statistical tools. In this study student success is defined as passing the course. The results showed that there is significant difference in the performances of students, and it is dependent on learning environment. Particularly, students who attended online classes have significantly higher-grade point averages.

*Keywords*: COVID-19, Online learning, Face-to-Face learning, Student performances

## 1. Introduction

The COVID-19 pandemic has resulted in educational institutions closed all over the world. The way of learning is changed for every single student [1]. In total, approximately, 1.2 billion youthful individuals are out of the classroom. This resulted in the largest "online movement" within the history of education [2]. With this unexpected change a lot of people are wondering if the adoption of online teaching will continue to proceed post-pandemic and how such a move would affect the worldwide education and student success. Whether students perform superior with online or face-to-face classes [3]?

This way of thinking leads to a need for investigation to get the right answers. There have been a few researches regarding this topic, among which the most famous one is at Oxford University [4]. It is discovered that half of the people accept that this spontaneous and fast move to online learning – with no preparing, will result in a bad experience followed by declining student averages and passing rates [5]. Others believe that an unused and new model of education will have significant benefits and improve student success. Most important observers here, students, are usually more for online classes because they support self-regulated learning [6]. Therefore, this is good time to seriously think, analyze, measure, and explore more in this area [7]. All information collected for the purpose of it are grouped together and estimated with the ANOVA procedure, to test all the concerns and derive an appropriate conclusion [8].

There are multiple factors that affect the student success and the nature of the classes itself. American University discovered during their research that there are some courses that are more appropriated to be conducted online in comparison with some other courses that are hard to figure out in online way of learning. Student success is depended on that [9]. The emotions of each student are another factor for success because students are more frustrated with in-class lessons and more relaxed and have less anxiety with online lectures [10]. Student confidence itself is important in studying for exams as well as for their success in each environment.

In this way, we can see that personal factors must be included in determining difference between learning environment [11]. However, there is a certain number of students that prefer these two environments mixed, which is called "blended" way of learning and believe it is the best solution to the current situation [12].

Young people in general like online classes more and have better success there and it is not only related to undergraduates. In "Journal of Higher Education" it is published that Master student also perform better with online exams [13]. This brings us to the social media influence and whether they are connected to the success in exam [14]. Not only that, but a psychological state and history of a student can be an important factor in learning. This was discovered during comparative study case in China [15]. The major problem discovered for online way of learning is that the teachers where not present enough as they would be in face-to-face classes. This resulted in students educating and investigating by themselves which brings us to the case where they are not ready for the exam because of lack of materials [16].

Some students choose their learning environment based on the cost. It is much cheaper to study online and that is motivation enough to make afford and pass the exam [17]. Same opinions have students with disabilities. It is stated in America Journal that they feel better under the camera and more similar to their colleagues, so the motivation is much more presented and result in better success [18].

The most interesting results were obtained in one of the largest studies related to this topic and published in "Institute of Educational Sciences" which implies that there is no difference at all in learning environment [19]. However, when it comes to skill-based course, much better success in measured for in-class courses which is very logical and expected because nobody can get certain skills online [20]. The similar is derived from the study case at "Advances at social work" where student success were the same in every way of learning [21]. Skills are very hard to learn online especially when it comes to the medicine field of science. In that case, online teaching can be only an addition to face-to-face [22].

To understand student success, we need to monitor student behavior in each environment. According to this factor no significant differences are found in "Harbin Institute of Technology" as well [23]. Online learning was analyzed from the time in history when it started and now. It is clearly stated that today's technology is so advanced that student do not see any difference in learning methodology [24].

The purpose of this research paper it to investigate the students' performance with the classes offered online and face-to-face. The paper uses quantitative approach to study accomplishment of students within a different environment. The goal is to create a holistic picture of ongoing online vs. in class activities, compare student results and if possible, establish the link between them. The main method used for this purpose is ANOVA statistical test. The result of this investigation will give the correct answer to the asked question "Does student perform better in online or in-class learning?". To answer this question, the following Hypothesis is going to be tested:

$H_1$: There is significant difference in grade point averages between students from the online and face-to-face learning environment.

## 2.    Research method

Before diving into methods used to conduct the student performance study, it is important to introduce the type and source of the data used. For this purpose, data is taken from a public university in Bosnia and analyzed using statistical tool MiniTab with a help of Excel solver. Investigation is done for two courses that were conducted two semesters completely online and three semesters completely face-to-face. Source of each data is the same university. Data is collected by conducting university management system who provided list of all students from last five semesters starting from Fall 2020, that were taking the two similar courses with final score in the exams and success for each one with passing/failing in the end.

