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# HISTORICAL

## AND PHILOSOPHICAL ANALYSIS OF THE DEVELOPMENT OF NON-CLASSICAL DIRECTIONS OF MODERN LOGIC

## ANÁLISIS HISTÓRICO Y FILOSÓFICO DEL DESARROLLO DE DIRECCIONES NO CLÁSICAS DE LÓGICA MODERNA

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ABSTRACT

The creation of individual components of the methodological system for teaching the logical foundations of computer science for students of engineering specialties at pedagogical universities requires, first of all, clarifying the content of this academic discipline. The theoretical foundations of informatics are a rather voluminous section, the foundation of informatics as a science, such sections as coding theory, discrete mathematics, probability theory, optimization theory, mathematical logic and mathematical informatics. The allocation of logical foundations as a separate component of the theoretical foundations of computer science requires a deep and meaningful analysis of those sections that are related and describe the logical foundations of the functioning of computers. To accomplish this task, in addition to analyze the fundamental literature on the theoretical foundations of computer science, philosophical, psychological, pedagogical and educational sources, an important place is occupied by a historical and philosophical analysis of the formation of logic as a science. This will allow a deeper understanding of the prerequisites for the emergence of formal logic and its transformation into mathematical logic, which is now the basis for the functioning of all electronic computing technology.

Keywords:

Non-classical logic, thinking, rationality, inference, judgment, laws of logic.

RESUMEN

La creación de componentes individuales del sistema metodológico para la enseñanza de los fundamentos lógicos de la informática para estudiantes de especialidades de ingeniería en universidades pedagógicas requiere, en primer lugar, aclarar el contenido de esta disciplina académica. Los fundamentos teóricos de la informática, son una sección bastante voluminosa, el fundamento de la informática como ciencia, secciones como teoría de codificación, matemática discreta, teoría de probabilidad, teoría de optimización, lógica matemática, informática matemática y similares. La asignación de fundamentos lógicos como un componente separado de los fundamentos teóricos de la informática requiere un análisis profundo y significativo de aquellas secciones que están relacionadas y describen los fundamentos lógicos del funcionamiento de las computadoras. Para llevar a cabo esta tarea, además de analizar la literatura fundamental sobre los fundamentos teóricos de las fuentes informáticas, filosóficas, psicológicas, pedagógicas y educativas, ocupa un lugar importante el análisis histórico y filosófico de la formación de la lógica como ciencia. Esto permitirá una comprensión más profunda de los requisitos previos para el surgimiento de la lógica formal y su transformación en lógica matemática, que ahora es la base para el funcionamiento de toda la tecnología informática electrónica.

Palabras clave:

Lógica no clásica, pensamiento, racionalidad, inferencia, juicio, leyes de la lógica.

## INTRODUCTION

Conducting a retrospective analysis will highlight the main patterns observed during the evolution of the views of prominent world thinkers on logic as a way of thinking, oratory, a means of persuasion, deriving new knowledge and proving theorems, turning it into mathematical logic, and finally becoming the basis for constructing the first computational machines and modern information technology in general.

The study of non-classical logics plays an important role in the preparation, for example, of future engineers, programmers, military specialists, etc., since it allows you to get acquainted with the modern directions of the development of logical teachings, go beyond ambiguities in logic, and become aware of innovative logical and philosophical ideas of our time.

