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НАВЧАННЯ ВИЩОЇ МАТЕМАТИКИ НА ОСНОВІ КОМПЕТЕНТНІСНОГО ТА ТЕЗАУРУСНОГО ПІДХОДІВ

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АНОТАЦІЯ

Постановка задачі. *Потреба у підвищенні рівня математичної підготовки майбутніх інженерів та зменшення кількості годин, відведених на викладання вищої математики, породжує необхідність розробки та вдосконалення методики її викладання. Метою даної статті є опис методики навчання вищої математики на основі тезаурусного підходу.*

Матеріали та методи. *Матеріалом дослідження є педагогічна та методична література, досвід зарубіжних та вітчизняних учених. У ході дослідження використовувалися загальнонаукові методи (аналіз, синтез, конкретизація, систематизація, узагальнення).*

Результати. *Тезаурусний підхід у навчанні сприяє з'ясуванню рівня математичної компетентності з певної теми. Основою навчальної інформації є навчальний тезаурус, лексикон студента, необхідний для оптимального розподілу навчальної інформації за видами навчального заняття та для розробки дидактичних матеріалів, вибір методів і форм навчання.*

Висновки. *Визначення змісту навчального тезауруса конкретної теми вищої математики допомагає чітко описати зміст математичної компетентності з відповідної теми, етапи її формування, проаналізувати та уточнити необхідну навчальну інформацію, розподілити її за типами занять (лекція, практичне заняття, самостійна робота). Визначення словникового запасу студента, необхідного для засвоєння нової теми, допомагає визначити методику й засоби навчання, зокрема розробити допоміжні завдання й запитання для актуалізації словникового запасу студента, встановити послідовні зв'язки між навчальним тезаурусом і словниковим запасом студента, здійснити розробку словникового запасу студента, розробити засади диференційованого підходу до навчання. Запропонована методика має властивості гнучкості, доповнень, модифікацій залежно від цілей навчання та конкретної академічної групи. Необхідні подальші дослідження щодо ефективного використання тезаурусного підходу в процесі навчання вищої математики.*

КЛЮЧОВІ СЛОВА: *вища математика; математичні компетентності; навчальний тезаурус; тезаурусний підхід; лексикон студента; визначники.*

TEACHING HIGHER MATHEMATICS BASED ON COMPETENCE-BASED AND THESAURUS APPROACHES

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ABSTRACT

Formulation of the problem. *The requirement to increase the level of mathematical training of future engineers and reduce the number of hours devoted to teaching higher mathematics gives rise to the task of developing and improving the methodology for teaching higher mathematics. The purpose of this article is to describe the methodology for teaching higher mathematics based on the thesaurus approach.*

Materials and methods. *The research materials are pedagogical and methodical literature, and experiences of foreign and domestic scientists. In the course of the study, general scientific methods (analysis, synthesis, concretization, systematization, and generalization) were used.*

Results. *The thesaurus approach to learning helps to clarify the mathematical competence of a particular topic, the basis of educational information is the educational thesaurus, the student's lexicon necessary for the optimal distribution of educational information by type of training session and the development of didactic materials, the choice of methods and forms of education.*

Conclusions. *Determining the content of the educational thesaurus of a specific topic of higher mathematics helps to clearly describe the mathematical competencies of the relevant topic, the stages of its formation, analyze and clarify the necessary educational information, distribute it by type of lesson (lecture, practical lesson, self-study). Determining the student's vocabulary necessary for mastering a new topic helps to determine the methodology and means of teaching, in particular, to develop auxiliary tasks and questions for updating the student's vocabulary, to establish successive links between the educational thesaurus and the student's vocabulary, to implement a differentiated approach to learning. The proposed methodology has the properties of flexibility, additions, and modifications depending on the learning objectives and specific academic group. Further research is needed on the effective use of the thesaurus approach in the process of teaching higher mathematics.*

KEYWORDS: *higher mathematics; mathematical competencies; educational thesaurus; thesaurus approach; student's lexicon; determinants.*

INTRODUCTION

Mathematics is a universal language for describing processes and phenomena of various natures, without mastering this language it is impossible to solve modern engineering problems, including mining problems. But in the context of a decrease in the number of hours devoted to mathematical sciences, mastering this universal language, raising the level of mathematical training of a future engineer, and identifying the application of mathematics in technical and related sciences becomes a difficult task. In this regard, there is a need to develop new and improved existing methods of teaching higher mathematics to students of technical specialties.

