INTERNATIONAL JOURNAL OF TECHNOLOGY AND ACADEMIC RESEARCH

ISSN: 2224-6878 | Pakistan Volume 6, No. 10.

IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

THE IMPORTANCE OF MATHEMATICS IN THE DEVELOPMENT OF SCIENCES

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Doi: https://doi.org/10.5281/zenodo.23375936

Abstract. The article reveals the relationship of mathematics with physics, chemistry, biology and other Sciences.

Keywords: differential, integral, derivatives, physics, biology, chemistry, engineering, ecology, interpretation, algorithm, model, function.

Annotatsiya. Maqolada matematikaning fizika, kimyo, biologiya va boshqa fanlar bilan uzviy bog‘liqligi ochib berilgan.

Kalit so‘zlar: Differensial, integral, hosila, fizika, biologiya, kimyo, texnika, ekologiya, Interpritasiya, algoritim, model, funksiya.

Аннотация. В статье раскрывается взаимосвязь математики с физикой, химией, биологией и другими науками.

Ключевые слова: дифференциальные, интегральные, производные, физика, биология, химия, техника, экология, интерпретация, алгоритим, модель, функция.

As people acquire scientific knowledge, they naturally become interested in who discovered the secrets of science and how these discoveries were made. They strive to understand the processes through which such knowledge was obtained. Those who are interested in scientific discoveries often aspire to uncover new knowledge themselves in the future. Therefore, they are particularly interested in the history and methods of discovering the scientific principles that have been established to date. Mathematics, also known as the science of quantitative relations, is a discipline that possesses immense intellectual appeal due to its countless and diverse mysteries.

By the middle of the twentieth century, science had begun to develop at an increasingly rapid pace. Revolutionary changes occurred in many scientific fields, resulting in major innovations and discoveries. Scientific progress, in turn, accelerated technological development and expanded the scope of practical applications. For example, the development of technologies for space exploration, the creation of electronic computing machines, and the construction of high-capacity power stations contributed to the emergence of the scientific and technological revolution. Today, the scientific and technological revolution is penetrating all spheres of nature, society, and human life [1].

“Science is systematised knowledge. Science is not merely the accumulation of facts; rather, it is the collective effort involved in gathering and organising information,” stated the English philosopher Herbert Spencer.

“Mathematics is an exceptionally elevated science in which a whole world of wonders is concealed,” remarked Mirzo Ulugbek.

ISSN: 2224-6878 | Pakistan Volume 6, No. 10.

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Modern sciences are generally classified into three major categories according to their subject matter: social sciences, natural sciences, and technical sciences. Each category encompasses numerous related disciplines, together forming an integrated system of scientific knowledge. Mathematics occupies an important position within this system. The term mathematics originates from the Greek word associated with learning and knowledge. The objects of pure mathematics are the spatial forms and quantitative relationships of the world, which are grounded in objective reality. Mathematics is developing rapidly, and its range of practical applications continues to expand [2].

Mathematics is widely applied in all branches of technology, including various types of computing machines, the modelling of the operating principles of nuclear reactors, mathematical control systems designed for space exploration, the control of jet aircraft, and numerous other fields. In short, practical experience confirms the close relationship between mathematics and production processes.

Thus, the traditional understanding that mathematics deals with the study of the "spatial forms and quantitative relationships" of objects in the real world has expanded considerably in both scope and content [3].

Despite their abstract nature, mathematical concepts reflect the properties and regularities of the real world. A concept is one of the fundamental forms of logical thinking that represents the general and essential characteristics of an object or phenomenon. A concept is considered complete and meaningful when it adequately and accurately represents the essential characteristics of an object that exists in reality or is expressed in an abstract form.

Concepts can be divided into two categories according to their content:

Basic (initial) concepts, which are accepted without formal definitions, that is, primitive concepts.

Complex concepts, which are defined by means of other concepts.

Concepts belonging to these two categories are classified, systematised, and progressively expanded. As a result, the content of a scientific discipline is developed. In the process of explaining and advancing scientific knowledge, the need arises to introduce new concepts. Their meanings are refined in form and enriched in content through previously established concepts. The development of concepts, in turn, plays an important role in systematising the content of a particular scientific field, advancing its development, and determining its practical applications.

