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OPPORTUNITIES FOR ENHANCING MATHEMATICAL COMPETENCE OF CHINESE FOREIGN STUDENTS IN UKRAINIAN HIGHER EDUCATION THROUGH LANGUAGE PROFICIENCY

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Abstract. This article explores issues related to enhancing the efficiency of teaching higher mathematics to foreign students, with an emphasis on the significance of interdisciplinary connections in the process. The scientific innovation of the article lies in scrutinizing the theoretical principles of a nationally oriented methodology designed to cultivate the mathematical competence of Chinese students using linguistic tools. Methodological approaches are justified by considering the primary distinctions between the Chinese and Ukrainian educational systems. Practical test results of this methodology in Ukrainian higher education institutions are presented, showcasing its efficacy in fostering mathematical competence among Chinese students. The author's nationally oriented methodology for developing mathematical competence is outlined, featuring examples of methodological techniques, tools, and forms. These include maintaining a working abstract, establishing a personal terminological dictionary, optimizing the use of visual aids, employing individual and group learning methods, considering psychological and pedagogical characteristics, implementing level differentiation, and customizing teaching approaches.

Keywords: mathematical competency; teaching higher mathematics; language preparation; international students

1. Introduction

The process of integrating foreign citizens into Ukrainian universities necessitates readiness to deliver educational services at a high professional

standard. Proficiency in language stands out as a crucial determinant for the success of foreign students' professional training, as it directly impacts their ability to attain comprehensive professional education in Ukrainian and facilitates the development of their professional skills.

Among foreign students learning the Ukrainian language, those from China encounter significant challenges, primarily due to substantial typological differences between the distant Chinese and Ukrainian languages. Notably, Chinese students tend to adopt a rational and logical learning style for foreign languages, unlike Arab or African students who often gravitate towards a communicative style. Furthermore, obstacles in learning may arise from differences in the psychological mindset between Slavic and Eastern personality types, as well as fundamental distinctions between educational systems.

Drawing on extensive experience in teaching foreign students, we observe that many first-year Chinese students often struggle to understand spoken Ukrainian and face difficulty comprehending lecture materials delivered in Ukrainian. Therefore, it is essential to consider these ethnopsychological and linguistic peculiarities when developing a nationally-oriented methodology for teaching foundational and specialized disciplines in Ukrainian, especially during the first year of university studies.

Higher mathematics serves as a fundamental cornerstone in the education of professionals across various disciplines in higher education. It contributes to the development of students' logical thinking and is essential for the study of mathematical, physical, information technology, engineering, and even certain psychological disciplines. The language of mathematics, the language of numbers, is universal, utilizing universally accepted symbols that are consistent worldwide. Educators must provide foreign students with the opportunity to understand that the language of mathematics in Ukraine is analogous to the language they learned in their home country.

2. Methodology

National-oriented teaching methodologies for foreign students studying professional disciplines in Ukrainian universities are currently a pertinent issue for Ukrainian educators. However, to date, only certain aspects of language and professional preparation of Chinese students in Ukraine have been explored in the works of scholars such as O. Palka (2003), Hu Zhunsi (2013), O. Vikhrova, N. Zinonos (2013), N. Tsisar (2014), V. Grutsiak (2015), L. Tulupova (2017), A. Kharchenko (2018), O. Karupu, T. Oleshko, V. Pakhnenko (2019), T. Leshchenko (2020), G. Onkovich (2022), N. Morgunova (2022), M. Komina (2023), and others. Several publications have focused on studying the peculiarities of mathematical preparation among foreign students but without specific emphasis on a particular national contingent – O. Fetisova (2014), A. Kozireva (2017), S. Kolpakova, O. Burdakova (2017),