THEORETICAL FOUNDATIONS OF THE RESEARCH

An analysis of scientific research on mathematical competencies and the competence of future specialists shows that mathematical competencies are defined for the entire course of mathematics. For example, V.A. Shershneva (2011) makes the

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following remark about the mathematical competence of future engineers. Mathematical competence is an integrative-dynamic characteristic of a student's personality, characterizing the student's ability and willingness to use mathematical modeling methods in their professional activities. Mathematical competence combines the mathematical knowledge, skills, and abilities provided for by educational standards and general cultural and professional competencies projected into the subject area of mathematics, the main core of which is the ability and willingness of the graduate to apply this knowledge in his professional activities.

According to Khom'yuk (2014), the mathematical competence of a future engineer is characterized by a set of competencies:

– logical-analytical (the ability to solve problems of a reproductive nature, recognize an applied problem, determine which topic it belongs to, the ability to identify the appropriateness of using mathematical methods to solve professional problems);

– visual-figurative (the ability to switch to the symbolic form of the problem, the ability to work with diagrams, graphs, the ability to draw up any information in a visual form);

– technological (the ability to independently obtain information, develop and find ways to solve problems, work with documents, the ability to use mathematical technologies to process the results of experiments);

– research (the ability to conduct a mathematical analysis of the results of the study, the ability to organize their research using the mathematical apparatus, to motivate their cognitive activity; to carry out a theoretical analysis of the research task; to establish cause-and-effect relationships, to formulate reasoned conclusions, based on the rational execution of mental operations; to independently carry out analysis of the solution, verification of the results obtained; the ability of self-education);

– creative and creative (the ability to show intuition, find an original solution, readiness for creative reflection on the use of mathematical knowledge, skills, and abilities in professional activities, the ability to make and justify decisions in non-standard situations (readiness to make decisions));

– modeling and prognostic (the ability to see, control, and assume the results of work at all stages of one's activity, the ability to identify the main processes and develop their mathematical models).

An analysis of works on mathematical competence in foreign countries (Holovan, 2014), (Niss & Højgaard, 2011), (Pepin et al., 2021) allows us to see that mathematical competence is defined using the concept of ability: mathematical competence means the ability to understand and evaluate mathematics and mathematical activity, its application and use in various contexts in which mathematics plays or can play a role. M. Niss considers mathematical competencies as clearly distinguishable and separate, basic components of mathematical competence, and describes 8 mathematical competencies, combined into two groups.

The above definitions of competence are very difficult to clarify for a specific topic (module) of higher mathematics. Therefore, there is a need to develop effective methods for refining the mathematical competencies of future specialists. In our opinion, it is advisable to enrich the introduction of a competency-based approach into the educational process of a university with a thesaurus approach.

The concept of thesaurus entered science from linguistics and computer science, expanded its meaning, and became a universal term. Thesaurus (thesaurus) in Greek means treasure, wealth, stock, treasure. In pedagogy, the concept of thesaurus appeared in the information-semantic model of education proposed by L.T.Turbovich. In this model, the author defines a thesaurus as a stock of concepts, assessments, and norms, including action patterns, embodied and preserved in a person's memory. According to this model, the formation of a person's consciousness is identified with the formation of his conceptual and psychological thesaurus (Kozhokar', 2009). When new information is added to the thesaurus, its expansion is interpreted by the author as teaching.

Miroshnichenko (2016), working within the framework of the technology of creating pedagogical thesauri, proposes to distinguish between personal thesauri and educational thesauri. In his opinion, each person has a certain thesaurus, which is formed under the influence of internal and external factors throughout his life.

