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ON PECULIARITIES OF TEACHING LINEAR ALGEBRA TO FUTURE IT SPECIALISTS WITHIN THE PROGRAM "EDUCATION IN ENGLISH" OF THE NATIONAL AVIATION UNIVERSITY

ABSTRACT

The article is devoted to the analysis of the practice of teaching linear algebra in English to Ukrainian and foreign students at the National Aviation University.

Formulation of problem. *When teaching mathematical disciplines in multinational groups, teachers face the problem of teaching educational material to students from different countries for which English is not a native language. The purpose of this study is to investigate the specifics of the project approach for teaching of certain sections of linear algebra, in particular, for the distance learning during quarantine, in English-speaking academic groups.*

Materials and methods. *The study of effectiveness of different methods of presentation of teaching material and organization of the educational process on lectures, practical classes, individual students' work is conducted by traditional methods, that is, by comparing the current and semester grades for different academic groups, interviewing teachers and analyzing the subjective students' assessments obtained through questionnaires.*

Results. *Teaching mathematical disciplines, in particular linear algebra, in multinational English-speaking academic groups requires modification of standard methods and approaches. As experiment, elements of the project approach were introduced. In particular, when teaching certain issues of linear algebra in practical classes in some specialties, teachers proposed to divide academic group into several international teams for joint considered problem solving and mutual verification of results.*

Conclusions. *Application of project approach based on the formation of international teams to solve problems in practical classes on linear algebra in English-speaking groups helps to improve students' mastering of education material. Considered approach increases interest of students and improves their performance. The use of this approach in the teaching of other mathematical disciplines gives some encouraging results.*

Keywords: *teaching mathematics, teaching linear algebra, teaching in English, teaching in multinational academic groups, training of future specialists for aviation and IT industry.*

INTRODUCTION

Formulation of problem. English is one of the official languages of ICAO (International Civil Aviation Organization). Therefore, the opportunity to receive professional education in English is very important for future professionals in the field of aviation.

Since for many years most foreign students at NAU studied in purely aviation specialties, from the very beginning of the introduction of teaching in English, most English-speaking groups were formed in these specialties. In recent years, in NAU the

number of foreign students studying in Field of Study 12 "Information Technology" has significantly increased. As a result, the number of multinational English-language academic groups majoring in Specialties 121 "Software Engineering", 123 "Computer Engineering" and 123 "Cybersecurity" increases. Teachers working in these groups face many questions about the specifics of teaching mathematical disciplines in English. It is worth noting the study of issues related to the methodology of teaching linear algebra, as some of its sections are difficult for many students.

Relevance of research. Investigation of teaching mathematics in higher education in Ukraine is strongly influenced by the well-known research of the methods by V. G. Bevz, O. S. Chashechnikova, Z. O. Serdyuk, O. I. Skafa, Z. I. Slyepkan, N. A. Tarasenkova, N. O. Virchenko and others.

Teaching to linear algebra in technical universities is traditionally provided by a large number of textbooks, manuals and various methodological developments. Methods of teaching linear algebra to students of technical fields of study have been considered by many authors. Teaching of this discipline to foreign students has certain specificity. General problems of teaching mathematics to foreign students were investigated in (Karupu, Oleshko & Pakhnenko, 2012; Dovhodko, 2013; Karupu, Oleshko & Pakhnenko, 2013; Ichanska & Nalyvaiko, 2017).

Teaching of linear algebra in English-speaking groups, where for the vast majority of students English is not their native language, also has its own peculiarities. Some aspects of professional orientation of teaching to mathematical disciplines, in particular, linear algebra, were investigated in (Chashechnikova & Chukhrai, 2008; Trofymenko, 2010; Armash, 2014; Oleshko, 2017; Fedak, Romaniuk & Fedak, 2017; Karupu, Oleshko & Pakhnenko 2018a; Rybalko & Stiepanova, 2020; Karupu, Oleshko & Pakhnenko, 2020).

