



Comparison of online and face-to-face exams conducted in Physics I course in higher education

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Abstract

The coronavirus pandemic has affected most fields, including education, and most lessons have had to be conducted as distance education. In this study, it is aimed to compare student success in face-to-face exams with that in distance exams in the Physics I course. The sample consisted of 167 students who took a multiple-choice exam in distance education in the 2020-2021 academic year and 155 students who took the multiple-choice exam in face-to-face education in the 2019-2020 academic year. In the first phase of the study, the questions asked in both types of exams were classified according to Bloom's taxonomy, and then descriptive and comparative statistics were used. As a result, according to Bloom's taxonomy, the majority of the questions asked were at the application level. In the statistical analysis, it was determined that the averages of both groups were close to 45 out of 100, and there was no significant difference between the group averages as a result of the t-test. Accordingly, it has been concluded that the use of online exams during the pandemic as an alternative to face-to-face exams in normal processes will not make a significant difference.

1. Introduction

Today's society faces different innovations in the field of technology with each passing day. These innovations are placed in every area of our lives and have become an irreplaceable part of them. Educational activities gain new and different perspectives as technology advances, and courses are delivered via the internet [1]. Especially recently, a pandemic all over the world has supported these developments, and the transition has been made rapidly from face-to-face training to online training in all areas. As a result, internet-based learning and teaching activities have almost entirely replaced face-to-face educational activities, not only in schools but also in all other sectors.

Due to the COVID-19 pandemic in our country, universities did not carry out face-to-face training for a long time and instead carried all their courses on the internet. When the applications carried out in this regard were examined, it was announced that the universities were suspended for 3 weeks on March 16, 2020, and then on March 23, 2020, they were asked to start distance

education according to their capacities [2]. As a result, universities sought serious infrastructure, and the courses began to continue their educational activities for a long time as synchronous or asynchronous.

As a result, some faculty members started the distance education process unprepared and inexperienced [2]. Course materials were inadequate, and this affected the activities to be carried out negatively [3]. Especially in quantitative courses such as mathematics and physics, students mentioned the problem of communication, as well as the fact that the course contents were not fully reflected in these areas and the documents were inadequate [4-5].

Due to the COVID-19 pandemic, all educational institutions have made some innovations in their assessment and evaluation activities, with radical changes in their online educational activities due to the COVID-19 pandemic. In this regard, each institution has sought solutions to the assessment and evaluation within its own means. While education was carried out online in primary and secondary education institutions, it was

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decided to conduct the exams face-to-face in these institutions during certain periods. However, all assessment and evaluation activities have been moved to online environments except for certain application-based areas in universities. As a result, the instructors used different types of exams, such as multiple choice, short answer, project, portfolio, educational games, etc. in online exams [6]. Two important factors to be considered in the conduct of such exams are to take care of validity and reliability just as attention is paid to face-to-face exams [7]. Cheating is one of the most important factors that are thought to affect reliability in the studies to be carried out here [4]. In addition, asking different questions can be another topic of discussion. However, asking questions that measure similar aspects of learning in online and face-to-face exams may seem like a solution to prevent this.

Various methods have been tried in order to carry out a consistent teaching activity in education. However, dividing the objectives and measurement tools into certain categories and planning the teaching according to these categories has been one of the most accepted approaches [8]. In this way, certain levels were created by ensuring standardization in education, and it was ensured that each student was evaluated equally at these learning levels. Although different approaches are used for this purpose, the most popular application is the taxonomy developed by Bloom [9]. With the help of this taxonomy, a standardization has been established in both teaching and measurement tools. In this way, it is aimed at making sure that each and every one of the students studying in different schools and classes learns and is evaluated equally. With Bloom's taxonomy, the knowledge and skill level of the attainment determined for the students is clarified and associated with a systematic [10]. As a result, the same behavior can be measured to an equal level by using different question types in assessment and evaluation.