In modern logic, the following historical periods can be conditionally distinguished:

1. The background of modern logic. In general, the beginning of modern logic can be considered the period of the XVII - beginning of the XVIII century. During this period, T. Hobbes forms the idea of considering the process of reasoning as a process of reckoning. The great French philosopher and mathematician R. Descartes introduces and justifies such concepts as "variable", "function", and G. Leibniz introduces a symbolic designation of logical variables. G. Leibniz's contribution to the development of logic was very great - his teaching monadology made it possible to talk about the multiplicity of phenomena in the world.
2. The period of the algebra of logic begins with the publication in 1847 by J. Boole of the book "Mathematical Analysis of Logic", in which the author introduces algebraic symbolism into logic to construct logical calculi, considers the process of inference as a solution of logical equalities.
3. The period of development of logic as a theory of substantiation of mathematics is associated with crisis situations in mathematics at the turn of the XIXth - early XX century, the development of G. Frege axiomatic construction of the propositional calculus, the theory of quantification, the basic principles of logical semantics and the theory of logical justification of mathematics B. Russell and A. Whitehead in the "Principles of Mathematics".
4. XX century, this is the period of development of metalogy, logical semantics and non-classical logic associated with the activities of the Lviv-Warsaw school, the works of R. Karnap, A. Tarski, J. Lukasevich, K. Lewis and others (Bazhanov, 2013).
5. The purpose of this article is to conduct a historical and philosophical analysis of the development of non-classical areas of modern logic to identify areas of development and familiarity with the scientific ideas of the most common modern logical theories.

### *RESEARCH METHODS*

Now many non-classical logical trends have appeared, however, logic as a science is only a theory, since both traditional, modern, and any direction of non-classical logic have a common subject and methods. So, traditional logic uses the formalization method, that is, elements of the natural language are used next to the symbolic language, while modern logic uses the formalization method in its purest form. In this work it is carried out an historical analysis of the evolution of logic from traditional to modern approach using as tools of investigation the analysis of historical documents with a qualitative design in order to support epistemologically the arrival at conclusions.

## RESULTS

Let us dwell in more detail on the prerequisites for the emergence and modern trends of non-classical logic. No classical is one of the directions of mathematical logic that arises at the turn of the 19th – 20th centuries, when the founder of intuitive logic L. Brouwer put forward the idea of the impossibility of applying the excluded third law in the theory of infinite sets.

"The logic is traditional and modern. Traditional logic was founded by Aristotle. The doctrine of the latter, in many ways supplemented, developed and partially distorted, existed until the beginning of the 20th century. At the beginning of the XX century, there was a kind of scientific revolution associated with the widespread use for the study of the relationship between thoughts and processes of thinking in the above structures (forms) of the methods of symbolic (mathematical) logic. At the same time, all achievements and all issues of traditional logic that are significant for science and everyday knowledge are preserved in modern logic (Ivlev, 2018).

One of the founders of non-classical logic, the Russian philosopher and logician N. Vasiliev at the end of the 19th century put forward the idea of the possible existence of logic without the laws of contradiction and the exclusion of the third, by which he understands metalogics, that is, imaginary logic that does not work in the world of real things, in which the rules for combining utterances must be determined by the subject himself. In his thoughts, N. Vasiliev proceeded from the fact that, in addition to the traditional Aristotelian logic, there are other logics, other logical operations (Getmanova, 2016).

Oddly enough, but the first rudiments of multi-valued logic can be traced in the writings of the scientist-logician of the Middle Ages - William Ockham. In the work of F. Benner, it is pointed out that the English logician considers three values of the truth of the statement: true, false and indefinite, implicitly describes the truth table of the implication operation for the three possible values of the truth of the statement (Konversky, 2018).

An analysis of the scientific works of scientists and researchers of non-classical logic allows us to conditionally distinguish three areas in the process of the formation of non-classical logic:

1. the emergence of multi-valued logics with criticism of the principle of ambiguity and the Aristotelian law of exclusion of the third;
2. a new interpretation of the content of logical operations, in particular, material implication and the emergence of intuitive logic;
3. viewing sections of traditional logic by means of non-classical and creating new sections of modern logic (modal, relevant logic of quantum physics, etc.).

The emergence of multi-valued logic is associated with the name of the Polish logician J. Lukasiewicz, who in 1920 in a small article considers three-valued logic, where utterances can take one of three possible truth values. A year later, regardless of Y. Lukasevich, the American logician E. Post built a system of multi-valued logic.