T. Belova (2017), O. Prudnikova (2018), A. Vasilyeva (2019), T. Isaeva, O. Milovanovich (2020), and others.

The relevance of our article is also driven by the insufficient coverage National -oriented teaching methodologies for foreign students studying professional disciplines in Ukrainian universities are currently a pertinent issue for Ukrainian educators. However, to date, only certain aspects of language and professional preparation of Chinese students in Ukraine have been explored in the works of scholars such as O. Palka (2003), Hu Zhunsi (2013), O. Vikhrova, N. Zinonos (2013), N. Tsisar (2014), V. Grutsiak (2015), L. Tulupova (2017), A. Kharchenko (2018), O. Karupu, T. Oleshko, V. Pakhnenko (2019), T. Leshchenko (2020), G. Onkovich (2022), N. Morgunova (2022), M. Komina (2023), and others. Several publications have focused on studying the peculiarities of mathematical preparation among foreign students but without specific emphasis on a particular national contingent – O. Fetisova (2014), A. Kozireva (2017), S. Kolpakova, O. Burdakova (2017), T. Belova (2017), O. Prudnikova (2018), A. Vasilyeva (2019), T. Isaeva, O. Milovanovich (2020), and others.

The relevance of our article is also driven by the insufficient coverage in academic sources regarding the interdisciplinary connections in educating foreign students, particularly the perspectives that unfold for both instructors and students in the interaction between language and fundamental or professional disciplines in the education of Chinese students.

The aim of the article is to demonstrate the effectiveness of using a nationally oriented methodology to develop mathematical competence in Chinese students through linguistic means, specifically by fostering interdisciplinary interaction between instructors of higher mathematics and the Ukrainian language as a foreign language. To achieve this goal, several tasks need to be addressed: analyzing the peculiarities of teaching higher mathematics to foreign students, identifying the challenges faced by students, formulating possible pedagogical strategies, recommending methods and techniques for developing mathematical competence in Chinese students through language preparation during higher mathematics classes, and presenting the results of our pedagogical experiment.

In pedagogical science, there are various interpretations of the concept of "mathematical competence" depending on the context of research tasks undertaken by scholars. For instance, I. Zinenko (Zinenko 2009) considers it as a quality of personality that combines mathematical literacy and experience in independent mathematical activities. M. Holovan defines mathematical competence as an integrative formation of personality encompassing both mathematical and general knowledge, skills, abilities, experience in mathematical and general activities, and personal qualities (Holovan 2014). According to R. Turner, mathematical competence is a combination of a person's mathematical knowledge, skills, experience, and abilities enabling the successful resolution of various problems requiring the

application of mathematics (Turner 2010). M. Niss and T. Jensen define mathematical competence as the ability to understand, judge, perform, and use mathematics in various circumstances, attributing components such as mathematical thinking, problem formulation and solving, mathematical modeling, reasoning, and communication with and about mathematics to its composition (Niss 2002).

Summarizing these scholarly approaches, mathematical competence involves students' understanding of the role of mathematics in understanding reality, mastery of mathematical terminology, logical reasoning, justification of actions, ability to use symbolic and graphical information, problem-solving skills, the ability to assess the appropriateness of using mathematical methods for solving specific practical problems, formulate mathematical models, interpret results, analyze and evaluate significance.

Modern educational programs for the discipline "Higher Mathematics" in Ukrainian higher education institutions invariably include the study of determinants, matrices, systems of linear algebraic equations; vectors, lines in the plane and in space, planes, curves, and second-order surfaces; sequences and functions and their limits, continuous functions and their properties; derivatives and differentials of functions of one variable, calculation, and applications; functions of several variables and their properties, partial derivatives and total differentials, and applications; indefinite integral and basic methods of integration; definite integral, its calculation, and applications; first-order differential equations, types of their solutions, and Cauchy problems; basic integrated types of first-order differential equations, simplest higher-order differential equations, linear homogeneous differential equations of the second and higher orders with constant coefficients. Other sections of mathematics may also be included in the curriculum of the discipline "Higher Mathematics".

The main reasons for difficulties in the process of studying higher mathematics by foreign students are language barriers, differences in educational systems, and organization of the educational process. Inconsistencies in the knowledge base acquired by students in their home countries and the volume of knowledge required for successful study of this discipline in Ukraine can be identified. Teaching mathematics in secondary schools in different countries has certain peculiarities in some aspects. There are sections of elementary mathematics that may be entirely unknown to students or known in insufficient volume. Alongside this, students may have a significantly higher level of knowledge in other sections. The organization of teaching higher mathematics to foreign students is also associated with other difficulties, namely limited vocabulary, pronunciation difficulties with some mathematical terms, slow written representation of educational material, poor listening skills, insufficient availability of adapted educational and methodological literature for foreign students, varying levels of basic mathematical preparation among students.

