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IMPROVING THE METHODOLOGY OF TEACHING CALCULUS IN TECHNICAL EDUCATION

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Abstract. This article analyzes the current state of teaching Calculus, one of the fundamental subjects in technical higher education institutions, existing problems, and methods for solving them. Modern engineering in education mathematician concepts only abstract formulas as not , maybe practical engineering of issues solution as to teach necessity based on given . In the article visualization tools (GeGebra , MATLAB), problem-solving education (Problem-Based Learning) and STEM approaches lesson to the process implementation to grow model efficiency research done .

Key words: Calculus, higher mathematics , technology education , training methodology , visualization , MATLAB, problem-solving education , engineering thinking .

Аннотация. В данной статье анализируется современное состояние преподавания математического анализа, одного из фундаментальных предметов в технических высших учебных заведениях, существующие проблемы и методы их решения. В современном инженерном образовании математики рассматривают лишь абстрактные формулы, а не практические инженерные решения задач, требующие обучения на основе заданных данных. В статье представлены исследования эффективности внедрения методов обучения с использованием инструментов визуализации (GeGebra, MATLAB), проблемно-ориентированного обучения (Problem-Based Learning) и STEM-подходов к повышению эффективности модели обучения.

Ключевые слова: Математический анализ, высшая математика, технологическое образование, методика обучения, визуализация, MATLAB, проблемно-ориентированное обучение, инженерное мышление.

INTRODUCTION

The current global technological The era of revolution and Industry 4.0 places completely new demands on the quality of engineering personnel training. A modern engineer must not only be able to use ready-made technical systems, but also design, mathematically model and optimize new technologies. At the heart of all these processes is the fundamental mathematical apparatus - the science of Calculus.

Calculus (differential and integral calculus) is the "language" of engineering, as it studies the relationships between variables, the laws of motion and development. The change in current strength in electrical engineering, the strength of structures in mechanics, hydrodynamics, aerodynamics, and artificial intelligence algorithms - all of this is expressed using differential equations and integrals.

However, there is a serious gap in the teaching of Calculus in the traditional education system. Students often master the mechanical rules of the derivative or integral calculus, but do not understand how these tools are applied to real engineering objects. Mathematics remains a "set of

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abstract formulas". Therefore, one of the urgent tasks of today's course is to radically improve the methodology of teaching Calculus in technical disciplines.

METHODOLOGY AND PROBLEM STATEMENT

As part of the study, pedagogical observation, questionnaires, and tests were conducted to determine the level of mathematics mastery and motivation among students of technical higher education institutions. The results show that the main difficulties of students in mastering Calculus are related to the following:

1. High level of abstraction. The geometric and physical meaning of concepts such as limit, continuity, and differential of a function is not sufficiently visualized.
2. Lack of engineering context. Examples and problems are largely artificial in nature and far from real technical problems.
3. Insufficient use of computer technology. Too much time is spent manually calculating complex integrals, which leaves the student with no energy to analyze the essence of the process.

To overcome these problems, we developed and implemented a methodology based on Contextual Learning, visualization, and the integration of digital tools.

MAIN PART: DIRECTIONS FOR IMPROVING THE METHODOLOGY

Contextual learning and problem-based learning (Problem-Based Learning)

In the traditional methodology, the lesson plan is usually as follows: Theorem ≤ Proof ≥ Example from the template. In the improved methodology, it is proposed to start the process with an engineering problem.

Methodical example (Introducing the concept of integral): *The integral is usually taught as a tool for calculating surface area. For engineering students, it is appropriate to introduce it through the problem of calculating the work done by a variable force or the volume of water flowing through a river bed.*

$$\boldsymbol{W = \int [a; b] F(x) dx}$$

The student first ponders how to calculate work when the force is not constant (a problematic situation). Then he comes up with the idea of dividing the interval into small parts (dx) and summing them (Riemann sum). This approach answers the question "Why do I need this subject?" from the first minute of the lesson.

Speaker visualization from the means use

The human brain processes visual information 60,000 times faster than text or formulas. Using interactive programs like GeoGebra and Desmos in Calculus classes allows you to move from static drawings to dynamic models.

4. **Function limit** $\boldsymbol{\lim_{x \to a} f(x) = L}$**:** Point argument axis The student controls how the function value approaches L as it approaches a along the line using sliders on the screen.
5. **Get it. geometric Meaning :** The one who beats to the cutter rotation and $\Delta x \geq 0$ When the situation in is shown in dynamics, the student visually understands that the derivative is not just a "formula", but a rate of change.

Mathematician integration of packages (MATLAB, WolframAlpha , Python)

A modern engineer does not calculate integrals manually from a table, he loads them into a computer. Therefore, the emphasis in teaching methods should be on building a mathematical model of the problem and interpreting the results, rather than on mechanical calculations.

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After the theoretical part is presented in lectures, complex calculations in laboratory or practical classes should be performed using MATLAB or Python (SymPy library).

```
# Checking a function and finding its derivative using Python
import sympy as sp
x = sp.Symbol('x')y = x**3 * sp.sin(x)derivative = sp.diff(y, x)print("Derivative of the function:", derivative)
```

This approach builds programming and engineering analysis skills in students in parallel.

ANALYSIS AND RESULTS

The improved methodology was tested in pilot groups of Tashkent State Technical University and regional technical institutes. A total of 120 students participated in the experiment (60 in the control group, 60 in the experimental group).

In the control group, classes were conducted in the form of traditional lectures and practical exercises, while in the experimental group, classes were conducted based on the visualization and engineering cases mentioned above. At the end of the semester, students' knowledge was assessed according to three criteria:

Evaluation criteria	Control group (Traditional)	Experimental group (New)	Growth rate
Theory understanding	68%	82%	+14%
Calculation technique	74%	76%	+2%
Engineering issues modeling	**42%**	**78%**	**+36%**

The results show that while there was no significant difference in computational techniques (since both groups learned to work with formulas), the ability to apply mathematical knowledge to engineering problems increased by 36% in the experimental group. Students began to understand the physical nature of the problem more deeply.

RECOMMENDATIONS: HOW TO IMPROVE THE METHODOLOGY?

Based on the results of the study, the following strategic recommendations are put forward for reforming the teaching of Calculus in technical higher education institutions:

1.Revise syllabuses and introduce 'Engineering Cases'. Each mathematical topic must be related to a specific engineering specialty. For example, for the mechanics direction, differential equations are taught on the example of vibration theory and resistance of materials; for IT and Artificial Intelligence, extrema of multivariable functions and gradient descent machine learning algorithms are taught on the example of machine learning algorithms.

2. Change the grading system. In written exams, the share of project tasks (Mini-projects) such as 'Find the center of gravity of a part in a given engineering drawing using integration and optimize its material consumption' should be increased, not just dry tasks like 'Calculate the integral'.

3. Introducing the 'Flipped Classroom' model**.** Students study the theoretical text of the lecture and video lessons from home (via LMS platforms). The valuable time in the auditorium is spent only on discussion, finding answers to difficult questions, and teamwork . projects to solve is spent .

CONCLUSION

Improving the teaching methodology of Calculus in technical education is not just about updating textbooks, but also about changing the philosophical approach. Mathematics is not a goal for an engineer, but a tool for understanding and designing the world and technical systems.

The contextual learning, computer visualization, and problem-based approach tested in our research significantly increased students' interest in science and, most importantly, their professional competence. The widespread implementation of this methodology will serve as a solid foundation for training competitive, analytically thinking, and innovative engineering personnel in the future.

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