The multi-valued logic as a branch of science is not limited to calculus, but embraces the general problems of constructing and substantiating calculus, their relationships, the attitude to two-valued logic, that is, it covers theoretical studies, the subject of which are multi-valued calculi.

The first three-valued logic system was developed by Y. Lukasevich, who, exploring the nature of modal statements, came to the conclusion that the means of classical logic are not enough to evaluate modal statements. Therefore, he suggests introducing a third meaning of the truth of the statement as "possible" or "neutral." In the future, three-valued systems of D. Bochvar appear, which creates a three-valued system of logic with the aim of solving the paradoxes of mathematical logic by making the statements empty and introduces the truth value of the statement "meaningless" and S. Kleene, who suggests "unknown" as the third value of the truth of the statement, "Not important", "unknown false is true."

It is interesting that all tautologies in the logic of Y. Lukasevich are tautologies in classical logic, because if we discard the third truth value, then all logical operations will coincide, but all tautologies of two-valued logic will be tautologies in three-valued logic, because there is a third truth value utterances.

Decades after the development of three-valued logic, Y. Lukasevich develops a four-valued logic system in the work "Aristotelian syllogistics from the point of view of modern formal logic" (Karpenko, 2015), and soon an infinite logic, the ideas of which he connects with calculus of probabilities, considering the value of the truth of statements as the degree of probability of the truth of the statement. In his four-valued logic, the scientist introduces two derivatives of truth from true and false, which is denoted by the numbers 0, 1, 2, 3. The new symbols introduced to denote the truth values of functions in the four-valued logic of Y. Lukasevich can be interpreted as "closer to the truth" and "closer to the flaw", and the values 1 and 0 are respectively "Truth" and "false".

Independently of Y. Lukasevich and almost simultaneously with him, the American logician E. Post, who came up with purely formal considerations, assuming that propositions and logical functions take truth values with some n-valued set, is developing their system of multi-valued logic. E. Post constructed his meaningful logic as a generalization of two-valued, and in his reflections he proceeded not from the fact that all the functions of multi-valued logic would be similar in the ambiguous, but from the assumption that for n = 2, as a special case we will get an ambiguous logical system. When constructing his system, E. Post introduces two objections, the first of which he calls cyclical, and the second coincides with the negation in classical logic, a characteristic feature of which is that with n = 2 these objections coincide with each other and with the negation of Boolean algebra. The first negation is defined by two equalities:

A = A = 1, with A = n = 1 and n = 1, and the second one: ~ A = n = A = 1. Conjunction and disjunction in the multivalued logic of E. Post is defined respectively as the maximum and minimum values of the component statements.

In 1932, the concept of multi-valued logic was generalized by G. Reichenbach, who created a system of infinite logic in which a statement can take an infinite number of truth values, and which was conceived by scientists as the foundation of a mathematical theory of probability. Later, T. Shvitskaya outlined the ways of applying multivalued logic in quantum physics, which were further developed by G. Birkhoff and G. Reichenbach.

Such a diverse interpretation of multi-valued logics excludes the possibility of a clearly defined attitude towards them from scientists and raises doubts about their value. Multivalued logics are used in solving the paradoxes of classical mathematical logic, in quantum mechanics, the

theory of relay-contact circuits, and the like. However, progress in the development of this area of logical learning is slow, which is caused by the improper perception of many scientists of the idea of ambiguity in logic, the small need for modern technology in ambiguous logic and the lack of advantages of ambiguous logic in solving logical problems.

Intuitive logic is one of the directions of modern non-classical mathematical logic based on the principles of intuitive mathematics. The Dutch mathematician L. Brouwer is considered the founder of intuitionistic mathematics, who in his works draws attention to the non-universality of the law of the excluded third, the law of double objection and the law of indirect evidence.