It should be noted that the teacher's work in multinational academic groups, in which both Ukrainian and foreign students study, has its own specifics. Application of information technologies to mathematical education were considered in (Trofymenko, 2008; Karupu, Oleshko & Pakhnenko, 2018b; Karupu, Oleshko & Pakhnenko, 2019a; Karupu, Oleshko, Pakhnenko & Pashko, 2019; Vlasenko, Lovianova, Armash, Sitak & Chumak, 2020).

Aim of research. The purpose of this work is to study the specifics of teaching certain sections of linear algebra to English-speaking students studying in IT specialties at the National Aviation University. The problems of teaching some issues of these sections to English-speaking foreign and Ukrainian students being not native speakers are considered. Problems of teaching and features of consideration of these issues in multinational academic groups, in which both Ukrainian and foreign students study together, are also analyzed.

RESEARCH METHODS

Research of efficiency of various methods of teaching of certain issues of separate sections of linear algebra and the organization of educational process during lectures, practical classes, individual work of students is carried out by traditional methods, that is by comparison of current and semester success of various groups, the analysis of subjective students' estimations, generalization and systematization of domestic and foreign experience, analysis of personal pedagogical experience in the organization of the educational process and discussion of results with colleagues.

RESEARCH RESULTS

Study of linear algebra is the important component of the professional development of future professionals in many specialties. Therefore, at the National Aviation University for all Educational Professional Programs of technical and IT specialties Syllabuses provide for the study of basic sections of linear algebra. The teaching of linear algebra in technical universities traditionally is supported by a large number of textbooks, and the teaching methods has been studied by many authors. However, the problems of teaching this discipline when teacher works with foreign students have their own specifics. The teaching of the discipline in English also has certain features.

Curricula for the training of future specialists in all technical and IT specialties provide for the study of linear algebra. At NAU for students of most specialties the questions of linear algebra are taught in the relevant sections of the synthetic discipline "Higher Mathematics" and only for some specialties requiring advanced mathematical knowledge, these questions are taught in the discipline "Linear Algebra and Analytical Geometry". However, some topics are included in the Syllabuses for all specialties. In addition, Syllabuses in some specialties also involve the study of certain additional issues of linear algebra such as linear spaces, linear operators, bilinear and quadratic forms.

Consider the main, in our opinion, problems that arise when teaching basic issues related to linear algebra to Ukrainian and foreign students of English-speaking groups.

A certain part of problems arising in teaching linear algebra to students of English-speaking groups is due to the peculiarities of mathematical and linguistic background knowledge of these students and arises also in teaching physics and technical disciplines. The rest of them are specific and arise only when teaching these students mathematical disciplines, in particular linear algebra.

Investigation of initial level of cognitive activity of English-speaking students of all specialties of the Field of Study 12 "Information Technology" in NAU shows that these students are representatives of different education systems, which often vary significantly.

Teacher must take into account that the level of knowledge and the amount of information acquired by foreign students during the school years, in many respects differs from the level and amount of knowledge of secondary school graduates in Ukraine. It is also necessary to take into account some differences in approaches to assessing the importance of different topics and their relationships, which were practiced in the education of these students in secondary school and specificity of their theoretical and practical training on some issues. Note that this difference is most often manifested in practical classes in the process of solving problems.

In addition, it should be noted that a significant impact on students' perception of the lecture material is the notation used by teacher. Some notations in Ukraine are slightly different from notations adopted in many other countries.

There are three types of English-speaking academic groups at the National Aviation University: groups in which only Ukrainian students study; groups in which only foreign students study; groups with international staff. The vast majority of English-speaking groups belong to a mixed type, that is, both Ukrainian and foreign students study in these groups. The authors have experience working in English-speaking groups of all three types. Teacher's work in academic groups of each of these types has certain specificity, although there are certain common features of work in English-speaking groups.

For the vast majority of students in these groups (both foreign and Ukrainian), English is not native language. At the same time, the vast majority of both Ukrainian and foreign students in secondary school studied in their native languages. Therefore, the teacher should always emphasize a certain specificity of terms, because for Ukrainian students (and for foreigners as well) it is desirable to have the best possible knowledge of both English and Ukrainian special terminology.

