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Development of mathematical competence as a key competence in English language teaching

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Abstract. The relevance of the study is conditioned to the need to explore new effective methods of implementing competence-oriented education while teaching English and forming key competences as a basis for learners' comprehensive development and successful integration into a fast-moving cross-cultural society. The purpose of the study was to substantiate the category "mathematical competence in English language teaching learning" and analyse the survey of English language teachers to determine its understanding among teachers of secondary educational institutions. General scientific and empirical methods, deduction, comprehensive analysis, and comparison facilitated achieving the set goals. Hence, this paper presents the research on implementing the competence-oriented strategy stated by the Law of Ukraine on Education in general and the features of developing mathematical competence in English language teaching/learning as a key one. The modern view on understanding the concept in scientific discourse was analysed, including considering mathematical competence as a subject-specific, key, and super-competence. Assuming that communication is one of the methods and ways of teaching the English language, the authors' vision of its definition regarding its development in the language learning was suggested. In addition, the survey of English language teachers was conducted and analysed and contradictions and problems in its comprehension and implementation among teachers were revealed: understanding the need to develop mathematical competence as a key one in teaching English; and the lack of methods and didactic materials for practical use at the English language lessons at secondary educational institutions. Furthermore, outlined prospects for future research in developing methods and efficient didactic materials for developing the mentioned competence and conducting an experiment to prove their effectiveness. These didactic materials also should comprise the psychological, linguistic, and lingua-didactic aspects, previously substantiated by the author of this paper, for developing mathematical competence as a key one in the process of teaching the English language

Keywords: comprehensive development; critical thinking; communicative problems; problem-solving; mathematical modelling; logical reasoning

INTRODUCTION

The relevance of exploring the development of mathematical competence within language teaching lies in the acknowledgment of education as pivotal for holistic individual development. Despite efforts to adopt a competence-oriented paradigm, substantial gaps persist, spanning from theoretical frameworks to practical application. Understanding and addressing the challenges identified, particularly regarding the clarity and applicability of mathematical competence, are essential steps towards enhancing language education practices. Therefore, this study aims to clarify the

concept of "mathematical competence in English language teaching/learning" and assess its implementation among secondary school English teachers, contributing to the advancement of competence-oriented language education.

Analysis of recent research and publications shows interest in the topic of study in scientific discourse. The fundamental problems of competence-oriented education in teaching language and mechanisms of overcoming are represented in papers (Goroshkina, 2022). Thus, N. Golub (2021) outlined that the development of key competences requires implementing of many processes, including understanding, demonstrating, applying, proving, promoting, utilising, applying, evaluating, choosing, substantiating, constructing, developing, etc. T. Polonska (2021) substantiated conceptual principles of competence-oriented foreign language teaching, the aims, tasks principles, and approaches. V. Redko (2023) explored the aspects of forming the key competencies in foreign language teaching, accentuating that competence-oriented foreign language teaching is a polyfunctional lingua-didactic system that aims to develop comprehensive personality, including strategic abilities to communicate in a foreign language and to maintain appropriate communicative behaviour in various situations of speech interaction. In addition, many researchers explored mathematical competence and its specifics. Scientists M. Niss & T. Højgaard (2019) conducted fundamental research on the mentioned category in teaching mathematics and relevant subjects and substantiated its constituent competencies, particularly communication, which is important for this study. In contrast, little attention was given to research methods for developing mathematical competence in English language teaching. There are also attempts to specify the mentioned phenomenon in Ukrainian language teaching by A.M. Romero (2021), a researcher specified the practical importance of mathematical competence in solving various real-life situations. In addition, L. Artemenko (2024) emphasised the methodological value and the necessity of developing a system of didactic tools for forming mathematical competence as an integral component of linguistic personality. Z. Bakum & A. Neguliaieva (2023) overviewed some theoretical aspects of the mentioned concept and developed its structure: motivational and value, cognitive, activity and communicative, and evaluative and reflexive components. I. Goroshkin (2019; 2020) defined the main problems of developing the mentioned concept as a key competence in language teaching/learning: its limpidness and situational basis. The purpose of this study was to substantiate the category "mathematical competence in English language teaching/learning" and analyse the survey of English language teachers to determine its understanding among teachers of secondary educational institutions.