According to L. Brouwer, pure mathematics is a free creation of the mind and has nothing to do with experimental facts. In intuitive mathematics, intuition is the only source of mathematics, and the criterion for the fidelity of mathematical concepts and proofs is "intuitive understanding". L. Brower first expresses the idea of creating a new logic, which was developed by his student A. Heyting and created in 1930 intuitive logic using implication, conjunction and disjunction, negation based on 11 axioms and two rules of inference - modus ponens and substitution rules. *"Logic-mathematicians no longer persistently shy away from philosophy, although they may not yet have a deep interest in the ideas that appear and circulate in the domestic logical-philosophical community, considering themselves self-sufficient thinkers, and non-classical, alternative logics to some extent "exotic", an overly innovative product. Nevertheless, both communities actually understand logic as a science of acceptable methods of reasoning, and therefore they have no fundamental disagreements"*. (Bryanik, 2013)

A characteristic difference between intuitive logic and classical logic is a different interpretation of logical operations. So, for example, the implication A = B is considered true if there is a method which, by reducing A to a proof for B, allows a disjunction to be true if at least one of the statements is true and there is a way to recognize the true and etc.

In the works (Zalenskaya, 2013; Zinoviev, 2017) it is alleged that intuitionists investigate constructive objects, that is, those whose existence is considered proven only when the method of their construction, construction is indicated.

According to Markov (Sukhin, 2015), the disadvantage of intuitive logic is that intuitionists do not recognize human practice as the source of the formation of mathematical concepts of mathematical construction methods and proof methods, arguing that intuition is the only source of mathematics, and "intuitiveness is the criterion of truth ". The outstanding mathematician-logician A. Kolmogorov defines the positive features of the development of intuitive logic, indicating that it organizes and generalizes the techniques that all mathematicians use in raising the solution of some constructive problems to the solution of others. It is also worth noting that as a result of the rethinking of intuitive logic, a modern direction of non-classical logic is being formed - constructive.

Viewing sections of classical logic by means of non-classical causes the appearance of completely new sections of modern logic, such as modal, relevant, dialectic, constructive logic, causality logic, quantum mechanics, and the like. They are widely used in modern science, because they can solve those problems that scientists are not able to solve by means of classical logic. Modal logic is one of the directions of modern non-classical logic, which explores the logical connections of modal statements by conducting their modal assessment through such concepts as "Necessary", "possible", "proved", "required", "allowed" and others. The works of K. Lewis and Y. Lukasevich in the field of developing a system of modal logic were aimed at the semantic construction of modal logic, the content of which only began to be developed in the works of R. Karnap, S. Kripke, J. Hintikka. R. Karnap in his studies develops the concept of "description of states", and S. Kripke and J. Hintikka formulate a method of semantics of possible worlds.

Based on the typology of modal operators, various types of modal logics are distinguished, among which the most canonical are: analytical logic - a section of modal logic that explores modalities "necessary", "possible", "random"; temporal (temporal) logic - a section of modal logic that explores the nature, attributes, logical connections of temporary statements, and the modalities are "was", "will", "earlier", "simultaneously", "later"; deontic logic (logic of assessments and norms) is a section of modal logic that explores the nature, properties, relationships of deontic statements and their functioning in the structure of reasoning, and the terms "allowed", "forbidden", and "obligatory" are modalities (Yashin, 2015).

Epistemological logic is a section of modal logic that explores the logical connections of utterances through modalities "proved", "refuted", "not resolved", "convinced", "doubted", "assumes".

Thus, modern model logic is not a fully formed scientific system, but is in a state of systematic research and study, and the question of the interpretation of modal logics remains open. Now there are opinions that modalities can be useful in mathematics, in describing the physical

world, in the process of analyzing causality; several axiomatic systems of modal logic have been developed by K. Gödel, V. Ackerman, J. Lukasevich, H. Curry, A. Tarski, C. Lewis, G. Gentsen, L. Brauer, R. Karnap and others (Konversky, 2017; Karavaev, 2017).

