Organizing Learning Using Interdisciplinary Connections In Mathematics Education

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A B S T R A C T
The main purpose of this article is to present a contemporary view of this field, which has emerged at the intersection of mathematics and engineering education.

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A R T I C L E I N F O
Article history:
Received 19 Feb 2026
Received in revised form 20 Mar 2026
Accepted 23 Apr 2026

Keywords: Integration, Mathematics in Engineering, Digital Technologies, Innovation, Mathematical Competencies

Introduction

Nowadays, mathematical ideas and methods are rapidly entering the research fields of many sciences. As a result, new fields of knowledge are being laid. As a result of the rapid development of mathematical knowledge, such disciplines as mathematical biology, mathematical economics, and mathematical linguistics have emerged. Not only the exact sciences, but also disciplines such as archeology and even linguistics and art history are increasingly in need of mathematical methods of scientific research. The role of mathematics in the implementation of national economic plans is also extremely large [1]. It is no exaggeration to say that in many cases the development of certain sciences was and is strongly influenced by mathematics. In various areas of science, many examples can be given of scientists using mathematical apparatus to overcome the abstract in areas that cannot be verified experimentally.[2] The research of Uzbek mathematicians on probability theory, mathematical statistics, topology, number theory, differential equations, computational mathematics and the application of mathematics in the national economy and technology is especially fruitful. Currently, worldwide mathematical research and the application of mathematical methods in the branches of technology and the national economy are increasingly gaining momentum.[3] Therefore, it is necessary to pay attention to the modern demand for teaching mathematics in general secondary education, higher and secondary specialized educational institutions. At the same time , it is worth highlighting the reasons why mathematics is needed and why it is necessary to study it :

-develops differentiation;

- sharpens memory;

- helps to achieve success in the gym;

develops skills to solve everyday problems ;[4]

-solving mathematical problems creates psychological stability. [5] At the same time, teaching mathematics consistently with natural sciences: physics, chemistry and engineering, helps students solve problems related to the identification, modeling and improvement of physical, chemical and technical processes,

expands the scope of independent thinking of students, ensures the emergence and development of humanitarian ideas in students, and connects the rules, laws and formulas of mathematics with natural sciences, creating opportunities for the development of students' mathematical abilities.[6]

Methodology.

The use of intersubject relationships in mathematics education is, first of all, the organization of a reserve of mathematical models, that is, their use in a more in-depth study of other subjects. This reserve of models includes the basic concepts of mathematics, namely: magnitude, number, function, figure, equation, derivative, integral, probability, etc. For example, derivative mathematics is used in solving various physical, chemical, and technical problems, as well as in studying the speed of mechanical motion, reaction rates, and changes in the flow of charges.[7] Mathematical models of problems:

-solving mathematical equations;

-find the largest and smallest value of a function;

-solving differential equations;

- search for functions satisfying initial conditions;

-finding patterns of certain quantities, etc.[8]

From a mathematical point of view, determining the center of gravity is one of the important applications of integral calculus. If the figure is bounded by curves , its surface area must be found not by simple geometric formulas, but by definite integrals. At the same time, not only the surface area, but also the static moments are calculated to determine the center of gravity [9]. This helps students to understand the physical and geometric meaning of the integral more deeply.

Results and Discussion.

