European Science Methodical Journal
ISSN (E): 2938-3641
Volume 2, Issue 4, April - 2024

APPLICATION OF MODERN INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE TEACHING OF THE EXACT INTEGRAL

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Abstract:

In the ever-evolving landscape of education, the integration of modern information and communication technologies (ICTs) has become a pivotal aspect in the teaching and learning of complex mathematical concepts, such as the exact integral. The exact integral, a fundamental notion in the field of calculus, represents a crucial tool for understanding and analyzing the behavior of continuous functions. As the demands of the 21st-century classroom continue to evolve, the strategic application of ICTs has emerged as a powerful means of enhancing the comprehension and mastery of this integral concept. The advent of digital technologies has revolutionized the way educators approach the teaching of the exact integral. One of the most significant advancements in this regard has been the development of interactive, multimedia-based learning platforms. These platforms, which often incorporate dynamic visualizations, simulations, and real-time feedback mechanisms, have proven to be invaluable in helping students develop a deeper understanding of the underlying principles and applications of the exact integral.

Keywords: exact integral, education, ICT, teaching problems, mathematics, theoretical calculus, mathematical operations.

Introduction

The exact integral is unquestionably an important topic in mathematics. We will confine our discussion to the teaching of the theorems and techniques in freshman calculus in American colleges. The subject is important partly because of the central role it plays in the calculus course, but more importantly because the teaching of integral calculus provides the first major opportunity for students to learn to understand and to use mathematical theory. This transition from manipulative calculus to theoretical calculus is a difficult one for students to make. For the first time they encounter functions defined only by differential equations or by verbal descriptions, and they must decide on a suitable method of solution or interpretation in terms of specific mathematical operations. This approach to the nature of modern calculus is new to most students, and they need help in making the transition. We feel that the better understanding of basic concepts and the increased skill in handling analytic methods are worthy objectives for students with widely differing mathematical abilities and diverse vocational interests. The teaching of these principles and methods is the aim of theoretical calculus at all levels, and integral calculus provides an excellent vehicle for introduction to the subject.

Importance of the exact integral in mathematics education

An ICT tool such as the TI-83/84 calculator is able to provide a visual link between these two concepts. This is done by using the calculator's "trace" function to build up a Riemann sum of the integral using rectangles and then comparing this with the calculator's built-in command to find the numerical value. Of course, this tool may not be suitable for students who are still struggling with the basic concept of the definite integral, and thus it is important to consider the readiness of the learners when deciding whether to introduce an ICT.

In elementary calculus courses, the exact integral provides a link between the areas of 2-dimensional regions and the accumulation of a quantity. Student difficulties with the concept have been a topic of much mathematical educational research. Part of the problem lies in the contrast between the definite integral as a signed area and as a numerical value. For simple functions, these are the same, but when dealing with real data, students have trouble understanding when it is appropriate to use each interpretation.

The importance of the exact integral to the study of mathematics, engineering, or physics cannot be underestimated. In every case where a physical system is modeled using mathematics, the exact integral will play a crucial role in finding a solution. Modern computing power has meant that it is often possible to avoid finding an exact solution to a differential equation; nevertheless, in order to determine the behavior of a system as the independent variable tends to infinity, or to determine an initial condition given a general solution, the exact integral will be required.

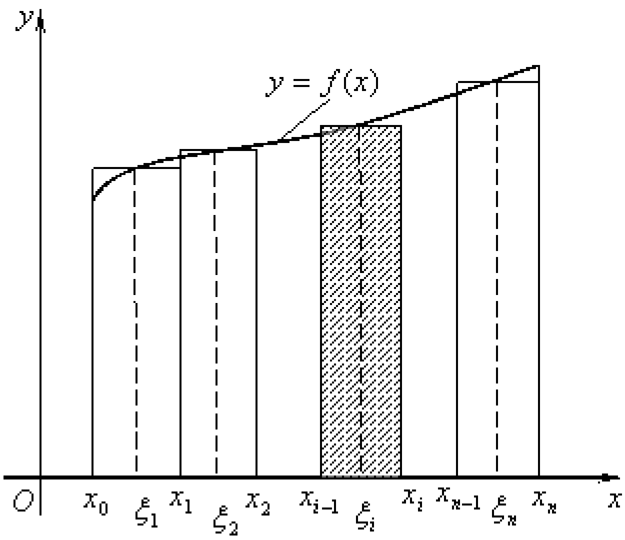
Overview of modern information and communication technologies (ICTs)

