The use of ICT in learning ESP by pre-service teachers of Mathematics in the wartime

O uso de tecnologias de informação e comunicação no estudo do inglês para fins específicos por futuros professores de matemática em tempos de guerra

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Abstract

O estudo trata do problema do uso das Tecnologias de Informação e Comunicação (TIC) no processo de aprendizagem de Inglês para Fins Específicos (IFE) por futuros professores de matemática. O objetivo do estudo é a justificativa teórica, o desenvolvimento metódico e a verificação experimental da tecnologia de aplicação de TIC para aumentar o nível de competência comunicativa em língua inglesa orientada profissionalmente no processo de aprendizagem da disciplina de inglês para fins específicos por futuros professores de matemática em condições de guerra. Com base na análise da literatura científica foi dada uma definição e foram desenvolvidas competências comunicativas em língua inglesa orientada profissionalmente, critérios multinacionais de actividades criativas e seus níveis (baixo, médio, alto), o que permitiu verificar o nível da competência comunicativa em língua inglesa profissionalmente orientada de futuros professores de matemática antes e depois do treinamento experimental. Foi desenvolvida e testada a tecnologia de utilização de ferramentas TIC no processo de estudo do IFE, foram dados exemplos de utilização de ferramentas TIC em aulas de inglês online e analisados os resultados da formação experimental de futuros professores de matemática. Os resultados do estudo confirmaram a hipótese de que o nível de competência comunicativa na língua inglesa profissionalmente orientada de futuros professores de matemática aumentará, se no processo de ensino à distância de IFE e as ferramentas TIC forem usadas de acordo com a tecnologia educacional desenvolvida.

Keywords: Uso de TIC. Inglês para Fins Específicos (IFE). Futuros professores de matemática. Tempo de guerra. Competência comunicativa em inglês profissionalmente orientada.

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Abstract

The research addresses the use of information and communication technologies (ICT) in English for Specific Purposes (ESP) learning by pre-service mathematics teachers in Ukraine. The study aimed to provide theoretical justification, methodological development, and experimental verification of the application of ICT. It aimed to enhance the pre-service mathematics teachers' professionally oriented English communicative competency (POECC) in ESP learning during wartime. The definition of POECC was based on a scientific literature analysis. The criteria for POECC were motivational, cognitive, operational, and creative, with three levels each (low, medium, and high). The authors developed and tested the use of virtual resources and digital tools in the process of learning ESP. They also provided examples of how ICT can be used in online English classes. The study evaluated the level of development of pre-service mathematics teachers' POECC before and after experimental training, and analyzed the results of the training. The study confirmed the hypothesis that the development of pre-service mathematics teachers' POECC level would increase during ESP online learning, even in wartime conditions, if virtual resources and digital tools were used in accordance with the developed educational technology.

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Keywords: ICT. ESP. Pre-service mathematics teachers. Wartime. Professionally oriented English communicative competency.

1 Introduction

The urgency of improving the professional training of modern teachers is determined by new social conditions. Special importance is attached to the preparation of professionals for foreign language communication. It should be noted that foreign language proficiency is a key condition for processing information sources, research, improving professional education, professional interaction with foreign colleagues, as well as student and teacher mobility. The opportunities for modern teachers to improve their professional training are significantly reduced without proper foreign language training. Improper foreign language training limits their access to foreign information sources, and their ability to work with computer technologies that require foreign language programs and editors. Learning foreign languages aims to enhance an individual's self-awareness and self-identification of an individual through the enrichment of experience, and understanding of cross-cultural and linguistic differences (Europe. Modern Languages Division, 2001)

Currently, a foreign language is an essential component of the overall teacher training system. Its purpose is to assist pre-service teachers in mastering their specialty as a fundamental aspect of their professional competency. The main objective of English for Specific Purposes (ESP) learning is to cultivate an individual who can coexist with representatives of different languages and cultures, for the purpose of self-development and self-realization. Therefore, it is essential to teach foreign language communication in professionally significant situations, rather than simply as a sign system with a set of typical phrases. In the process of ESP acquisition, pre-service teachers develop the level of professionally oriented English communicative competency (POECC). The concept of POECC refers to the ability and readiness of pre-service mathematics teachers to engage in professional communication in English. It includes the active and practical use of English to express opinions related to their professional activities.

Taking into consideration the war is ongoing in Ukraine, the following peculiarities of teaching a foreign language to prospective teachers shall be highlighted:

1) distance learning, which involves synchronous and asynchronous forms of remote online learning; 2) the number of English classes is limited by the program, and at the same time there are high requirements for mastering a foreign language at the end of the course; 3) different IQ levels of applicants entering a non-language pedagogical institution of higher education; 4) implementation of the specific course "English for professional communication" in the training program of pre-service teachers of mathematics.

