# Students' Attitude Towards Learning of Fundamentals of Electrical Engineering and Their Professors

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***Abstract*** **– In this paper, the attitude of the students towards learning of fundamentals of electrical engineering and their professor is considered. For this purpose, a survey of first-year students studying this subject was conducted. The survey was conducted on two generations of students from the academic year 2020/2021 during the COVID-19 pandemic and 2022/2023 generation after the pandemic. Our goal is to see students' opinion about the teaching process and the professor and determine if there is a difference in the students' opinion. It should be noted that during the COVID-19 the teaching took place online, and after the COVID-19 with physical presence. Students during the COVID-19 period gave lower ratings for their professors and found the colloquiums more difficult, expressing less satisfaction with the lectures and exercises. Their colloquium results were also worse. Additionally, final exam results showed that a higher percentage of students from academic years with physical presence passed the exams.**

***Keywords*** **– Learning, COVID-19 pandemic, exams.**

DOI: 10.18421/TEM133-32
https://doi.org/10.18421/TEM133-32

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*Received: 22 February 2024.*
*Revised: 12 June 2024.*
*Accepted: 20 June 2024.*
*Published: 27 August 2024.*



## 1. Introduction

Education is important for a society and represents a process of positive change of the individual in society. Education includes educational contents, which are covered and integrated in the most important educational institution in society, the school.

Although, apart from the formal education that is included in the school, the individual also acquires informal education from the family and the environment in which he lives. Education teaches the individual how to think correctly, how to make decisions correctly, how to behave correctly, in fact how to function correctly in accordance with social rules and norms, and in accordance with the interaction with other individuals with whom he is surrounded in his environment. The process of formal education in our society is long and is presented through three stages: primary, secondary, and higher education, where the first two are mandatory while the third is not. In this paper, we will refer to higher education, which is taking off.

Education all over the world, but also in our country, always faces a variety of challenges in different periods of time, which are related to different reasons of everyday life. Challenges are sometimes related to the development of society as a positive change in social norms and rules. Sometimes the development of science and its unequivocal results influence the improvement of educational processes. The impact of global educational processes is also a significant educational challenge. Health challenges such as pandemics should also not be overlooked. All those challenges, positive or negative, condition changing the educational processes in a society and its development. Every positive challenge means a positive development of education and is welcome in every sense of the word.

But the negative challenges, no matter how terrible they seem at the beginning and disastrous for the educational process, in the end there are always positive aspects and a source of invaluable knowledge, which makes a positive contribution to education.

Our society, as well as the whole world, faced such a negative health challenge just three years ago. In 2020, it was the COVID-19 pandemic. It completely changed the whole notion and conception of the educational process. The conditions in which education took place demanded new forms of implementation of the educational process and new ways of learning. For the first time we encountered distance learning, which for all of us meant something new, incomprehensible and difficult. But over time we all saw that it is not so bad and difficult. This way of conducting education, with all its negatives, also opened up new opportunities for global connection, learning and acquiring new skills, which we had not even thought of before. The whole society, including education, turned in the direction of taking advantage of the new normality. Today after the pandemic, although we have returned to educational institutions, we are richer with new experiences, skills and knowledge, which are invaluable and which also mean a positive development of educational processes.

Today, we can look back and analyze what we gained and what we lost. Our paper will also go in that direction.

Understanding the attitudes of students toward learning the fundamentals of electrical engineering is crucial for educators and educational institutions seeking to enhance the effectiveness of their teaching methods. The field of electrical engineering serves as the backbone for numerous technological advancements, making it imperative to assess how students perceive and engage with the foundational concepts within this discipline.

Students' attitudes toward learning are multifaceted, encompassing aspects such as interest, motivation, confidence, and the perceived relevance of the subject matter. Exploring these attitudes provides valuable insights into the challenges students may face and the potential enhancements needed in the educational approach.

The fundamentals of electrical engineering lay the groundwork for future specialization and professional application, making it essential to gauge students' attitudes at this foundational level. Positive attitudes can foster a deeper understanding, intrinsic motivation, and a greater likelihood of success in more advanced courses and real-world applications.

