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Experimental Research on the Challenges of Distance Learning

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Abstract: As a result of the development of the Covid-19 pandemic, a rapid transition from the classic classroom-lesson form to a distance form of education was required. Thus, many questions arose regarding the applicability of this training method and its comparison with the classical face-to-face method. This article presents a study of the examination results of face-to-face and distance-learning students, assuming all other circumstances being equal. A hypothesis test is performed, regarding a difference between means of two independent samples for quantitative indicators that have normal distribution. Student's t-test for independent samples is applied. The research takes place in the University of Mining and Geology in Sofia, Bulgaria. The experimental results show that the examination results of the students are different for both methods and in the majority of the cases the results of the present in the class students are better. Comparing the advantages and disadvantages of both methods, it is concluded that only a combination of different forms of education - present in class, remote, hybrid and blended, can provide a modern education aimed at the sustainable development of society.

Keywords: Face-to-face learning, Distance learning, Blended learning, Hypothesis test

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Introduction

The sudden appearance and severe course of the disease caused by the Covid-19 virus posed a great challenge to

the education system in all countries of the world (Barrot, 2021). Rapid measures were needed to move traditional education into an electronic environment (Ferri, 2020). This gave a powerful head on the development of distance learning. It is an attractive mode of education for independent study. (Bozkurt, 2022). But all learners, regardless of whether they are in the class or at home, need support and observation, hence there is a need for reintegrating social and teaching presence in online and distance education practices (Naidu, 2023).

Distance Education is defined as "a process to create and provide access to learning when the source of information and the learners are separated by time and distance, or both" (Stauffer, 2023). Unlike online learning, which can be both in and out of class, distance learning places the teacher and students in different locations. (Hodges, 2020, March 27). Online learning can be used as a blended learning method, together with other teaching techniques. In distance learning, the interaction between the teachers and the students is not face-to-face and nowadays it is realized mostly by digital communication. Therefore, we can consider online learning as the major form of distance learning (Bernard, 2009). The main advantage of distance learning is its flexibility. Students are feeling more independent and they can organize better their schedule. Distance education offers the students accessibility of time and place. It improves the concentration of the students on the studied material. The slow learners have an opportunity to study with their own speed of assimilation of new material. Distance education reduces students' financial costs for transportation, accommodation, etc. It provides them with a comfortable environment to enjoy the education process (Stauffer, 2023).

On the other hand, there are also disadvantages. Focusing on the screen for a long time becomes boring for some students and their attention begins to be distracted and diverted to other pursuits. This circumstance determines the necessity of more breaks during the learning process. Another problem is to provide a consistent Internet connection with decent speed. Some students don't have even personal computers at home. It causes a lack of stability and continuity in the education process. The lack of physical interaction between the students and their teachers, and also their peers creates a feeling of isolation. (Stauffer, 2023). Online and distance learning is not an easy solution. It requires the same level of rigor that is required for the development of campus-based learning experiences (Naidu, 2023). The adoption of distance education during the pandemic allowed educational institutions to continue their work in limited ways, challenging both the teachers and the students. This caused many studies to be conducted on the influence of different teaching methods on the quality of the learning process, which in turn led to the improvement of the process as a whole and its enrichment with new techniques.

Main aim of the study

Distance learning during the Covid-19 pandemic raises a number of questions about the quality of the learning delivered and how it compares to face-to-face classroom learning. The main criterion for the quality of learning is the degree of achievement of the learning outcomes. This is a very important and complicated task. Usually,

the degree of assimilation of the learning material is determined by the exam results of the students. The exam has to cover all learning outcomes and has to include challenging tasks. The exam has to be (Semerdzhiev, 2021, b):

- fair – it should provide the students with equal opportunity;
- resource efficient, according to the available resources;
- technology agnostic – should avoid requirements for a specific hardware or software;
- fault-tolerant – should be independent of technical failures, as much as possible;
- auditable – should allow for an independent audit;
- familiar for the different students;
- secure – should avoid possibilities of cheating and unfair behavior of students.