In terms of teaching and learning the exact integral, ICTs offer a variety of ways in which the visualization of, and subsequent intuition about, the exact integral can be enhanced. Visualization is important because it is closely linked to students' conceptual understanding of mathematical ideas (Schoenfeld, 1992). At the completion of a first course in the study of the integral, students possess only a limited collection of integrals for which they are able to find the exact value. In attempting to evaluate the exact value of integrals beyond their limited collection, students tend to resort to Riemann sum approximations or the use of technology to find numerical approximations. This is often because the understood meaning of the integral – as the accumulation of a quantity or the computation of some other exact answer – is not connected with the symbolic manipulation of the expression to find the antiderivative and the evaluation of this expression at the limits of integration. These methods may be applied to any integrand and will sometimes yield an exact answer. Given that an exact integral is a direct application of the antiderivative – which is the most important single idea in the study of elementary calculus (Robinson, 1962) – it is desirable to enhance understanding of the exact integral at both the calculus and pre-calculus levels, by connecting it with the accumulation idea and by providing as many varied opportunities as possible to find the exact value of an integral. A main advantage of ICTs is that it can offer dynamically linked visual and numerical methods to find the exact value of an integral and to confirm that it agrees with the accumulation result.

Information and communication technologies (ICTs) are a diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information. Brenner (1997) defined ICTs to include "any device or system that allows the acquisition, processing, storage and/or dissemination of information, and includes both Internet and computer-based technologies as well as more traditional forms of technology such as radio, television, and telephone". As we will detail below, each of these devices and systems has the potential to impact student learning of mathematics and the teaching of it – including the teaching and learning of the exact integral.

The problem of the surface of a curved trapezoid

A rectangular Cartesian coordinate system is included $[a;b]$ in the plane and Oxy, $b>a$ in the cross-section is continuous and non-negative $y=f(x)$, i.e., $f(x)\geq 0$ let the function be defined. A figure bounded from above $y=f(x)$ by the arc of the graph of the function, from below by the section Ox of the axis $[a;b]$, from the sides $x=a,\ 0\leq y\leq f(a)$ and $x=b,\ 0\leq y\leq f(b)$ by straight lines is called $aABb$ a curved trapezoid (Fig. 2). $aABb$ we describe the surface $[a;b]$ of a curved trapezoid. S we divide



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$a=x_0<x_1<\ldots<x_{i-1}<x_i<\ldots<x_{n-1}<x_n=b$ the section into small sections: n we mark the abscissas of the points of division. the set $\{x_i\}=\{x_0,x_1,\ldots,x_n\}$ of points of division $[a;b]$ is called the division of the cross section. we draw a straight line x_i parallel to the axis $x=x_i$ through the dividing points Oy. These straight lines $aABb$ divide the trapezoid into segments $aABb$ with n bases . $[x_{i-1};x_i]$ the surface n of the trapezium S is equal to the sum of the

surfaces of the tapes. n is sufficiently large and $[x_{i-1};x_i]$ when all cross-sections are small, n the surface of each strip can be replaced by the surface of a corresponding right rectangle, which is easy to calculate. We select a point in ξ_i each section $[x_{i-1};x_i]$, calculate $f(x)$ the value of the function at this point $f(\xi_i)$ and take it as the height of the rectangle. $[x_{i-1};x_i]$ a continuous function has a small change in the cross section when the cross section is small. $f(x)$ Therefore, the function $f(\xi_i)$ can be said to be constant and approximately equal in these sections. The surface area of one strip $f(\xi_i)(x_i - x_{i-1})$ is equal to, the surface $aABb$ of a curved trapezoid is S approximately S_n equal to:

$$S \approx S_n = \sum_{i=1}^{n} f(\xi_i)\Delta x_i, \quad \Delta x_i = x_i - x_{i-1} \quad (14.1)$$

(14.1) $d = \max_i \Delta x_i \ (i = \overline{1,n})$ the smaller the value, the more accurate the approximation. is called the diameter of the division d into size $\{x_i\}$. In this $n \to \infty$ too $d \to 0$. Thus, the surface of a curved trapezoid is defined S as S_n the limit of the dividing diameter of the surface of the rectangle as it tends to zero, i.e.

$$S = \lim_{d \to 0} S_n = \lim_{d \to 0} \sum_{i=1}^{n} f(\xi_i)\Delta x_i. \quad (14.2)$$

So, the problem of calculating the surface of a curved trapezoid is reduced to the calculation of the limit in the form (14.2). We return to the problem of the surface of a curved trapezoid. (14. 2) the right side of the equation consists of an integral sum. Then formula (14.5) gives $f(x)$ the geometric meaning of the definite integral : if the function $[a;b]$ is integrable on the section and non-negative, then $[a;b]$ the definite integral obtained from the function on the section $f(x)$ $y = f(x) \geq 0, \ y = 0, \ x = a, \ x = b$ $a < b$ with lines
is equal to the surface of a bounded curved trapezoid.