This study aims to delve into the nuanced dimensions of students' attitudes towards the fundamentals of electrical engineering, examining factors that may influence their engagement, confidence levels, and overall learning experience. By gaining a comprehensive understanding of these attitudes, educators can tailor their instructional strategies to better resonate with students, creating a more conducive learning environment and ultimately contributing to the long-term success of students in the field of electrical engineering.

As a teaching staff, we strive for students to acquire greater knowledge. For this purpose, we conduct surveys and analyze the data obtained to determine the opinion of students on a certain subject. Also important is the grade that they will assign to the professor for the lectures and exercises.

This paper analyzes the results of two generations of students. Something similar was done in the papers [1], [2], [3], [4], [5], [6], [7], [8], [9], [10]. In paper [1] analyses of results of the electronic testing for the subject mathematics 2 on two different groups of students were done. The conclusion was that all students did not know the subject math enough. Paper [2] talks about students' attitude towards learning digital logic. There is the results from partial and corrective exam and the better results are get with the corrective exam. Improving the teaching curriculum of calculus 2 in paper [3] is done. Using analysis of data obtained from two generations of students (one learning with classic method, and the other one learning with combination of classic method and mathematical software). Better results were obtained when the classical method was combined with mathematical software. In paper [4] analyze of the impact of the knowledge gained from the previous math education in interaction with knowledge gained from lectures and exercises in mathematics is done. Tests were conducted. Half of the students had an electronic test and the other half classical test. According to the results students that had electronic tests were better, but there is no way to define which results are more reliable. In paper [7] also as in paper [4] analysis of two groups of students was done. One which used to learn online using Microsoft Teams platform (in COVID time) and the other one which learned on traditional classical way. Better results are shown by the students that learn online. So, from here we can conclude that online learning is not a bad way of learning.

## 2. Research Methodology

In this paper will be analyzed and compared students attitude for the subject Fundamentals of electrical engineering within University "Goce Delcev"– Stip using statistical data processing.

The survey was conducted on two separate groups of students from faculty of computer science who have studied this subject in first year academic studies in two different academic years.

The first ones are in COVID time in academic year 2020/2021, and the others with physical presence in academic year 2022/2023. In COVID time the survey was responded to by 31 students. This group of students learns from home, not in a classical learning environment. They had classes via the Internet using Microsoft Teams, and professors solved tasks using electronic tables. In the physical time group, the survey was conducted with 24 students. They were in physical presence in classrooms with chalk and green tables. Both groups of students listened to lectures and exercise assignments from the same professor and for a duration of 3 to 4 hours per week. There were six lectures and assignments for the first colloquium and six lectures and assignments for the second colloquium respectively. They also have homework and projects. Projects are done in groups as teamwork.

For each subject students take two colloquia and final exam. Each colloquium consists of textual questions and assignments and is graded with 20 points. To take the final exam they must pass two colloquia. So, for that reason students' attitude is important for us as teaching staff.

## 3. Statistical Analysis of Students' Attitude

The questions for the survey were divided into three groups: demographic questions, questions about teaching process and questions about colloquium as follows in the next section. Our survey was conducted after the second colloquia.

### *3.1. Demographic Questions*

The first group of questions was about the demographic structure of students. The question was about the student's gender. In the first group there were 31 students or 67.74% male and 32.26% female (the blue columns in the chart, Figure 1). In the second group there were 24 students i.e., 58.33% male and the rest 41.67% female (the red columns in the chart, Figure 1).

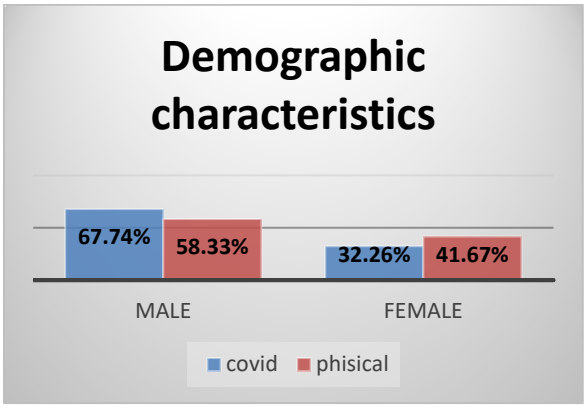


*Figure 1. Gender of students in COVID time academic year vs. in academic year with physical presence*

### *3.2. Questions About Teaching Process*

The second group of questions was aimed at the teaching process. We want to see if students are satisfied and is the given material for learning and practicing enough for them or they need some additional material. We used to learn more than 20-word pages document each class and around 15 exercise assignments. Also, there were some exercises for home and the other exercises for self-preparing.

