E-KURS „PODSTAWY GRAFIKI KOMPUTEROWEJ" W SERWISIE EDUKACJI NA ODLEGŁOŚĆ

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Adnotacja. Artykuł uzasadnia opracowanie elektronicznego kursu z podstaw grafiki komputerowej w serwisie edukacyjnym „Google Classroom", który zapewnia realizację zdalnej formy kształcenia bakałarzy w zakresie kształcenia zawodowego. Udowodniono celowość korzystania z platformy edukacyjnej Google Classroom (Cloud Oriented Learning Environment), która jest podstawą do nauczania online i monitorowania wiedzy studentów. Określono główne tryby pracy w systemie nauczania na odległość Google Classroom, za pomocą których krok po kroku śledzone są zadania, przeprowadzana jest ocena, wprowadzane są korekty i istnieje możliwość zintegrowanej oceny osiągnięć studentów. Na podstawie eksperymentalnej i badawczej weryfikacji skuteczności tego kursu ustalono, że stworzone środowisko edukacyjne poprawia komunikację w systemie „nauczyciel-student", proces nauczania staje się bardziej dostępny i efektywniejszy, co potwierdza wzrost jakości wiedzy studentów.

Słowa kluczowe: kształcenie zawodowe, E-kurs, nauczanie na odległość, grafika komputerowa, Google Classroom.

E-COURSE "BASICS OF COMPUTER GRAPHICS" POWERED BY THE DISTANCE LEARNING SERVICE

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Abstract. The article justifies the development of an e-course on the basics of computer graphics using the "Google Classroom" learning service, which provides the implementation of distance learning for training Bachelors of Vocational Education. The expediency of using the Google Classroom educational platform (cloud-based learning environment), which is a framework for online learning and monitoring student knowledge, is proven. The main operation modes within the Google Classroom distance learning system are determined, which assist in tracking task performance step by step, assessing, making adjustments; an option of integrated assessment of student achievement is available. By relying on an empirical study of course effectiveness, it was found that the designed learning environment improves communication in the teacher-student system, and the educational process becomes more intelligible and effective as it appears from the advancement of students' knowledge.

Key words: vocational education, distance learning, computer graphics, e-course, Google Classroom.

ЕЛЕКТРОННИЙ КУРС «ОСНОВИ КОМП'ЮТЕРНОЇ ГРАФІКИ» В СЕРВІСІ ДИСТАНЦІЙНОГО НАВЧАННЯ

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Анотація. У статті обґрунтовується розробка електронного курсу з основ комп'ютерної графіки в сервісі навчання «Google Classroom», який забезпечує реалізацію дистанційної форми навчання бакалаврів професійної освіти. Доведено доцільність застосування освітньої платформи Google Classroom (хмаро орієнтоване навчальне середовище), що є основою для онлайн-навчання та моніторингу знань студентів. Визначені основні режими роботи у системі дистанційного навчання Google Classroom, за допомогою яких покроково відстежується виконання завдань, проводиться оцінювання, вносяться корективи і є можливість інтегрованого оцінювання досягнень студентів. На підставі експериментально-дослідної перевірки ефективності цього курсу установлено, що створене освітнє середовище покращує комунікацію в системі «педагог-студент», навчальний процес стає доступнішим і ефективнішим, що підтверджено підвищенням рівня якості знань студентів.

Ключові слова: професійна освіта, електронний курс, дистанційне навчання, комп'ютерна графіка, Google Classroom.

Introduction. At the present stage of development of Ukrainian higher education institutions, the search for diversified approaches and methods for improving the effectiveness of training remains essential. And the rapid progress of modern information and communication technologies, i.e., the Internet, ensures a transition to other training forms to improve the quality of the educational process.

The intensity of changes and approaches occurring in the research space impose specific requirements and ways for obtaining appropriate knowledge. One case is contactless education, which implies accessibility to study materials from any place and at any time and stimulates future specialists to pursue self-education and lifelong learning. At the same time, the use of modern information technologies, including distance learning, considerably amplifies traditional approaches to organizing the educational process in higher education institutions. On the one hand, the above is driven by the rapid evolution of information and communication technologies and hence the emergence of modern innovative pedagogical approaches to holding lectures and practical and laboratory classes. On the other hand, it is about the change of the very student who, according to current conditions, possesses personal qualities not inherent in senior students (Umryk, 2014: 82).

