

# Integral Calculus via Nomotex DLS

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**Abstract.** The paper describes the peculiarities of the development of an innovative digital course "Integral calculus of functions of one variable" in the digital learning system Nomotex (DLS "NOMOTEX") [1], designed for classroom and remote classes with digital educational resources.

## 1 Introduction

For different areas of training and specialties, different mathematical courses with variable depth of content are required, which correspond to the competencies of university graduates. [2, 3, 4, 5, 6] The need for designing personalized courses occurs during training on individual trajectories. [7, 8, 9, 10, 11, 12]

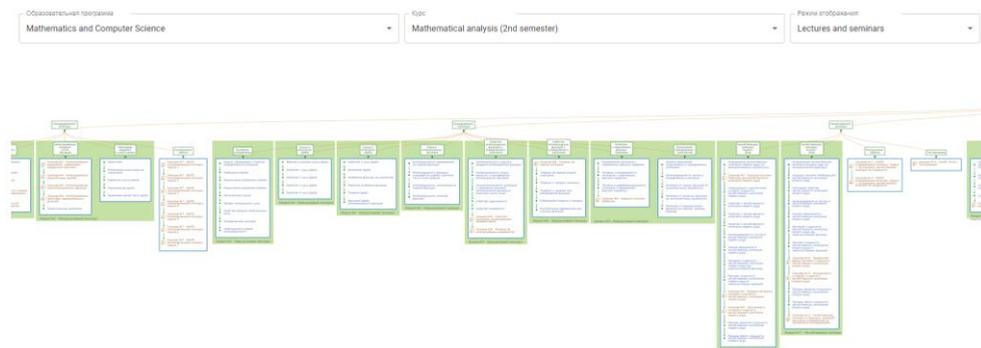
## 2 Integral calculus of functions of one variable

The digital course "Integral calculus of functions of one variable" (IC) was developed as an integral part of the general Knowledge Base of the digital learning system NOMOTEX. This methodology made it possible, on the basis of the basic course, to design several different courses for various areas of training, differing in the amount of hours allocated for the study of the course and the target student audience.

The following courses were created: a) the IC course, which is a module of the course "Mathematical analysis (2nd semester)" and b) the IC course, which is the first module of the course "Integral Calculus and Differential Equations", taught for mathematic and engineering specialties, respectively. Figure 1 shows the structure of the course "Mathematical analysis (2nd semester)", which includes the IC module.

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**Fig. 1.** The structure of the course "Mathematical analysis (2nd semester)" in the DLS "NOMOTEX".

The IC electronic course consists of lectures and seminars, which are combined into a single structure, lectures are highlighted on the screen in the background in accordance with the calendar plan, in red text - seminars. The seminars are directly related to the theoretical course, and contain links to all the basic concepts necessary for solving problems. [1]

The IC lecture course, in comparison with the previous one, was significantly modernized, became more rigorous in presentation, and at the same time, illustrated with visual examples. All statements included in the course have been reformulated in accordance with the strict structure adopted by the DLS "NOMOTEX" (Fig. 2):

### Mean value theorem (T)

1. Theorem and its connections

The function  $f(x)$ , defined on the segment  $[a, b]$  and integrable over this segment.

If a  $m \leq f(x) \leq M$  for  $\forall x \in [a, b]$ ,

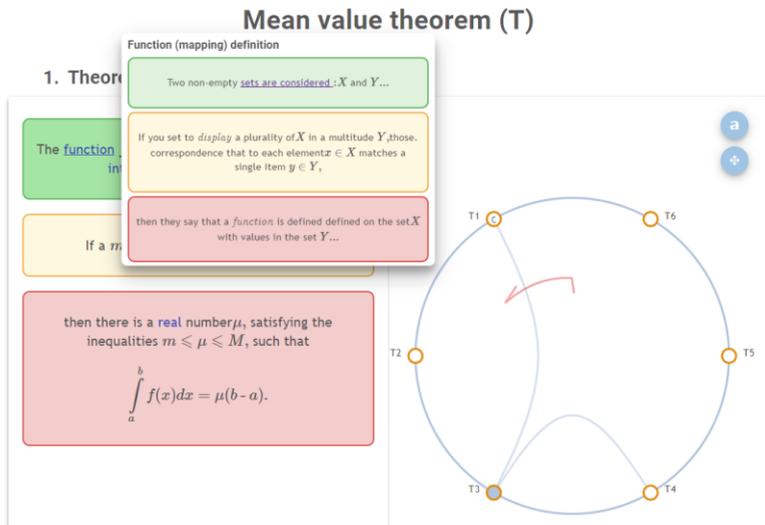
then there is a real number  $\mu$ , satisfying the inequalities  $m \leq \mu \leq M$ , such that