The first question of this group was "Are you satisfied with the lectures (theoretical part)?". The answers are given on chart (Figure 2). We will discuss it in detail. With yes 77.42% of students in COVID time answered, 6.46% with no, and the rest 16.13% with can be better. All the students (100%) from the other group which had classes with physical presence said that they were fully satisfied with theoretical lectures.

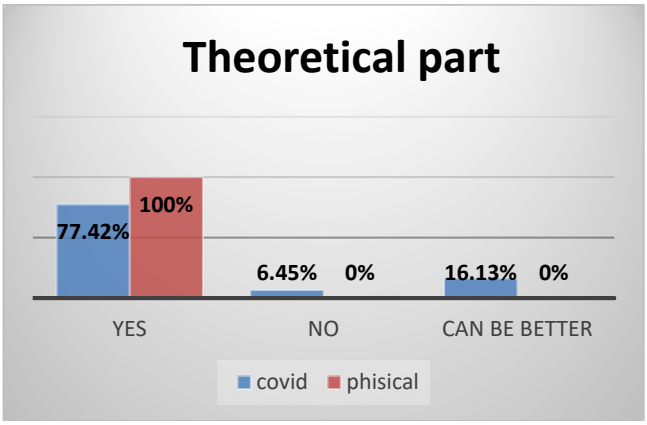


*Figure 2. Are you satisfied with the lectures (theoretical part)? - COVID time academic year students vs. students in academic year with physical presence*

Although the students who listened during the COVID time have an advantage because they can record the lectures and listen to them at any time, according to the results of the survey, more than 20% are dissatisfied with the lectures. This is because during online lectures, students not only do not listen, but they can also sleep at home, and later they are too lazy to listen to the lecture again.

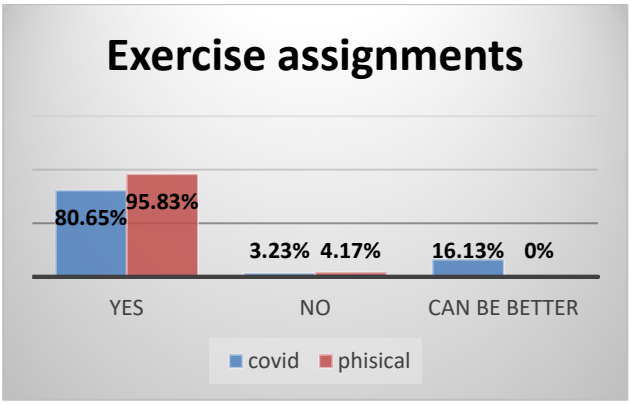


*Figure 3. Are the exercise assignments well explained? - Are the exercise assignments well explained? - COVID time academic year students vs. students in academic year with physical presence*

The second question of this group was "Are the exercise assignments well explained?". From the chart (Figure 3) we can see that again in COVID time group more than 80% are not satisfied with the exercise assignments explanation and 16.13% said that the explanation can be better. 95.83% of physical time students answer with yes, i.e. that they are satisfied with exercise assignments explanation and the rest 4.17% with no, i.e. they are not satisfied with exercise assignments explanation.

The third question of this group was "Do you think you need additional theory materials?". More than half of the students in both groups do not need any additional theory material. They think that the studied material is enough for good mastery of the material (Figure 4).