In domestic higher education institutions, the teacher and the student are the principal participants in the educational process. Therefore, the teacher, as a subject of professional activity, should organize the study of discipline in advance, conduct control over the educational process and, if required, adjust it in such a way as to achieve the maximum indicator of know-how and practical skills. As a result, the decision to develop and introduce the original e-course within the Google Classroom framework is considered pedagogically sound. It will contribute to the improvement and diversification of the professional training of future teachers in computer graphics and attract the attention of many those wishing to study graphic content. Relevance is also due to the fact that such a form of training arrangement has a clear focus and a certain set of important characteristics (openness, modularity, self-sufficiency, flexibility, parallelism, accessibility, and continuousness), which maintain the thorough and conscious study of the educational material in the discipline "Basics of Computer Graphics". The mentioned components will primarily contribute to academic mobility, advance performance, make it possible to allocate time, form spatial imagination and critical thinking, and stimulate the search for creative ideas to solve specific professional tasks.

Analyzing the recent trends in the development and use of modern information technologies in education, it can be said that many scientists have professionally dealt with specific aspects: T. Herliand, A. Hurzhii, M. Zhaldak, M. Kademiia, Ye. Polat, Yu. Ramskyi, O. Spirin, S. Yashanov, and others. Among foreign specialists, it is worthwhile to mention J. Piper, N. Mentzer (Mentzer, 2013: 95), P. Fisser, M. Fillips (Phillips, 2020: 19).

As for the course concerned, it is important to note that methodological aspects of teaching computer graphics are covered in scientific contributions by M. Baker, H. Veselovska, I. Herasymenko, O. Hlazunova, S. Horobets, O. Kepko, S. Reffold, O. Slobodianiuk, and N. Chumak. At the same time, T. Basiuk, D. Kozhushko, I. Maliakova, V. Osadchyi, O. Shevchenko, and others were actively studying technological capabilities and problems of computer graphics.

It is essential to mark that S. Nowell (Nowell, 2014: 123) and N. Mayer (Maiier, 2017: 102). in their scientific developments, support the course's introduction to modern teaching methods, namely, the application of innovative Internet technologies in education. Bykov's opinion that distance learning technologies, which maintain and ensure distance education (DE), are among the most recent educational technologies, which have been emerging at the end of the 20th century and became widespread in advanced economies remains relevant. There was the redistribution of the global educational space where DE played a leading role by significantly diversifying the educational services market (Bykov, 2008: 142).

Problems and prospects for the development of scientific principles of distance learning were studied by researchers with various expertise: O. Andreiev, O. Voronkin (Voronkin, 2016: 191), O. Hlazunova, V. Kukharenko (Kukharenko, 2002: 28), N. Morze (Morze, 2001: 42), V. Oliinyk, O. Rybalko, Ye. Smyrnova-Trybulska (Smyrnova-Trybulska, 2007: 243), and A. Khutorskyi.

Based on research findings by O. Romanovskyi, O. Kvasnyk, V. Moroz, N. Pidbutska, S. Reznyk, V. Shapolova, amd A. Cherkashyn, "the intensity of manifestation of individual determinants of development of distance education was analyzed, and essential advantages and disadvantages were identified (Romanovskyi, 2019: 42). The practical application of distance learning technologies in education was the focus of the scientific attention of foreign scientists: G. Rambl, K. Harry (Harry, 2018: 26)12, F. da Costa, A. Pelissari, and I. Gonzalez (Gonzalez, 2018: 135)13.

At the same time, it was investigated the basic capabilities and characteristics of top contactless educational services, which assist in organizing and arranging the training of specialists in higher education institutions. The relevant data was analyzed in publications (Smyrnova-Tribulska, 2007: 240)10 which dealt with the Moodle platform, (Pappas, 2022: 2) – eFront, (Demida, 2011: 107)15 – ATutor.

It goes without saying that every year there will appear innovative services for distance learning. Moreover, the number of e-courses and the degree of their adaptability in HEIs will increase. However, as of now, no unified system that firmly designs the individual trajectory and meets the student's academic ability and goals given academic needs. Therefore, the topic of the present scientific article is of immediate interest and requires an in-depth study.

Research purpose. Development, testing, and implementation of the e-course "Basics of Computer Graphics" for training future vocational education teachers within the Google Classroom framework.

To achieve the article's goals, the following methods were used: theoretical (analysis of the state of educational process organization by using electronic courses based on different distance learning services; search for cross platforms for their introduction into the system of training future teachers; study of Ukrainian legislation, instructional and psychological-pedagogical literature), empirical (talks with participants to the educational process).