Concern about cheating in distance education exams and the idea that undeserved grades may be taken have been cited as the most important reasons for the formation of anxiety in students [5]. Comparing the success of face-to-face exams in real environments with the success scores obtained from online exams, on the other hand, may provide an idea of the specific opinions to be given in this regard. In the literature examined in this regard, it was seen that there are mostly studies aimed at developing online exams and the focus is on the problems carried out in online courses. For this reason, it is necessary to examine student success by comparing face-to-face exams with online exams. Therefore, the main purpose of the study is to conduct a comparison of the end-of-term exams of the Physics I course conducted face-to-face and online in terms of success. The sub-problems of working in this direction are:

1. What is the classification of the questions asked in the face-to-face paper-pen and online end-of-term exams according to Bloom taxonomy in the Physics I course?

2. Is there a statistically significant difference in the end-of-term exam results of Physics I courses between face-to-face pen and paper exams and online exams?

2. Method

2.1. Research Design

Comparative research is used to examine the relationship between at least two variables and the situations that occur between them [11]. In such studies, two different events can be involved, and comparisons can be made between these events. In the current study, the end-of-term grades of the students who took the Faculty of Engineering and Natural Sciences Physics I course between the 2019-2020 and 2020-2021 academic years were compared. In this respect, the study is a comparative research study.

2.2. Sample

The sample of this study consists of students who took the Physics I course at Gümüşhane University, Faculty of Engineering and Natural Sciences, in the fall semesters of the 2019-2020 and 2020-2021 academic years. The study is based on a comparison of these two groups. One of these groups consisted of 155 students who took this course face-to-face and participated in the Physics I end-of-term exam in the fall semester of the 2019-2020 academic year. The exam for this group was administered as a paper and pencil test. The other group consisted of 167 students who took the course online and also participated in the end-of-term exam conducted online in the fall semester of the 2020-2021 academic year. In both years, the students taking the Physics I course were from various departments. These departments were civil engineering, geomatics engineering, genetics and bioengineering, food engineering, electrical and electronics engineering, and mechanical engineering. The total sample of the study consists of 322 people. Both exams were conducted as multiple choice.

2.3. Data Collection

Within the scope of the courses given in two different periods, it was carried out by two different faculty members over the same curriculum, achievements, and textbook. The questions prepared in both terms were created separately by the instructors of the courses, but care was taken to ensure that the gains, number of content items, and quality were the same. To show that online exams are replaceable with face-to-face exams, they have to be equivalent in most respects. One of them is the level of knowledge they are assessing. Bloom's Taxonomy shows us a standardized method for defining the level of cognitive achievement. Here, different tests are applied to different students, but the number of items, their quality, and the competencies they measure are similar to each other [11]. In both exams, one held at the end of the semester in the 2019-2020 and the other held in the 2020-2021 academic years, tests consisting of 20 multiple-choice questions were administered to the students. Five choices were included in both test questions. In the face-to-face exam, students from different departments were gathered in the same lecture hall, and the exam was conducted in one session with the

same question order for all. For the online exams, an exam hour was determined, and all students were asked to take the Physics I exam at this time via the online system. In the online exam, 20 questions and 5 options per question were both mixed and presented to the students, and so the question-and-answer options order was different for each student. Unlike in the face-to-face

exam, in the online exam, after completing a question, it was not possible to return and change your answer to the same question again. In Table 1, one can see examples for all three stages of Bloom’s taxonomy: comprehension, application, and analysis stages, from both exams.

Table 1. Examples of Bloom's taxonomy stages for both exams

Face To Face Exam	Online Exam
Comprehension Level	
Which of the following is not a vectoral quantity? a) Velocity b) Acceleration c) Force d) Displacement e) Kinetic energy	Which of the following is a scalar quantity? a) Angular acceleration b) Velocity c) Potential energy d) torque e) displacement
Application Level	
If $A=2i+3j-4k$, $B= i+j+7k$, where A and B are vectors, find the angle between vectors A and B. a) 126.7 b) 136.7 c) 146.7 d) 156.7 e)166.7	The vectors $A=i+2j-3k$ and $B=4i-5j-6k$ are given. Find the sine of the angle resulting from the cross product of $A \times B$. a) 69 b) 85 c) 60 d) 50 e) 21
Analysis Level	
Which variable or variables affect the acceleration of an object due to the change in the direction of its velocity? a) Velocity and radius b) Mass and force c) Gravitational acceleration and angular velocity d) Linear velocity and mass e) Linear acceleration and displacement	Which of the following is among the variables that affect angular acceleration? a) travel distance and linear velocity b) radius and angular velocity c) Linear velocity and mass d) Kinetic energy and mass e) Mass and force

