Application of Information and Communication Technologies during Linear Programming Learning

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Abstract

The study of the effectiveness of using various systems of computer mathematics in the implementation of means of finding a solution to the problem of linear programming is carried out. The influence of the introduction of packages of special applied programs on the educational process is analyzed. It was found that the application of the GeoGebra program makes it possible not only to streamline the heuristic search, but also to free up time for additional independent research in order to confirm the practical significance of mathematics and the need for its study. The implementation of the main provisions of the study is aimed at a qualitative transformation of the existing practice of using information and communication technologies. The substantiation and generalization of the results of the study of complex processes of mathematical training on the tested model in accordance with the innovative principles of folding the complex prompted the identification of the leading link in the preparation of the student's personality, through which the influence of the evolutionary processes of structuring in the effective pedagogical activity of mathematical education of the future is carried out. The use of the GeoGebra dynamic mathematics system in the educational process makes it possible to speed up, facilitate, visualize the solution process, which makes it possible to dynamically vary the variables in order to understand the essential connection between them.

Keywords [1]

Mathematics, Efficiency, Tasks, Programs, GeoGebra, Linear Programming.

1. Introduction

World COVID-19 epidemic changed usual way of life and approaches to education [1]. The pandemic has forced the global academic community to turn to new teaching methods, including distance and online learning [2]. This has proven challenging for both students and teachers, who have to cope with the negative emotional, physical and economic consequences of the disease while helping to combat the spread of the virus. No one knows what the future holds, especially the millions of students who, after graduating from university this year, will face a global economy severely hit by the pandemic [3].

Distance learning has become one of the areas that have been seriously impacted by the coronavirus pandemic. Of course, as part of the Edtech technology world, it has been around for a long time. Students remotely use various online tools: from modern services and video communication platforms with support for file sharing to special educational sites. The increased demand we are seeing today is driven by the need for people to keep learning even during epidemics and crises. A scalable information

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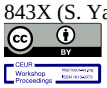

infrastructure should be a guarantee that in the future it will be easier to organize distance learning, and educational institutions will not have to spend on unnecessary capacities and resources.

The economic impact of the current crisis is significant in different countries [4-6]. The United Nations Department of Economic and Social Affairs estimates that COVID-19 could cause the global economy to contract by almost 1% by the end of 2020 [7], while the International Labor Organization predicts an increase in global unemployment of between 5,3 million and 24,7 million [8], and the World Trade Organization – a decline in world trade this year by 13-32% [9]. The economic downturn can affect universities in many ways, including: reduced employment opportunities for graduates who may enter the labor market in the next few months; possible delays in payment or complete lack of the opportunity for students to pay for tuition [10]; failure of governments to meet commitments to government agencies to the desired level [11]; and, most importantly, changes in student behavior in relation to regimen and preference for certain programs [12]. While the impact will vary depending on the situation, overall it will be quite significant.

Since 12th of March 2020 lockdown in Ukraine have changed the way of study to distance [13]. Currently, all educational institutions had to change the traditional (full-time) form of education to distance learning, for the first time organizing for their pupils / students the opportunity to continue their studies without leaving home. Precisely because the long quarantine has become a bolt from the blue in an unplowed field of preparation for such challenges, quarantine distance learning has exposed a lot of problems that should be paid attention to, because scenarios for the development of events with an epidemiological situation may turn out to be unexpected.

However, it is important to note that the current crisis differs from previous economic downturns in its type and in the availability of alternative technology-based education models at relatively lower costs [14-15]. And now trends of digitalization not only in organization of educational process, but in Public Health [16-20], medical diagnostics [21-22], security [23-25], management [26-29], financial branch [30] and other spheres of human being are developed with high speed.

The current crisis could lead to different scenarios for three reasons:

- changes in labor markets may lead people to use their skills to move to another industry (for example, aviation and hospitality managers may apply for jobs in areas where similar knowledge, skills and attitudes apply);
- as human health is at risk, many traditional sectors / industries may experience significant changes in consumer behavior with changes in the nature and quantity of demands;
- students may be reluctant to return to traditional educational models after they have tried alternative educational models at a lower cost.

The methods of linear programming opened the way for mathematics to be put into practice and aroused interest in sections and theoretical propositions that mathematicians left without attention to this moment [31].