During the war caused by Russia's aggression against Ukraine, all Ukrainian educational institutions were compelled to switch to remote online learning. While this allowed students to continue their studies regardless of their location, it also gave rise to new educational challenges. Therefore, the development of new approaches to remote online learning became crucial. Online language learning has led to the development and implementation of various virtual resources, digital tools, and technologies for their use. The use of information and communicative technology (ICT) tools has become essential for successfully mastering a foreign language.

Therefore, the implementation of remote online learning due to the state of war in the country compels educators to seek methods, forms, and tools, including ICT, that would facilitate the acquisition of ESP and the development of POECC.

The *aim* of this study is to develop and experimentally verify the technology of ICT use to enhance POECC of pre-service mathematics teachers in remote online learning of ESP in the wartime. The study *hypothesizes* that the level of POECC development of pre-service teachers of mathematics will increase if ICT tools are used in online ESP learning in accordance with the developed educational technology.

2 Theoretical Background

POECC refers to the ability to effectively use English language skills in a specific professional context or field. It goes beyond general language proficiency and focuses on the specialized language, terminology, and communication strategies relevant to a particular profession or industry. This type of competency enables individuals to communicate accurately and fluently in English within their professional domain, whether it be business, healthcare, engineering, or any other field. It involves not only linguistic skills but also an understanding of the cultural and contextual aspects of communication within a specific professional setting. POECC requires expertise in English, subject-specific knowledge, and adherence to the norms and rules of the English-speaking professional community. Additionally, it requires the ability to conduct independent educational activities (Dmitrenko, 2020).

The goals and learning outcomes of POECC are determined in two areas. Firstly, the motivational and personal-value sphere reflects the social and personal characteristics of pre-service mathematics teachers, including their abilities, interests, awareness, and desire for improvement and development. Secondly, the cognitive sphere contains knowledge of the content essence of POECC and includes the ability to effectively solve various problems in professional English communication. The operational (psychomotor) sphere involves demonstrating competency in various situations and developing a set of skills and abilities. The creative sphere reflects the personal and creative qualities of pre-service mathematics teachers, including their capacity for creative thinking and readiness for professionally oriented English communication (Dmitrenko *et al.*, 2020).

Integrative relations between the study of mathematics and English for Specific Purposes (ESP) aim to improve knowledge in mathematics and develop the language skills necessary for professional practice. ESP involves the study of basic and specialized terminology, the formation of practical language knowledge and skills, and the preparation of students to apply professional knowledge to solve various tasks in foreign language practice.

Egloff and Fitzpatrick (1997, p. 2) highlighted the importance of considering the individual's wishes and motivation when learning foreign languages for professional purposes. This includes language needs in both professional training and practice, as well as personal everyday life. It also fosters an interest in foreign language communication in professional practice. Trim (1997) states that learning English for professional purposes is a complex and dynamic process that involves various factors such as goals, content, methods, and the roles of teachers and students. This process requires changes in language learning content and methods, such as a focus on communicative methods, which play a crucial role in personality development and cognitive skill enhancement. Additionally, the use of ICT in the learning process is also important.

The use of ICT tools in foreign language learning has been extensively studied by scholars. Ebadi and Goodarzi (2017), Hsu (2017), Jalali and Dousti (2014), and Oz (2015) have all confirmed the significant role of ICT in foreign language learning, as well as the positive attitude of English as foreign language students towards computer-based language learning (CALL). Yao (2016) reported that students had a positive attitude towards learning English through the Internet. (Hsu, 2017) found that students had a favorable attitude toward the use of e-textbooks in foreign language lessons. Alshabeb and Almaqrn (2018) demonstrated that ICT played a prominent role in EFL learning. Furthermore, Sutherland, Armstrong, and Barnes (2004), Rosa (2016), and Awada, Burston, and Ghannage (2020) have revealed the benefits that teachers could gain from the use of ICT in English classes. (Røkenes; Krumsvik)'s ((2016)) research has also shown that ICT could assist teachers in achieving pedagogical goals and have a positive impact on students' speaking and foreign language skills. In their (2018) study, (Lai; Hu; Lyu) investigated the experiences of students learning foreign languages outside of the classroom, as well as the factors that affect distance learning. Similarly, Lee and Dressman (2018) explored the issue of digital foreign language learning, with a focus on form and content and its impact on foreign language communicative competency.

Janowska (2017) described the use of electronic accounts, emails, online forums, and communication chats for foreign language classes. Budiman (2020) explored students' engagement with a foreign language teacher's educational website. Huzairin, Gede, and Bambang (2020) studied the use of smartphones in online EFL classes. Janowska (2017) studied the use of podcasts in online foreign

language classes, while Gałan and Półtorak (2019) described methods for working with electronic dictionaries in such classes. Nocentini, Zambuto, and Menesini (2015) investigated the possibilities of diversifying online foreign language lessons through the use of interactive computer games and provided recommendations for introducing game-based learning elements. Carrió-Pastor and Skorczynska (2015) examined the effect of educational games and interactive tasks on the enhancement of students' listening, speaking, reading, and writing skills in online foreign language lessons.