It should be noted that mastering English mathematical terminology in linear algebra, unlike other sections of mathematics, does not cause special difficulties for both foreign and Ukrainian students. The only exception is memorizing the names of the products of vectors and coordinate systems.

In addition, since every graduate of a Ukrainian university must know Ukrainian special terminology, we must provide a translation of terms into Ukrainian when considering all topics.

Topic "Elements of Vector Algebra" is generally well mastered by students of all IT specialties. Most foreign students of NAU are well versed in the basic concepts of vector algebra, and some of them are better prepared than a significant part of Ukrainian students. Note that they use theoretical knowledge quite effectively to solve problems. However, it should be noted that in order to master the skills of applying the products of vectors with confidence, a certain part of students needs more classroom study time than can be allocated by Syllabuses.

Topic "Elements of Linear Algebra" is more difficult for many foreign students. We will note that the majority of foreign students quite well operate with determinants and matrices. Usually their level of perception of more abstract issues is much lower. Certain problems arise for most students with the calculation of the rank of the matrix by the method of bordering minors (basis minor method), and it should be noted that some of them do not understand what they are calculating. The method of elementary transformations (reducing matrix to row echelon form) is much better mastered, as some foreign students met with the Gaussian method in secondary school. Generally it is even more difficult for many foreign students to find eigenvalues and eigenvectors of a matrix. We consider it appropriate to provide students with recommendations on the use of computer algebraic systems (CAS) for the calculation of determinants and inverse matrices, for operations with matrices and determinants. At the same time, we consider it necessary to show students the restrictions on the use of these systems.

Topic "Systems of Linear Algebraic Equations" is well received at the level of algorithms of basic methods for solving systems and worse at the level of investigation of SLAE for system consistency. We believe that in teaching this material to students of all categories teacher should pay special attention to the Gaussian method, emphasizing the importance of the Gaussian method with the choice of the leading element as a method used in numerical methods. In addition, we consider it appropriate to announce the connection between the Gaussian method and the simplex method of linear programming, which students will study in the discipline "Mathematical Methods of Optimization".

Topic "Linear Spaces and Linear Operators. Bilinear and Quadratic Forms" is significantly more difficult for many foreign students to learn (not only in English, but also in Ukrainian and Russian) because commonly their level of perception of more abstract issues is much lower. Many foreign students find it difficult to study this topic, both in terms of understanding the theoretical material and in solving even simple problems. These difficulties, as a rule, arise both from insufficient understanding of the theory of quadratic forms, and from insufficient level of skills of operation with quadratic forms and insufficiently high level of general analytical skills. Ukrainian students, especially those who studied in high school in classes with advanced study of mathematics, show slightly better results.

Note that some of the problems that arise when teaching foreign students linear algebra, due to the rather superficial level of perception of most students of technical universities (both Ukrainian and foreign) abstract questions of linear algebra and their lack of understanding of the importance of theoretical material, without which solving problems is impossible. In our opinion, it is important not only to provide some theoretical knowledge and practical skills for solving problems, but also to form a holistic perception of linear algebra methods in the process of its study. For this understanding the essence of the algebraic approach is necessary. Understanding the concept of a linear operator and its relationship to matrices promotes the development of mathematical skills of students.

Also, when teaching to issues difficult for students, we use collective forms of work organization as part of implementation of the project approach. To do this, the academic group is divided into several teams to jointly solve several problems, cross-check the assimilation of material, prepare presentations in practical classes with further discussion and comparison of results. The formation of teams of Ukrainian and foreign students (preferably from different countries, such as Asia and Africa), consisting of three to five people, proved to be very effective.

In particular, in the last two academic years, this approach to the organization of teamwork has been implemented in practical classes on linear algebra and analytical geometry for English-speaking students of the Faculty of Cybersecurity, Computer and Software Engineering.

