Teaching of Numerical Systems and Their Extensions

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ABSTRACT

The organizational aspects, practical importance and theoretical foundations of the implementation of the pedagogical education cluster are highlighted. The author tried to justify his views with the opinions of Western scientists. The scientific researches of Western scientists regarding the educational cluster are analyzed and the author's attitude to them is expressed

Keywords: numbers, number systems, natural, whole, rational, and complex numbers, numerical expansions and their characteristics

Enter. The role of numbers in the development of science, technology, and human life in general is incomparable. That is why it is very important to study the construction of numbers and their properties on a theoretical basis. It can be said that numerical systems form the basis of general secondary education mathematics. Because some operations on natural numbers that are formed intuitively, their comparison is studied in elementary school, and then the system of natural numbers is expanded with negative numbers. Natural, whole and rational numbers, operations between them, and properties of these operations are studied up to VII grade. Going to grade VIII, the concept of the approximate value of a number and square root, which will be the basis for introducing the concept of irrational number, will be studied.

Simple applications of mathematics are simple a+x=b and ax=b $(a \neq 0)$ is shown by solving linear equations of the form It can be said that first negative numbers and then fractional numbers entered mathematics in the need to solve similar equations. But in mathematics, there are different equations. As a continuation of the above points $x^n - a = 0$ and $x^2 + 1 = 0$ Number systems are expanded using irrational and complex number systems in order to determine the solutions of such equations.

Rational and irrational numbers together are known as the real number system, and this system is studied in general secondary education, and the complex number system is studied in vocational colleges and academic lyceums.

The question of whether it is possible to further expand the numerical expansions built due to the need to solve simple mathematical equations is fully answered in some areas of higher education. Next, we present some suggestions for the teaching of real and complex number systems, along with considerations for the construction of complex number system extensions. For the sake of simplicity, we would like to mention the use of

the following special symbols for some sets of numbers:
N is the set of all natural numbers;
Z is the set of all integers;
Q is the set of all rational numbers;
I is the set of all irrational numbers;
R is the set of all real numbers;
C is the set of all complex numbers;
Q($\sqrt{2}$) - $\{a+b\sqrt{2}, a,b \in Q\}$
Q($\sqrt[3]{2}$) - $\{a+b\sqrt[3]{2}+c\sqrt[3]{4}, a,b,c \in Q\}$
Q(θ) – $\{a+b\theta+c\theta, a,b,c \in Q, \theta \notin R\}$

Since the extensions of numerical sets are related to the solution of simple mathematical equations, it is necessary to introduce the concepts of rings and fields when determining the existence of solutions of these simple equations (in a definite set of numbers). But these concepts are studied only in some areas of higher education.

The concepts of ring and field are defined by two operations - addition (+) and multiplication(.). A large number of sets (e.g. N,Z, Q,R, C, Q($\sqrt{2}$) , Q($\sqrt[3]{2}$) , Q(θ)) addition (+) and multiplication(.) operations are defined in , Q,R, C, Q($\sqrt{2}$) , Q($\sqrt[3]{2}$) , Q(θ)) is an area. In addition, it is possible to compare the elements in these sets, that is, the ordering relationship may be defined in these sets.

If the order relation in a set of numbers (≤) for the addition operation (+) in it for any three elements a,b,c of this set a ≤ b from the relationship a +s ≤ b + s if the relationship occurs, then the addition operation ≤- it is said that it adapts according to the order. The same is also any numbered set a,b and c>0 for the elements a ≤ b out of necessity a s ≤ b s if an inequality occurs, then it is said that the relation of order is compatible with the operation of multiplication.

If the order relation in a ring (or field) is compatible with addition and multiplication operations in a ring (or field), then this ring (or field) is said to be ordered. If a ring (or field) is ordered, for any two elements a and b of it a ≤ b if a ≥ b if at least one of the inequalities holds, then this ring is called a linearly ordered ring (or field).

In the school mathematics course, it is proved that the sets Z, Q, R are linearly ordered rings. However, in the process of studying complex numbers in vocational colleges and academic lyceums, no opinion was expressed in the current textbooks about the order relationship in it. In our opinion, although it is possible to establish different order relationships between complex numbers , then it is necessary to mention that it is not possible to determine the relation of order which is compatible with the operation of multiplication.