The analysis of educational and methodological studies has led to the generalization that the use of ICT tools in ESP learning has positive effects. The use of authentic materials in language teaching has several benefits, including motivating learning, enabling teachers to apply an individual approach, promoting the development of students' independence, increasing awareness of foreign languages and cultures, improving language competency through exposure to various types of texts, offering up-to-date and relevant learning material that meets the interests and needs of students, and providing an opportunity for students to check and self-check their acquired knowledge, skills, and abilities.

The implementation and use of ICT in ESP classes can be effective and helpful as technical visual and auditory aids. It is important to note that these benefits are objective and supported by evidence. They can also serve as auxiliary tools for the educational and cognitive activities of students. Additionally, they can increase students' motivation for ESP learning and provide a quick and effective means of assessing and controlling their knowledge, abilities, and skills.

Furthermore, the use of ICT in ESP learning can enhance interactive and communicative activities, promote individualized educational activities for students, optimize the assimilation of language structures and grammatical rules, and overcome the monotony of classes in the formation of POECC.

3 Methodology

The use of ICT virtual resources and digital tools in ESP classes during wartime has been studied through analysis of scientific and methodological literature. This has allowed for the development of an educational technology that can be implemented at all stages of the learning process. Both in preparation for classes and during the learning process, the specified technology can be used for explaining new material, fixing errors, repeating information, checking for understanding, correcting mistakes, and summarizing learning material. This approach allows for the principles of activity, interactivity, and a dialogic style of education to be employed, while also combining individual and group work. Additionally, it helps to maintain students' psychological comfort, optimize the process of ESP learning, and develop students' POECC. The ICT tools presented can be used to engage and motivate students in online classes, diversify visual aids, and create interactive educational materials for whiteboards. Despite the challenges of wartime and remote learning, resources such as Skype, Blogger, Teams, and Zoom enable the organization of individual group work, communication with students, creation of various tasks, and automatic evaluation of their completion. The described platforms have several advantages, including the ability to use free versions, accessibility from different browsers and devices, and an easy-to-understand interface that demonstrates the tool's capabilities. A variety of content and formats, including tests, quizzes, puzzles, crosswords, games, mind maps, and diagrams in Kahoot, Quizizz, Quizlet, Learning Apps can help to prevent the monotonous repetition of typical exercises. Students can create their own organizers and bookmarks using tools such as Padlet, Evernote, and Pinterest. Effective visual aids for presenting learning material include Canva, Prezi, Maze, and Row Toon. The online platforms Dropbox, Padlet, Pinterest, and Penzu enable users to share their work and ideas. Students do not always have access to a computer, so using platforms via mobile phones allows them to complete tasks anywhere and without special technical requirements.

3.1 Criteria

According to the theoretical analysis of the development of the POECC in the motivational, cognitive, operational, and creative spheres of the pre-service teachers of mathematics identified the following criteria: motivational, cognitive, operational, and creative. Due to the specified criteria, the development of POECC was assessed during the pre- and post-stages of the experimental training of using

ICT technology in ESP learning. Table 1 presents the main criterion characteristics and indicators.

Table 1. POECC development criteria (Dmitrenko, 2020).

Criterion	*Characteristics of the criterion*	*Indicators of the criterion*
Motivational	ensures involvement in professional activity. It represents the positive attitude toward pedagogical creativity, awareness of the importance of POECC, which is revealed in satisfaction with the teaching profession, a desire for self-education, and active participation in work.	the desire to acquire knowledge, and improve ESP skills; awareness of personal meaning and significance of professional self-improvement; formation and orientation of the need for POECC, self-education, and professional development; formation of motives; interest in ESP, intercultural knowledge, and skills; motivational interest in the chosen specialty.
Cognitive	is defined as a system of acquired knowledge and skills including purpose, principles, content, methods, techniques, and organizational forms of educational activities.	the completeness, correctness, and quality of the application of theoretical knowledge; the ability to select, process, and systematize ESP information; experience in recognizing norms of professional expression; free use of the thesaurus of professional terms; understanding and producing English texts related to the specialty.
Operational	is the appropriate application of POEC ; as well as the ability to manage the educational process and one's own development.	the initiative, organization, self-discipline, self-control, productivity, the level of POECC, the presence of professional thinking, and the ability of self-education, etc.
Creative	describes the level of creativity and personal qualities of pre-service mathematics teachers, as well as their ability to think creatively, develop, analyze, and assess their readiness for professional activities in English for Specific Purposes (ESP).	the ability to structure the process of solving educational tasks, outline the stages; correlate methods with types of tasks; self-control and adjust further activities; compare expected and obtained results; correlate practical experience and theoretical information.

Source: (Dmitrenko, 2020).