In the study, a second researcher was asked to classify both online and face-to-face exams according to Bloom's taxonomy. Huberman and Miles [12] proposed the formula $[\text{Agreement} / (\text{Agreement} + \text{Disagreement}) \times 100]$ to compare the secondary data obtained with the original data. As a result of this calculation, the agreement of the coders was determined as 82%. Since 70% or more of this value is accepted as a perfect fit in

the calculations, it has been concluded that the coding is reliable.

In addition, the exam questions asked of both groups were analyzed on a subject-by-subject basis, and care was taken to ensure that they were close to each other. Table 2 below shows the distribution of topics for these exams.

Table 2. The distribution of the numbers of questions in online and face-to-face exams by subject

Subject	Face-to-face	Online
Physics and measurement	2	2
Vectors	1	1
One-dimensional movement	2	2
movement in two dimensions	2	2
Newton's laws of motion	2	2
Work and energy	2	2
Potential energy and conservation of energy	2	2
Linear momentum and collisions	2	2
Rotation of rigid bodies about a fixed axis	3	3
Rolling motion, angular momentum, and torque	3	3

2.4 Data Analysis

The data obtained from the study was analyzed in two stages. First, the questions in both exams were examined in terms of content. For this purpose, the questions were analyzed, taking into account the Bloom taxonomy. In this analysis, the questions were examined in accordance with the taxonomy, taking into account their contents, and notes were taken to the edge of each one. Then, within the specified grades, questions for both exam types were transferred to the tables. Finally, with the help of the tables created, the data was converted to writing and the necessary results were created.

In the study, only total scores were taken into account when examining quantitative data, and each question was examined separately. The data obtained was first graphed, and histograms of both face-to-face and online exams were presented separately. In the analysis of quantitative data, both descriptive statistics and comparative statistics were used among statistical techniques, and the results obtained were compared with each other. The general mean, median, standard deviation, and variance, skewness, and kurtosis values were found in the descriptive statistics, while the t-test analysis values were obtained for Levene and independent samples for comparative statistics. These

operations have been confirmed by calculating with SPSS.

If the test of the equality of variances is significant, Welch's t-test should be used instead of Student's t-test because the assumption of equal variances is violated. Since Welch's t-test has practically the same power as Student's t-test [13]. SPSS provides Welch's t-test statistics in the second row of the t-test statistics with the title "equal variances not assumed" section.

Finally, both test results were interpreted for the sample, and the data was displayed.

3. Results

Depending on the data obtained, the findings are presented in two sub-categories. In the first stage, the

questions were examined in terms of content and presented by classifying them according to Bloom's taxonomy. In the second stage, quantitative data was examined and the findings from this part were included.

3.1. Findings on the classification of questions according to Bloom's Taxonomy

In this section, the data from the test, consisting of 20 questions for each group, totaling 40 questions, asked in the Physics I course in the 2019-2020 and 2020-2021 academic fall semesters are presented by grouping them according to Bloom's taxonomy.

Table 3. Classification of questions asked in different years according to Bloom's taxonomy

	Comprehension	Application	Analysis
Face-to-Face Exam	5	14	1
Online Exam	3	16	1

When Table 3 is examined, it is seen that the most frequently asked question level in both years was the "apply" step. While the application-level questions are 14 questions in the 2019-2020 academic year, there are 16 questions in the 2020-2021 academic year. In both years, only 1 question was asked at the analysis level. At the comprehension level, while 5 questions were asked in the 2019-2020 academic year, 3 questions were asked in the 2020-2021 academic year. As seen in Table 3, the distribution of the questions belonging to both years according to cognitive learning levels is not very different from each other.