MATERIALS AND METHODS

The study was based on reviewing modern scientific publications of Ukrainian and foreign scholars regarding the problem of competence-oriented foreign language teaching. General scientific methods, deduction, analysis, and comparison were used to shed light on the features of the development of mathematical competence as a key one in English language teaching. The comparison revealed similar characteristics of the research concept, including logical reasoning, critical thinking and problem-solving with educational and communicative purposes. An analysis of competencies, abilities and skills was used to define mathematical competence in English language teaching in secondary educational institutions as a basis for the comprehensive development of an individual. In addition, analysis of studies revealed the potential of mathematics to maintain communication in various educational and real-life situations, thus considering competency of mathematical communication as a fundament of foreign language interactions, and developing mathematical competence in English language teaching.

Furthermore, an anonymous survey was conducted in September 2023 at the secondary educational institutions of Kryvyi Rih city (8 participants), Kryvyi Rih Oblast (2 participants), and Kherson city (4 participants), involving 14 teachers. The survey aimed to diagnose the level of awareness among English language teachers regarding the development of mathematical competence during language teaching. The survey had several stages. Firstly, the questionnaire using Google Forms was created according to abilities and skills inherent to mathematical competence in language teaching. It included 12 questions with different options to respond to (multiple-choice, open-ended responses, and ranking definitions). Questions were formulated to specify teachers' awareness of the explored concept and its place among key competences, study their attitude towards the development mathematical competence in English language teaching, recognise appropriate skills and abilities inherent to the researched concept, and reveal the necessity of developing methods of forming mathematical competence in English lessons. Secondly, an online survey was carried out without a time limit for its completion. Then, comprehensive analyses of the result were used to diagnose the state of the problem and reveal possible contradictions. Mathematical methods and forms of representation of information were used to represent the survey results. The survey procedure in the study complied with ethical standards, did not violate the dignity of the participants, and followed the recommendations of the Declaration of Helsinki (2013). The results were published anonymously.

RESULTS AND DISCUSSION

Ukraine's education strategy is reoriented towards developing key competences necessary for each modern individual, their successful socialisation, and self-fulfilment. The affiliation of mathematical competence to one of the 11 key competences by the Law of Ukraine No. 2145-VIII "On Education" (2023) provides the possibility of using the potential and resources of the mentioned competence in teaching/learning the English language. However, it also creates a problem concerning its theoretical substantiation and

practical implementation in the language teaching/learning field. The idea that mathematical competence is fundamental is not only stated by Ukrainian Law. Thus, The National Curriculum in England (2014) includes statements on the development of learners' competence in numeracy and mathematics, which means the necessity to develop pupils' numeracy and mathematical reasoning so that they understand and appreciate the importance of mathematics, use every relevant subject to develop students' mathematical fluency. The programme for international student assessment (2022) also measures competence in 3 domain subjects, including mathematical literacy, which is an individual's capacity to reason mathematically and formulate, employ, and interpret mathematics to solve problems in various real-world contexts, ability to use mathematics knowledge and skills to meet real-life challenges, and the capacity of individuals to reason mathematically and solve various problems of 21st-century contexts.

Hence, there is no doubt that mathematical competence must be developed when teaching all subjects, not only mathematics-relevant ones, because its main purpose is to develop an individual's reasoning and ability to problem-solve in real life and the learning process. Defining the category "mathematical competence in English teaching" requires distinguishing the categories "competence" and "competency". Numerous scientists, including T. Polonska (2017), researched the mentioned issue. Overall, here are two approaches to understanding the relationship between these concepts. The first approach considers "competence" and "competency" to be identical and describes them as a skill or ability (The American heritage dictionary, 2022). The second one indicates the subordinate nature of the relations of these concepts: mathematical competency is a clearly recognisable and distinct principal constituent of mathematical competence (Niss, 2003). Adopting the second viewpoint it is considered that competence is the integrative quality of personality, which appears in some competencies, skills, and abilities. There is no common perspective of the discovered concept in scientific discourse. Thus, M. Holovan (2014) defines mathematical competence as an integrative development of personality that combines mathematical knowledge, abilities, skills, experience in mathematical activities, and personal qualities that lead to the desire, willingness, and ability to solve mathematical problems. O.V. Ovcharuk (2003) outlines the investigated competence as functional, which involves components of intellectual development, the ability to apply logic, mathematical knowledge and abilities, systemic thinking and the ability to solve complex logical and mathematical constructions, spatial ability, and modelling. O.V. Onopriienko (2016) also supports the idea that mathematical competence is a subject one. In addition, N. Rudnytska (2022) substantiated the importance of general and mathematical knowledge and experience of its utilisation, personal qualities that are essential for successful self-realisation.