Along with the personal thesaurus, scientific publications also use the concept of a lexicon. Lexicon - in translation from the ancient Greek language means "word". The lexicon is a collection of words that a person possesses, a vocabulary (wealth). Vocabulary is divided into two types: active and inactive (passive). Active vocabulary includes words that a person uses in speech and writing. Inactive vocabulary consists of words that a person recognizes (knows) when reading or hearing but does not use himself in speech and writing. Usually, the stock of inactive words is several times larger than the stock of active words.

One of the problems of teaching a personality is the formation of a lexicon, through which, by giving the lexicon certain properties, teachers can control the process of learning, assimilation of information, and build a professionally oriented lexicon. It should be noted that the thesaurus is relatively static, while the lexicon is dynamic; this is how the lexicon differs from the thesaurus (Zharov & Turgunbaev, 2019).

In this case, the thesaurus approach makes it possible to clarify the educational and didactic support of the subject or module of the subject, in particular, the content of education. At the same time, the content of education is determined by the content of the educational thesaurus, it includes the basic concepts of the educational discipline, as well as methods of an educational activity (general educational methods, general mathematical methods of activity, methods of activity characteristic of certain sections of mathematics, special methods of activity for solving basic problems), basic tasks on each topic and methods of activity to solve these problems (Turgunbaev, 2021).

In this case, the composition of competencies for each topic of higher mathematics can be formed as follows (Turgunbaev & Kushmurotov, 2021):

a) know the basic concepts and facts of the topic;

b) know the properties of the basic concepts and theorems expressing the connections between new concepts, as well as previously studied concepts;

c) know and apply methods of activity to solve the main tasks of the topic;

d) be able to transform and transfer the reception of activities to solve the main problems to solve new problems;

e) apply the above competencies in the study of related and professional disciplines.

The study aims to describe the methodology for implementing the teaching of higher mathematics in technical universities based on the competence-based and thesaurus approaches using the topic "Determinants" as an example.

RESEARCH METHODS

In the course of the study, general scientific methods (analysis, synthesis, concretization, systematization, and generalization) were used.

RESULTS AND DISCUSSION

For a student to master a concept (definition, theorem, proof, rule), his lexicon must have a vocabulary (concepts) and methods of activity corresponding to this concept. By the assimilation of a new concept by a student, we mean establishing a connection between this concept and concepts in the student's lexicon, expanding the student's lexicon, and giving the student's lexicon a new quality. For this reason, each element taken from the educational thesaurus must correspond to a group of elements from the student's lexicon. Otherwise, the student will not learn this element.

Educational thesaurus of the topic "Determinants". With the help of the analysis of educational literature and the method of questioning experts, an educational thesaurus of the topic "Determinants" was determined. Basic concepts: Second order determinant, notation, diagonal elements, row determinant, column elements, determinant evaluation, properties, third order determinant, determinant order, minor, algebraic addition, a triangular method for calculating the third order determinant, Sarrius method, row expansion method or column, calculation of the determinant of the nth order.

Main questions: 1) direct calculation of the determinant of the 2nd, and 3rd order; 2) calculation of the determinant by its properties.

Methods of activity for solving the main problems:

1) acceptance of activities for calculating the second-order determinant:

1. Select the main diagonal, and multiply its elements.
2. Select the auxiliary diagonal, and multiply its elements.
3. Calculate the difference between the first and second products.
4. Write an answer.

2) acceptance of activities for calculating the determinant of the third order by definition:

1. Expand by elements of a certain row (or column);
2. Calculate algebraic additions;
3. Calculate the value of a numeric expression
4. write an answer.

3) Acceptance of activities for calculating the determinant of the nth order:

1. Determining the order of the determinant;
2. Expand by elements of some row (or column);
3. Calculate algebraic additions (if necessary, use a decrease in the order of the determinant);
4. Calculate the value of a numeric expression;
5. Write an answer.

Competences on the topic "Determinants"

Competences based on this educational thesaurus can be formed as follows:

As a result of training, the student knows:

– determinants of the second (third, ..., n-) order and their designations;

– elements of the determinant (order, diagonals, row, column);

– methods for calculating the determinant of the 3rd order (the triangle method, the Sarrius method, the method of expansion by the elements of a row or column);

– properties of the determinant;

– the minor, algebraic complement of the determinant;

– methods for calculating the determinant of the nth order (zero the elements of a column or row, decompose by elements of a row or column).