The relevance of our research is associated with the great theoretical and practical importance of the linear programming methods and the need to improve the teaching methodology using information and communication technologies.

Aim of the research: to find out the effectiveness of using new methods of studying linear programming by means of information and communication technologies.

The object of the research is the educational process for the development of applied problems of linear programming.

The subject of the research is the graphical method of solving them using the Geogebra application.

Research objectives:

- to analyze the impact of the introduction of packages of special applications on the educational process of linear programming;
- to prove the expediency of using GeoGebra when studying linear programming.

2. Materials and Methods

While developing the research concept, we turned to the works of scientists from many branches of science, covering and substantiating various aspects of the problem we have chosen in the following areas:

- conceptual foundations of new pedagogical technologies [32-33];
- methodology for the introduction of information environments in the learning process of mathematics [34-36];
- general theory of the use of ICT in education [37-38];
- methodology for applying factor analysis to the study of the problem of knowledge quality [39-40];
- conceptual foundations of professional training of future specialists [41-42];
- design of pedagogical systems [43-44].

In accordance with the research problems, we propose new methods for studying linear programming by means of information and communication technologies. The processing of the research results was carried out using factor analysis. The choice of research methodology was influenced by the fact that the student collective is a complex system with many parameters, and the factor analysis technology allows working with systems that contain many variables. To confirm the hypothesis, it is necessary to create a model of educational activity. Mathematical models open up ways for educational researchers to understand the patterns of learning and upbringing processes and can be used to analyze specific numerical data related to the process under study and, on their basis, to develop new pedagogical teaching technologies using information and communication technologies.

3. Results

The analysis of the training content allowed us to put forward a research hypothesis – the effectiveness of knowledge formation grows in the conditions:

- substantiation of the theoretical and methodological foundations for the use of ICT, taking into account modern requirements;
- development of a model and implementation of technology for the formation of mathematical knowledge in the field of linear programming using ICT;
- introduction into the educational process of the content, forms, methods of studying linear teaching based on new technological approaches;
- application of the methodology of the stage-by-stage knowledge formation.

The use of dynamic modeling tools in the process of studying linear programming at school, selecting tasks in accordance with the individual educational program of the student, contributes to an increase in interest in teaching mathematics and develops mathematical intuition. A reasonable selection of dynamic models, taking into account the age characteristics of the ward, will provide the teacher with new opportunities to fulfill his educational request for effective teaching of mathematics.

First of all, when it comes to the use of ICT. They allow performing various mathematical operations and transformations of algebraic expressions given in numerical and symbolic (variables, functions, polynomials, matrices, etc.) forms. For example: MathCad, MatLab, Gan, Maxima, MathPaper, etc. Currently, there are a large number of online pro-grams that help with calculations, plotting, models and other mathematical objects. An example is the online computing tool WollfrAmalpha. Some math pack-ages are found both online and in the pre-installed version (GeoGebra).

Among the variety of these programs, we have chosen the GeoGebra program, as one of the recommended by governmental institutions. We believe that the use of GeoGebra to find a solution to linear programming problems, namely the use of dynamic mathematics programs as an effective means of forming students' functional thinking. Each new version of the program is enriched with services and expands the directions of its application not only in the field of school mathematics.

In our opinion, geometric extremum problems often cause difficulties even for children whose level of mathematical education is above average. These problems have a complex, even a little unusual for typical exercises, way of formulating a condition and finding an answer. After all, it is necessary to separate the given values, construct a function that will connect these values with the de-sired value, and then further investigate this function for the presence of an extremum. These actions are often recognized by typical students, since they additionally require already established geometric concepts and analytical skills. Constructive approaches to solving such problems, implemented in the program of dynamic mathematics, reduce the weight of analytical calculations and high-light the need for the ability to model the required structure, take into account the dependencies between its parameters, visualize individual positions of possible results, even "see" the desired function for which you need to determine the extremum.

We believe that the advantages of the GeoGebra dynamic system of mathematics include its constant updating and improvement. A valuable feature of GeoGebra's dynamic mathematics system is its integration into the Moodle distance learning system.

Evaluation of the effectiveness of students' work in the classroom to find a solution to the linear programming problem using the GeoGebra program was carried out in terms of quantitative and qualitative indicators, their dynamics, and comparison of results.