An essential contribution to the investigation of mathematical competence was made by M. Niss (2003). According to the researcher, mathematical competence means understanding, judging, doing, and using mathematics in various intra- and extra-mathematical contexts and situations in which mathematics plays or could play a role and consists of eight competencies: thinking mathematically; posing, and solving mathematical problems; modelling mathematically; reasoning mathematically; representing mathematical entities; handling mathematical symbols and formalisms; communicating in, with and about mathematics; making use of aids and tools. Whereas communication is the main form and method of teaching/learning language, close attention was given to competency, "communicating in, with, and about mathematics". According to M. Niss (2003), this competency includes understanding others and expressing oneself in different mathematical forms about matters having such content. Thus, it means communication is held with the means of mathematical science and knowledge of different forms and ways of its expression. Exploring mathematical competencies, R. Turner (2010) outlines communication as one of them: it comprises incoming abilities of reading, decoding, and interpreting statements and mathematical information and outgoing skills of explaining, presenting, and arguing. The skills mentioned are necessary for all individuals and should be developed and used in teaching/learning languages (Ouyang *et al.*, 2021).

Recent scientific research on the development of mathematical competence in language education shed light on some aspects, L. Artemenko (2021) considers mathematical competence as a key one: person's innate mathematical skills and abilities acquired through knowledge in the learning process, which give a unique opportunity to find, using the laws of mathematics and logic, trustworthy solutions in thoughts and actions and implement them in practice for full self-realisation in society. In addition, the researcher proposes the formulation of mathematical competence in learning Ukrainian: a unique opportunity to study modern Ukrainian literary language standards using logical, algorithmic, and critical thinking for their correct application during speech activity and specified the practical importance of mathematical competence in solving real-life situations. The authors of this study agree with I. Goroshkin (2020) opinion, that in the current stage of scientific research mathematical competence is developed while acquiring a foreign language on the situational basis in the process of solving communicative and educational problems by the learners, for instance, while dealing with time concepts, amount, dates, prices, air temperature and has certain limitedness of its utilisation. However, to be an efficient, comprehensive development tool, mathematical competence should be developed regularly in learning/teaching the English language at educational institutions.

Summarising those mentioned above and adopting an attempt made by A.O. Neguliaieva (2022), the authors of this study define mathematical competence as the integrative quality of personality, which manifests in the ability to engage "mathematical communication competency"

effectively; the ability to build mathematical models of various situation of speech interaction; applying logical, mathematical, and critical thinking to overcome real-life problems in the process of learning English; to conduct critical analysis of information, one's own and others' statements, efficient use of mathematical tools, methods in language learning. Furthermore, competency of "mathematical communication in the teaching the English language" is considered to be the ability and readiness of learners to communicate with the means of mathematical science, to read and decode information with efficient utilisation of mathematical tools, methods, and forms in the process of English language communication, processing information through mathematical methods, solving problems in the process of speech interactions on a situational basis.

For a comprehensive investigation of the mentioned concept in secondary educational institutions, a survey among English language teachers was conducted. The survey results determined that 64.29% of teachers attribute mathematical competence as a key competency, while 35.71% consider it a subject-specific one. Moreover, the perceived necessity of developing the investigated competence varies across defined educational sectors (Fig. 1): 100% of respondents suggest that it is necessary to foster the investigated competence in mathematical, technological, and informational fields, 50% in natural and social (health-preserving) domains, 42.86% in civic and historical sectors, 35.71% see this necessity during the study of language and literature subjects, 21.43% in the artistic field, and 7.14% during physical education lessons.