The experiment is done at the University of Mining and Geology, Sofia, Bulgaria. The University course is "CAD systems" which is offered to full-time and part-time students. The main part of the course is dedicated to specialized middle-class general-purpose software, having an internal programming language, containing a powerful toolkit for automating the drawing activity and capabilities for modeling complex solid three-dimensional objects. Students become familiar with the possibilities of the system for creating and editing drawings in the two-dimensional and three-dimensional space, inputting and outputting graphic information, creating libraries of graphic elements. The computer graphics system AutoCAD is widely known in engineering and it is widely used in the automation of drawing activities and in supporting design and construction work. The accumulation of practical skills in the approaches to its use provides a good start in the profession of future engineers. Lecture material is presented in the form of multimedia presentations and demonstration work in an Autodesk AutoCAD environment.

After completing the course, students are expected to be able to:

- use AutoCAD tools to create and edit elementary drawings;
- use the capabilities of the system to work in different layers;
- create and use blocks;
- annotate and print their drawings.

The knowledge and practical skills for working with CAD systems obtained within that course can be used in the other special and profiling courses of the students' training programs.

The assessment of the students is based on passing a written exam in the form of a test and practical work in the environment of the studied software, as a result of which the final assessment is formed.

The goal of this study is to compare the results of the examination of students, taught by the two methods - present in class and distance learning through online lectures, other circumstances being equal.

The present study considers the results of the examination of students, learning the same syllabus, with learning materials prepared by the same teacher, delivered by two methods - present in class and distance learning through online lectures. In both cases, the exams are done in the class and they include questions and tasks of the same degree of difficulty. The results of the exams are presented in points out of 100. Students are divided into groups according to their majors, as well as according to their type of study - full-time and part-time students.

Research method

The research in this article is based on statistical inference and hypotheses. The term hypothesis in the context of statistical inference is usually defined as an assumption about the value of one parameter (or several parameters) of the sample space. This preset value has no direct relation to the statistical conclusion and is usually obtained on the basis of theoretical knowledge and prior experience in the research area (Bluman, 2004).

Hypothesis testing involves assessing the extent to which a predetermined parameter value is plausible, i.e. to conclude whether the information, obtained from the sample corresponds to expectations. In this way, a decision can be made about accepting or rejecting the hypothesis based on the results of the observations. The inferences that are drawn must relate to the whole sample space, and the data available to the researchers cover only the sample. Thus assumptions (hypotheses) are initially formulated and a check is made whether the data from the sample confirms or rejects them.

Two hypotheses are defined. The null or working hypothesis claims that there is no statistically reliable difference in the compared statistical indicators in the sample space. Although some variation may be observed in the samples, it is due to random factors and cannot be generalized to the whole sample space. Alternative hypothesis claims that the observed difference in the samples is statistically reliable and can be generalized to the whole sample space.

Decisions made in statistical hypothesis testing have a probabilistic nature character. This is due to the fact that the studies are representative, i.e. the conclusions about the total space are made based on the study of a relatively small part of it. The reception for the rejection of the null hypothesis is done with a degree of certainty, as in the same time the possibility of statistical inference error is allowed.

The degree of certainty with which the alternative hypothesis is accepted as true is called assurance probability or confidence level. The risk of making a mistake by accepting the alternative hypothesis as true is called significance level.

In this article, a hypothesis test is presented regarding a difference between the means of two independent samples for quantitative indicators that have normal distribution (Bluman, 2004). Student's t-test for

independent samples is applied. Two samples are used for each major and for each type of study. The first sample considers the results of the exam of the students who studied online and the second sample considers the results of the exam of the students who presented in class. Since both samples are of small size (≤ 30), t-test is accepted in this case. The populations are of equal variances.