Just as every scientific discipline consists of a systematised body of concepts, mathematics also comprises a specific system of interconnected concepts and their applications. Mathematical concepts are abstract. They do not exist directly in the real world as independent objects; rather, they are expressed through representations of objects and the elements that constitute them. Mathematical concepts reflect the properties and regularities of the real world. They may also be regarded as symbols representing the forms and patterns of development of nature and society. Concepts play a crucial role in explaining the content of mathematics and presenting its internal logical relationships systematically [4].

The foundations of mathematical development, like those of other sciences, arise from the practical needs of human activity. Scientific progress is closely associated with the development of production. As is often emphasised, "Mathematics, like other sciences, emerged from the practical needs of people, including measuring land areas, determining the capacity of containers, measuring time, and solving elementary problems of mechanics."

Indeed, although different branches of mathematics are distinguished by the diversity of their methods for studying the spatial forms and quantitative relationships of the real world, they are united by their common principles and underlying unity.

The content of mathematics can be described through the following components:

ISSN: 2224-6878 | Pakistan Volume 6, No. 10.

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Facts accumulated throughout the development of the discipline.
Scientific hypotheses formulated on the basis of these facts. Such hypotheses are subsequently tested through experimentation and developed into theories and laws.
Methodology, which involves studying theories and laws and expressing the general principles and approaches characteristic of mathematical inquiry.
Generalisation of facts and experimental results, which contributes to the formation of new scientific knowledge and the development of mathematical theories.

Let us examine the significance of mathematics in the development of science in the context of military and applied problems. The following section focuses on several case studies designed to support cadets' independent learning on the topic of Random Events and Probability, together with the methodological procedures for their implementation [5].

Case Study 1

Electric light bulbs are manufactured at three factories. The first factory produces 45% of all the bulbs, the second produces 40%, and the third produces 15%. Of the bulbs manufactured by these factories, 70% of those produced by the first factory, 80% of those produced by the second factory, and 81% of those produced by the third factory are of standard quality.
Products from all three factories are delivered to a shop. Determine the probability that a light bulb purchased from the shop is serviceable.

Questions and Tasks

1. Examine and analyse the problem in detail.
2. Identify the main problem and its subproblems.
3. Determine the principal event under consideration.
4. Can you identify any hypotheses in the problem?

Is it appropriate to apply the law of total probability to solve this problem?
Problem Statement. Determine the probability that a light bulb purchased from the shop is serviceable. Teacher's Guidance. Identify the mutually exclusive events that constitute a complete group of events. Apply the classical definition of probability and the law of total probability.

Method 1: Solution Using an Elementary Approach

The proportion of functional light bulbs is 70% at the first factory, 80% at the second factory, and 81% at the third factory, out of a total of 100% of light bulbs. Therefore, the average proportion of functional light bulbs among the purchased bulbs is $\frac{0,7+0,8+0,81}{3}=\frac{2,31}{3}=0,77$.

Method 2. Solution Using Probability Theory

Based on the conditions of the problem, let us introduce the following events.
Let B denote the event that a purchased light bulb is found to be functional. The occurrence of this event is directly related to the occurrence of the following events:
A_1 – the event that the purchased light bulb was manufactured at the first factory;
A_2 – the event that the purchased light bulb was manufactured at the second factory;
A_3 – the event that the purchased light bulb was manufactured at the third factory.
From the conditions of the problem, we can derive the following:

$P(A_1)=0,45,\ P(A_2)=0,40,\ P(A_3)=0,15;\ P(B/A_1)=0,70,\ P(B/A_2)=0,80,\ P(B/A_3)=0,81.$

Furthermore, since, it follows that the probability we are seeking is equal to $B=A_1B+A_2B+A_3B$.

$P(B)=P(A_1)P(B/A_1)+P(A_2)P(B/A_2)+P(A_3)\ P(B/A_3)=0,45\ \ 0,70+0,40\ \ 0,80+0,15\ \ 0,81=$

$=0,7565$

Comparing the results obtained, the superiority of the second method becomes evident.