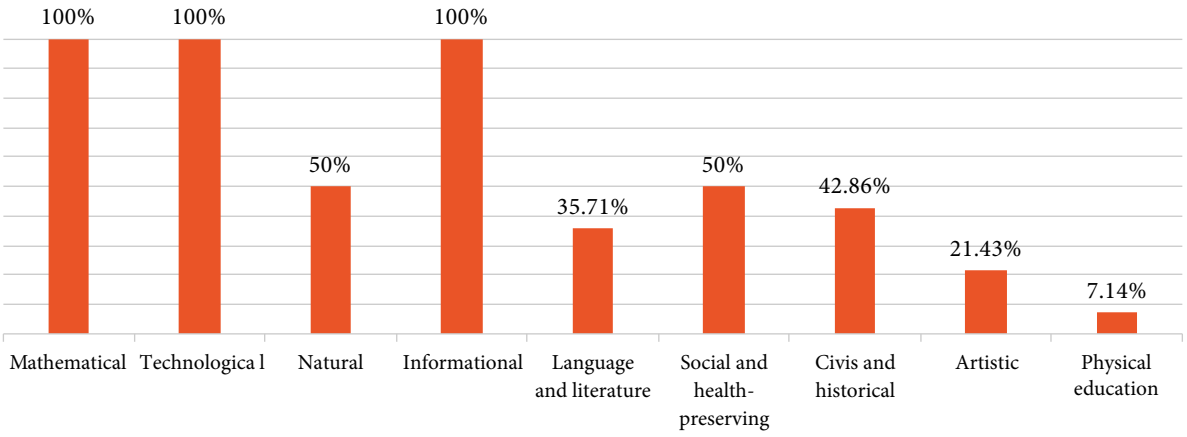

Figure 1. The necessity of developing mathematical competence in educational sectors (among the interviewed teachers)
Source: developed by the authors

The summary of responses regarding the frequency of using mathematical methods of representation of information in English language teaching is displayed in Figure 2. Accordingly, tables (71.43%) and diagrams (64.29%) are the most frequently employed formats, while respondents mainly did not indicate the use of timelines (71.43%), graphs (78.57%), charts (86.71%), and algorithms (92.86%) at their lessons.

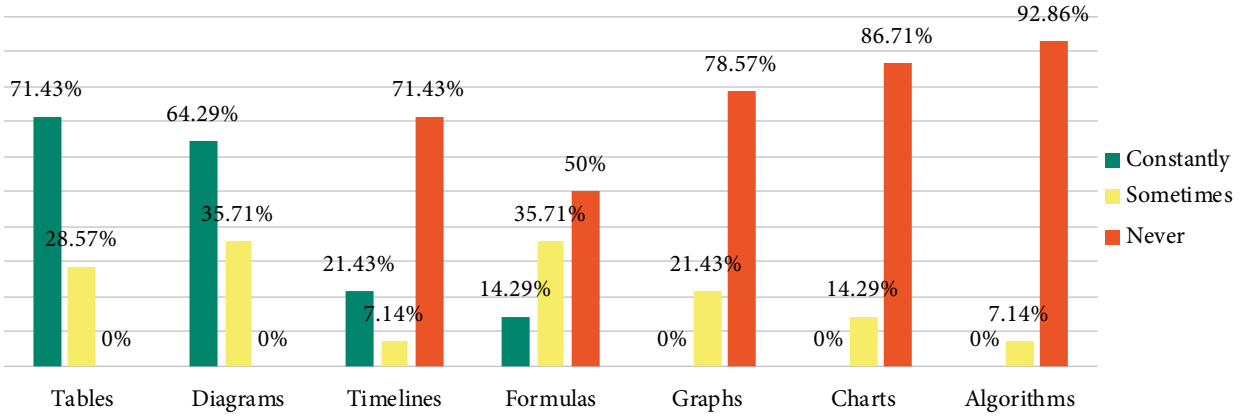

Figure 2. The frequency of using mathematical formats to present information in English language teaching
Source: developed by the authors

Respondents indicated (Fig. 3) that, for studying grammatical material, they choose to use rules – 100%, table format – 71.43%, diagrams – 64.29%, algorithms – 7.14%, formulas – 14.29%, and timelines – 21.43%. In

addition, according to the survey, a deductive approach predominates in grammar instruction: 100% of the respondents noted the use of deduction, while only 14.29% also employed induction when explaining grammatical material. However, using such formats as timelines, formulas, algorithms, and induction may become an efficient way to teach grammar, for instance, when teaching verb forms and tenses.