Based on the given criteria, the pre-service teachers of mathematics were classified into three levels of POECC development: low, medium, and high (Table 1).

In the process of implementing developed technology, virtual resources, and digital tools were used in the experimental ESP online training of pre-service teachers of mathematics.

In order to provide free access, a resource center of teaching materials intended for use by students was created. It was placed on a separate page of the teacher's website "English for Students of Mathematics". The site page contained placement tests, current and intermediate control tests; thematic texts, speech and language exercises; texts on specialty for annotation and summary; an electronic manual; additional materials: an English-Ukrainian mathematical dictionary, examples of reading mathematical expressions, tips for writing annotations and summaries, tips for choosing and using learning and communication strategies, etc. (Figure 1).

The created e-textbook allowed the students to 1) practice professional lexical skills; 2) carry out current control of the understanding of the content of the text on the specialty; 3) communicate using the learnt professional vocabulary; 4) discuss educational and professional problem situations; 5) prepare public speeches on a number of professional issues; 6) search for new textual, graphic and audio professionally oriented English information and analyze it; 7) write professional letters and documents in English (Figure 2).

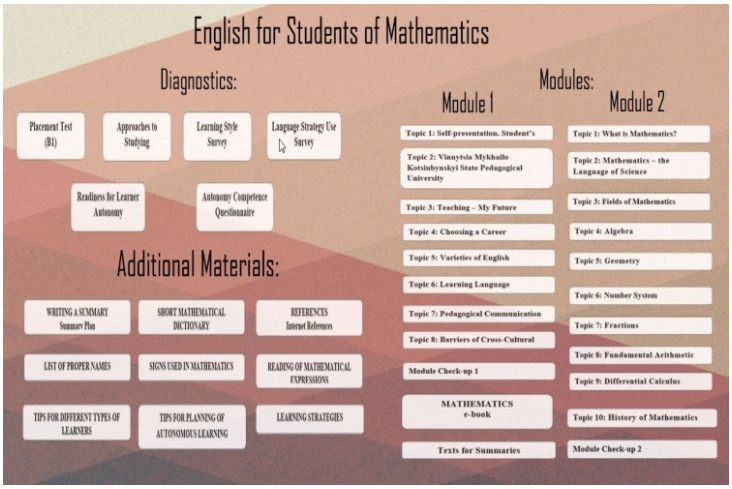
Various applications have been used for interactive online ESP classes. For example, the universal designer of interactive tasks LearningApps.org was used to support the ESP learning process with the help of interactive modules. Both the teacher and the student could create interactive tasks based on ready-made templates. Such verification and consolidation of the students' knowledge in a playful

Table 2. POECC development criteria (Dmitrenko, 2020).

Criterion/Level	*Low level*	*Medium level*	*High level*
Motivational	The student may not fully appreciate the personal and social importance of professional activity in ESP. They may not feel a strong need for it and may even view it negatively. As a result, they may only engage in ESP professional activity when required and may not demonstrate long-term commitment or independence.	The student is aware of the importance of professional activity in ESP formation of professional qualities, and willingly participates in it, shows positive emotions, quite active and independent in solving typical tasks but often requires a teacher's help.	The student clearly expresses persistent interest in ESP professional activity, eagerly participates in it, shows responsibility, strives for independence and leadership, and actively shows positive emotions.
Cognitive	The student has a limited understanding of ESP, recalling only basic concepts from memory and often misunderstanding their essence. They possess some ideas about the structure and methods of ESP professional activity, but these are not fully developed.	The student demonstrates an understanding of the role of ESP professional activity and possesses the necessary knowledge to explain, retell, and provide specific examples. However, there are some inaccuracies in their application of this knowledge when performing typical tasks.	The student has a fairly fluent command of terminology, can give accurate definitions and characteristics of concepts, clearly distinguishes the activity stages, passes existing knowledge, and applies it in new conditions to perform atypical tasks.
Operational	The student is partially aware of the content of ESP professional activity and its operational composition, begins to carry it out, can report on his / her actions but cannot organize his / her actions without outside help, and cooperates with others quite successfully.	The student consciously and independently performs previously learned ESP professional activity in a typical situation and knows how to identify the inconsistency of a new task and a learned way of acting.	The student performs ESP professional activities quite fluently, is aware of each step, critically evaluates his / her actions at all stages, and can change a well-known method of action or build a new one to perform a non-typical task.
Creative	The student uses the semi-patterned activity and the primitive tools, stays within the given or initially found method of action, and does not see alternative ways of performing the task.	The student looks for alternative solutions in a typical situation, independently combines known methods, analyses the task conditions, and is ready to describe the cause of difficulties or a new method.	The student freely applies acquired knowledge and a method of activity in non-standard situations, offers alternative ways of solving tasks, and reasonably chooses the optimal one.