Personal information was not collected because of privacy policy. Students are listed by ordinal numbers and each number is representing one student (first column). All five tables contain the same attributes. Second column is for final score with the range from 0 - 100 points where 55 points is minimum for passing the course. Last column just indicates if the student failed or passed the course.

In this study student success is defined as passing the course. Comparisons between learning environments on outcomes (tests, final exam = final score) were made using ANOVA [25], with learning environment as the factor, with two levels (online and in class). This is the main method used for the research as stated above, with

mean and standard deviation comparison. T-test is used for comparison of variances to investigate if some group differs significantly from others.

Calculated $F_0$ value is compared with corresponding value from standard critical value table ($F_{cr}$) at significance level of $\alpha = 0.05$ and appropriate degree of freedom. Two cases where investigated: If $F_0 > F_{cr}$ (or *p-value* < $\alpha$ ), there is no significant difference between the five groups, and we can reject hypothesis. If $F_0 < F_{cr}$ (or *p-value* > $\alpha$), there is significant difference between the five groups, and we can accept hypothesis.

For the mean value of measurement in this research the following formula is used:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{1}$$

where $\bar{X}$ is mean value (average) of our dataset and n is number of sample data (measurements).

Standard deviation is obtained with the following formula:

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{(n-1)}} \tag{2}$$

where $S$ is standard deviation, n is number of sample data and $\bar{X}$ is mean value [26].

Total sum of squares is calculated as:

$$SS_T = SS_{Gr} + SS_e \tag{3}$$

where $SS_{Gr}$ is sum of squares of learning environments and $SS_e$ is error sum of squares.

The three sums of squares from above are determined using the following formulas:

$$SS_T = \sum_{i=1}^{\alpha} \sum_{j=1}^{n} (y_{ij} - \bar{y})^2 \tag{4}$$

$$SS_{Gr} = n \sum_{i=1}^{\alpha} (\bar{y}_i - \bar{y})^2 \tag{5}$$

$$SS_E = \sum_{i=1}^{\alpha} \sum_{j=1}^{n} (y_{ij} - \bar{y}_i)^2 \tag{6}$$

Observed value of $F_0$-test was determined as the ratio between mean sum of squares of learning environments ($MS_{Gr}$) and mean sum of squares of error ($MS_E$):

$$F_0 = \frac{\frac{SS_{Gr}}{\alpha-1}}{\frac{SS_E}{\alpha(n-1)}} = \frac{MS_{Gr}}{MS_E} \tag{7}$$

where, $(\alpha - 1)$ represents degrees of freedom of the numerator (between the groups) and $\alpha(n – 1)$ represents the degrees of freedom of the denominators (error) [26].

To determine which of the semesters from the group differs significantly, *t*-test is used with case upper significance level corrected using the following *Bonferroni* correction:

$$\alpha_{cor} = \frac{\alpha}{m} \tag{8}$$

where *m* is number of comparisons and significant difference was identified for each *p*-value $\leq \alpha_{cor}$. The difference between five learning environments is analyzed with T-test with the following formula:

$$t_0 = \frac{\bar{X}_1 - \bar{X}_2 - \Delta_0}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \tag{9}$$

The following cases are investigated: if *p*-value $< \alpha_{cor}$, there is no significant differences between the learning environments. If p-value $> \alpha_{cor}$, there is significant difference between the learning environments. These tests were performed using Excel solver.

## 3. Results and discussion

Performance of the five groups of learning environments were tested using ANOVA at 95% confidence interval in Excel solver. Mean, standard deviation and standard error are calculated for every group – semester separately, so that they can be compared later. Number of records in each table is different, but it did not represent any problem during the calculation process. After that, ANOVA is applied by using the equations from above. The summary of ANOVA results is displayed in Table 1.

Table 1. ANOVA results

| | Source | Degrees of Freedom | Sum of Squares | Mean Square | $F_0$ | $p$-value |
|---|---|---|---|---|---|---|
| **Student Success** | Between Groups | 4 | 19306.5374 | 4826.6343 | 10.135 | 0. 00001* |
| | Within Groups | 247 | 117629.3604 | 476.2322 | | |
| | **Total** | 251 | 136935.8977 | | | |
| * significant at $p < 0.05$ | | | | | | |

From Table 1 it is observed that there is significant difference in student success among the groups of the learning environments. The $p$-value is 0.00001 which is significant at $p < 0.05$.