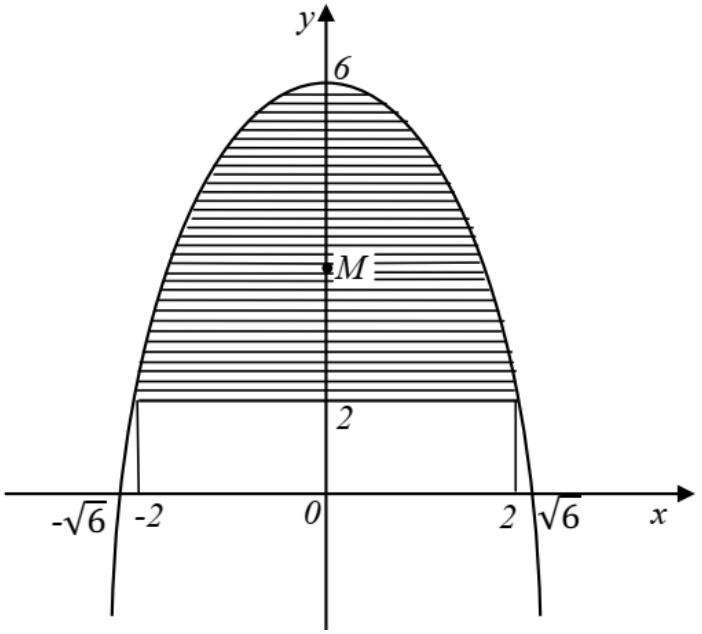
Theoretically, the concept of the center of gravity is also closely related to symmetry. If a figure is symmetrical, its center of gravity is located on the axis of symmetry. In complex figures, mathematical analysis methods are used to find this point. Therefore, such problems teach students logical thinking, geometric imagination, and mathematical modeling .[10]

Example. $y = 6 - x^2$ and $y = 2$ Find the center of gravity of a homogeneous flat figure bounded by lines.

Solution. Since this figure is homogeneous and symmetrical Figure 1. $x_c = 0,\ y_c = ?$ and to find ,

$$x_c = \frac{\int_a^b x\,[f_2(x) - f_1(x)]dx}{S}, \quad y_c = \frac{1}{2}\frac{\int_a^b [f_2^2(x) - f_1^2(x)]\,dx}{S}$$

We calculate by the formula, where is $S = \int_a^b f(x)\,dx$the surface area of the trapezoid.



$$y_c = \frac{1}{2}\frac{\int_{-2}^{2}((6-x^2)^2-2^2)\,dx}{\int_{-2}^{2}(4-x^2)\,dx} = \frac{1}{2}\frac{\int_{-2}^{2}(32-12x^2+x^4)dx}{2\int_{0}^{2}(4-x^2)\,dx} =$$

$$= \frac{1}{2}\frac{\left(32x-4x^3+\frac{x^5}{5}\right)\Big|_0^2}{\left(4x-\frac{x^3}{3}\right)\Big|_0^2} = \frac{1}{2}\frac{\frac{192}{5}}{\frac{16}{3}} = 3{,}6\,.$$

teaching this topic to engineering students is that in real production processes, many physical quantities — for example, pressure, temperature, speed, electric voltage, or energy consumption — are expressed by complex functions. When it is difficult to find their integral exactly , the trapezoidal formula provides a fairly accurate result. This provides a quick and convenient solution in engineering calculations.[11]

The trapezoid formula also prepares students for numerical analysis. Modern computer programs, such as MATLAB, Mathcad, ANSYS or Python libraries, calculate the integral using exact numerical methods. If a student does not know the theoretical basis of this method, it will be difficult to understand and verify the results of the program. Therefore, it is important to learn the formula by hand .[12]

Example. $\int_0^1 \frac{dx}{2+x}$, $n = 5$ We calculate the approximate value of the integral using the trapezoid formula.

Solution $f(x) = \frac{1}{2+x}$, $\frac{b-a}{n} = 0{,}2$.

k	0	1	2	3	4	5
x_k	0	0.2	0.4	0.6	0.8	1
y_k	$\frac{1}{2}$	$\frac{1}{2{,}2}$	$\frac{1}{2{,}4}$	$\frac{1}{2{,}6}$	$\frac{1}{2{,}8}$	$\frac{1}{3}$

$$\int_0^1 \frac{dx}{2+x} \approx 0{,}2\left(\frac{0{,}5+0{,}333}{2}+0{,}4545+0{,}4167+0{,}3571\right) \approx 0{,}4059$$

Now let's evaluate the error :

$$f'(x) = -\frac{1}{(2+x)^2}\,,\quad f''(x) = \frac{2}{(2+x)^3}\,,\quad f'''(x) = -\frac{6}{(2+x)^4}\,.$$

$f''(x)$ function$[0\,;\,1]$ It does not have any stationary points.