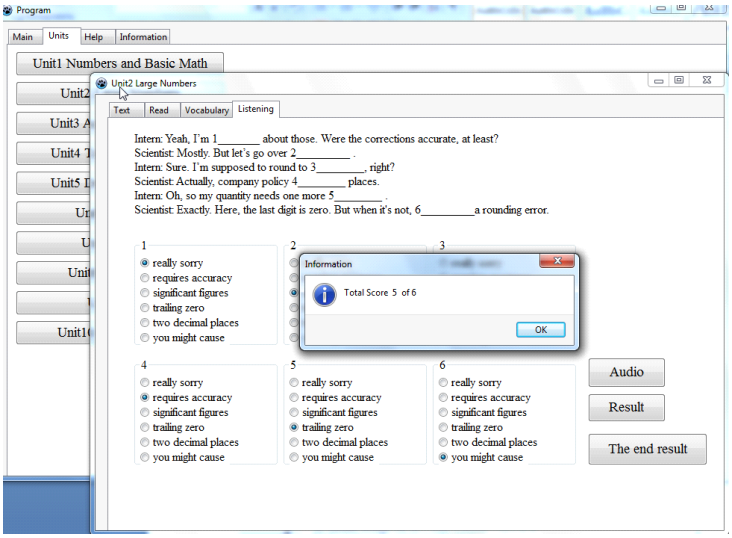
Source: (Dmitrenko, 2020).

Figure 1. Website page of ESP for pre-service teachers of mathematics.



Source: (Dmitrenko, 2020).

Figure 2. Screenshot of the page (listening to the dialogue) of the e-textbook "Mathematics".

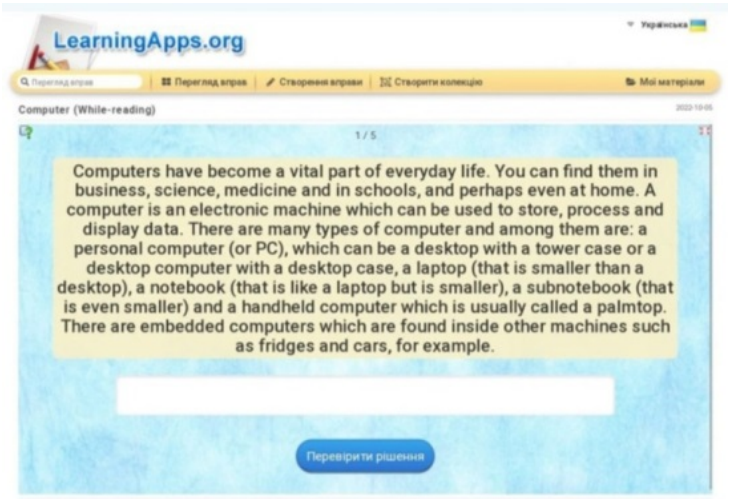


Source: (Dmitrenko, 2020).

way contributed to the formation of their cognitive interest in the ESP educational component. The service included a gallery of publicly available interactive tasks in English and all learning materials might be posted publicly or for private use. An effective mobile web-based learning application for ESP classes Quizlet was used to study and repeat lexical and grammatical material with the help of self-made flashcards, which contributed to the rapid assimilation of English training material. The Quizlet Live application allowed students to check the quality of the learned lexical material in an individual or group format. The Kahoot!, was used to create tests, games, and quizzes and is freely accessible from any browser on any device with internet access. The teacher could create (or use a database of ready-made ones) interactive tests, lead discussions, and present other learning materials. Some examples of applications for creating exercises are presented below.

Example 1. The purpose of the exercise is to acquaint students with the typical features of using computers, to check the level of understanding of the text, and to read silently (intensive reading). Instructions: "Follow the link. Read the first paragraph of the text and write the title. Check the correct answer by clicking on the button 'Check your answer'. Click on the arrow and move to another paragraph. You have 15 minutes to do this" (Figure 3).

Figure 3. An example of an exercise in the application Learning Apps.



Source: (Dmitrenko, 2020).

Example 2. The exercise aims to check the level of understanding of lexical items from the text. Instructions: "Follow the link. Match the word with its definition. While doing the task, you will see the timer which will count the time you have to complete the exercise. If you choose the wrong answer, the time will be doubled. The person who completes the task the fastest gets the highest score" (Figure 4).

Example 3. The purpose of the exercise is to check the level of reading comprehension and text analysis. Instructions: "Take your mobile phone and follow the link (https://kahoot.it/). Ask your teacher for the code, enter it and your name. On the teacher's screen, you will see the fact about computers and two sentences with red and blue colors. Read the fact and choose the right color for yourself on the phone. If you already know the fact, then you are doing great. If you don't know the fact, then explain what exactly you want to discover about it. The one who shares the opinion the most of all will get the highest score" (Figure 5).