When assessing the quality of conducting elective courses, we were guided by the following criteria:

Class attendance level:

- high - 100-90%;
- sufficient - 90-60%;
- medium - 60-50%;
- low (initial) - less than 50%.

Student activity level:

- non-independent activity. These are students' perception of teachers' explanations, assimilation of a model of mental action, performance of independent reproductive work with the help of a teacher;
- semi-independent activity. This is the assimilation of knowledge by students in a new situation, their participation in a joint search with the teacher for solving the assigned educational tasks;
- independent activity. This is the implementation by students of independent work of the reproductive-search type, the application of acquired knowledge in a new situation with little help from a teacher;
- creative activity. This is the implementation by students of independent work that requires creative imagination, logical analysis, the discovery of a solution, independent proof without the help of a teacher.

The level of student activity in the course:

- reproductive. This is the level of activity at which they apply the acquired knowledge in practice in algorithmic, standardized situations, perform tasks according to a template, a stencil, a sample;
- partially creative. This is the level of students' activity, upon reaching which they are occasionally able to apply the acquired knowledge in practice creatively, in non-standard situations, to produce new skills and abilities on the basis of the existing ones;
- creative. This is the level of students' activity, upon reaching which they are able to constantly apply the theoretical knowledge gained in practice creatively, in non-standard situations, to produce new skills and abilities on the basis of the already established ones;
- research. This is the level of students' activity, upon reaching which they are able to acquire knowledge independently in the course of setting up experiments, studying phenomena, objects.

Satisfaction level with activities and their organization:

- high – all students are satisfied;
- sufficient – more than 75% of students are satisfied;
- average – more than half of the students are satisfied;
- low – most students are dissatisfied.

To identify the results of the formative experiment and the effectiveness of the experimental work program, we, firstly, carried out diagnostic work to determine the level of formation of students' skills, achieved by them during the approbation of a series of classes. Secondly, a comparative analysis of the qualitative criteria obtained in the course of research work was made.

Table 1
The level of student achievements in learning

Students quantity	High level	Satisfying level	Middle level	Low level	Learning rate
20	10 50%	6 30%	4 20%	-	76.4%

For the implementation of pedagogical diagnostics, the students were offered test tasks, applied problems of linear programming. Some of the tasks were solved using GeoGebra software. Each option consisted of three parts, which differed in the complexity and form of test items.

Table 2
The level of student achievements in learning

№	Knowledge Elements	Completely completed		Partially completed		Haven't completed	
		Num.	%	Num.	%	Num.	%
1	Analysis of initial data	11	55	9	45		
2	Building a mathematical model	17	85	3	15		
3	Solving a system of inequali-ties	15	75	5	25		
4	Building a solution polygon	15	75	4	20	1	5
5	Objective function image	11	55	7	35	2	10
6	Finding the optimal solution	10	50	6	30	4	20

In the first part of the test, five tasks were proposed with the choice of one correct answer, corresponding to the educational achievements of students at primary and secondary levels. The second part of the test was an applied linear programming problem with a formulated mathematical model, corresponding to a sufficient level of educational achievements of students. The decision was carried

out in the GeoGebra program and had a short record of the decision without justification. The third part of the test consisted of one task, which corresponded to a high level of students' knowledge, the solution of which was a detailed record of the decision with justification. Analysis of the research results shows that the student learning rate was 76.4% (Fig. 1).

Figure 1: Level of students achievements

We conducted a study of the level of student activity in traditional classes and in classes using information and communication technologies. An increase in activity and an increase in the concentration of attention on the material is observed using the GeoGebra dynamic mathematics system.

If we show the level of activity and attention in a traditional lesson as a percentage, we will see that 6% of students were inactive, 26% were moderately active, 68% of students were highly active.

If we show the level of activity and attention in a lesson with the use of information technologies as a percentage, we will see that there were no inactive students - 0%; 13% - average activity in the lesson; 87% - high student activity.

Comparing the results shown in the two diagrams after the traditional lesson and the lesson using information and communication technologies, we can conclude that the non-standard lesson is more effective. In such a lesson, all the students of the class were involved in the work, the level of their activity and attentiveness in comparison with the traditional one has higher indicators. Gone is the percentage where there was low activity in the lesson. The advantages of a lesson using information and communication technologies over traditional ones are obvious.

