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# Natural and mathematical publications of the Dnipro region at the end of the 19th–beginning of the 20th century: Establishment of educational technology as a science

***Abstract.*** *The article defines the role of the Journal of Elementary Mathematics, the Bulletin of Experimental Physics and Elementary Mathematics, and the “Mathesis” Publishing House in transforming the total knowledge about the technology of teaching natural and scientific disciplines into Science. When organizing the research, for a meaningful analysis of its subject, the analysis of information from publications the generalization of the elements of natural and mathematical knowledge presented in the publications, and the systematization of descriptions of the technology of teaching natural and mathematical disciplines were used. Quantification of text, collection of empirical data, their generalization, and mathematical and statistical processing were used in the process of quantitative analysis. As a result of the research of the materials of both magazines and the products of the “Mathesis” Publishing House during the entire period of their operation, the authors came to the following conclusions. Firstly, from 1886–1925, the ideas of technologies were actively*

*developed in the pages of authoritative publications of the Russian Empire at the time, which functioned in the territory of the Dnipro region – "Journal of Elementary Mathematics", "Bulletin of Experimental Physics and Elementary Mathematics" and book editions of the "Mathesis" Publishing House teaching of natural and mathematical disciplines, the contents of textbooks and methodical manuals in Mathematics and Natural Sciences were published and discussed, the peculiarities of teacher training were analyzed, methodical schools of outstanding scientists and methodologists were started and fixed, educational programs were reviewed. This shows that thanks to the activities of both magazines and publishing houses, real conditions were created for the meaningful and technological provision of the transitional period from the stage of formation of methodological approaches to the stage of scientific substantiation of the technology of teaching natural and mathematical disciplines in high school in the global context of its formation as a Science. The total volumes of publications, the number of their articles and books, the quality of execution, and the breadth of coverage of the content of natural and mathematical disciplines testify to the ability of editorial offices to carry out the planned measures for the production of substantive and methodical support for teaching and distribution of popular science publications to motivate a wide range of young people (and older members of the population) to study Mathematics, Physics, Astronomy, Biology, Chemistry, and Geography. Both journal editors and the management of the publishing house were aware of the important role of practice in the study of natural and mathematical disciplines – for all analyzed institutions, more than a fourth of the volume of all publications was allocated for problem material and laboratory workshops. Articles and books of a methodological nature became an important component of the publications, in which the peculiarities of the teaching technology were revealed, the subject terminology was clarified, discussions were organized about teaching models, the peculiarities of the speeches of famous mathematicians and natural scientists at various level congresses and congresses were highlighted, and the pedagogical and scientific heritage was disseminated, famous scientists.*

***Keywords:*** *educational and scientific periodicals; publishing house; teaching technology; natural and mathematical disciplines; science*

**Introduction.**

The problem of researching the process of transformation of a set of scientific information, a set of knowledge, and methods of activity into a scientific unit requires for its solution the study and analysis of certain conditions that ensure systematicity, objectivity, and methodological validity. The body of knowledge must be tested and repeatable, systematized and have a theoretical basis, amenable to generalization and classification, capable of self-correction and adaptation. An important condition for such a transformation is the institutionalization of the totality of knowledge, in particular, its provision with professional and methodical sources. It was at the turn of the 19th and 20th centuries that the technology of teaching natural and mathematical disciplines as a Science took place in Europe. That is why the best forces of

mathematicians and nature researchers of the Dnipro region were actively concerned with the need to participate in the processes of reforming the educational sector of the then Russian Empire. Such activity was manifested in the publishing movement – first in Kyiv, later in Odesa, authoritative centers for the publication of popular science, natural, and mathematical periodicals appeared, which existed for almost 40 years. The study of the role of these centers of literature publication in the process of transformation of the technology of teaching natural and mathematical disciplines into science appears to us to be an urgent problem.

**Literature Review.**

Research on the development of popular scientific publications from the cycle of natural science and mathematics disciplines for the formation of natural and mathematical knowledge in young people, for teacher training, as well as to meet the educational needs of science and mathematics lovers was carried out by various scientists. Among the different works, we can single out the voluminous meaningful analysis of the mathematical part of the "Journal of Elementary Mathematics" and the "Bulletin of Experimental Physics and Elementary Mathematics", which was carried out by *S. A. Dakhiya* (Dakhiya, 1956). A detailed biography of the Odesa scientist *V. M. Kagan*, who was directly related to most of the publications analyzed in the article, can be found in *A. M. Lopshytsia, P. K. Rashevsky* (Lopshits, 1969). A brief description of the activity of popular scientific publications of that time in the context of the activity of natural and scientific societies of Ukraine was made by *I. O. Demuz* (Demuz, 2014) and *V. S. Savchuk* (Savchuk, 1994). A general description of the operation of the Odesa "Mathesis" Publishing House was created by *Yu. D. Katsenelson* (Katsenelson, 1960). Finally, the authors of this article revealed the peculiarities of coverage in the "Bulletin of Experimental Physics and Elementary Mathematics" of biographical materials about famous scientists and teachers (Pasichnyk, Rizhniak, & Deforzh, 2022) and about the organization, conduct and results of domestic and foreign congresses and congresses of mathematicians and natural scientists (Pasichnyk, Rizhniak, & Deforzh, 2023).