The null hypothesis holds that by applying both methods (distance learning and present in class), the same results are obtained, assuming a significance level of 0.05.

The empirical values (test values) are computed by the formula:

$$t_E = \frac{|\bar{x}_1 - \bar{x}_2|\sqrt{n_1 + n_2 - 2}}{\sqrt{(s_1^2 n_1 + s_2^2 n_2)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where: $\bar{x}_1$ and $\bar{x}_2$ are the means of the samples;

s_1 and s_2 are the standard deviations;

n_1 and n_2 are the volumes of the samples;

The degrees of freedom $\phi = n_1 + n_2 - 2$

The critical values are taken from the t-Distribution table with one tail and significance level of 0.05.

Experimental results

The results of the empirical values t_E and the corresponding critical values t_C are presented in Table 1 and Table 2.

All empirical values of the t-test, from both tables, are less than the corresponding critical values from the t-Distribution table. Therefore, we can conclude that the null hypothesis is rejected, and the two samples originate from populations with different means, i.e. in both methods are obtained different results.

Table 1. T-test for full-time students

Majors	Empirical values t_E	Critical values t_C
Major 1	0.067057177	1.75305
Major 2	0.006134321	1.739607
Major 3	0.077879555	1.76131
Major 4	0.331991348	1.812461
Major 5	0.190978986	1.894579

Table 2. T-test for part-time students

Majors	Empirical values t_E	Critical values t_C
Major 1	0.133816696	1.697261
Major 2	0.381733369	1.76131
Major 3	2.87319E-06	1.697261
Major 4	0.0149027	1.697261

In Table 3 and Table 4 we present the corresponding mean values of the students' results of the majors from Table 1 and Table 2.

Table 3. Mean values of full-time students' results

Majors	Mean value (distance education)	Mean value (in-class education)
Major 1	76.4	88.75
Major 2	40.71	70.8
Major 3	51.36	70.8
Major 4	51.75	57.5
Major 5	59	74.3

Table 4. Mean values of part-time students' results

Majors	Mean value (distance education)	Mean value (in-class education)
Major 1	91.06	88.38
Major 2	61.25	57.08
Major 3	41.56	74.29
Major 4	41.41	55.80

When we compare the mean values of the students' results in the columns of Table 3, it is seen that for full-time students of all majors, the mean values of the students who studied only online are less than the means of the students presented in class. Therefore, we can conclude that for this type of students, definitely, the in-class education is more effective than distance education. Full-time students usually are coming directly from high school where the class-lesson form of education is predominant and they need face-to-face contact with the teacher. To a large extent, they rely on help from their teachers and fellow students in learning the study material.

But, on the other side, for part-time students, presented in Table 4, there are majors (Major 1 and Major 2), for which the mean values of presented in-class students are slightly less than the mean values of online students. These exemptions can be explained by the fact that part-time students already have established self-training habits. Also, many of them are working in companies, where they are using similar software tools and they have

experience with them. Part-time students usually are more mature, more independent, and highly more motivated than full-time students. They cope more successfully with independent learning of new material, based on their accumulated life experience and skills to solve real problems.

Discussion

Recently, the Covid-19 pandemic created asituation that forced teachers to rethink the class-lesson system and direct their efforts to the development of hybrid education and blended learning. Very often these methods are considered equal but there is a difference between them. Hybrid learning is a form of synchronous learning that happens both physically and remotely. On the other hand, blended learning is a combination of traditional face-to-face education with modern digital technologies. Blended learning describes the introduction of computer labs, interactive whiteboards, and educational software to the learning process. It is used to include online self-study to supplement in-class lessons. Blended learning may involve playing games, working in groups, online quizzes, etc. (Dziuban, 2018).

Although this approach requires a lot of human skills and technology resources, it is worth to invest in such a method of teaching because of its many advantages. For example, students are feeling more flexible and engaged in interactive simulations; it doesn't depend on geographical constraints and provokes the development of students' creative abilities.