When analyzing the criterion for students attending the course, it should be noted that classes are missed only for valid reasons and the indicator is at the level of 85-95%.

After analyzing the satisfaction of students with the classes and their organization with the appropriate questioning, we can conclude that classes using information and communication technologies, in particular the GeoGebra dynamic mathematics system, arouse high interest among students, since each class differs from each other in its uniqueness and variety of forms of conduct.

One of the means of information and communication technologies for teaching mathematics, recommended by the curriculum in mathematics for students in grades 10-11 of general education institutions (for classes of mathematical direction), is the GeoGebra dynamic mathematics system. The functionality of the program and powerful web support for GeoGebra users provide an opportunity to effectively use it when studying the vast majority of theoretical and practical materials of the main course of mathematics. The application of this program reveals to the student a large number of heuristic tools of a general nature, valuable for the mathematical development of the personality, used in the study and in the process of studying the following topics of mathematics.

We have conducted a study on the effectiveness of using GeoGebra in the implementation of means of finding solutions to linear programming problems. The study of the level of activity of students took place in traditional classes and in classes using information and communication technologies. An

increase in activity and an increase in the concentration of attention on the material is observed using the GeoGebra dynamic mathematics system.

The effectiveness of organizing the work of students in the classroom using information and communication technologies is confirmed by the results of the experimental study. The quality of knowledge, skills and abilities in mathematics in 80% of students is at a high and sufficient level, 50% of them develop professionally significant personality traits: independence, initiative, activity.

Analysis of the research results shows that the level of academic achievement of students increased 1.6 times, motivation – 1.4 times, the development of independence, activity, initiative – 1.2 times. For students who studied according to the traditional method, the corresponding indicators remained almost unchanged. This indicates that the proposed methodology of using ICT in the work of students turned out to be effective.

4. Conclusions

The obtained results of the study make it possible to consider that the developed methodology for using the GeoGebra dynamic mathematics system is correct, the tasks have been implemented, the goal has been achieved, the set of scientific conclusions obtained is important for the theory and practice of the development of pedagogical science. The implementation of the main provisions of the study is aimed at a qualitative transformation of the existing practice of using information and communication technologies. The substantiation and generalization of the results of the study of complex processes of mathematical training, the use of ICT on the tested model in accordance with the innovative principles of folding the complex prompted the identification of the leading link in the preparation of the student's personality, through which the influence of the evolutionary processes of structuring in the effective pedagogical activity of mathematical education of the future is carried out. The use of the GeoGebra dynamic mathematics system in the educational process makes it possible to speed up, facilitate, visualize the solution process, which makes it possible to dynamically vary the variables in order to understand the essential connection between them. In addition, the application of the program allows not only to streamline the heuristic search, but also to free up time for additional independent research in order to confirm the practical significance of mathematics and the need to study it.

Thus, the content of technical education, enriched with the use of information technologies, which is associated with the acquisition of such key competencies as social, communicative, informational, cognitive and special, will become much deeper and more meaningful if the following conditions are met:

- creating real conditions for the training of pedagogical personnel capable of taking an active part in the implementation of educational informatization programs;
- a significant increase in the level of professional and general humanitarian interaction between teachers and students due to the possibility of implementing joint projects, including telecommunications;
- implementation of continuous open education, when students can take an active part in organizing the learning process by choosing courses that are available at any time thanks to telecommunications;
- the emergence of qualitatively new conditions for the implementation of the student's creative potential by expanding the capabilities of traditional libraries and laboratories of the university through access to electronic libraries and virtual laboratories, to scientific, educational and other culturally and socially significant resources of the Internet;
- increasing the efficiency of independent work of students with traditional and electronic resources thanks to developed systems for self-control and support of feedback with the teacher.

Fulfillment of the listed conditions will contribute to the achievement of the main goal of modernization of education - improving the quality of education, increasing the availability of education, meeting the needs of the harmonious development of the individual and the information society as a whole.

It was found out that in the system of purposeful formation of educational and cognitive activity, information and communication technologies attract students to educational and professional types of activity and contribute in the future to a more effective formation of professional skills.

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