Research results. Our analysis established that learning materials prepared for "Basics of Computer Science" are quite hard to master using traditional teaching methods and means. Thus, considering the structure and content of the subject matter, it is expedient to test new approaches to compensate for time consumption and achieve maximum efficiency.

The creation of the e-course "Basics of Computer Graphics" commenced in Google Classroom. This was driven by the ideas of M. Clarà and E. Barber (Clarà, 2013: 136) under which "the cooperation and teamwork of the course participants are crucial components of distance learning. The service aims to facilitate the dissemination, use, and classification of tasks and enhance performance by exchanging information between the teacher and the student.

The introduction of the electronic course "Basics of Computer Graphics" within the distance learning service took place in teacher training universities (Dragomanov Ukrainian State University, Pavlo Tychyna Uman State Pedagogical University, Rivne State University of the Humanities, Ternopil Volodymyr Hnatiuk National Pedagogical University, and Drohobych Ivan Franko State Pedagogical University), where undergraduate students (vocational education/digital technologies) studied. The participants were 364 students and 17 lecturers. The principal training stages comprised:

– arrangement of appropriate engineering support, development of training
– materials and programs and their adaptation to a remote form;
– analysis of relevant distance learning services for elaborating and implementing the e-course;
– selection of the Google Classroom service as one of the most accessible and optimal in the educational environment;
– designing an electronic database of study materials; study of students and teachers to work in the system.

Therefore, the curriculum of specialty 015 "Vocational Education. Occupational Safety" consists of 6 ECTS credits for mastering the discipline "Basics of Computer Graphics".

Guided by the appropriate program, the formation of professional competencies in computer graphics in future HEI teachers and achievement of their key learning outcomes require the awareness of types, features, purpose, benefits, and drawbacks of using computer graphics involving basic parameters of computer images, the principles of creating raster and vector graphic images; methods of image processing in raster and vector graphics editors, skills to use the means of input and output of graphic information; organization principles and types of color models, the concept of graphic file formats, their main characteristics and transformations; skills to edit, mount, retouch photos using different means of artistic design; application of various effects and properties to the text; skills of color correction of photographs, creation of raster and vector images from graphic primitives, formatting vector drawings, adjustment of their parameters and posterization, and application of computer animation.

To design the e-course, the principal stages are firstly arranged, and the content and structure are specified in Table 1, taking into account the educational and professional program and the particularities of training future VET teachers.

Table 1

Reduced plan for implementing measures to study of the discipline "Basics of Computer Graphics" using the Google Classroom distance learning service

№	Principal stages of tasks	
1	Names of modules and subjects	
	Theoretical basics of computer graphics	Graphics software. Graphic editors
	Computer graphics and its types	Adobe Photoshop. Basic operation, menu, and tools
	Color theory. Color modes and models. Image file formats	Work with layers, masks, and color correction
	Classification and capabilities of graphic file processing systems	CorelDRAW. Basic operation, menu, tools, and attributes
	–	Vector graphics editor. Technological capabilities
2	Practical and laboratory works. Raster graphics editor	
3	Practical and laboratory works. Vector graphics editor	
4	Assessment test	
5	End-off-course test	

Considering the above, let us clarify the course, which includes two comprehensive modules: "Theoretical basics of computer graphics" and "Computer graphics software. Graphic editors". The information volume of the first block comprises three topics, the first of which is theoretical and provides for the study of general basics and types of computer graphics. At the same time, the second one is aimed at testing the image's key characteristics, color modes and models. The coding process is also regarded as a modern segment in cultivating subject competencies in graphic training of future VET teachers. The third important topic implies the thorough study of graphics processing systems, their capabilities and classifications. Thus, the attention is focused on mastering different programs for technical processing of files by future specialists. It is worth noting that the module's specifics rely on knowledge gained by students when studying the disciplines of fundamental, natural scientific, professional, and practical training.

The second comprehensive block "Computer graphics software. Graphic editors" is an essential component of the electronic course. It helps students acquire practical knowledge of using graphic software programs crucial not only for solving applied professional problems but in the field of commercial image editing tools. Therefore, acquired skills within the module, which comprises four topics, justify the effectiveness of pedagogical training at higher education institutions. Following the list, it is necessary to be aware of the basic operation modes of both raster (Adobe Photoshop) and vector (CorelDRAW) graphics editors. The primary function of mentioned software products is dealing with two-dimensional computer graphics.