As a result of training, the student can: 1) directly calculate the determinants of the 2nd and 3rd order; 2) calculate the determinant by its properties; 3) Calculate the determinant of the nth order.

As a result of training, the student transforms and transfers the methods of activity for solving basic problems to solving new problems.

These competencies are developed in the following topics: "Matrices" (finding the inverse of a matrix, determining the rank of a matrix), "System of linear equations" (Cramer's formula), "Analytic geometry in a plane and space" (area of a triangle, equations of a straight line passing through two points, equations normals, conditions for the intersection of three lines, equations of the plane), "vector algebra" (vector product, mixed product of vectors, condition of perpendicularity of vectors), in electrical engineering (calculation of electrical circuits), etc.

Student's lexicon

The methodology for determining the student's vocabulary, necessary for studying a particular topic, is described in the article (Turgunbaev, 2022). Based on this technique, we determine the student's vocabulary corresponding to the above topic. The concept of a determinant is associated with numbers and arithmetic operations on numbers, the order in which actions are

performed, in addition, when introducing this concept, the words column, row, diagonal, triangle, triangle base, triangle apex, parallel, and order are used. If systems of linear equations with two unknowns are used to motivate the introduction of the concept of a determinant, then the student's vocabulary should also contain the concepts of the unknown, equations, solution of an equation, a linear equation, coefficients of an equation, a system of linear equations with two unknowns, methods for solving a system of linear equations with two unknowns (substitution, addition).

Determining the necessary student vocabulary for studying this topic will help identify gaps in the student's real vocabulary, outline means, and methods for eliminating gaps in the student's vocabulary and updating the vocabulary. And also to develop means of motivation to study a new topic, means (questions and tasks) of expanding the student's vocabulary based on an educational thesaurus.

Implementation of the thesaurus approach in teaching

To introduce the concept of a second-order determinant in a lecture, you can use the method of solving a system of linear equations with two unknowns. After getting acquainted with the basic concepts (determinant, order of the determinant, determinant elements, element designations, column elements, row elements, main diagonal, auxiliary diagonal), students can be offered the following tasks to "discover" the properties of the determinant:

1) Calculate the determinants $\begin{vmatrix}0&0\\2&3\end{vmatrix}$; $\begin{vmatrix}0&3\\0&1\end{vmatrix}$. What do they have in common? (expected answer: if the elements of a row (column) of a determinant are equal to zero, then the value of this determinant is equal to zero.). Is the reverse true?

2) Calculate the determinants $\begin{vmatrix}2&3\\2&3\end{vmatrix}$; $\begin{vmatrix}2&6\\2&6\end{vmatrix}$. What do they have in common? (expected answer: If two rows (columns) of a determinant are equal, then the value of this determinant is zero). Is the reverse true?

3) Calculate the determinants $\begin{vmatrix}4&6\\2&3\end{vmatrix}$, $\begin{vmatrix}1&3\\2&6\end{vmatrix}$. What do they have in common? (expected answer: if two rows (columns) of a determinant are proportional, then the value of this determinant is zero). Is the reverse true?

4) Calculate the determinants $\begin{vmatrix}4&6\\2&8\end{vmatrix}$, $\begin{vmatrix}2&8\\4&6\end{vmatrix}$. What do they have in common? (expected answer: if you swap the rows, then the values of the determinants are equal). Are the statements for the columns true?

After such "discoveries", students are given information about the concepts of a third-order determinant, minor, algebraic complement, and methods for calculating a third-order determinant, and they are invited to independently study similar issues discussed above. Then the concept of the determinant of the nth order is introduced, and the questions of calculating the determinant of the nth order and its properties are considered.

At the beginning of the practical lesson, students can be offered the following auxiliary tasks. These tasks serve to update the knowledge (student's vocabulary) necessary to solve the type of tasks considered below, and also give the motivation to learn generalized methods for solving them.