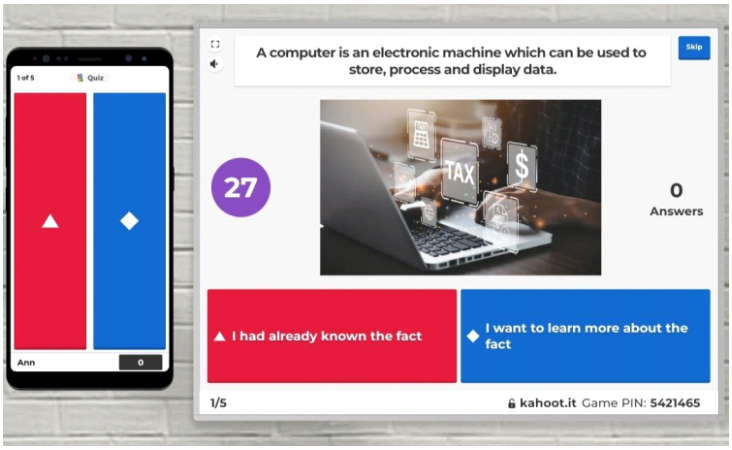
3.1.1 Participants

The pre-service teachers of mathematics were divided into two homogeneous groups: the control group (CG) – the formation of POACC under usual conditions and the experimental group (EG) – the formation of POACC under the influence of an active pedagogical factor – with the use of virtual resources and digit tools. The participants of the study were second-year students of the specialisation "Secondary Education. Mathematics", and "Mathematics" at the Faculty of Mathematics, Physics

Figure 4. A sample of an exercise in the Quizzlet application.

Source: (Dmitrenko, 2020).

Figure 5. An example of an exercise in Kahoot!



Source: (Dmitrenko, 2020).

and Computer Sciences, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University. The total number of participants was 100 students, 50 participants in CG and EG respectively. The experimental training was carried out during one semester (17 weeks), and the ESP classes were held twice a week. The ESP classes were held synchronously online and lasted 80 minutes. Students were informed about the goals, tasks, and conditions of experimental training and participated voluntarily.

3.1.2 The Study Stages

The study on the appropriateness of using ICT technology in ESP learning by pre-service teachers of mathematics consisted of three stages. The task of the *first* stage was to measure the level of development of the POECC of pre-service teachers of mathematics in EG and CG at the beginning of the experimental training. The task of the *second* stage was to carry out the actual experimental training of ESP in EG using the developed technology of ICT with virtual resources and digital tools, and traditional training (without ICT tools) in CG. The task of the *third* stage was to diagnose and compare the level of development of POECC of pre-service teachers of mathematics in CG and EG after the introduction of an active pedagogical influence factor, namely, the educational technology of using ICT in ESP learning.

3.1.3 Instruments

The students' level of POECC was measured at the beginning and after the experimental training (pre- and post-phases). The test was administered to the students to assess the development of POECC according to the following learning outcomes, which included 4 parts: 1) knowledge of basic English professional terms; 2) the ability to translate professional texts; 3) the ability to analyze the content of English professional sources; 4) the ability to listen and understand the oral professional speech.

The evaluation was carried out by experts (English teachers) on a 100-point scale for four components: knowledge of basic English professional terms, translation of professional texts, content analysis of English professional sources, and the ability to listen to oral professional speech. Each component was evaluated in terms of 25 points. The maximum level of development of each component was estimated at a maximum of 25 points; the possible minimum was 1 point. The total score for all components determined the level of development of the POECC of pre-service teachers of mathematics: a low level – from 4 to 40 points; an average level – from 41 to 74 points; and a high level – from 75 to 100 points. The assessment was carried out according to the methodological recommendations of a group of experts.

The initial part of the test assessed the participants' understanding of fundamental mathematical terms in English. The task required the translation of fifty English terms, with each correct answer being awarded two points. The second part of the test evaluated the students' ability to translate professional English texts from English into Ukrainian. Students were given to read and translate an English professional text on a mathematical topic. The third part of the test assessed students' capacity to analyze professional English sources and select the appropriate section for further detailed study, analysis, and use in pedagogical practice. The fourth part of the test evaluated students' ability to comprehend spoken English in a professional context. They were required to listen to a professional English text and translate it into Ukrainian.

To assess group homogeneity and result reliability, we performed statistical processing on the data using Pearson's χ^2 test. We calculated the empirical value using the formula:

$$X^2_{emp} = N.M. \sum_{i=1}^{L} \frac{(\frac{n_i}{N} - \frac{m_i}{M})^2}{n_i + m_i} \tag{1}$$

- N and M represent the numbers of EG and CG members respectively.
- The i-th level of pre-service teachers' readiness for ESP online learning was demonstrated by the number of EG and CG members.
- The variable L represents the quantity of chosen levels.
- The data was processed using the Microsoft Excel 2019 program.

4 Results and Discussion

Table 3 presents the general results of determining the level of development of POECC of pre-service mathematics teachers in CG and EG based on the described criteria, including motivational, operational, cognitive, and creative aspects.