The analysis of the performance of English-speaking students studying in the specialty "Software Engineering" for the training module № 1 "Elements of Linear Algebra" of discipline "Linear Algebra and Analytical Geometry" is given in table 1, which is similar to the table for the training module № 2 "Elements of Analytical Geometry" (Karupu, Oleshko & Pakhnenko, 2019b):

Table 1

Final grades for the module "Elements of Linear Algebra"

Academic Years	Final grades (percentage)			
	Excellent	Good	Satisfactorily	Bad
2017-2018	28,20	51,80	16,30	3,70
2018-2019	31,00	57,63	7,30	4,07
2019-2020	34,30	52,43	9,37	3,90
2020-2021	35,00	43,00	18,00	4,00

It should be noted that in the groups studying in this specialty, a large percentage are graduates of schools with advanced study of mathematics. Generally, these students have both the highest scores in external evaluation and the best performance in all disciplines compared to students of other IT and technical specialties.

The analysis of the performance of English-speaking students studying in IT specialties for the training module "Elements of Linear Algebra" in 2020-2021 academic year is given in table 2.

Table 2

Final grades for the module "Elements of Linear Algebra"

Specialty	Final grades (percentage)			
	Excellent	Good	Satisfactorily	Bad
121 Software Engineering	35,00	43,00	18,00	4,00
123 Computer Engineering	13,00	44,00	37,00	6,00
125 Cybersecurity	25,00	36,00	36,00	3,00

We analyze the performance of students on the module "Elements of Linear Algebra", which is taught in the first semester.

It should be noted that the conditions of study in the first semester of 2020-2021 differ significantly from the 2019-2020 academic year. In the 2019-2020 academic year the 1st semester was held under normal conditions. In the 1st semester of the 2020-2021 academic year, we all encountered new difficulties related to the forced introduction of distance learning. In our opinion, it is especially difficult to organize effective practical classes.

Distance learning at NAU during quarantine is conducted in the Google Workspace (former G Suite) using Google classroom and Google Meet.

The work of students' teams in practical classes and consultations, implemented using Google Jamboard, was generally quite effective. In our opinion, although the obtained results do not allow to draw far-reaching generalizations, they are encouraging for further study of the considered approach.

The vast majority of foreign and Ukrainian students of English-speaking groups are very receptive to supporting materials, which in addition to equations and figures also contain verbal descriptions of the characteristics of the objects. Note that foreign students majoring in "Computer Engineering" and "Software Engineering" in the Field of Study 12 "Information Technology" are more receptive to reference materials that include flowcharts of relevant algorithms in contrast to students majoring in technical specialties, for which reference materials in the form of tables are more effective.

Most of both foreign and Ukrainian students are aware of the existence of computer algebraic systems and Internet resources and try to use them. We consider it appropriate to provide students with recommendations for the use of computer mathematics systems, showing restrictions on their use.

Availability of reference materials and manuals in English, which contain the necessary theoretical material with a large number of solved examples and the necessary terminology with translation, is critical for the vast majority of foreign and very important for Ukrainian students. Sections related to the teaching of linear algebra in English are supported by two manuals (Denisiuk, Grishina, Karupu, Oleshko, Pakhnenko & Repeta, 2009; Antonova, Klyus, Lastivka, & Trofymenko, 2018). In addition, the theory of quadratic forms and its application to the study of curves and surfaces of the second order, the study of which is included in the program of the discipline "Linear Algebra and Analytical Geometry", is given in the English manual (Grebenuk & Karupu, 2004). We also find it helpful to provide students with guidance on finding mathematical information on online resources.

We will note that joint training of foreign and Ukrainian students has, generally, positive features. In particular, Ukrainian students get the opportunity to communicate in English with foreign students who have received language training in other countries. The use of collective forms of organization of work with the division of academic groups into several teams for joint problem solving not only improves the assimilation of educational material, but also facilitates future professional communication in English for our graduates.

DISCUSSION

Teaching linear algebra in English in academic groups with a multinational staff makes it possible to introduce new forms of organization of educational work for future specialists both in the field of aviation and in the field of IT.