C. Lewis, exploring the paradoxes of material implication, criticizes the classical theory of logical following and develops non-classical, which is the basis of relevant logic, where the contradictions are a natural result of solving another problem - formalization of conditional statements; It is not recognized as a principle allowing any statement to be deduced from a contradiction. "In the thinking of modern man there is also *"a synthesis of knowledge about the real, possible and impossible worlds, the identification of subjective and objective modalities, anticipation of the foundation, the imposition on the world of regularities that are only in our consciousness". In order to identify and overcome "archaic" errors, gaps, patterns and contradictions, mutual disagreement and mutual misunderstanding, thinking needs to be reflexed, that is, organized and comprehended, fixed in rules and norms. Nonclassical logicians who can consistently describe everything that is logically connected can well help solve this problem".* (Kuskova, 2018)

The advent of quantum mechanics and the inadequacy of classical logic to describe its laws stimulated the development of special logic to streamline physical thinking and describe the logical connections between quantum objects. Classical physics used the usual formal logic that describes facts, and quantum mechanics used quantum, probabilistic relationships between objects, so to fully describe these connections, it was necessary to turn to new patterns of thinking. The first attempt to build the logic of quantum mechanics can be traced in the works of American mathematicians D. von Neumann and D. Birkhoff, and a complete theory of the logic of quantum mechanics was developed by G. Reichenbach.

There are other later interpretations of quantum logic, differ in the number of laws used in them, and in the methods of their justification. They most often abandon the classical laws of associativity and distributiveness, which formalizes complex statements constructed using logical connectives (Bondarenko, Matorin & Soloviev, 2000; Bazhanov, 2013).

## CONCLUSIONS

During its existence, non-classical logic contributed to obtaining important results for the further development of mathematical logic. The questions developed in it determine the substantial restructuring of the entire structure of logic. Many mathematicians and logicians are of the opinion that studies of non-classical logics can be useful methodological beliefs, namely: (1) the adoption of a different interpretation of the content of propositional relationships, (2) another point of view on the question of the truth and falsity of statements and (3) the metatheory of some non-classical formalized theories is related to the topology and theory of lattices. However, non-classical logic does not abolish the laws of classical logic, but is one of the areas of mathematical logic in which new problems of logic are developed, new tools and methods for logical research are searched for, and ways of practical application of modern mathematical logic in science and technology are being sought.

## BIBLIOGRAPHIC REFERENCES

Bazhanov, V.A. (2013). The "rut" effect in Russian logic and university philosophy. Bulletin of the Russian Humanitarian Scientific Foundation, (1), 66-72.

Bondarenko, M. F., Matorin, S. I., & Soloviev, E. A. (2000). Features of the theory and practice of solving complex problems based on ontology. Artificial Intelligence, 3, 25-33.

Bryanik, N.V. (2013). The philosophical meaning of the picture of the world of non-classical science. Questions of Philosophy, (1), 93-104.

Getmanova, A. D. (2016). Logic. Vyatka Printing House.

Ivlev, Yu.V. (2018). The subject and prospects of the development of logic. Logical Research, 24 (1).

Karavaev, E. F. (2017). Temporary logic. Logic: a textbook. Saint Petersburg State University.

Karpenko, A. S. (2015). Non-classical logic versus classical. Logico-philosophical studies, (3), 13-47.

Kuskova, S. M. (2018). The problem of normative acts of consciousness. In, Human World: The Normative Dimension-5 (pp. 44-50).

Yashin, B. L. (2015). Rationality and logical thinking. Philosophical Thought, (10), 75-87.

Zalenskaya, N.S. (2013). Modern studies of the prospects for the application of methods of non-classical logic in practical philosophy and argumentation. Historical, philosophical, political and legal sciences, cultural studies and art history. Questions of theory and practice, 8(34), 96-99.

Zinoviev, A. A. (2017). Russian tragedy. The death of utopia. Aegitas.