The introduction of distance learning directs the attention of teachers to another modern method, which is called flipped learning (Roehling, 2018). In order to activate the participation of students in the learning process, teachers provide students with the opportunity to independently prepare some topics from the study material. This is a type of student-centric pedagogy in which the students are more actively engaged in the learning process. The teachers provide students with some materials – articles, video lectures, tutorials, etc. on which the learners prepare to understand the new topic of the syllabus. In this way, the students have more responsibilities and greater confidence in their own capabilities.

Flipped learning is based on the following pillars (Ozdamli, 2016):

- Flexible environment: Different learning modes are available. Students can choose when and where to learn, in groups or individually.
- Learning culture: The teacher-centered approach is changed by the student-centered approach and the students are deeply involved in the learning process.
- Intentional content: Students develop cognitive understanding and procedural fluency.
- Professional educator: Teachers provide professional feedback, constructive criticism and tolerance to the students.

The most important advantages of flipped learning can be summarized as follows (Ozdamli, 2016):

- Increasing the interactive activities and the discussion period in the class;

- Supporting team working;
- Flexible time of learning, at individual speed;
- Stimulation of inventive research process.

Another good practice in Computer science and Software engineering education is to incorporate unit tests (Semerdzhiev, 2021, a). This method is recommended to intermediate or advanced courses.

The main goals of this method are the following:

- To guide students how to control and improve the quality of their knowledge;
- To provide additional means of students' submissions;
- To automate the tasks;
- To improve the quality of learning tools and materials.

In this way, students become more familiar with the teaching material at the early stage of their learning, as well as, they feel themselves more comfortable with the process of testing.

Conclusion

The results of this study confirm the need for face-to-face education but enriched with the advantages of online learning.

Electronic lectures and videos can provide more options for students who are working or engaged by other activities, as well as for slow learners. Also, they ensure independence of the learning process from the time and place of learning. On the other hand, nothing can replace the experience and skills of a good teacher to direct students' attention to the essence of the studied material, its diversity, and its application in different fields and for different purposes. The ability to quickly react and answer questions that arise during training, as well as to discuss problems with peers, is a great advantage of attending training.

The main challenge of the modern education is to prepare students to work in rapidly changing environment, with multiple sources of information, to analyze and to make their own conclusions. It is important to stimulate students to develop their own research and to acquire lifelong learning skills. Combining the advantages of classroom-based learning, the possibilities of modern technologies for remote communication between participants in the learning process, and the availability of numerous educational sources in an electronic environment, significant results can be achieved in modern education.

Recommendations

Similar research can be done to compare the exam results of students trained in different methodologies, for

example, blended or flipped learning and traditional education.

Modern education must be oriented toward the rapidly developing digital world. Technology becomes a key factor for effective learning. We can outline at least five levels at which technologies may be used: presentation, demonstration, drill and practice, interaction, and collaboration (Haddad, 2002). Nowadays, the learning process should be based on cloud computing, virtual reality, augmented reality, etc. (Madini, 2017).

Students are increasingly turning to mobile technology because of its flexibility of location and time. They have the opportunity to download, upload and work online via wireless or mobile networks. The main platforms for such connectivity include smartphones, PDAs, MP3/MP4 players, tablets, mini notebooks, gaming devices, etc. (Kukulska-Hulme, 2009). They are accessible and easy to use by students. That's why the teaching process should be also connected to such devices.

Another direction of development is the emphasis on the team work, both in class and online, as well as in the development of course projects (Usher, 2020). The competition between the teams motivates the students to demonstrate their full capacity and to feel satisfied with their efforts. During online education, working in teams is facilitated by mobile applications, such as Viber, WhatsApp, Kahoot, etc., that can be used for tutorials, homework or course projects.

Only the combination of different forms of education - present in class, remote, hybrid, blended, and flipped, can provide a modern education aimed at the sustainable development of society.

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