$$\int_a^b f(x) dx = \mu(b - a).$$

**Fig. 2.** The structure of statement adopted in the DLS "NOMOTEX".

As can be seen in the figure, all the terms used in the text have links within the system, and students in the process of passing the training course have the opportunity to refresh their memory of the material already passed.

For example, the following is a link to a statement about the concept of a function introduced in a previous course in Mathematical Analysis (Fig. 3):



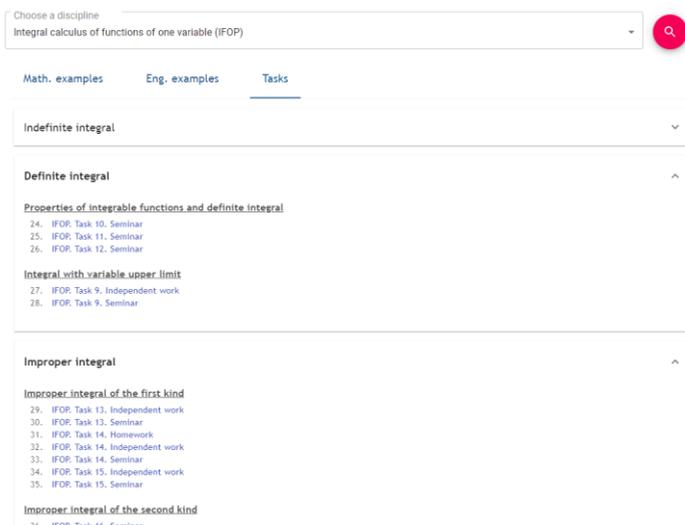
**Fig. 3.** Links in the DLS "NOMOTEX".

The workshops were created in accordance with the approved curriculum and calendar, with special attention to the most common tasks in subsequent engineering disciplines. [4-5]

At the same time, the tasks analyzed in the classroom were divided into so-called types of tasks, written in accordance with the curriculum of the discipline, and covered the full scope of tasks that had to be completed during the semester.

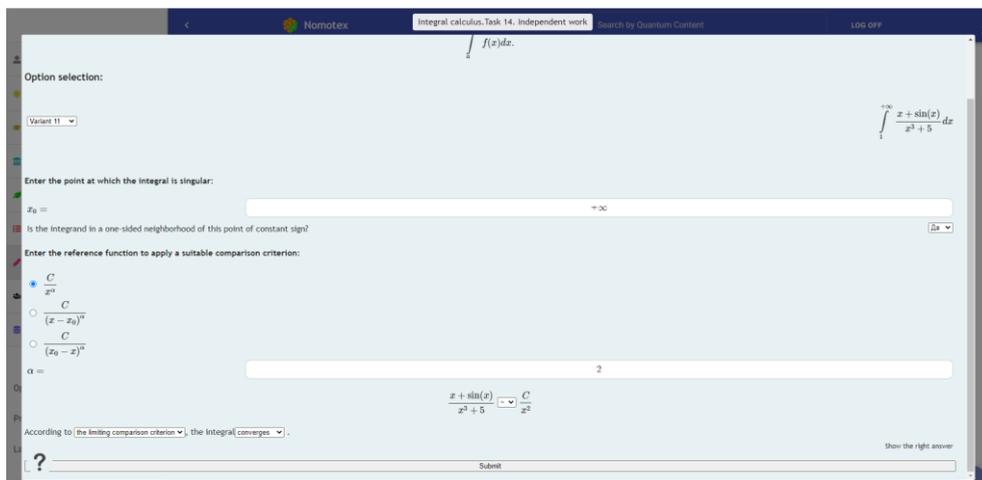
An example of the names of problem types from the module "IFOP": "Find an indefinite integral using the method of integration by parts", "Investigate the existence of an improper integral with several singularities", "Find the area of a figure given in polar coordinates", etc.