Still, it is not clear which group differs significantly in comparison to others. The following step is to separate each group and calculate its $p$-value. Then, those values are compared with each other in order to discover which group differs the most.

To determine that, post-hoc $t$-test is used with correction $\alpha_{cor} = \frac{\alpha}{m} = \frac{0.05}{5} = 0.01$. The result of this analysis is displayed in Table 2.

Table 2. Comparative $t$-test results

| Compared group | Other groups | Mean Difference | $p(T \leq t)$ one-tail | $p(T \leq t)$ two-tail |
|---|---|---|---|---|
| **Group 1** Semester Fall 2018. FACE-TO-FACE | Group 2 | 3.5598 | 0.2677 | 0.5355 |
| | Group 3 | -6.7081 | 0.0562 | 0.1124 |
| | Group 4 | -17.7383 | 0.00007* | 0.00001* |
| | Group 5 | -19.311 | 0.00002* | 0.00004* |
| **Group 2** Semester Spring 2019. FACE-TO-FACE | Group 1 | -3.5598 | 0.2677 | 0.5355 |
| | Group 3 | -10.2679 | 0.0147 | 0.0294 |
| | Group 4 | -21.2981 | 0.00002* | 0.00004* |
| | Group 5 | -22.8708 | 0.00001* | 0.00002* |
| **Group 3** Semester Fall 2019. FACE-TO-FACE | Group 1 | 6.7081 | 0.0562 | 0.1124 |
| | Group 2 | 10.2679 | 0.0147 | 0.0294 |
| | Group 4 | -11.0284 | 0.0015* | 0.0030* |
| | Group 5 | -12.6029 | 0.00004* | 0.00009* |
| **Group 4** Semester Spring 2020. ONLINE | Group 1 | 17.7383 | 0.00007* | 0.00001* |
| | Group 2 | 21.2981 | 0.00002* | 0.00004* |
| | Group 3 | 11.0284 | 0.0015* | 0.0030* |
| | Group 5 | -1.5727 | 0.3467 | 0.6938 |
| **Group 5** Semester Fall 2020. ONLINE | Group 1 | 19.311 | 0.00002* | 0.00004* |
| | Group 2 | 22.8708 | 0.00001* | 0.00002* |
| | Group 3 | 12.6029 | 0.00004* | 0.00009* |
| | Group 4 | 1.5727 | 0.3467 | 0.6938 |
| **\* significant at $p < 0.01$** | | | | |

The result of the investigation shows us that Group 4 and Group 5 which are online learning environments are differing significantly from Group 1, 2 and 3, which are face-to-face environments. The $p$-value is compared and calculated for both: one-tail and two-tail test. The same results are obtained for the each one of them. In every group, there is at least one value that is significantly different than others. For the groups with the face-to-face learning environments, that value is for Groups 1-3, and for the online learning environment that value is for Group 4 and 5.

There was only one measurement of the student success and that is final score and passing the course. Passing rate was much higher in online classes. There is not any other variation between groups with same learning environment. That is very interesting. It means that even though professors, study program or materials might be slightly different in each semester (year), the students will perform similarly - if the learning environment is the same.