3.2. Findings from the data obtained from the exam gradings

Descriptive statistical techniques were used in the analysis of quantitative data. The sample sizes of the two groups to be compared are quite close to each other (n=155 and n=167). The comparison of some descriptive statistics of these students can be seen in Table 4.

Table 4. The results of the Physics I course's descriptive statistics

	Online	Face to face
n	167	155
Avg	45.96	44.13
S. Dev	14.28	25.37
Variance	203.90	643.88
min	0	0
max	85	100
Kurtosis	0.66	-0.42
Skewness	0.17	-0.22
mode	45	50
median	45	50
Quartile1	40	30
Quartile2	45	50
Quartile3	50	60

Looking at Table 4, it can be seen that the numbers of members of the groups are quite close. The end-of-term exam averages of both groups are very close to each other. Whether this difference was statistically

significant or not was re-evaluated with the t-test in the next section.

A remarkable situation is the difference between the standard deviation, variance, kurtosis, and skewness of

the groups. The standard deviation of the online exam is about 14.3, while the standard deviation of the face-to-face exam is about 25.4. In light of these findings, it can be said that the distribution of students who participated in the face-to-face exam is more heterogeneous. The same situation can be observed when the variance of the online end-of-term exam, which is about 204, is compared with the variance of the face-to-face exam, which is about 644.

The kurtosis of the online exam was 0.66, and the kurtosis of the paper-pencil exam was -0.42. The online

exam is sharper, and the face-to-face exam is quite flat. Since one of these two values is positive and the other is negative, the difference is quite obvious. When the quartiles are examined, it is understood that the paper-pencil exam has a wider distribution.

Histogram graphs of students who participated in both face-to-face and online exams were examined separately. Figure 1-a shows the data of the students who participated in the face-to-face exams, and Figure 1-b shows the students who participated in the online exams.