The types of problems correspond to the material covered in the theoretical lecture course, they are collected into a single structure in the "Visual Mathematics" section and systematized in accordance with the structure of the theoretical course (Fig. 4):



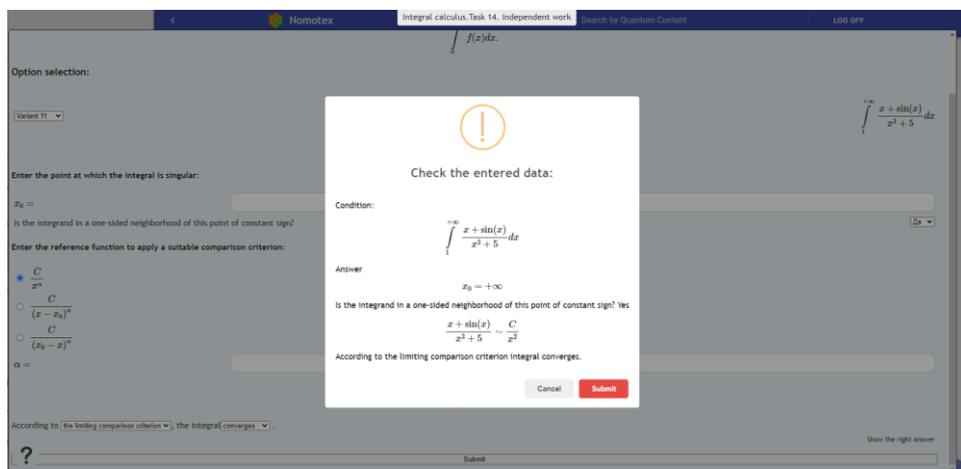
**Fig. 4** Structure of practical lessons in the digital course IC.

For each topic of tasks, tasks of the "Independent work" type were created, which were provided with an interface for checking solutions and the corresponding functionality in the system. Answers to all tasks are entered in the system, while character-by-character input is available (including entering the answer as a function). Some problems, for example, on the study of the convergence of improper integrals, have a whole system for entering an answer that simulates the solution of the problem by a student (Fig. 5):

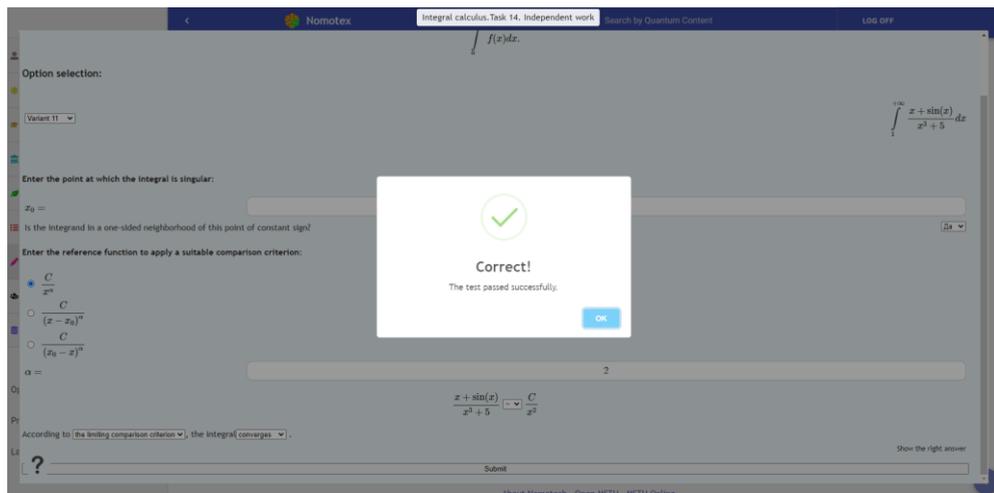


**Fig. 5.** Entering the answer in the DLS “Nomotex”.

When solving problems, a student has an unlimited number of attempts to enter an answer, i.e. the student has the opportunity to make a mistake, correct it and re-check the correctness of the answer. After each input of the answer, the student receives a message about the correctness or incorrectness of his solution (Fig. 6a, 6b):