Therefore, there is an apparent contradiction between the need for high-quality mathematical training for foreign students studying in Ukrainian and the insufficient development of specific teaching methodologies for them. It is crucial to consider the level of basic mathematical preparation of foreign students, differences in knowledge, skills, and abilities compared to Ukrainian students, as well as the gradual formation of mathematical competence in the Ukrainian language.

For teachers working with foreign students in the first year, addressing quite complex tasks is necessary: reorienting the knowledge already formed in a foreign student to the Ukrainian language and, with a minimum of language tools, solidifying entirely new scientific concepts in the student's consciousness. Therefore, classes in fundamental disciplines, including mathematics, should be based on principles of accessibility and assimilation.

Mathematical disciplines contain a large number of new concepts and terms, challenging to grasp even for native speakers, let alone foreigners. The choice of the language teaching method depends on the principle of forming educational groups. Teaching in groups where Ukrainian and foreign students study together is most challenging for educators. Working with a group of only foreign students allows the teacher to address specific difficulties that arise during the learning process. The most effective approach is teaching in groups formed based on ethnocultural characteristics, such as a group of Chinese students, for example.

The pace of teaching disciplines in study groups where foreign students study together with Ukrainians is oriented towards students studying in their native language, making it a challenging task for foreigners to keep up. Virtual resources, particularly lecture summaries presented as presentations, can be helpful in overcoming this. The availability of lecture presentations partially resolves the issue of foreign students taking notes, which we consider the most challenging task for them. Having the opportunity to familiarize themselves with future lectures and take notes in advance, foreign students can focus their attention on mastering new material during the lecture. After the lecture, if necessary, they can ask questions to the teacher. In case a student hasn't fully understood the material, they can independently review it at a slower, more comfortable pace for them.

The quality of knowledge acquisition by students is significantly influenced by the differences in methods, technology, and forms of organizing the educational process in different countries. Based on communicative and behavioral differences among representatives of various world regions, it is essential to consider ethnocultural features of foreign students' perception and processing of educational information, as well as their ethnocultural characteristics in communication with the instructor. For example, the ethnocultural communication features during educational sessions differ between students from China and Africa. In the culture of the former, the instructor is considered the sole source and bearer of fundamental knowledge, and only their opinion can be considered correct. In contrast, African

students typically express their own opinions on the studied phenomenon, with mandatory support for their views using real-life examples.

Since the focus of our article is on examining the peculiarities of developing mathematical competence through linguistic means specifically for Chinese students, we will concentrate on this group without drawing parallels with the learning characteristics of other ethnogroups of foreign students.

Let's consider some significant differences between the mathematical education systems in Ukraine and China. Mathematics is a key school subject in China, with 12 – 16 hours of classes dedicated to it weekly in high school. Even students in humanities need to master set theory, work with complex numbers, and use vectors, among other concepts. There is intense competition in Chinese secondary schools, driven by overcrowded classrooms (50 – 70 students per class). The 40-minute lesson duration in such large classes does not allow for the development of individual creative abilities. Daily tests, presented in the form of logic-based quizzes, lead to memorization rather than understanding of the material. Therefore, the educational activities of Chinese students rely more on mechanical memory rather than comprehension of the material.

Chinese teachers organize the educational process based on the principle of building new knowledge upon existing knowledge to promote students' understanding of the connection between new material and the previous one. This approach aims to help students master algorithms and develop the ability to flexibly apply acquired knowledge in various situations. While the teacher is allowed to transfer ready-made knowledge to the student, successful learning and memorization of the material in this case require the development and use of practical life situations (cases) in the educational process, leading to the application of mathematics in solving real-life problems. Practical skills are honed through numerous varied tasks with subsequent complexity.