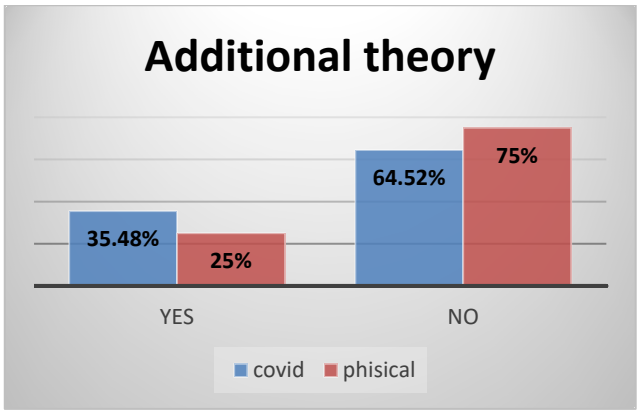


*Figure 4. Do you think you need additional theory materials? - COVID time academic year students vs. students in academic year with physical presence*

The fourth question was "Do you think you need additional assignment materials?". In COVID-19 time 58.06% of the students said that they do not need additional assignments material, and the rest 41.94% said that they need additional material. 75% of the students with physical presence said that they do not need additional assignments material and only 25% need more material for assignments learning (Figure 5).

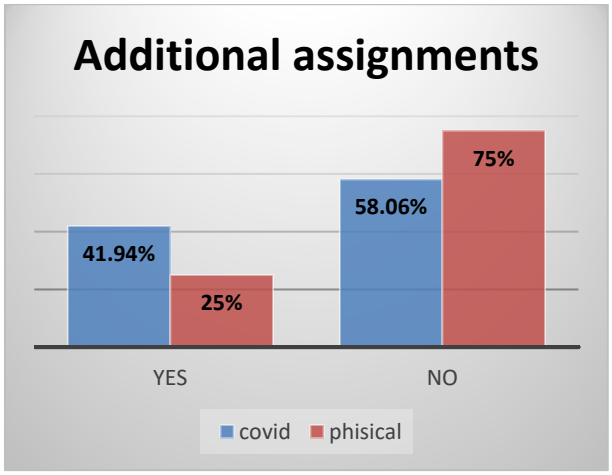


*Figure 5. Do you think you need additional assignment materials? - COVID time academic year students vs. students in academic year with physical presence*

The fifth question was to rate the teacher's expertise with 5 level scale - 1 for worst, 5 for best (Figure 6). In COVID-19 time almost half of the students give 5, the rest one rate with 3 (6.45%) and 4 (35.48%). 83.33% of the students in academic year with physical presence give rate 5 and the rest 16.67% rate 4. And again, students in academic year with physical presence are more satisfied from the professor and give better rating against the COVID-19 time students.

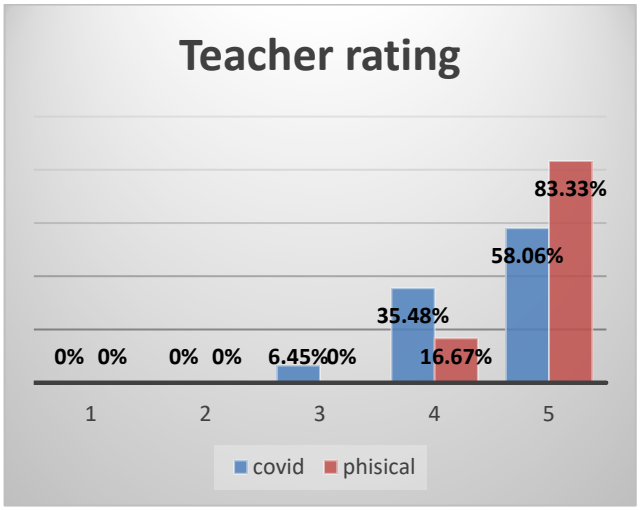


*Figure 6. Teacher rating - COVID time academic year students vs. students in academic year with physical presence*

The fourth and the last question was to give comments for the professor and the further teaching process. In the table below, some of the answers are given (Table 1). As can be seen the students are satisfied with the way the professor teaches, with the material offered, with the difference that the students from COVID-19 time wish to have lectures and exercises with physical presence. In global all the students' comments are positive.