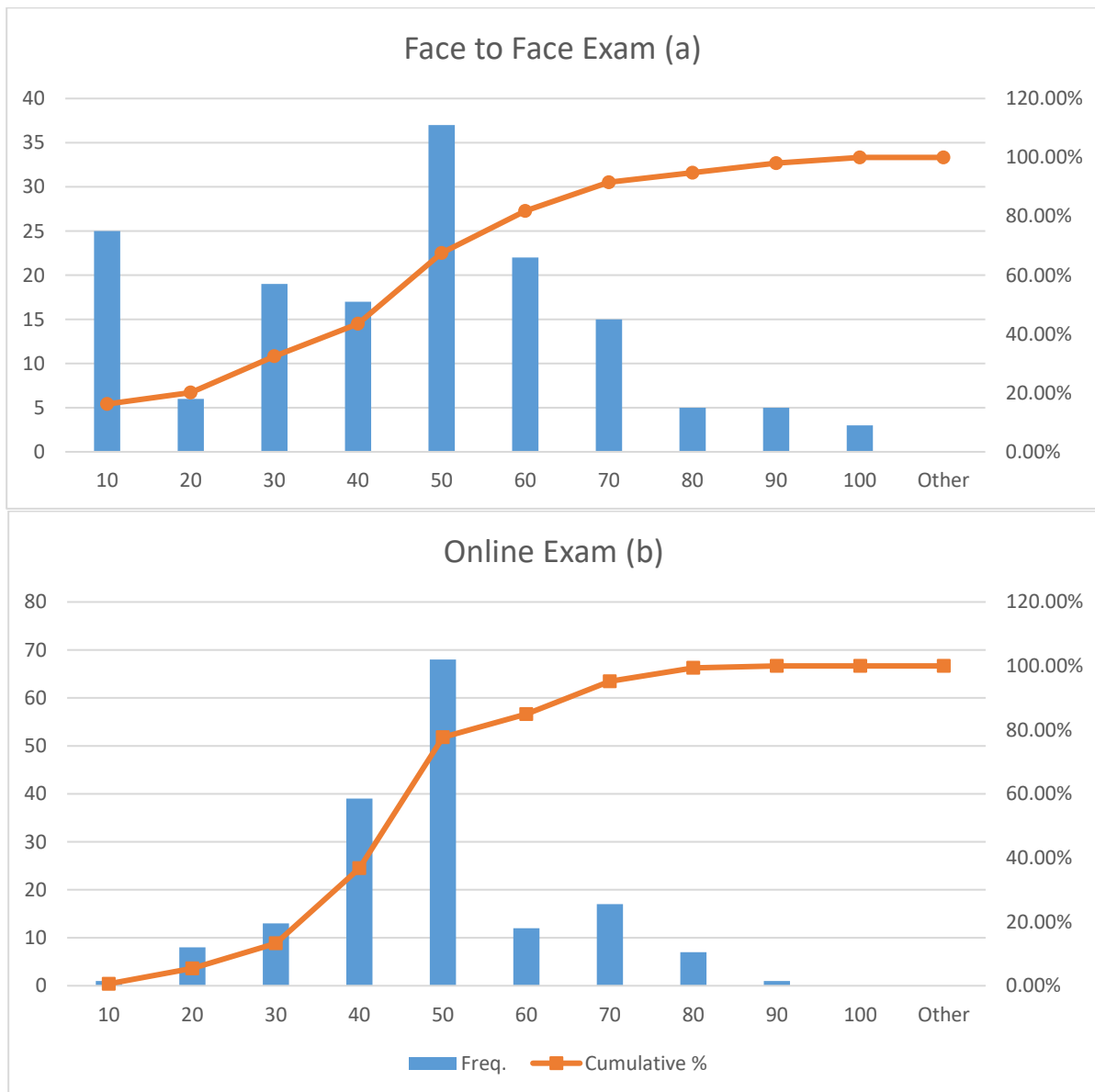


Figure 1. Face-to-face and online exam histogram

Figure 1-a shows histograms and the cumulative percentage curve for face-to-face exams. As can be seen in Figure 1-a, below 30 and over 70, the curve has a slightly less steep slope. From the histogram, it can be observed that the highest frequency of the scores is on scores 10 and 50.

Figure 1-b shows histograms and a cumulative percentage curve for online exam results. As can be seen in Figure 1-b, below 30 and over 70, the curve has a slightly less steep slope. From the histogram, it can be observed that the highest frequencies for the scores are

on scores 40 and 50, while all other scores have relatively lower frequencies.

When the skewness values in Fig. 3-a and Fig. 3-b are examined, it can be said that there is a separation in terms of this parameter since the skewness of the online exam is about 0.17 and the skewness of the paper-pencil exam is -0.22, although not as much as kurtosis. The online exam is more skewed to the right than the paper-and-pencil exam is more skewed to the left. Although the difference is not huge, it is still striking.

Table 5. Data for cumulative frequencies for online and face-to-face exams

Score	Face-to-face Exam		Online Exam	
	Freq.	Cumulative %	Freq.	Cumulative %
10	25	16.23%	1	0.60%
20	6	20.13%	8	5.42%
30	19	32.47%	13	13.25%
40	17	43.51%	39	36.75%
50	37	67.53%	68	77.71%
60	22	81.82%	12	84.94%
70	15	91.56%	17	95.18%
80	5	94.81%	7	99.40%
90	5	98.05%	1	100.00%
100	3	100.00%	0	100.00%
Other	0	100.00%	0	100.00%

Table 5 represents the data for the cumulative frequencies and percentages for face-to-face exam results and for online exam results. As seen in Table 5, the scores vary between 10 and 100. There are quite a lot of students with a score of under 10 on the face-to-face exam. Other than that, the majority of the scores on the face-to-face exam are between 30 and 70.

In Table 5, it is observable that the scores for online exams vary between 10 and 90. The distribution seems quite normal at first glance. Other than that, the majority of the scores are between 30 and 70.

When Table 6 is examined, it is seen that the the average of the online group is about 46, and the average of the face-to-face exam is about 44. The standard

deviation of the online group is approximately 14.28, while the standard deviation of the face-to-face exam is approximately 25.37. The mean of the online group's standard error is about 1.1, and the face-to-face exam is about 2.0.