Chinese students often play the role of passive knowledge recipients. Ukrainian teaching methodology, on the other hand, emphasizes active interaction between the teacher and students. However, the principles of cooperative pedagogy are new and unclear to the Chinese, who expect clear instructions and may not act in the absence of them. The democratic, creative communication model between the teacher and students faces resistance due to established Chinese stereotypes. Chinese students perceive the possibility of dialogue with the teacher as weakness and lack of authority, and attempts by the teacher to rely on feedback from students during material explanation are met with rejection and surprise (Hrutsiak 2015). Redirecting Chinese students to new learning strategies should be based on their national language teaching traditions – prioritizing reading and writing, systematic control, and dictionary use.

An effective way to work with Chinese students is to create a unified language environment through interdisciplinary coordination. In this approach, the Ukraini-

an as a Foreign Language instructor collaborates with teachers of fundamental and specialized disciplines. Interdisciplinary connections serve as a foundation for a comprehensive understanding of new knowledge, skill development, and the formation of abilities. They allow for the generalization and systematization of language and speech experience, ensuring the completeness of knowledge (Babich 2018). In our case, the interdisciplinary approach involves developing and implementing a system of exercises in higher mathematics classes aimed at developing mathematical competence using the Ukrainian language – integrating two academic disciplines within one lesson.

The principles of teaching higher mathematics to foreign students in Ukrainian include the principles of professional orientation, the activity of the individual, invariance of mathematical competencies regarding the language of instruction, and the principle of visual representation, i.e., knowledge visualization. The principle of information visualization involves the use of mathematical symbols, expressions, and graphs, which are effective means of clarity and provide meaningful support. It directs students' thinking, reducing the impact of the language barrier and making learning more accessible. Modern students exhibit a pronounced "clip thinking" as a result of widespread high technologies. Since receiving information from screens is common for contemporary students, the use of computer presentations during classes is effective. They offer not only auditory but also more accessible visual information perception, crucial in foreign student education due to the existing language barrier. The advantages of using presentations include ensuring the sequence of topic learning, accelerating the learning process, and increasing student interest.

The effectiveness of teaching foreign students in a higher education institution depends significantly on the didactic provision of the discipline and the pedagogical methods and approaches used. When working with Chinese students, the best methods include the demonstration method (visual clarity), semanticization (using translation and interpretation), instructive explanation, deductive presentation of new material, predominantly using training exercises, questioning exercises, schemes, and dialogs, as well as systematic strict control.

According to O. Karupu, T. Oleshko, V. Pakhnenko, when working with foreign students, special attention should be paid to developing skills in recognizing basic forms of typical problems and working with non-standard tasks. The detailed algorithmization of this process during practical classes and consultations, using various reference summaries, is necessary. For students with weak mathematical and language preparation, it is recommended to provide algorithms for solving the simplest typical problems. Before studying each new topic, it is advisable to conduct preparatory work, creating a terminological dictionary on the subject. The teacher should provide a written list of new mathematical terms in the language of instruction, explain their meaning, paying attention to pronunciation and spelling.

The Confucian principle of self-education widely accepted in China remains relevant today. Therefore, encouraging students to work independently during classes is essential. Collective forms of educational work are traditional for the Chinese and should be utilized in the Ukrainian education process.

All these methodological principles formed the basis of our developed national-oriented methodology for developing mathematical competence in Chinese students using language means and were used during its implementation.

3. Results and analysis

Experimental teaching of higher mathematics to Chinese students in the Ukrainian language using a nationally oriented methodology was implemented at Kharkiv National Automobile and Highway University during the academic year 2022-2023. Participants in the experiment were divided into 4 groups: two groups were taught using traditional methodology (CG), and two were taught using the nationally oriented methodology (EG). The total number of participants across both groups (CG and EG) was 66 people. Participants were informed about the research and the option to withdraw from the experiment without any impact on their education, and they provided their consent.

To conduct a comprehensive study on the effectiveness of implementing a nationally oriented methodology for developing mathematical competence among Chinese students through language training, we employed a combination of methods: methodological experimentation for planning and organizing the teaching of experimental groups, research-experimental teaching to test the proposed nationally oriented methodology, the observation method to study the intensity of mathematical competence development in Chinese students, the diagnostic method (testing and interviews) to assess the level of mathematical competence formation, quantitative-comparative and qualitative-comparative methods for comparing quantitative and qualitative indicators of mathematical competence formation between the control (CG) and experimental groups (EG), and the descriptive method for presenting the experiment results.

