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Exploring Mathematical Analysis Based on Project Activity

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In modern learning environments project activity is considered as one of the innovations of the educational system. Study authors devoted to the development and the search for new methods in teaching students to define the role of educational projects in the study of mathematical analysis, establish the basis for the control of knowledge on the subject. Educational projects in mathematical analysis aimed at systematization of knowledge, establishing relationships between individual concepts provisions of the course, on the relationship between different substantively meaningful methodological lines of the subject that provides a holistic perception of the course of mathematical analysis.

Key words: Mathematical analysis, the project activity, the training project.

Mathematical analysis is a large and constantly developing area of mathematics that studies functions using methods based on the theory of limits. It is what holds up modern mathematics, through which its main contact with non-mathematical areas is effectuated. The role of mathematical analysis in the educational process lies not only in the study of major concepts and results related to particular topics. What is of greater importance is that it plays a key role in shaping mathematical culture? This subject vividly demonstrates deep interrelationships both within the discipline and with other areas of mathematics[1]. At present, there is a full-fledged need to introduce innovative methods alongside the traditional expounding of the subject[2-4]. Such innovations may include project activity[5, 6].

Main part

One can employ educational projects throughout the course of study of mathematical analysis. Let us illustrate the stages in their implementation through the example of the topic "One-Dimensional Definite Integrals":

1. Collecting material on the topic from lectures and educational literature. Giving regard to information not provided in lectures. Comparing material in lectures and textbooks in terms of commonness and differences.
2. Working with collected material, studying it through comparing, generalizing, and analyzing certain facts, concepts, and theorems.
3. Making up check questions and tests on the topic under study.

Studying the discipline using projects is, in essence, exploring mathematical analysis[7-9]. The expression

$$\int_a^b f(x)dx := \lim_{\lambda(p)\to 0} \sum_{k=1}^{n} f(\xi_k)\Delta x_k,\ \xi_k \in [a,b] \quad ...(1)$$

is a mathematical notation of the Riemann definite integral.

In accordance with the fundamentals of project activity, we have to not just write the expression down (1) but try to see, notice, and

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grasp what has been written. First and foremost, the student needs to give regard to the operation λ (p) → 0 and try to make out what it means and what follows from it. As a result of grasping it, the student infers that the process is equivalent to the conditions: 1) , i.e. the number of divisions of the segment into parts increases infinitely; 2) the lengths of all the segments tend to zero

$$\lim_{k\to\infty} \Delta x_k = 0 \qquad \text{... (2)}$$

By taking a subsequent, deeper, look the student manages to point up the following facts:

1) in the cases of (1) and (2), one is engaging the theory of limits and the theory of infinitely small quantities;
2) at λ (p) → 0, all the summands in (1) are infinitely small quantities, and each final sum in the first part of (1) is also an infinitely small quantity, but in the limit at λ (p) → 0 we generally do not get a null result (the Riemann definite integral);
3) each of the partial segments $[x_{k-1}, x_k], k = \overline{1,n}$ deforms to a point;
4) in the limit at λ (p) → 0, the discrete summation resolves itself to continuous, which we denote using the symbol for the integral.

Thus, the definite integral is a limiting summation, a continuous summation, as a result whereof the sum's sign is replaceable by the definite integral's sign.

This topic also offers the opportunity for explorations and discoveries of subjective novelty – namely, in the expression (2) and in conceptualizing the differential *dx*, which has been of interest to many thinkers. Based on the above, we have illustrated how much we can derive from regular formulas if we just make ourselves see and explore them.

In accordance with State standards introduced at colleges, much attention is paid to extracurricular independent work by students. In this regard, instructors are facing the objective of putting together the content of assignments for independent work by students and coming up with methods for control over knowledge received.

Teaching mathematical analysis presupposes the creation of a base for control over knowledge on specific topics and sections of the subject. Based on creative reworking of special literature[10-12], we have worked out check questions and assignments on mathematical analysis with elements of project activity.

Here is an example of project questions on the topic "The Definite Integral".

1) Knowledge of which section of mathematical analysis is crucial to computing the definite integral? (That of the indefinite integral).
2) Can we compute the definite integral without engaging the indefinite one via:
   a) differentiation b) multiplication,
   c) the theory of limits d) continuity?
3) In general, under an unlimited increase in the number of division points will the length of all partial segments tend to zero at n→ ∞ ? (No).
4) In general, will the decomposition diameter λ(p) of the segment [a,b] tend to zero at n→ ∞, i.e. under an unlimited increase in the number of division points? (No).

In studying mathematical analysis using project activity, the exploration of a certain topic goes on in conjunction with other topics in the subject – namely, after the study of the Riemann integral we engage for consideration collected material on the improper integral of the function *f*(*x*), on the proper integral $\int_a^b f(x, y)dy$ which depends on the parameter *y*, and the improper integral which depends on the parameter *y*. At the conclusion of work on each of the four integrals, we explore the issue of the interrelationship between them. In this regard, we should put an increased focus on the comparative analysis of these integrals – separately explore the functional properties of the integrals which depend on a parameter and the legitimacy of switching the symbols.

Let us take a look at a couple of examples of project questions on each of the integrals separately and the sections under study as a whole.

1) Which facts should be pointed up in examining the definitions of the improper integral of the function *f*(*x*)? (The improper integral is defined in terms of the limit and is expressed in terms of the proper integral – to be more accurate, as a limit of a family of proper integrals).
2 Is the definite integral a number, an infinity,

an indefiniteness, or a function? (It is a number if the definite integral is proper and does not depend on a parameter. It is an infinity or an indefiniteness, if it diverges. It is a function if the integral depends on a parameter and converges).

3) Which types of integrals are possible? (the Riemann proper integral of the function $f(x)$; the improper integral of the function $f(x)$; the proper integral which depends on a parameter; the improper integral which depends on a parameter)

4) List the types of convergence of integrals that depend on a parameter. (pointwise and uniform).

5) For which integrals are functional properties considered? (integrals that depend on a parameter; integrals with variable upper integration limit).

6) The availability of which property of the integral which depends on a parameter is crucial in considering its functional properties? (uniform convergence)

7) Which properties of functions and integrals that depend on a parameter belong to functional? (the existence of a limit, continuity, integrability, differentiability).

8) The possibility of which non-algebraic operations is established in considering the functional properties of integrals that depend on a parameter? (the possibility of a passage to the limit, differentiation, integration under the integral sign).

9) The subintegral function $f(x)$ is defined on the following sets: a) [a,b]; b) [a,b] ; c) [a,b]×[c,d]; d[a,b]×[c,d]) . For each case, one has to determine the situation of defining the type of integral: (a) the Riemann proper integral of the function $f(x)$; b) the improper integral of the function $f(x)$, whose improperness is associated with the point b; c) the proper integral which depends on a parameter; d) the improper integral of the function $f(x,y)$, whose improperness is associated with the point b.

Inference

The study of mathematical analysis using projects is effectuated by way of establishment of interrelationships and interdependencies between concepts, topics, and sections of the course in mathematical analysis through analogy, generalization, co-subordination of various objects, and through geometrical interpretation of certain concepts and facts. The accumulation of knowledge is attained through the application of major concepts, ideas, and methods of mathematical analysis, analogy, comparison, collection and processing of information. The student is oriented towards the independent acquisition of knowledge in learning new material through the analysis of information and the ability to work with scientific literature, by defining the problem, identifying primary conceptual aspects in proofs, and establishing links between various phenomena. That said that the effectiveness of realizing educational projects on mathematical analysis is attained if their application is not of an episodic nature but is oriented towards systematic work throughout the learning process.

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