*Table 1. Comments for the professor and the further teaching*

| COVID-19 time | Physical presence |
|---|---|
| I am satisfied with the teacher. It is just that the course is hard, and it's not about the professor. The course itself is difficult. | I have no complaints; I am satisfied with the lecture. |
| Good | There is no need for any change in further teaching! |
| I have no negative opinion. | The best professor. |
| The professor teaches very well and honestly if we pay enough attention we can learn very quickly, and for further teaching I hope it will be with physical presence because we can learn more. | Prof. Mirjana is one of the best professors at the Faculty of Computer Science |
| Excellent attitude towards students. | Everything is great, keep it up. |
| No comment | |
| The lectures are excellent, we hope to continue at the same level as with physical presence. | |

### *3.3. Questions About Colloquium Weight*

The third group of questions was aimed at colloquium weight. We want to see students' meaning about colloquium weight. Is the given colloquium difficult, medium, or easy according to them.

The weight of the first colloquium is given in the range from 1 (difficult) to 5 (easy) in Figure 7. According to COVID-19 time students, the first colloquium was difficult with a weight of 22.58% (weight 1) and 22.58% medium to difficult (weight 2). For 38.71% the colloquium is medium weight. For the rest 16.13% it was easy to write the colloquium. 50% of the students in academic year with physical presence give weight 3 i.e. according to them the colloquium was with medium weight. Rest 41.67% define the weight of colloquium as medium to easy (weight 4), and only for 8.33% the colloquium was easy (weight 5).

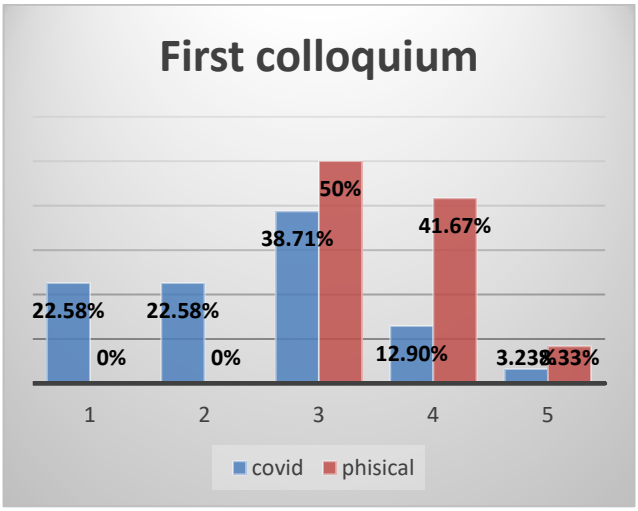


*Figure 7. First colloquium weight – COVID-19 time academic year students vs. students in academic year with physical presence*

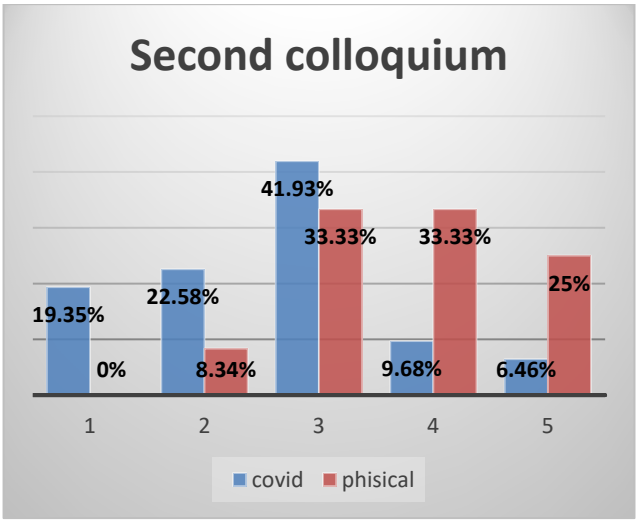


*Figure 8. Second colloquium weight – COVID-19-time academic year students vs. students in academic year with physical presence*

The weight of the second colloquium is given in the range from 1 (difficult) to 5 (easy) in Figure 8. 25% of the students in academic year with physical presence define the second colloquium weight as easy. 33.33% as medium to easy, 33.33% as medium and 8.34% medium to difficult. Again, according to COVID-19 time students the colloquium was more difficult against physical time students. 41.93% of the students said that colloquium was difficult, 41.93% said the colloquium was medium and according to only 16.14% the colloquium was easy.