Therefore, as an experiment, we use collective forms of work organization within the implementation of the project approach, in particular in the study of certain issues of linear algebra. To this end, on practical classes the academic group has been split into several teams to jointly solve problems, cross-check the mastery of the material, prepare presentations with further discussion and comparison of results. Formation of teams of Ukrainian and foreign students (preferably from different countries), consisting of three to five people, proved to be sufficiently effective.

The results of the implementation of this approach to the organization of educational classes from the training module № 1 "Elements of Linear Algebra" of the discipline "Linear Algebra and Analytical Geometry" of English-speaking students majoring in 121 "Software Engineering" for 4 academic years. A comparison of current performance in linear algebra of students studying 123 "Computer Engineering" and 125 "Cybersecurity" also had been made.

CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

Teaching linear algebra to Ukrainian and foreign students who are not native speakers of this language in English in multinational academic groups has certain features and requires teachers to modify standard methods of teaching this discipline.

It is useful to apply a variety of supporting materials, and the adaptation of their form for students of different specialties has a certain effectiveness. Note that students majoring in Computer Engineering, Software Engineering, and Cybersecurity are more receptive to reference materials that include flowcharts of relevant algorithms. It is important to pay sufficient attention to bringing to the students the peculiarities of the use of terminology and providing students with methods of using computer algebraic systems (CAS) and Internet resources. Note that the joint training of foreign and Ukrainian students in English-speaking groups provides them with the skills of teamwork in multinational groups, which is important, both for foreign and Ukrainian students.

In further research, we plan to consider the further development of this approach and investigate its application in multinational academic groups with different students and explore the features of its application in the teaching of other mathematical disciplines.

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**ПРО ОСОБЛИВОСТІ ВИКЛАДАННЯ ЛІНІЙНОЇ АЛГЕБРИ МАЙБУТНІМ ІТ-СПЕЦІАЛІСТАМ ЗА ПРОГРАМОЮ
«ОСВІТА АНГЛІЙСЬКОЮ» В НАЦІОНАЛЬНОМУ АВІАЦІЙНОМУ УНІВЕРСИТЕТІ**

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Анотація.

Формулювання проблеми. При викладанні математичних дисциплін українським та іноземним студентам в англомовних групах перед викладачами Національного авіаційного університету постає проблема викладу навчального матеріалу студентам з різних країн, для яких англійська мова не є рідною. Метою даної роботи є дослідження специфіки проєктного підходу у викладанні в англомовних групах окремих розділів лінійної алгебри, зокрема і в дистанційній формі в умовах карантину.

Матеріали і методи. Дослідження ефективності різних методів викладу навчального матеріалу та організації навчального процесу під час лекцій, практичних занять, самостійної роботи студентів проводилося традиційними методами, тобто шляхом порівняння поточної та семестрової успішності різних груп, опитування викладачів та аналізом суб'єктивних оцінок студентів, отриманих за допомогою анкетування.

Результати. Викладання математичних дисциплін, зокрема лінійної алгебри, в мультинаціональних англомовних академічних групах вимагає модифікації стандартних методик та підходів. Було впроваджено елементи проєктного підходу. Зокрема при викладанні на практичних заняттях окремих питань лінійної алгебри на деяких спеціальностях здійснювався поділ академічної групи на декілька інтернаціональних команд для спільного розв'язування задач і взаємної перевірки засвоєння матеріалу.

Висновки. Застосування проєктного підходу на основі формування інтернаціональних команд для розв'язування задач на практичних заняттях з лінійної алгебри в англомовних груп сприяє покращенню засвоєння навчального матеріалу студентами. Розглянутий підхід дав підвищення зацікавленості студентів і покращення їх успішності. Певні обнадійливі результати дає використання цього підходу і при викладанні інших математичних дисциплін. Планується продовження досліджень при викладанні математичних дисциплін англійською в мультинаціональних академічних групах студентам інших спеціальностей.

Ключові слова: викладання математики, викладання лінійної алгебри, викладання англійською мовою, викладання в мультинаціональних академічних групах, підготовка фахівців в галузі авіації та в галузі інформаційних технологій.