Table 3. Levels of development of POECC of pre-service teachers of mathematics at the pre-and post-stages of experimental training.

Levels of development		Criteria							
		Motivational		Operational		Cognitive		Creative	
		CG	*EG*	*CG*	*G*	*CG*	*G*	*CG*	*G*
Low level	N	26	27	21	20	22	20	29	30
	%	52	54	42	40	44	42	58	60
Average level	N	19	19	23	25	21	24	17	16
	%	38	38	46	50	42	48	34	32
High level	N	5	4	6	5	7	6	4	4
	%	10	8	12	10	14	12	8	8
Total	N	50	50	50	50	50	50	50	50
	%	100	100	100	100	100	100	100	100

Source: Own elaboration.

The analysis of the results obtained from both the EG and CG showed a generally low level of students' knowledge of professional English terminology, as well as their ability to translate professional English texts and comprehend oral professional speech. The students lacked both professional foreign language skills and basic listening skills. However, the results also indicated an average level of the students' ability to analyze professional English sources. The students were able to understand the English content, but they struggled to comprehend it as a whole.

The analysis of the results of establishing the level of development of POECC of pre-service mathematics teachers in CG and EG showed no significant statistical difference. 11% of CG prospective teachers and 9% of EG future teachers demonstrated a high level of POECC development, while 40% (CG) and 42% (EG) demonstrated an average level, and 49% (CG) and 49% (EG) demonstrated a low level.

The χ^2 criterion was used to determine statistical significance (with 2 degrees of freedom and a significance level of $p < 0.05$). The critical value,χ^2_{cr}, was found to be 5.991, while the empirical value, χ^2_{emp} , was 0.468. As $\chi^2_{emp} < \chi^2_{cr}$, the null hypothesis H_0 was accepted, indicating that there was no statistically significant difference in the level of development of POECC between pre-service teachers of mathematics in the CG and EG and that any differences observed were likely due to chance. It has been concluded that the difference in results between the EG and CG at the beginning of experimental training was statistically insignificant ($\chi^2_{emp} < \chi^2_{cr}$). The results obtained indicate that there were no significant differences in the level of development of POECC between the pre-service teachers of mathematics in the CG and EG.

Therefore, the assessment of pre-service mathematics teachers' level of development in terms of their knowledge of basic English professional terms, translation of professional texts, analysis of the content of English professional sources, and ability to listen to oral professional speech indicated a low or average level of proficiency in English for Specific Purposes (ESP). The study confirmed the necessity of adjusting the training program by incorporating the use of ICT tools in the development of POECC for pre-service mathematics teachers. The insufficiently formed level of POECC among pre-service mathematics teachers may be related to their low awareness of the potential of using English information resources in ESP online classes.

During the experimental training, CG students followed the traditional ESP training program and curriculum, while EG students were taught using virtual resources and digital tools.

Following the experimental training, a final test of ESP proficiency was conducted for both groups according to four criteria. The experts conducted an assessment using a 100-point scale for four components, graded similarly to the beginning of experimental training. The level of development of POECC among pre-service mathematics teachers after experimental training (post-stage) was evaluated based on motivational, cognitive, operational, and creative criteria. Table 4 presents the results of the dynamics of the development of POECC levels of pre-service mathematics teachers according to motivational, cognitive, operational, and creative criteria.

Table 4. Generalized comparative analysis of the levels of POECC development of pre-service teachers of mathematics.

Levels of development of POECC	Test of ESP proficiency before experimental training				Test of ESP proficiency after experimental training			
	CG		G		CG		G	
	N	%	N	%	N	%	N	%
Motivational criterion								
Low	26	52	27	54	24	48	21	42
Average	19	38	19	38	21	42	22	44
High	5	10	4	8	5	10	7	14
Operational criterion								
Low	21	42	20	40	19	38	16	32
Average	23	46	25	50	26	52	26	52
High	6	12	5	10	5	10	8	16
Cognitive criterion								
Low	22	44	20	40	23	46	17	34
Average	21	42	24	48	21	42	25	50
High	7	14	6	12	6	12	8	16
Creative criterion								
Low	29	58	30	60	28	56	22	44
Average	17	34	16	32	18	36	20	40
High	4	8	4	8	4	8	8	16

Source: Own elaboration.

The results indicate a positive change in the level of POECC development of pre-service mathematics teachers in the experimental group (EG) compared to the control group (CG). Specifically, the percentage of pre-service mathematics teachers with a low level of POECC decreased to 11% in the EG, while the percentage of those with an average level increased to 4.5% and those with a high level increased to 6.5%. Although the positive changes were not significant, they were statistically large enough to be noticed. The results demonstrate that the use of ICT in ESP learning significantly contributed to the development of pre-service mathematics teachers' POECC. It is evident that POECC development is a long process, and only minor positive changes were observed during the one-semester study.