In addition, using the concept of isomorphism studied in the higher education system, Q($\sqrt[3]{2}$) through the linear order relation in the field Q(θ) as an example, it is possible to establish a linear order relation in the field (here $\theta = \frac{-1+i\sqrt{3}}{2}$ yoki $\theta = \frac{-1+i\sqrt{3}}{2}$ it is necessary to mention that it will be).

In number systems, the set of R-real numbers seems to be perfect, but it cannot be said that any polynomial with positive real coefficients in this set has at least one root. However, in the field of complex numbers, which is an extension of the field of real numbers, any polynomial with real coefficients of any positive degree has at least one root. At the same time, we note that one of the main properties of the field of real numbers - the property of being a linearly ordered field - is not fulfilled in order to build a system of complex numbers, that is, there is no linearly ordered (other than itself) extension of the field of real numbers.

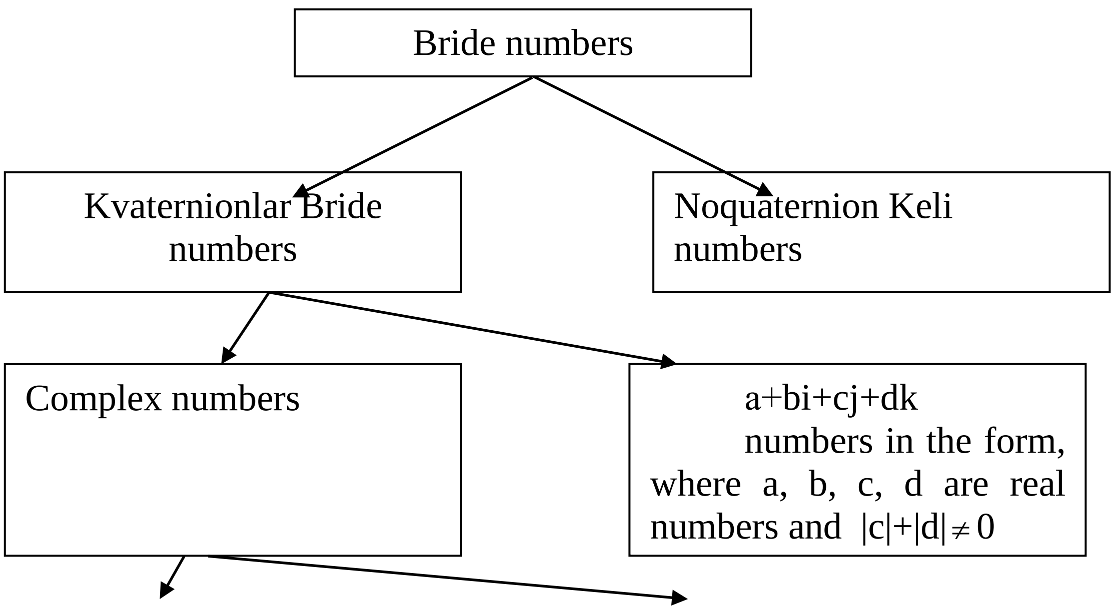
Naturally, with the construction of the field of complex numbers, a theoretical question arises as to whether it has an extension. To answer this question, we use the fact that the field of complex numbers is an algebra of dimension 2 over the field of real numbers. (For a set A to form an algebra over a field R, the set A must be a ring and a linear space over the field R, and any a, b ∈ A va $\lambda \in$R for s λ (a b)=(λ a) b= a (λ b) condition must be met)