**Fig. 6a.** Entering the answer in the DLS “Nomotex”.



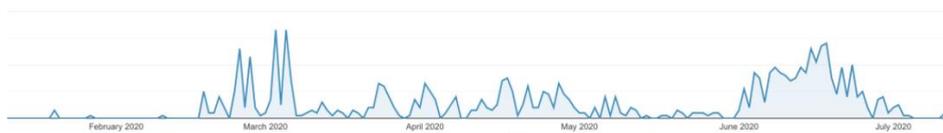
**Fig. 6b.** Entering the answer in the DLS “Nomotex”.

For teachers, the ability to view the correct answer is also implemented for easier verification of the student's solution.

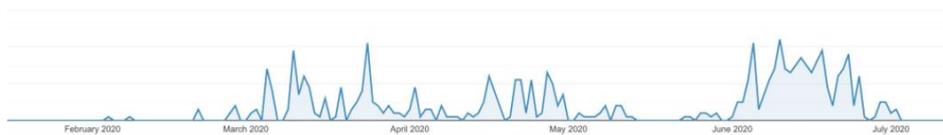
In the 2018-2019 and 2019-2020 academic years, the IC digital course was read to students of the faculties of "Power Engineering", "Aerospace", and for spetiality «Mathematics and Computer Sciences», for a total of 12 and 34 student groups in 2018-2019 and 2019-2020, respectively.

In 2020, there was a particular interest in the course due to the massive transition to distance learning.

Below, for example, graphs of changes in the number of visits to some of the main theorems and definitions of the course of Integral Calculus are presented (quanta Definite integral, Theorem on the estimation of an integral, Change of variable (substitution) in a definite integral, Definition of improper integral of the first kind (over an unlimited interval), Definition of improper integral of the second kind (from unlimited function)) (Fig. 7a, 7b, 7c, 7d, 7e).



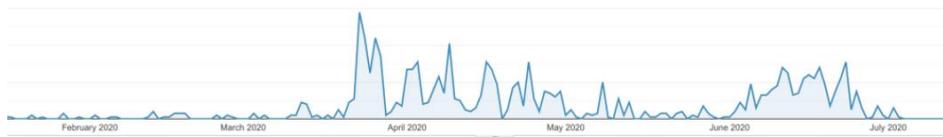
**Fig. 7a.** Dynamics of visits to the quanta Definite integral.



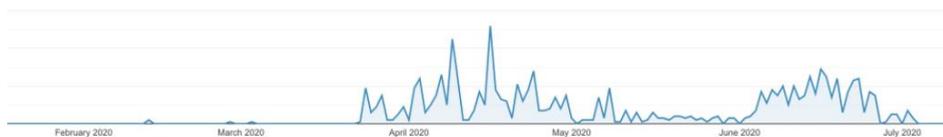
**Fig. 7b.** Dynamics of visits to the Theorem on the estimation of an integral.



**Fig. 7c.** Dynamics of visits to the Change of variable (substitution) in a definite integral.



**Fig. 7d.** Dynamics of visits to the Definition of improper integral of the first kind (over an unlimited interval).



**Fig. 7e.** Dynamics of visits to the Definition of improper integral of the second kind (from unlimited function).

On the graphs, the first bursts of attendance of quanta coincide with the beginning of the learning of quanta in the DLS "Nomotex". The quanta are located sequentially one after the other in the course, and the first surge occurs in the week when the quantum was learning in accordance the curriculum. Uniform bursts for all quanta at the end of April - beginning of May - the period when students were passing the tests. Values distributed over 1–2 weeks. Then, in May, there was a decline in interest, students studied different material at that time, depending on the course. The peak period from early June to early July is the period of the session when students began to prepare en masse for exams.

### 3 Conclusions

Thus, the course aroused a keen interest among students, since the teaching technology for this course was significantly modernized compared to the traditionally taught course, while the course was complete, containing all the necessary materials for training, and available at any time and from any device.

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