The structure of the electronic course envisages the co-dependencies of the aforementioned comprehensive modules on the skills they form. Such an organizational property involves obtaining systematic knowledge and providing students with comprehensive assistance and contains multi-faceted recommendations on the effectiveness of using graphics editors as intended.

According to the curriculum, we are going to specify how the course's content is filled and formed, and how the option of using distance learning is implemented. Putting such ideas into action took place in Google Classroom. Its functionality allows creating an infinite number of educational courses, organizing the study of fundamental disciplines in modern conditions, arranging and structuring high-quality content, and exchanging files with top information web resources or apps, etc.

In the software shell of Google Classroom, we introduced integrated electronic course "Basics of computer graphics". First of all, to use the distance learning service, students need to create a personal account that gives access to cloud services *GOOGLE WORKSPACE FOR EDUCATION* – a set of free adds provided by the Google company for educational institutions. One merely needs to take the following steps: log in to GMAIL (@gmail.com), download the browser, and acquaint oneself with Google applications. To do this, open a new tab and click on the app icon in the upper-right corner next to the account image. Move the mouse cursor to the "Class" icon and choose it in the opened context window (Fig. 1).

The electronic course has several constructive pages, such as "Class", "Tasks", "People", and "Marks". Such a sequence of structural components is user-friendly and convenient for studying various disciplines, including computer graphics.

The "Class" page (Fig. 2) conveys detailed information about the object concerned, which covers the discipline name, specialty name, courseware, curriculum, a list of lectures, and practical tasks for mastering the course in computer graphics by future VET teachers.

It is worth emphasizing that it allows providing feedback to every publication or discussing a particular problem. You can also follow an invitation, join video calls, etc. The service immediately renders s all updates while ensuring maximum efficiency and effectiveness of the educational process.

The "Tasks" tab gives students access to labs enshrined in "Basics of Computer Graphics" and contains a module test and one for evaluating knowledge, know-how, and skills (Fig. 3).

It goes without saying that software feature include feedback. In addition, students can sign up for the course on their own following an invitation sent to an email address or directly to social media as a link. It is appropriate to

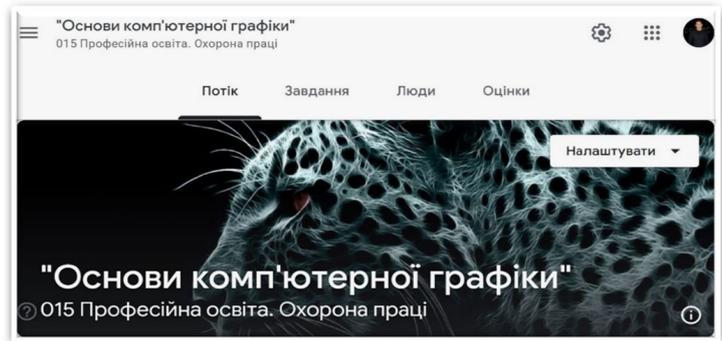**Fig. 1. Graphic representation of the login to the distance learning service**
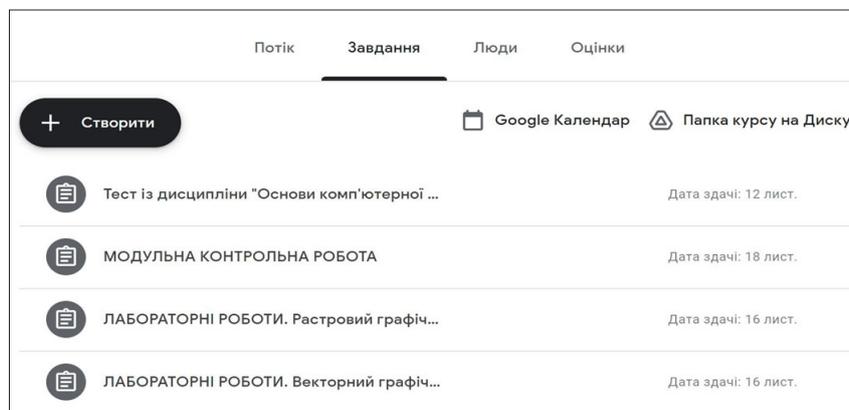

Fig. 2. Front view of the "Class" tab

Fig. 3. A fragment of the "Tasks" tab

check relevant information in the "People" tab, which contains general information about the persons involved in the study (Fig. 4).