The pedagogical experiment was organized into three stages: preliminary assessment, experimental teaching, and final assessment. The preliminary assessment aimed to determine the level of mathematical preparedness of Chinese students in the EG and CG for experimental teaching. A written test, including multiple-choice tasks, was used for this assessment. Overall, the preliminary assessment indicated that the level of knowledge in both EG and CG during the pre-experimental period could be characterized as average.

To validate the results of employing the nationally oriented methodology for developing mathematical competence among Chinese students through language training, we conducted a final assessment and comparative analysis of students' academic achievements in mathematical competence formation during the concluding examination of the winter session of the academic year 2022 – 2023.

In assessing the level of mathematical competence formation, we relied on the understanding of this concept as "the ability to understand, judge, make, and use mathemat-

ics in various intra- and extra-mathematical circumstances and situations" (Niss 2002). The following components of mathematical competence were examined during the assessment: mastery of mathematical terminology, mathematical thinking, formulation and solving of mathematical problems, mathematical modeling, mathematical reasoning, representation of mathematical essence, manipulation of mathematical symbols and formal systems, ability to use symbolic and graphical information, ability to solve mathematical problems, ability to assess the appropriateness of using mathematical methods to solve a particular practical problem, ability to formulate mathematical models of practical problems, solve them using mathematical methods, interpret the obtained results, and analyze and evaluate them.

According to the results of post-experimental testing, all participants in the study achieved a sufficient level of mathematical competence. Specifically, 39.4% of students (13 individuals) who were taught using the nationally oriented methodology (EG) demonstrated a high level of mathematical competence, providing over 90% correct answers; 51.5% (17 students) showed an average level, and only 9.1% (3 students) exhibited a low level of mathematical competence. In the groups taught using traditional teaching methods (CG), the results were as follows: a high level of mathematical competence was observed in 21.2% of Chinese students (7 individuals), an average level in 30.3% (10 students), and a low level in 48.5% (16 students). This demonstrates the effectiveness of using the nationally oriented methodology in teaching higher mathematics to Chinese students through language training.

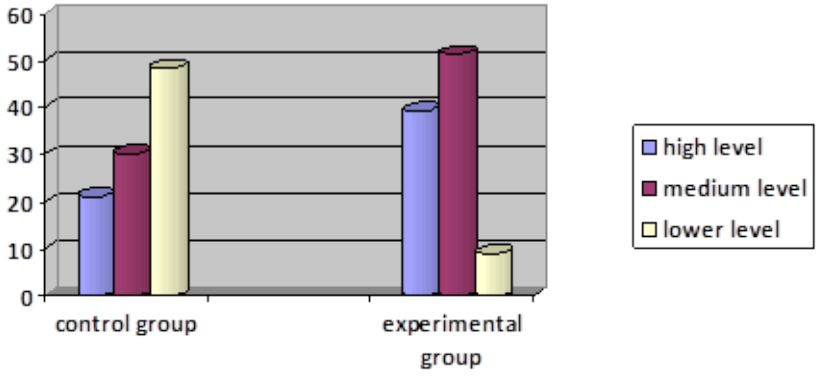

Figure 1. Results of mathematical competence formation using the traditional teaching methodology (CG) and the nationally oriented teaching methodology for Chinese students (EG)

The statistical significance of differences between learning outcomes in the EGs and CGs was assessed using Pearson's chi-square test. To reject the null hypothesis (H_0) of no difference and accept the alternative hypothesis (H_1) indicating statistically significant differences, we compared the calculated chi-square statistic (χ^2_{emp}) with critical values at significance levels of $p = 0{,}05$ and $p = 0{,}01$: $\chi^2_{emp} > \chi^2$ at $p = 0{,}05$: (23,2188 > 7, 815) and $\chi^2_{emp} > \chi^2$ at $p = 0{,}01$ (23.2188 > 11.343).

The calculated chi-square statistic (χ^2_{emp} = 23.2188) exceeds the critical values both at $p = 0.05$ and $p = 0.01$ (7.815 and 11.343, respectively), indicating that the observed differences in learning outcomes are statistically significant.