In this research, we will determine the role of the Journal of Elementary Mathematics, the Bulletin of Experimental Physics and Elementary Mathematics, and the "Mathesis" Publishing House in transforming the body of knowledge about the technologies of teaching natural and scientific disciplines into science.

**Methodology.**

When organizing the research, for a meaningful analysis of its subject, an analysis of information from publications and a synthesis of logical references and conclusions were used, as well as a generalization of the elements of natural and mathematical knowledge presented in the publications and a systematization of descriptions of the technology of teaching natural and mathematical disciplines. Quantification of text, collection of empirical data, their generalization, and mathematical and statistical processing were used in quantitative analysis (Atteslander, 2003; Früh, 2003). At the stage of quantification of the text as a unit of content, issues of magazines were used,

which were combined according to the years of publication, as well as individual books of the publishing house. All the analyzed texts were classified – Mathematics and the main components of Natural Science: Physics, Biology, Chemistry, Geography. Publications on Philosophy and interdisciplinary areas were also highlighted separately. The number of pages in a specific issue of magazines and a specific edition was used as a unit of account (parts of the volume of pages were determined from the ratio of the occupied area on the page).

**Main Research Results.**

"Journal of Elementary Mathematics" was published during 1884–1886 in Kyiv. Its founder and editor was Kyiv University professor *Vasyl Petrovych Yermakov*. Since 1886, the editing of the magazine was handed over to *Erasm Korneliyovych Shpachynskyi*, who had also previously taken an active part in the editorial and publishing work of this publication. At the same time, the magazine changed its name to "Bulletin of Experimental Physics and Elementary Mathematics" (hereinafter referred to as "Bulletin"), and at the request of *E. K. Shpachynskyi V. P. Yermakov* remained the ideological leader of its mathematical department. Both magazines were considered the best editions of popular science periodicals of the Russian Empire of the late 19th and early 20th centuries. In 1891, the editorial office of Bulletin moved to Odesa, and the editing of the magazine from 1898 (after a short stay in the role of editor-in-chief of Professor *V. Y. Zimmerman*) until the end of its publication was transferred to private docent *V. F. Kagan*. The fate of Bulletin is connected in the future with the mathematical department of the Novorossiysk Society of Naturalists and with the teachers of the Novorossiysk (Odesa) University. The publisher of the magazine during 1897–1917 (from No. 259) was *V. O. Gernet*.

In 1904, the "Mathesis" Publishing House (Greek: mathesis – knowledge) was founded in Odesa. The first mention of this project appeared on the pages of Bulletin on January 15, 1904. Further, announcements about books being prepared for publication and catalogs of published literature appeared regularly in the magazine until 1914. The founders of the publishing house were private docents of Odesa (Novorosiysk) University, famous mathematicians *V. F. Kagan*, *S. O. Shatunovskyi*, astronomer *A. R. Orbinskyi*, and the owner of the printing house *M. F. Shpencer*. The central figure of "Mathesis" was *Veniamin Fedorovych Kagan*. During the first 10 years of its activity, the publishing house became one of the largest in the Russian Empire and the largest among publishing houses that specialized in publishing educational and popular scientific literature in the natural and mathematical direction. The books on Mathematics, Physics, Astronomy, Chemistry, Biology, History, and Philosophy of Natural Science, published thanks to the "Mathesis" Publishing House, have become outstanding examples of literature on the history of science, education, and book publishing.

Based on this, it is possible to consider the results of the content analysis of the contents of the "Journal of Elementary Mathematics", Bulletin and publications of "Mathesis" as representative for formulating conclusions regarding the peculiarities of

the formation of the technology of teaching natural and mathematical disciplines as a science at the turn of the 19th and 20th centuries.

It is known that total knowledge goes through several important stages for its registration into science (see, for example, Lane, Flagg (2010) or N. Lederman, J. Lederman (2019)). In the first stage, the accumulation of empirical data takes place: a large number of observations, facts, and empirical data are collected; observations are replicated to confirm their reliability. This is followed by the stage of forming hypotheses: based on the accumulated data, hypotheses are put forward that explain the observed phenomena or regularities. The next step is experimental testing of hypotheses: hypotheses are tested through controlled experiments and research. The fourth stage is a theoretical generalization: after the successful testing of hypotheses, theories are formed that unify individual hypotheses and explain broader patterns and principles. The fifth stage is the systematization of knowledge: knowledge is systematized, classified, and structured into a complete system; scientific concepts, categories, classifications, and terminology are developed. The next stage is methodological substantiation: research methods are developed and improved, which allows for obtaining reliable and objective data; standards and protocols for conducting research are created. The seventh stage is the institutionalization of science: specialized scientific institutions and research centers are created, where systematic research and training of new generations of scientists are carried out; scientific societies, journals, and conferences for the exchange of knowledge and research results are emerging. In the eighth stage, the dissemination and implementation of knowledge is implemented: research results are published in scientific journals, monographs, textbooks, and scientific knowledge is implemented in practice, technology, education and other areas of life. At the next stage, critical analysis and self-correction are carried out: adaptation and correction of knowledge in response to new data, discoveries and achievements. Finally, at the tenth stage, the evolution and development of science is realized: new knowledge and approaches are integrated, and new scientific disciplines and interdisciplinary areas emerge, which contributes to the further development and complication of science.