Therefore, there is significant difference between the way of learning and taking exams. The initial assumption is correct and proved above therefore, the hypothesis can be accepted. To better understand data, there is graphically representation of groups of the numerical data through the quartiles. Figure 1. shows the data samples by using boxplot.
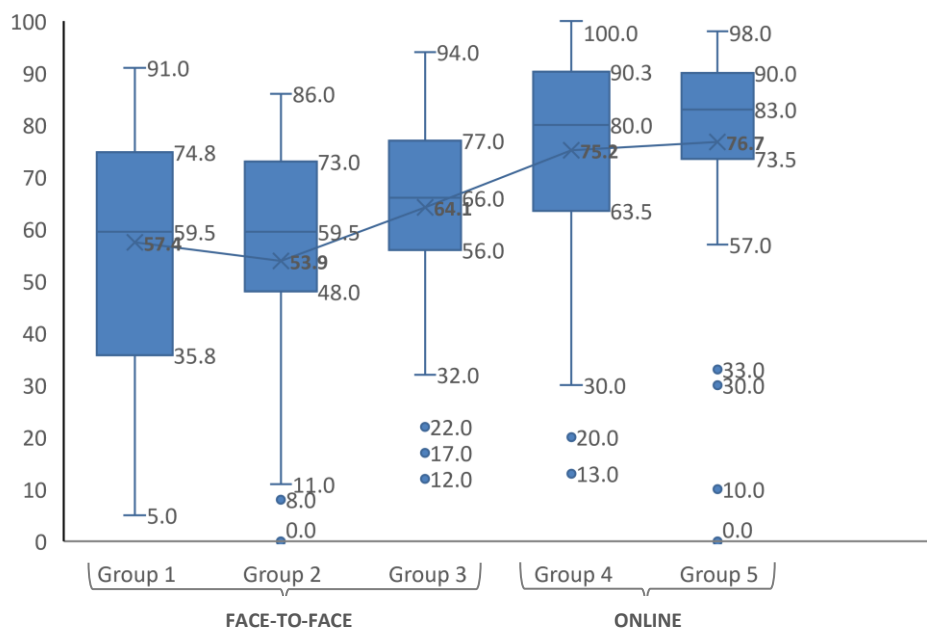


Figure 1. Distribution of score points for each group

The sample size used to create the boxplot varies among Groups. Each group has a separate box plot. In Figure 1. we can see that median is 59.5 for a Group 1, and minimum and maximum values are 5 and 91. First quartile is 35.8, third quartile is 74.8. Values of other groups can be distinguished in the same way. We have some outliers for the Group 1 as well as for all other groups. From the figure, we can notice that median values of Groups 4 and 5 that correspond to online learning lies outside of the boxes from other three groups which represent face-to-face classes. Because of it, there is likely to be a difference between those two cases which is exactly what the calculation confirmed.

Table 1. Key result comparisons with similar studies

| Case study, Country | Results | Reference |
|---|---|---|
| A large university, US (*140,444 students enrolled in 6,012 courses over a period of ten academic terms*) | No significant difference in grade-based student performance between an online learning compared to a face-to-face learning. | [19] |
| Fort Valley State University (FVSU), US (*548 FVSU students who completed the same class over 7 years*) | No significant difference in student performance between online and face-to-face learning with respect to gender and class rank. | [5] |
| Students form 29 Austrian universities, Austria | Students prefer face-to-face learning if conceptual knowledge in the subject matter or skills are to be acquired. Students prefer online learning if skills in self-regulated learning are to be acquired. | [7] |

| Case study, Country | Results | Reference |
|---|---|---|
| Students from James Madison University (JMU), US | Students with more proficient reading and writing skills will perform better in online classes. | [9] |
| Master's-level students from an US university, US | A significant difference was observed between final exam score. Face-to-face students achieved a significantly higher score than the online students. | [13] |
| Students from a large public university, US | Face-to-face students earned a significantly higher outcomes than online students even when using the same technology. | [20] |
| Master's-level students from a large public university, US | No significant difference in student performance between online and face-to-face learning. | [21] |
| Undergraduate students from a large public university in Bosnia, Bosnia | Student success depends on the learning environment. Significantly higher points earned in an online learning environment. | This study |

Based on the table above, the results of similar studies differ depending on the area, course level, perception, and type of the study. Results are mixed, several studies proved that there is no significant difference between learning environments which would indicate that the score outcome depends on how hard the students actually work. The study conducted in James Madison University is the only one that got the same results as the study described in this paper. The rest concluded that students are better in face-to-face classes. However, the reason behind it could be that the period for which the students are observed is one semester at most or just one exam. This is not a long enough observation to be able to derive proper global conclusion. In this paper, five semesters and different setup and type of students were investigated. Another difference is that not all studies were conducted at the global pandemic time. This means that those from the past had different factors and conditions than students during COVID-19. In the end, all the studies are similar because of the one fact, they all compared student success based on the two environments and none of those included a blended exam or lectures approach.

## 4. Conclusions

This study investigated student performances in an online learning vs. face-to-face learning environment. The results showed that there is a significant difference between classes conducted online and face-to-face. Five semesters were compared, two of them online and three face-to-face. Although in both learning environments students were mostly passing the course, there was a significant difference in score points in the end. Significantly higher score points obtained students from online environment. Based on these findings, it can be concluded that the student success in this case is dependent on the learning environment. To understand what is exactly causing these environmental differences, a further analysis has to be done with more influencing factors taken into consideration.

**Declaration of competing interest**

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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