These findings confirm our initial assumption regarding the positive impact of the methodology for developing mathematical competence among Chinese students through language training.

4. Discussions

The positive outcomes of our study and the subsequent analysis provide a basis for a detailed discussion of the proposed methodology and its implementation specifics.

For mathematics lecturers working with foreign students, a crucial task is to distill essential concepts from the subject matter and structure a lecture course around them, minimizing the use of complex Ukrainian language styles. This approach ensures the development of students' fundamental mathematical terminology competence. Our primary focus when teaching Chinese students was on imparting higher mathematics through active engagement with its terminology – listening, understanding, reading, and speaking.

Chinese students generally possess a strong foundation in school mathematics, compensating for language barriers. This allows them to use mathematical language to comprehend Ukrainian lexical constructions.

For instance, when explaining the concept of a function limit, a lecturer might pre $\lim\limits_{x \to x_0} f(x) = A$ on the board:

Let the function $y = f(x)$ be a function defined in domain D, excluding possibly at x_0. The number A is the limit of $f(x)$ as x approaches x_0 if, for any small positive ε, there exists a positive δ such that for all x satisfying the condition $0 < |x - x_0| < \delta$, the inequality $|f(x) - A| < \varepsilon$ holds.

This formulation can be challenging for Ukrainian students, but the symbolic representation,

$$\forall \varepsilon > 0\ \exists \delta > 0\ \forall x\ |x - x_0| < \delta \Rightarrow |f(x) - A| < \varepsilon,$$

significantly aids Chinese students' understanding by leveraging the quantifier language of mathematics, aligning well with their mathematical readiness.

– Given that foreign student groups are typically small (15 – 20 individuals), lectures and practical sessions can be organized into several subgroups based on students' mathematical and language proficiency:

– Students strong in elementary mathematics but with weak Ukrainian language skills.
– Students weak in mathematics but proficient in Ukrainian.
– Students weak in both mathematics and Ukrainian.
– Students strong in mathematics and Ukrainian.

Unfortunately, the fourth subgroup usually consists of only 1 – 2 students per cohort. For them, developing an individualized advanced program within lectures and practical sessions, with short consultations available for difficulties, is methodologically appropriate.

Lecture classes typically involve one-way communication from the lecturer, requiring adaptation to students' language perception. Structured reference summaries play a pivotal role in theoretical material study by foreign students, emphasizing key concepts and interrelationships while minimizing secondary elements.

The next step in teaching a new concept involves simplifying its definition, using layman's terms, and relating it closely to practical or well-understood mathematical objects. By focusing on individual terms, we guide students to comprehend both the scientific idea and its linguistic context.

Conclusions and summary

The scientific novelty of this article lies in its analysis of the theoretical foundations of a nationally oriented methodology for developing mathematical competence among Chinese students through language preparation, a subject that has not been previously explored. The methodological approaches proposed are substantiated considering the primary differences between the Chinese and Ukrainian educational systems, as well as accounting for the influence of national mentality on the learning process of Chinese students. Additionally, practical testing results of this methodology are presented.

Experimental teaching conducted at two Ukrainian higher education institutions demonstrated the effectiveness of the nationally oriented methodology for developing mathematical competence among Chinese students, replacing traditional methods. Key factors contributing to this effectiveness include maintaining a working summary, creating a personal terminology dictionary, maximizing the use of visual materials, applying individual and group learning methods, considering psychopedagogical peculiarities, enhancing educational and methodological manuals, providing didactic materials in higher mathematics, and offering methodological recommendations for leveling differentiation and individualization of learning. These factors activate students' cognitive activity and enhance the quality of the learning process.

It is anticipated that this scientific research will contribute to the advancement of methodologies for teaching mathematical disciplines to foreign students. The methodological developments provided can be applied in planning practical classes and creating educational and methodological manuals.

Achieving successful teaching outcomes for foreign students necessitates a comprehensive understanding of the nuances involved in working with this student category, the utilization of modern educational technologies, the development of specialized working methods, and the coordination of efforts across all structures involved in educating foreign citizens at educational institutions.

NOTES

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