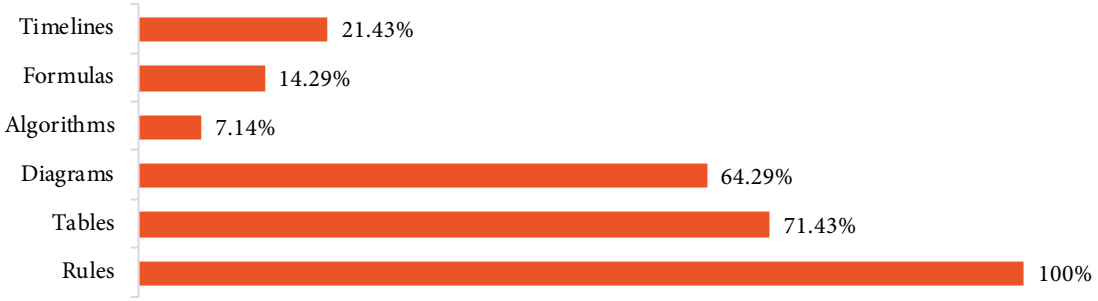

Figure 3. The frequency of using mathematical methods of representation of information in English language teaching
Source: developed by the authors

In response to the question: "Do you see advantages in developing mathematical competence among students in the process of English language teaching?" 78.57% of respondents chose the option "hard to say", 14.29% – "yes", and 7.14% – "no". Furthermore, 64.29% of those surveyed expressed a desire to use mathematical language, methods of representing information during the teaching of the English language, while 35.71% – "not decided". The analysis of responses to the question: "In your opinion, how will the use of learners' mathematical competence affect the quality and strength of English language knowledge?" is presented in Figure 4. The responses to the importance of developing specific characteristics, qualities, skills, and abilities in English language education are presented in Table 1. According to the obtained results, respondents believe that the most essential skills for learners in teaching/learning English include the ability to solve communicative (educational) problems (85.71%), draw conclusions (generalisations, systematisation) (78.57%), and compare (contrast) (71.43%). Meanwhile, the fewest respondents perceive the need for skills in mathematical modelling (14.29%) and the use of mathematical tools (28.57%).

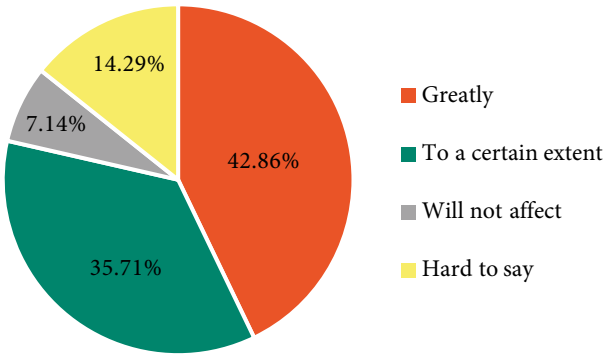

Figure 4. The impact of usage of mathematical competence on quality and strength of knowledge abilities and skills to communicate in the English language
Source: developed by the authors

Table 1. The importance of developing specific characteristics, qualities, skills, and abilities in English language teaching/learning

No.	Characteristics, qualities, skills, and abilities	Rating		
		Essential	Important to a certain extent	Not essential
1.	Compare and contrast	71.43%	21.43%	7.14%
2.	Analyse, distinguish between main and secondary	64.29%	35.31%	0%
3.	Draw conclusions, generalise, systematise	78.57%	21.43%	0%
4.	Solve communicative, educational problems	85.71%	14.29%	0%
5.	Creative approach to problem-solving	57.14%	21.43%	21.43%
6.	Represent a position in a mathematical format	28.57%	21.43%	50%

Table 1. Continued

No.	Characteristics, qualities, skills, and abilities	Rating		
		Essential	Important to a certain extent	Not essential
7.	Use mathematical tools in the process of teaching the English language	28.57%	21.43%	50%
8.	Explore various ways to complete tasks	50%	35.71%	14.29%
9.	Apply mathematical modelling	14.29%	21.43%	64.28
10.	Solve logical problems	14.29%	14.29%	71.42%
11.	Think logically	50%	50%	0%
12.	Expressing position with reasoning	71.43%	28.57%	0%
13.	Critical thinking	64.29%	28.57%	7.14%
14.	Conduct a critical analysis of own communicative activities and conversation partners	57.14%	42.86%	0%
15.	Self-reflection, self-analysis	78.57%	21.43%	0%

Source: developed by the authors

The overwhelming majority of respondents (92.86%) desired to learn more about mathematical competence and its formation methodology in teaching the English language, 7.14% – "not decided", and 0% – "do not have such readiness". Furthermore, among the reasons hindering the development of the investigated competence during language teaching/learning, 100% of respondents noted the absence of a corresponding methodology, and 71.43% mentioned a lack of time for preparation or insufficient didactic material. The results of responses to the question: "If you were provided with the necessary didactic materials and knew the corresponding methodology for developing mathematical competence, would you form it in English language teaching?" indicate the motivation of teachers to learn more about the researched issue: 92.86% answered "yes" to the question, 0% – "no", and 7.14% – "not decided".