So,

$$\max_{[0\,;\,1]}\left|\frac{2}{(2+x)^3}\right| \Big|_{x=0} = \frac{1}{4}|R_5| \le \frac{1}{12\cdot 25}\cdot\frac{1}{4} \approx 0{,}00083 < 0{,}001\,.$$

Therefore, the topic of approximate integral calculation using the trapezoidal formula is taught to engineering students to explain the practical application of mathematical analysis , to model real processes, to understand computer calculation methods, and to form the theoretical preparation necessary for future engineering activities .[13]

The results show that the relationships between vocational teachers and mathematics teachers are described differently. However, what they have in common is mutual respect and recognition of the competence of other groups as teachers. Most vocational teachers describe themselves as teachers who have very good relationships with students, who meet with students frequently, and whose students value their expertise. They also speak very positively about mathematics and as something valuable and useful in their profession. Not all vocational teachers speak as successfully about the integration project as mathematics teachers. One of the most important elements in describing the project as successful is that mathematics teachers approach their professional colleagues with humility and a genuine interest in identifying the different ways in which mathematics is part of different professions. This identification also includes finding ways to incorporate this “workers’ mathematics” into mathematics teaching. The school has attempted to develop similar integration projects in other subjects. However, these projects have not been very successful, and vocational teachers say that it is more difficult to identify these subjects in their professions, so collaboration is not very effective. An important aspect of the relationship between vocational teachers and mathematics teachers is that the school offers only vocational programs. There are no theoretical programs. The school has the ambition to act as a model for a workplace where teachers act as managers rather than teachers, and this creates an environment where power and status come not from having theoretical knowledge, but from developing and maintaining good relationships. Historically, there has been an evolution in the literature on mathematics curricula in engineering education. Initially, mathematicians had their own ideas about how to teach mathematics to engineers. Subsequently, research using relevant theories and methods has developed consistently, including a more in-depth analysis of current mathematics curricula in engineering. Another theoretical concept that can inform educational interventions is the concept of “techno-mathematical literacy”, initiated by Kent and Noss and developed by Van der Wal et al.[14] Research on student practice, particularly interventions that focus on instructional strategies, suggests that they can have a positive impact on engineering student achievement. We observed that the actual practice of instructors has not yet been comprehensively explored; this could be an interesting direction for future research that could inform the design of innovations. The area of resources, particularly digital curriculum resources, has probably developed the most in the last decade. With digitization and the emergence of a large number of open educational resources, students and teachers have access to and can choose from a wide range of digital resources. University teachers have also changed their course materials to be digitally available, and students can access digital resources wherever they are (e.g. at home, on the train). In addition, students can prepare for course modules, learn and organize curriculum resources to suit their individual learning and study paths

and their own rhythm. This means that designers of mathematics courses for engineers need to change their mindset from teacher-centered teaching to student-centered teaching ("which math modules do I need"). In other words, it is not clear to what extent teaching and (expected) learning approaches are adapted to this new digital environment, where new and different interactions are appropriate and can be anticipated. However, most of the existing research on resource use by engineering students is not specific to the engineering context.[15]

Conclusion.

We therefore believe that more research is needed on how engineering students and their teachers might select and use resources. In such an innovative environment, the university should consider the following:

Mathematics teachers cannot rely solely on their own experiences of teaching and learning (in traditional ways), but should be encouraged to ask: what does it mean to be "practical" or "challenge-based" in mathematics education, and how can I design, teach, and assess such learning? Developing and implementing these reflections requires time and resources, as well as support from the institution/university.

Prospective students may come to campus not to attend lectures, but to work in innovative/maker spaces with their peers, and are expected to learn mathematics using a variety of devices. Learning mathematics on campus or off campus in a mobile way may require different activities and learning methods than those traditionally envisioned.

Traditionally, mathematics education has been expected to provide the necessary knowledge for an engineering curriculum, as it has been found to lay the foundation for basic mathematical knowledge as well as analytical and problem-solving skills frequently required in traditional engineering.

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