1. Given $\Delta=\begin{vmatrix}5&4\\-2&3\end{vmatrix}$ a) Name the elements of the 1st row of the determinant, b) Name the elements of the 2nd column, c) What is the element a_{21}? d) Specify the elements of the main diagonal; e) Name the elements of the auxiliary diagonal;

2. Given $\Delta=\begin{vmatrix}1&-2&2\\3&4&1\\1&0&5\end{vmatrix}$ a) Name the elements of the 1st row of the determinant, b) Name the elements of the 2nd column, c) What is the value of A_{21}? d) Name the elements of the auxiliary diagonal; d) What M_{31} is equal to?

3. Given $\begin{vmatrix}2&0&3\\5&6&0\\1&4&-1\end{vmatrix}$. Determine a) the order of the determinant; b) name the elements of the column; c) name the elements of the line; d) name the elements of the main diagonal; e) name the elements of the auxiliary diagonal; f) write the minors on the first line; g) write algebraic additions on the first line; h) Calculate the determinant.

After solving these problems together with students, it is necessary to solve the main problems, to formulate methods of activity corresponding to these tasks. If necessary, you can offer students to draw up methods of activity in the form of a map. The following can be identified as the main tasks:

1. Calculate:

a) $\begin{vmatrix}3&-2\\1&5\end{vmatrix}$ b) $\begin{vmatrix}sin\alpha&-cos\alpha\\cos\alpha&sin\alpha\end{vmatrix}$

2. Calculate by expansion by row or column.

a) $\begin{vmatrix}1&5&4\\3&-1&7\\1&6&3\end{vmatrix}$ b) $\begin{vmatrix}1&3&4\\2&3&1\\-1&8&2\end{vmatrix}$

3. Calculate the determinants using the triangle method.

a) $\begin{vmatrix}13&4&-4\\5&2&2\\1&2&7\end{vmatrix}$ b) $\begin{vmatrix}1&7&2\\5&0&4\\6&3&1\end{vmatrix}$

4. Calculate by Row or Column Decomposition

a) $\begin{vmatrix}1&2&3&4\\2&3&1&1\\1&2&2&1\\3&1&2&1\end{vmatrix}$ b) $\begin{vmatrix}2&-1&1&0\\0&1&2&-1\\3&-1&2&3\\3&1&6&1\end{vmatrix}$

As noted above, after solving each problem, together with the students, a method for solving these problems is compiled. These methods of activity should be recorded in students' notebooks, or distributed to students in the form of pre-prepared handouts.

It is important to give developing tasks to students who easily solve typical problems. Developing ones include non-standard (olympiad type) mathematical problems, and problems aimed at using a generalized method in solving practical (professional) problems. For example,

1) Solve the equation: $\begin{vmatrix} x^2 & 4 & 9 \\ x & 2 & 3 \\ 1 & 1 & 1 \end{vmatrix} = 0.$

2) Calculate the determinant.

1. $\begin{vmatrix} 1 & 1 \\ 0 & 2 \end{vmatrix}^n$ 2. $\begin{vmatrix} 1+i & 1-i \\ 0 & 1-i \end{vmatrix}^n$ 3. $\begin{vmatrix} 1 & 7 & 8 & 9 \\ 0 & 1 & 13 & 14 \\ 0 & 0 & 1 & 15 \\ 0 & 0 & 0 & 1 \end{vmatrix}^n$

To organize independent learning, students are offered differentiated tasks, consisting of theoretical questions, tasks for the development of general mathematical methods of activity, and individual tasks for practicing the skills of calculating determinants.

CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

Determining the content of the educational thesaurus of a specific topic of higher mathematics helps to clearly describe the mathematical competencies of the relevant topic, the stages of its formation, analyze and clarify the necessary educational information, distribute it by type of lesson (lecture, practical lesson, self-study). Determining the student's vocabulary necessary for mastering a new topic helps to determine the methodology and means of teaching, in particular, to develop auxiliary tasks and questions to update the student's vocabulary, and to implement a differentiated approach to learning. The proposed methodology has the properties of flexibility, additions, and modifications depending on the learning objectives and specific academic group. Further research is needed on the effective use of the thesaurus approach in the process of teaching higher mathematics.

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