Again, when comparing the results from the first and the second colloquium, according to COVID-19-time student the colloquiums were difficult. Physical time group students said that colloquiums were medium to easy.

Physical time group students learn in a traditional way, so they are more satisfied with lectures and assignments, and they mastered the material better and are well pleased with the difficulty of the colloquiums.

## 4. Principal Component Analysis

Principal component analysis (PCA) is a statistical technique used for dimensionality reduction and feature extraction in data analysis and machine learning. It helps simplify complex datasets by transforming them into a new coordinate system, where the data's variability is maximized along the first few principal components [11], [13].

The key objectives of PCA include:

- Dimensionality reduction: PCA aims to reduce the number of features or variables in a dataset while preserving as much of the original information as possible. This is particularly useful when dealing with high-dimensional data, as it can simplify the analysis and improve computational efficiency.
- Decorrelation: PCA transforms the original features into a set of linearly uncorrelated variables called principal components. By doing so, it removes redundant information and helps identify the essential features that contribute most to the dataset's variance.
- Variance maximization: The first principal component captures the maximum variance in the data, followed by subsequent components in decreasing order. This allows for a prioritized representation of the most significant patterns or trends within the dataset.

The process of performing PCA involves the following steps:

- Standardization: Standardize the features to have zero mean and unit variance, ensuring that all variables are on a comparable scale.
- Calculation of covariance matrix: Compute the covariance matrix for the standardized dataset, which describes the relationships between different variables.
- Eigen decomposition: Find the eigenvalues and corresponding eigenvectors of the covariance matrix. These eigenvectors represent the directions (principal components), and the eigenvalues indicate the variance along these directions.
- Selection of principal components: Sort the eigenvectors in descending order based on their corresponding eigenvalues. The top-k eigenvectors (where k is the desired number of dimensions) become the principal components.
- Projection: Transform the original data onto the new subspace defined by the selected principal components.

PCA is widely used in various fields, such as image processing, pattern recognition, and data visualization, to uncover underlying patterns and reduce the computational complexity of analyses while retaining essential information.

In Table 2 and Figure 9 summary statistics of grades obtained from the exam are given. As we can see from the table below from COVID-19-time academic year students only 2 have grade ten, 3 grade nine, 6 grade eight, 5 grade six and seven, and 10 students didn't pass the exam. Around 35.48% have grade eight and more than eight from COVID time academic year students. On the other hand, from physical time academic year students only 25% have grade eight and more than eight, 4 students have grade seven, 11 grade six and 3 students or 12.5% did not pass the exam. Globally from student in COVID time 67.74% pass the exam and from student in physical presence 87.50% pass the exam.

*Table 2. Grades from final exam - COVID time academic year students vs. students in academic year with physical presence*

| grades | covid | physical |
|---|---|---|
| five | 10.00 | 3.00 |
| six | 5.00 | 11.00 |
| seven | 5.00 | 4.00 |
| eight | 6.00 | 3.00 |
| nine | 3.00 | 2.00 |
| ten | 2.00 | 1.00 |

Summary statistics:

| Variable | Observations | Obs. with missing | Obs. without | Minimum | Maximum | Mean | Std. deviation |
|---|---|---|---|---|---|---|---|
| covid | 6 | 0 | 6 | 2.000 | 10.000 | 5.167 | 2.787 |
| physical | 6 | 0 | 6 | 1.000 | 11.000 | 4.000 | 3.578 |

*Figure 9. Summary statistics*

Principal component analysis is given via eigenvalues. Higher eigenvalues correspond to principal components that explain more variance in the data. The first eigenvalue equals 1.140 and represents 57.021% of the total variability. Each eigenvalue corresponds to a factor, and each factor to a one dimension. The first factor allows us to represent 57.021% or more than half of the initial variability of the data (Figure 10 and Figure 11) [12].