An example

$$\int_{-3}^{3} \sqrt{9 - x^2}\,dx$$

we calculate the integral based on its geometric meaning.

In this case, x the change from too $y = \sqrt{9 - x^2}$ has -3 an 3 equation

the line $x^2+y^2=9$ will consist of the upper part of the circle. Therefore, $x=-3,\ x=3,\ y=0,\ y=\sqrt{9-x^2}$ a curved trapezoid bounded by lines $x^2+y^2=9$ forms the upper part of the circle. His face $S=\dfrac{9\pi}{2}$ is equal to.
So,

$$\int_{-3}^{3}\sqrt{9-x^2}\,dx=\frac{9\pi}{2}.$$

Now let's move on to the question of the path taken. Since the right-hand side of the equation (14.3) consists of an integral sum, from the formula (14.5) we come to the following conclusion: if $v(t)$ the function $[a;b]$, $a<b$ is integrable in the section and is non-negative, then $v(t)$ the definite integral obtained from the velocity in the time interval $[a;b]$ is equal to the path traveled by the material in the time interval from $t=a$ to. $t=b$

Properties of definite integral

1°. If the function under the integral is equal to one, then

$$\int_a^b dx=b-a$$

will be

2°. Taking the constant multiplier out of the definite integral sign possible, that is

$$\int_a^b kf(x)dx=k\int_a^b f(x)dx,\quad k=const.$$

3°. Algebraic sum of a finite number of functions definite integral is equal to the algebraic sum of definite integrals of addends , i.e.

$$\int_a^b (f(x)\pm\varphi(x))dx=\int_a^b f(x)dx\pm\int_a^b \varphi(x)dx.$$

4°. If $[a;b]$ the section is divided into several parts, then $[a;b]$ the exact integral obtained over the section is equal to the sum of the exact integrals obtained over each part. For example,

$$\int_a^b f(x)dx=\int_a^c f(x)dx+\int_c^b f(x)dx,\quad c\in[a;b].$$

5°. If $[a;b]$ the function does not change its sign in the intersection, then the sign of the definite integral of the function is the same as the sign of the function, that is:

$[a;b]$ when $f(x) \geq 0$ in $\int_a^b f(x)dx \geq 0$;

$[a;b]$ when $f(x) \leq 0$ in $\int_a^b f(x)dx \leq 0$.

6^o. If it is $[a;b]$ in the section $f(x) \geq \varphi(x)$, then

$$\int_a^b f(x)dx \geq \int_a^b \varphi(x)dx$$

will be

Newton-Leibniz formula

Calculating the definite integral as the limit of the sum of integrals is quite difficult even for simple functions. For this reason, let's get acquainted with the practically convenient and widely used method of calculating the exact integral based on formula (15.3).

Theorem 2 (the main theorem of integral calculus). If $F(x)$ the function is the initial function of a function $[a;b]$ that is continuous in the section $f(x)$, then $[a;b]$ the exact integral obtained from the function $F(x)$ in the section $f(x)$ is equal to the product of the function in the interval of integration, i.e.

$$\int_a^b f(x)dx = F(b) - F(a) \quad (15.4)$$

Newton-Leibniz formula to formula (15.4). is called

$F(b) - F(a)$ the difference conditionally $F(x)\Big|_a^b$.

This agreement results in the Newton-Leibniz formula

$$\int_a^b f(x)dx = F(x)\Big|_a^b \quad (15.5)$$

expressed in clothing.

Conclusion

Despite these challenges, the potential benefits of incorporating modern ICTs in the teaching of the exact integral are undeniable. By leveraging the power of digital technologies, educators can create engaging, interactive, and personalized learning experiences that foster a deeper understanding of this fundamental concept in calculus. As the educational landscape continues to evolve, the strategic application of ICTs in the teaching of the exact integral will undoubtedly play a crucial role in preparing students for the demands of the 21st-century workforce and beyond.

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