Ukraine's educational strategy now emphasises the importance of mathematical competence as one of the key competencies necessary for modern individuals, aligning with international educational standards that advocate for its integration across various subjects, including language learning. This recognition poses both opportunities for enhancing English language teaching through mathematical reasoning and challenges related to its theoretical and practical implementation. Surveys among teachers highlight a keen interest in incorporating mathematical competence into language education, though they also reveal significant gaps in available methodologies and resources for doing so effectively. In summary, the integration of mathematical competence into English language teaching is seen as a key strategy for enhancing students' reasoning, problem-solving skills, and overall ability to apply mathematics in various contexts. However, the lack of established methodologies and resources presents a significant challenge to its practical implementation, pointing to a need for further research and development in this area.

CONCLUSIONS

This paper emphasises the problem of developing mathematical competence as a key competence while teaching foreign languages in secondary educational institutions. The current approach to understanding the researched concept was analysed, and its theoretical substantiation was suggested according to the specific features of language teaching, considering communication as a basis for successful teaching/learning English. Hence, mathematical competence is the integrative quality of personality, which comprises the ability to communicate with the help of mathematics in various communicative interactions while learning language, build mathematical models of real situations, utilise mathematical tools, methods, means and conduct problem-solving with the help of logical, mathematical, and critical thinking; critical analysis of own and others' opinions, conclusions, and statements in the process of teaching English. In addition, English language teachers were surveyed and contradictions and problems in developing mathematical competence in educational institutions in teaching the English language were revealed. These issues include the willingness to work in a specified area, a lack of corresponding methodology and didactic material, the necessity of developing specific characteristics inherent in the investigated competence, but with a lack of awareness of the importance of some of them, and insufficient use of mathematical methods and formats when explaining material (grammatical, lexical, and phonetical) in English language teaching/learning. Therefore, further prospects for research include creation of methods for developing mathematical competence in English teaching/learning in secondary educational institutions and practically experimenting with its effectiveness. While developing the mentioned methods and didactic materials, the survey's results and those previously substantiated linguistic, lingua-didactic, and psychological aspects should be considered.

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CONFLICT OF INTEREST

None.

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Формування математичної компетентності як ключової в навчанні англійської мови

Анотація. Актуальність дослідження зумовлена необхідністю пошуку ефективних способів реалізації компетентнісної парадигми навчання та формування ключових компетентностей як підґрунтя гармонійного розвитку учнів і учениць, успішного інтегрування в швидкозмінне крос-культурне суспільство. Мета статті полягала в обґрунтуванні математичної компетентності в навчанні англійської мови, здійсненні аналізу опитування вчителів англійської мови закладів загальної освіти щодо обізнаності окресленого питання. Задля досягнення поставленої мети використано наукові та емпіричні методи, дедукцію, комплексний аналіз, зіставлення. Відповідно, у статті представлено дослідження стану упровадження визначеної Законом України "Про освіту" компетентнісно орієнтованої стратегії освіти загалом і особливостей формування математичної компетентності як ключової в навчанні англійської мови. Проаналізовано сучасні підходи до розуміння математичної компетентності, які охоплюють витлумачення її як предметної, ключової та супер-компетентності. Зважаючи на комунікативну спрямованість навчання англійської мови, запропоновано визначення означеної категорії, яке ураховує специфіку її формування в мовно-літературній царині. Проведено та проаналізовано опитування вчителів англійської мови в ході якого виявлено протиріччя в розумінні досліджуваної категорії та її імплементації: визнання потреби формування математичної компетентності як ключової в навчанні англійської мови; та відсутність ефективної методики, дидактичного забезпечення для практичного її використання на уроках англійської мови в закладах середньої освіти. Окрім того, окреслено подальші перспективи наукових розвідок, які убачаються в розроблені і експериментальній перевірці методики формування означеної компетентності. Зазначені матеріали мають також ураховувати попередньо обґрунтовані психологічні, лінгвістичні та лінгводидактичні аспекти формування математичної компетентності як ключової у процесі навчання англійської мови

Ключові слова: гармонійний розвиток; критичне мислення; комунікативні проблеми; розв'язання проблем; математичне моделювання; логічне мислення