Table 6. Distribution of end-of-term grades by groups

Group	N	Avg	S. Dev	Std. Err. Mean
Online	167	45.96	14.28	1.10
Face-to-Face	155	44.13	25.37	2.04

Table 7. Comparative statistical results of the Physics I course end-of-term exam

	F	Sig	t	df	Sig.	Mean Diff.	Std. Diff.	Err.	Lower	Upper
Equal variances assumed	48.96	.000	.80	320	.42	1.83	2.27	-2.64	6.30	
Equal variances are not assumed			.79	238.70	.43	1.83	2.32	-2.74	6.40	

When the Levene test results are examined in Table 7, it is seen that the F value is approximately 49 and the significance is zero. According to these results, it can be said that the variances and homogeneity of the two groups are different. At the beginning of the findings section, this difference, kurtosis, skewness, etc., was also demonstrated in terms of other parameters.

When the results of the independent samples t-test are examined, it is seen that the t value is approximately 0.79. However, the significance (bipolar) was 0.43, which shows us that there is no statistically significant difference between the end-of-term exam grades of the two groups. Other data for the t-test can be examined from Table 7.

4. Discussion and Conclusion

Bloom's taxonomy consists of six steps: knowledge, comprehension, application, analysis, synthesis, and evaluation [14-17]. However, considering only three steps (comprehension, application, and analysis) in both exams and preparing questions for these steps can be expressed as a deficiency. What is expected from such exams is an assessment for all levels. What will provide this evaluation is to prepare questions for students at all levels.

In the study, the structure of the Physics I exam questions was examined according to Bloom's taxonomy. Here it is seen that both exams mostly contain application-level questions. However, in the face-to-face

exam, it was understood that several questions were at the level of comprehension. In this respect, it can be stated that there is not much difference in difficulty between online exams and face-to-face exams, and that they are exams of similar difficulty. The questions in the knowledge, comprehension, and application steps are the questions prepared to measure the knowledge at the basic level [18]. Here, the fact that both exams have questions at close levels according to Bloom's taxonomy shows that the two exams can be easily compared.

As a result of the examination of quantitative data, the descriptive statistical values of the groups, excluding skewness and kurtosis, are parallel to each other. Although the variances were different, when the t test results were examined, there was no statistically significant difference between the end-of-term exam results taken from the face-to-face exam and the results of the end-of-term exam carried out online in distance education. However, the study conducted by Yağcı, Ekiz and Gelbal [19] shows differences in the scores of students for different types of exams (face-to-face and online). It is thought that this difference in comparison with the current literature may be due to a lack of computer usage skills. Because students who use the internet too much have a positive view of online exams and do not worry too much about them [20-21]. However, recently, education has mostly moved to digital platforms, and students frequently use such platforms in their lessons, enabling them to become more familiar with subjects such as the internet, online exams, and computer knowledge. In this respect, it is believed that the validity of online exams may increase. In this context, it was seen that there was no difference in the online application of the same type of exam as an alternative to face-to-face exams, and it was concluded that there was no difference in the results of the exams in this way. It can also be said that the instructor can administer the exams online or face-to-face depending on his or her own preference. There is no difference that will affect the results of assessment and evaluation in both types of exams. The absence of such a difference will provide the instructor with the opportunity to administer exams with broader possibilities. In particular, higher education students studying in different cities from the city they live in often have problems when they have to take a make-up exam for any course. The student has to make a long journey just to take a single exam. However, such exams can be administered online, which is extremely convenient for the student. So, it is recommended that alternative assessment and evaluation tools can be used in addition to traditional assessment and evaluation tools in online exams used in the field. In addition, instructors do not rely on online exams in some cases. In such cases, although the exam is still done online, it can be supported by alternative measurement tools to make online exams more secure. In this study, only multiple-choice question types were compared. However, in assessment and evaluation, many different types of questions can be used, both face-to-face and online. It is recommended to compare other measurement tools and question types in future studies.

Author contributions

Mustafa Nuri Ural: Data Analysis, Writing, Reviewing and Editing, **Zeynep Başkan Takaoğlu:** Reviewing, Methodology, Educational Analysis, Literature Reviewing, Writing, Reviewing and Editing

Conflicts of interest

The authors declare no conflicts of interest.

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