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Case Study 2.

There are 12 containers. Six belong to the first group, which contains 3 white balls and 4 black balls; three belong to the second group, which contains 2 white balls and 8 black balls; two containers belong to the third group, which contains 6 white balls and 1 black ball; and one container belongs to the fourth group, which contains 4 white balls and 3 black balls. One ball is selected at random. What is the probability that the selected ball is white and belongs to the third group [6].

Questions and Tasks:

1. Analyse the problem in its entirety.
2. Clarify the problems involved.
3. Identify the principal event.
4. What do you understand by the term hypothesis?
5. How many hypotheses are there in the problem?

Explain the meaning of Bayes' formula.

Problem: Determine the probability that the selected ball is white and belongs specifically to the third group.

Teacher's guidance: Use the classical probability formula and the formula for conditional probability.

Method 1. Solution using probability theory formulas.

Based on the conditions of the problem, let us introduce the following events. Let B denote the event that the selected ball is white. The occurrence of this event depends on the following assumptions:

A1 — the event that the first group is selected;

A2 — the event that the second group is selected;

A3 — the event that the third group is selected;

A4 — the event that the fourth group is selected.

We determine the probabilities of these events using the classical probability:

$$P(A_1)=\frac{6}{12}=0{,}5,\ P(A_2)=\frac{3}{12}=0{,}25,\ P(A_3)=\frac{2}{12}=\frac{1}{6};\ P(A_4)=\frac{1}{12}.$$

Furthermore, using the facts that, $B=A_1B+A_2B+A_3B+A_4B$ va A_3/B we determine the required probability.

$$P(B/A_1)=\frac{3}{3+4}=\frac{3}{7},\ P(B/A_2)=\frac{2}{2+8}=\frac{2}{10}=\frac{1}{5},\ P(B/A_3)=\frac{6}{6+1}=\frac{6}{7},\ P(B/A_4)=\frac{4}{4+3}=\frac{4}{7}.$$

By applying the formula for hypotheses, we find the probability that the white ball belongs to the third group.

$$P(A_3/B)=\frac{P(A_3)P(B/A_3)}{P(A_1)P(B/A_1)+P(A_2)P(B/A_2)+P(A_3)P(B/A_3)+P(A_4)P(B/A_4)}=$$

$$=\frac{\frac{1}{6}\ \frac{6}{7}}{\frac{1}{2}\ \frac{3}{7}+\frac{1}{4}\ \frac{1}{5}+\frac{1}{6}\ \frac{6}{7}+\frac{1}{12}\ \frac{4}{7}}=\frac{\frac{1}{7}}{\frac{3}{14}+\frac{1}{20}+\frac{1}{7}+\frac{2}{21}}=0{,}314\ ..$$

Thus, the probability that the white ball comes from the third group is 31.4%

Method 2. Solution using elementary mathematics.

There are 12 containers in total. Two of them belong to the third group, which contains 6 white balls and 1 black ball. The total number of white balls across all groups is 15. If 15 is taken as 100%, we can determine what percentage the 6 white balls in the third group represent. Thus, 6 white balls account for 40%, or 0.4 [7].

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Despite the amount of calculation involved, Method 1 is the optimal approach. The margin of error is small. In conclusion, using case-based tasks in mathematics lessons can greatly help teachers improve cadets' intellectual knowledge and skills as they work to solve problem-based examples and tasks related to the topics studied.

Through its applications, mathematics evokes emotional responses in people in much the same way as reading literature, listening to music, or admiring landscapes. In doing so, it encourages thought and helps shape a person's worldview [8].

In conclusion, it should be emphasised that mathematics arose from practical needs in the past and has remained a powerful tool for exploring the world throughout every stage of human conscious life—from the era of primitive people to the invention and development of electronic computers, one of the major scientific and technological achievements of our time, and to spaceflight. It will continue to serve this purpose in the future. All sciences are connected, to varying degrees, with the numerical relationships and spatial forms of the world around us. Whether a process is physical, biological, sociological, or chemical, mathematics is used to study these relationships.

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