Similarly, other subjects of teaching activities can use the service. Such a form of training students eliminates the learning process's monotony and ensures impartiality in evaluating the mastered material. The involved teachers are allowed to take the same measures as the author, except for deleting the course itself. To assess the knowledge of the discipline "Basics of Computer Graphics", the final test was made up, the results of which are shown in the diagram (Fig. 5).

The service's particularity is an option to calculate the number of correct answers and construct a chart conveying the distribution of marks gained by students. Upon test completion, statistics analyzing any respondent's answer are available. The test consists of thirty subject-related questions, and the maximum mark, which is eventually counted, is 10 points.

The program's capability deals with "complicated" questions, which are most often answered incorrectly. The advantage is that the system automatically generates false options and renders them as a histogram. Such property
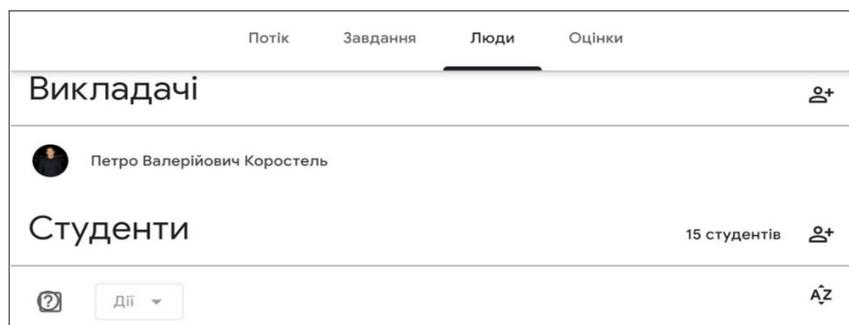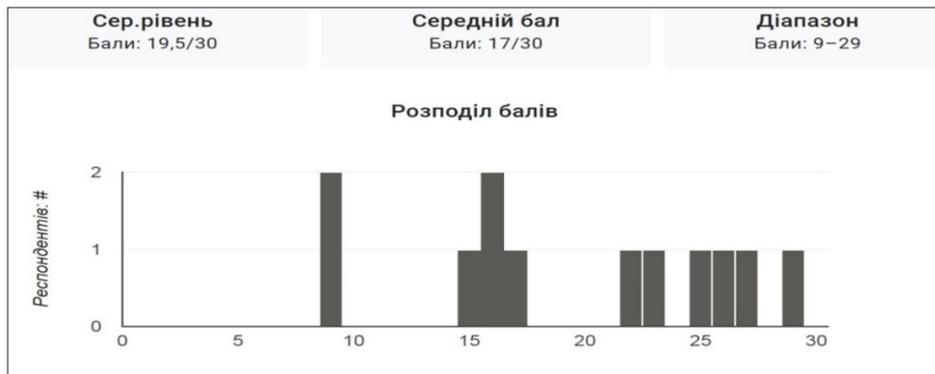

Fig. 4. An image of the "People" tab

Сер.рівень	Середній бал	Діапазон
Бали: 19,5/30	Бали: 17/30	Бали: 9–29

Розподіл балів

**Fig. 5. Test marks gained by students when mastering the academic discipline
"Basics of Computer Graphics"**

contributes to understanding what should be firstly taken into account and demonstrates the actual proficiency of future VET teachers in graphics. At the same time, students' learning outcomes "Basics of Computer Graphics" are available in the "Marks" tag (Fig. 6).

The points for every task are partially shown in the assessment form. The total score in percentage terms is calculated according to the 100-point scale. It is worth noting that the "Draft" page indicates shortcomings and incompleteness of task performance by students. In this case, the teacher sends files back complemented with their own comment in the relevant text box using a special form. Students subsequently receive a notification about the need to complete the task. The control test allows for an impartial evaluation of students' acquired knowledge and skills and adjustment of training requirements.

To test Google Classroom, experimental work was arranged, which made it possible to verify its effectiveness in the professional training of VET teachers that became a groundwork for developing an algorithm for introducing the service covering the following stages: preparatory, motivational, organizational, and practical (Fig. 7).