To ensure the reliability of the results, we formulated the null hypothesis (H_0) that the difference in the levels of POECC development of pre-service mathematics teachers in the control group (CG) and experimental group (EG) was statistically insignificant. The alternative hypothesis (H_1) stated that the difference in the levels of POECC development of prospective mathematics teachers in the CG and EG was statistically significant and reliable. The statistical criterion χ^2, as per eq. (1), was used to evaluate the homogeneity of groups.

The critical value of the criterion was 5.991 with 2 degrees of freedom and a significance level of $p < 0.05$. The empirical value was calculated to be $\chi^2_{emp} = 9.156$. The criterion was used to determine the statistical significance of the difference in the levels of POECC development of pre-

service teachers of mathematics in the CG and EG. As χ^2_{emp} was greater than χ^2_{cr}, the null hypothesis H_0 was rejected. This indicates that the difference in the levels of POECC development between the two groups was statistically significant and had a regular character.

The statistical analysis of the data from EG and CG revealed that the difference between the values before and after the experimental training in EG was significant, while the difference between the pre- and post-training data in CG was insignificant (refer to Table 6).

The comparative result analysis of the averaged indicators of the levels of POECC development is shown in Table 5.

Table 5. Comparative analysis of the average indicators of the levels of POECC.

Levels of development of POECC	before experimental training		after experimental training	
	CG	*G*	*CG*	*G*
	%	*%*	*%*	*%*
Low	49	49	47	38
Average	40	42	43	46.5
High	11	9	10	15.5
Total	100	100	100	100

Source: Own elaboration.

The results indicate a positive change in the level of POECC development of pre-service mathematics teachers in the experimental group (EG) compared to the control group (CG). Specifically, the percentage of pre-service mathematics teachers with a low level of POECC decreased to 11% in the EG, while the percentage of those with an average level increased to 4.5% and those with a high level increased to 6.5%. Although the positive changes were not significant, they were statistically large enough to be noticed. The results demonstrate that the use of ICT in ESP learning significantly contributed to the development of pre-service mathematics teachers' POECC. It is evident that POECC development is a long process, and only minor positive changes were observed during the one-semester study.

To ensure the reliability of the results, we formulated the null hypothesis (H_0) that the difference in the levels of POECC development of pre-service mathematics teachers in the control group (CG) and experimental group (EG) was statistically insignificant. The alternative hypothesis (H_1) stated that the difference in the levels of POECC development of prospective mathematics teachers in the CG and EG was statistically significant and reliable. The statistical criterion x^2, as per **??**, was used to evaluate the homogeneity of groups.

The critical value of the x^2 criterion was 5.991 with 2 degrees of freedom and a significance level of $p < 0.05$. The empirical value was calculated to be $x^2_{emp} = 9.156$. The x^2 criterion was used to determine the statistical significance of the difference in the levels of POECC development of pre-service teachers of mathematics in the CG and EG. As x^2_{emp} was greater than x^2_{cr} , the null hypothesis H_0 was rejected. This indicates that the difference in the levels of POECC development between the two groups was statistically significant and had a regular character.

The statistical analysis of the data from EG and CG revealed that the difference between the values before and after the experimental training in EG was significant, while the difference between the pre- and post-training data in CG was insignificant (refer to Table 6).

The data revealed that, following experimental training, students in the experimental group (EG) demonstrated a higher level of development in the area of POECC than students in the control group (CG). This was not due to chance, but rather due to the advantages of implementing ICT in ESP learning by pre-service mathematics teachers. The study confirmed the hypothesis that the use of ICT in ESP learning is effective. The technology was developed and implemented in experimental training. Following the integration of ICT technology into education, there has been a noticeable improvement in the development of pre-service mathematics teachers' POECC. This is due to an

Table 6. x^2 Pearson test values.

Groups	The calculated value of x^2_{emp}	x^2_{cr} 0,05
Before the experimental training		
G and CG	0,468	5,991
After the experimental training		
G and CG	9,156	5,991

Source: Own elaboration.

increased focus on the ability to understand and translate professional English texts, analyze their content, and comprehend professional speech. It is important to note that these skills require a solid foundation in basic English professional terminology.

The obtained study results are consistent with previous research conducted by Sutherland *et al.* (2004), Awada *et al.* (2020), Røkenes and Krumsvik (2016) that proved the effectiveness of ICT use in ESP learning and its positive impact on English communicative competency. Rosa (2016), Gałan and Półtorak (2019) analyzed the digital English courses on educational platforms, which included all necessary learning materials and tools for checking completed tasks, and as well argued that the level of English proficiency increased in the case of ICT use in the ESP learning.

Due to the small sample size (N=100), the survey results cannot be generalized to the entire population. Therefore, this study should be considered as an exploratory investigation aimed at identifying possible issues and trends for further research.

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