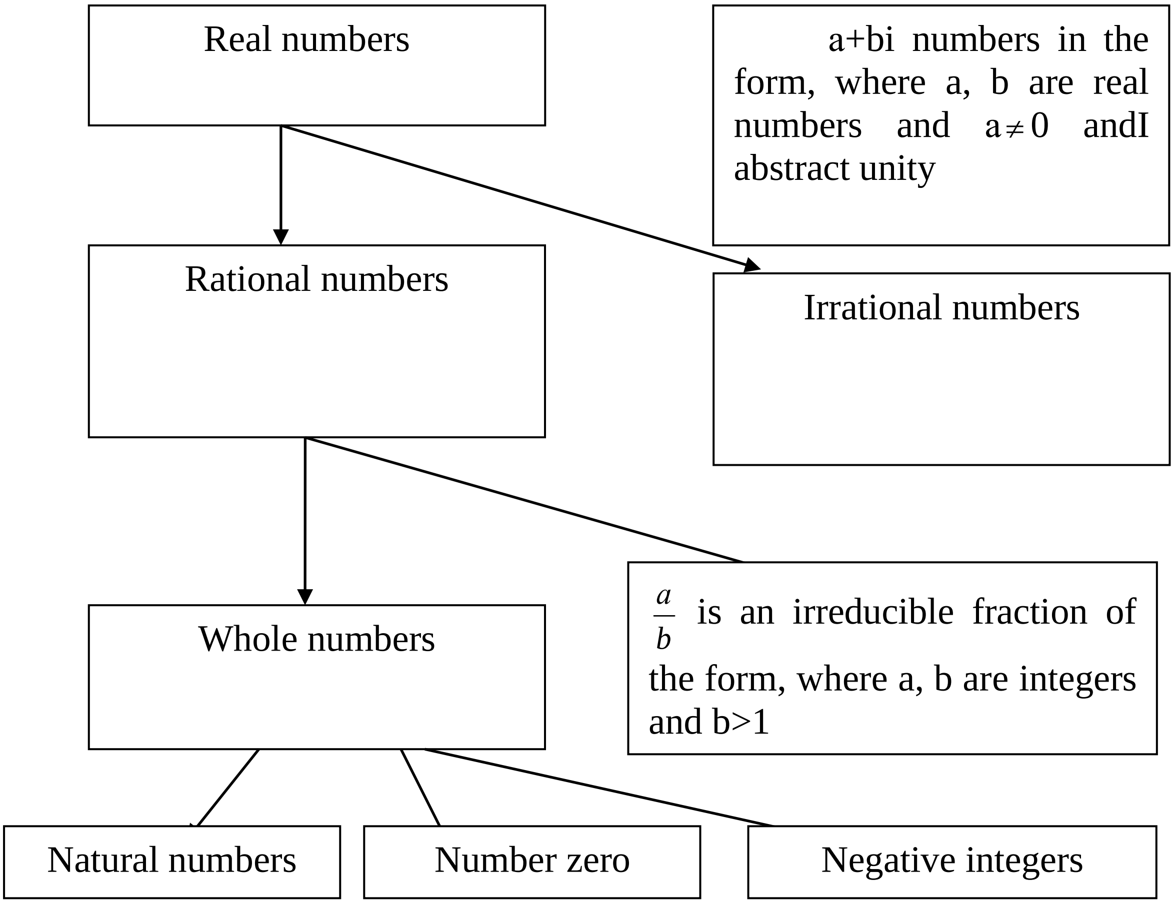
If the equations of the form ax=b, ya=b have a solution for arbitrary elements a, b (a 0) of the algebra, such an algebra is called an algebra with division. The field of real numbers is an algebra with dimension 1 over itself, and the field of complex numbers is an algebra with division over the field of real numbers with dimension 2. It is proved that a finite-dimensional algebra with division over the field of complex numbers can only be a field of complex numbers. Hence, it follows that extensions of the space of real numbers can be constructed only by increasing its dimension. However, it has been proved that there is no algebra of dimension 3 with division over the field of real numbers, only algebra of quaternions with dimension 4 exists. But the quaternion algebra is a non-commutative algebra. It is also established that there are no divisible algebras of measure 5 or higher. All these ideas follow from the Frobenius theorem.

It should be noted that when constructing extensions of the field of real numbers, one of its specific properties must be abandoned. Because when building a system of complex numbers, it is necessary to abandon the relation of order in it. By abandoning commutativity, the quaternion algebra is constructed, and by abandoning associativity, which is another property, a Keli algebra with dimension equal to 8 is constructed over the field of real numbers. Denoting the algebra of quaternions by K- and the Keli algebra by A-, the properties of all numerical systems and their extensions can be expressed in the following table:

	N	Z	Q	R	C	K	A
a+x=b equation of the form has a solution	-	+	+	+	+	+	+
ax=b,ya=b equation of the form has a solution ($a \neq 0$)	-	-	+	+	+	+	+
linearly ordered	+	+	+	+	-	-	-
multiplication is commutative	+	+	+	+	+	-	-
multiplication is associative	+	+	+	+	+	+	-

Conclusion: to master all built-in extensions and their properties, we recommend using the table above to learn, and to master their components, we recommend using the following scheme.





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