Experimental verification occurred within the training system designed for Bachelors of Vocational Education at the following institutions: Dragomanov Ukrainian State University, Pavlo Tychyna Uman State Pedagogical University, Drohobych Ivan Franko State Pedagogical University, and T.H. Shevchenko National University "Chernihiv Colehium". It **involved 132 students and 6 teachers** who were divided into two groups. The first group ("A", experimental) comprised students whose academic activity envisaged using Google Classroom to master the e-course "Basics of Computer Graphics". Another group, "B", studied the discipline in a "traditional way", that is, without applying the specified service. The performance analysis according to the ECTS scale is displayed in the diagram (fig. 8, 9).

Analyzing results of the groups, it is noticed a significant improvement in the knowledge of students from the experimental group after introducing the relevant course. The numerical dynamics of the A and B groups are shown in (table 2).

After analyzing the table, it is evident an increase in the number of A marks and a substantial decrease in the number of low ones. It is important to highlight that in the A group, positive results were achieved under optimal indicators of time spent on training. There was also a substantial increase in student motivation for the specific form of education.

Потік	Завдання	Люди	Оцінки		
		12 лист.	18 лист.	16 лист.	16 лист.
		Тест із дисципл…	МОДУЛЬ НА…	ЛАБОРАТ ОРНІ…	ЛАБОРАТ ОРНІ…
Загальна оцінка		з 10	з 10	з 40	з 40
60%		6	6 Чернетка	31 Чернетка	28 Чернетка
88%		5	9	34	40
87%		5	8	36	38
73%		10	8	30	25

Fig. 6. A partial image of the "Marks" tab

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┌─────────────────────────────────────────────────┐
│      Google Classroom Distance Learning Service   │
└─────────────────────────────────────────────────┘
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┌──────────────────┐   ┌──────────────────────────────────┐
│   Preparatory   │ ◄──   │ Analysis of various means, needs, │
└──────────────────┘   │ and resources. Implementation   │
                            │ program   │
                            └──────────────────────────────────┘

┌──────────────────┐   ┌──────────────────────────────────┐
│   Motivational   │ ◄──   │ The system of special incentives; │
└──────────────────┘   │ creation of a positive atmosphere;│
                            │ definition of service advantages │
                            └──────────────────────────────────┘

┌──────────────────┐   ┌──────────────────────────────────┐
│   Organizational │ ◄──   │ Criteria, requirements and levels │
└──────────────────┘   │ of material support, experience   │
                            │ analysis   │
                            └──────────────────────────────────┘

┌──────────────────┐   ┌──────────────────────────────────┐
│   Practical   │ ◄──   │ Formation of competencies for   │
└──────────────────┘   │ studying the course via Google   │
                            │ Classroom   │
                            └──────────────────────────────────┘
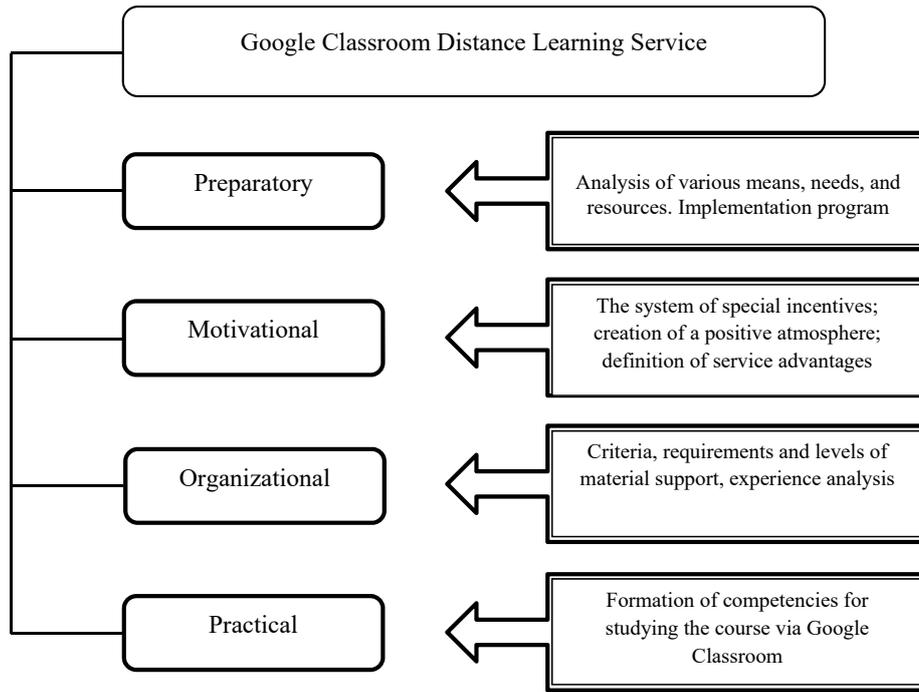
Fig. 7. Schematic representation of the implementation stages and their characteristics
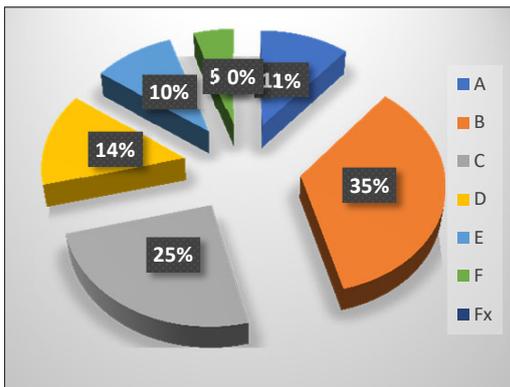
Fig. 8. Learning outcomes of the "A" group