| Eigenvalues: | | |
|---|---|---|
| | | |
| | F1 | F2 |
| Eigenvalue | 1.140 | 0.860 |
| Variability (%) | 57.021 | 42.979 |
| Cumulative % | 57.021 | 100.000 |

*Figure 10. Principal component analysis - eigenvalues*

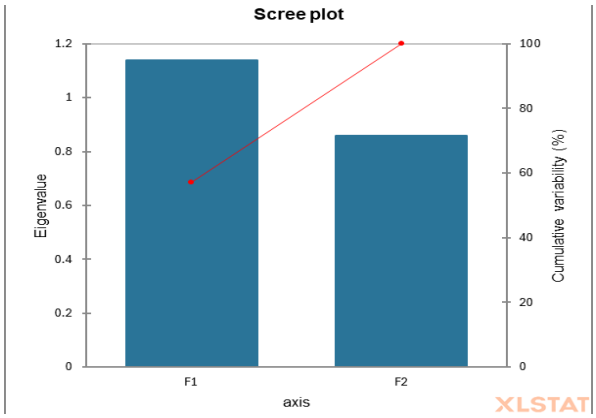


*Figure 11. Screen plot of eigenvalues*

The squared cosine of a variable in PCA is a measure of the contribution of that variable to a particular principal component. It helps to understand how well the original variables align with the principal component. Squared cosines of the variables are given in Figure 12.

| | F1 | F2 |
|---|---|---|
| covid | **0.570** | 0.430 |
| physical | **0.570** | 0.430 |

*Figure 12. Squared cosines of the variables*

Values in bold correspond for each variable to the factor for which the squared cosine is the largest.

The observation axes in PCA are the new coordinate system defined by the principal components, providing a way to represent and analyze data in a more informative and compact manner. Each observation's position along these axes reveals its pattern and relationship in the transformed space (Figure 13).

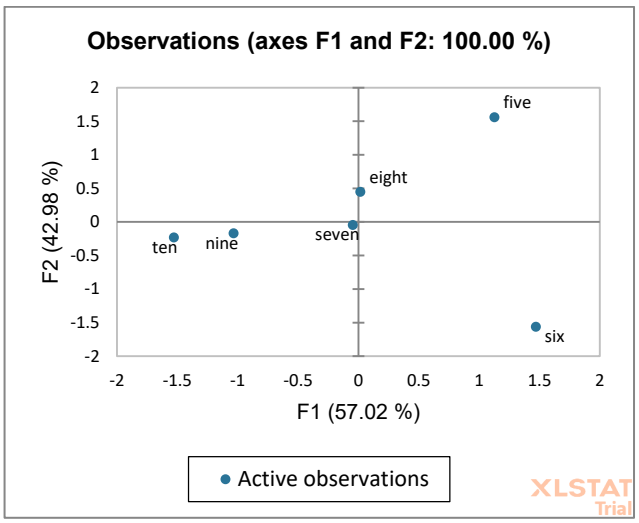


*Figure 13. The observation axes*

## 5. Conclusion

To conclude, it can be said that students who listen to the course during the COVID-19 time have an advantage, because they can record the lectures and exercises and can listen to them multiple times. Here we consider that students in COVID-19 time do not spend time on consultations with professor. However, these students give lower ratings for the professor and the difficulty of the colloquiums and are less satisfied with the lectures and exercises. Students are not satisfied because they do not listen enough and do not pay attention during the lectures, and therefore do not devote themselves to learning enough. On the other hand, students who study in traditional conditions, if they want to learn, they pay attention in class, and if they have unclear things, they could ask before the beginning of each next class or to come for a consultation with the professor. Even the colloquium results are worse for COVID-19 time students considering that they have a higher chance of rewriting. Students take exams in groups of 9 students, through the Microsoft Teams platform. The process is more difficult to control, and more people are needed to conduct the colloquia. The desire of the COVID-19 time students was to start with traditional teaching because physical contact between student and professor and physical presence are very important in the process of learning and mastering the course material. Solving tasks on the board itself remains in the student's subconscious, while writing on the virtual board can go unnoticed by some students, which is confirmed in our case. Also, the results from the final exam confirm that students from academic year with physical presence passed the exam in greater percentage.

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