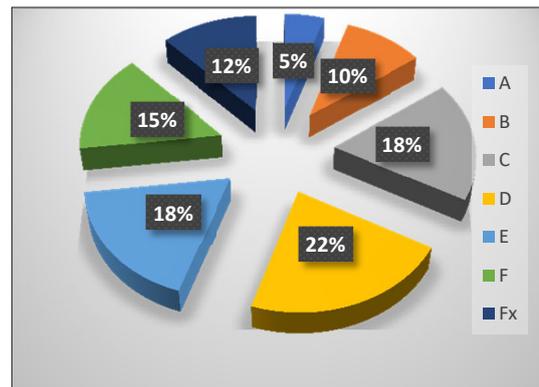**Fig. 9. Learning outcomes of the "B" group**

Table 2

Group	Knowledge level													
	Excellent A (90–100)		Good						Satisfactory				Fail	
			B (80–89)				C (70–79)		D (65–69)		E (60–64)		Fx (35–59)		F (1–34)	
	N	Mark	N	Mark			N	Mark		N	Mark	N	Mark	N	Mark	N	Mark
A_{exp} 15 persons	2	100	5	89	88	89	4	79	78	2	69	1	64	–	–	1	34
		99		88		89		78	79		69						
B_{Trad} 15 persons	1	90	1	86			3	77		3	65	3	64	2	54	2	34
								79			65		63				
								73			67		61		48		32

It is worth mentioning that students were highly motivated to study e-course, and works submitted for review contained much fewer errors than before. We believe that it happened because students did not have contact with the teacher and hence were on their own and more carefully dealt with the provided learning material, which was sufficient for obtaining knowledge of the course qualitatively.

The quality of the knowledge obtained in the experimental group is substantiated. Thus, the average score for the course is 79.46 (≈80), that is, the level of the acquired skills and know-how in the discipline "Basics of Computer

Graphics" is equivalent to the "good" mark. It is 15.6% higher than in the "B" group, where the same indicator was only 63.86 (≈64).

Consequently, the present study justifies that the organization of the educational process involving the distance learning service is highly beneficial. In addition, the effectiveness under such context is confirmed by marks obtained by Bachelors of Vocational Education during two examination periods (83% – "excellent", 17% – "good") and defense of their graduation theses in June 2022: 74.8% of graduate students got "A", 25.2% – B. The average mark was – 4.8 and thus, absolute and quality assurance – 100%.

Conclusions and perspectives for further research. Based on the analytical-critical study of scientific and methodological literature, it was elaborated the e-course for the academic discipline "Basics of Computer Graphics", which is intended for Bachelors of Vocational Education. The introduction of digitalization to the system of training workers, and thus VET specialists, envisages the advancement of a computer graphics component.

The advantages of the educational environment involving a cloud-based Google Classroom service amidst distance learning are outlined.

According to the educational-professional training program for teachers of vocational education in the field of digital technologies, the structure and content of basics of computer graphics are validated.

Experimental and research verification of the implementation of the course of computer graphics using Google Classroom into the educational process confirmed the positive dynamics of student performance (qualitative indications increased by 15.6%), which proves its efficiency.

Prospects for further research involve extending the electronic course with video and audio materials, detailed development of individual modules and tasks, and improvement of the distance platform's interface with additional tabs.

The next step will include examining the experience of using foreign training management services, the organization of their operation, and available tools, methods, and forms of training.

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