The formation of the technology of natural and mathematical disciplines as a Science is related to the development of Pedagogy in the context of specific Sciences, such as Mathematics, Geography, Biology, Chemistry and Physics (Arnold, 2012; Pollet, 2023). This issue is closely related to the content of these sciences, education reforms and changes in school curricula.

The substantive and quantitative analysis of the contents of the “Journal of Elementary Mathematics” the Bulletin and “Mathesis” publications made it possible to determine the positioning of the technology of teaching natural and mathematical disciplines as a science at the turn of the 19th and 20th centuries. We will present its main results.

*Content analysis*. From the very beginning, the “Journal of Elementary Mathematics” (Journal of Elementary Mathematics, 1884–1885) published articles from various sections of mathematics and physics. The efforts of Professor *V. P. Yermakov* concentrated, in addition to the general editorial issues of the

magazine, on the preparation and editing of mathematical material. In total, 36 issues of the magazine contained popular science articles on various topics of Elementary Mathematics: Properties of Numbers and Operations on them (for example, Vol. 1, No. 1), Identical Transformations of Algebraic Expressions (Vol. 1, No. 5), Properties of Geometric Figures (Vol. 1, No. 1, 5), Solving Equations and Inequalities (Vol. 1, No. 8), Theory of Probability (Vol. 1, No. 4), Properties of Functions (Vol. 2, No. 16). *E. K. Shpachynskyi* was responsible for the preparation and editing of materials on Physics in the journal. During the two years of publication, articles appeared on Electricity (Vol. 1, No. 8), Kinematics (Vol. 1, No. 3), Optics (Vol. 2, No. 4), Astronomy (Vol. 2, No. 5), Mechanics (Vol. 2, No. 6). The journal also featured articles on the History of Natural Science (Vol. 1, No. 12) and Technology of Teaching Mathematics and Natural Sciences (in the form of reviews of published textbooks and manuals for students – (Vol. 2, No. 3). Each issue of the magazine contained (at least 12.5% of the volume) texts of Elementary Mathematics problems for readers and a detailed analysis of their solutions. In general, the magazine *V. P. Yermakov* implemented the goals of developing and popularizing knowledge of Elementary Mathematics (and, partially, Physics) and was designed for teachers and students of secondary schools.

Compared to the "Journal of Elementary Mathematics", the "Bulletin of Experimental Physics and Elementary Mathematics" (Bulletin of Experimental Physics, 1886–1917) was a larger and more durable educational tool for students and teachers in the field of physical and mathematical sciences. That is why the Bulletin's program was expanded and consisted of articles on physics and mathematics (in reality, it was supplemented, in addition to those named, with materials on Astronomy, Chemistry, Biology, the History of Science and Philosophy), articles of pedagogical content, bibliographic indexes, reviews and criticism on the subjects of Physics and Mathematics, problems and questions from Physics and Elementary Mathematics and their solutions, a chronicle of scientific news, scientific bulletins, messages, notes and instructions.

A meaningful analysis of articles on Mathematics showed that a significant part of the volume of the Bulletin was devoted to articles on Geometry, and all materials can be divided into the following sections: a) Elementary Geometry, including the Geometry of a triangle; b) Basics of Geometry and non-Euclidean Geometry; c) Theory of Geometric Constructions; d) Special questions of Geometry. The most complete overview of the problems of Triangle Geometry was contained in the articles of *D. Yefremov* (No. 230–232, 234, 236, 239, 240, 244, 246, 249, 273, 281, 282) and *D. A. Kryzhanovskyi* (No. 571–574). More than two dozen articles were devoted to Constructive Geometry (see articles by *I. I. Aleksandrov* (No. 92), *S. O. Shatunovskyi* (No. 517), *V. F. Kagan* (No. 126, 127) and others). Bulletin became the first mathematical Journal in which the ideas of non-Euclidean geometry were popularized (see articles by *V. P. Yermakov* (No. 17), *Henri Poincare* (No. 143, 144), works by *V. F. Kagan* "Essay on Lobachevskyi's Geometric System" (No. 174–276), "Introduction to the teaching of the Basics of Geometry" (No. 662–666, 669–672), etc.). Special issues of Geometry were revealed in the articles of *K. Lezan* (No. 588)

(vector calculus), *A. Filipov* (No. 610–612) (inversion transformations), *M. Maliyev* (No. 621) (topology), and others.

Algebraic material on the pages of the Bulletin was presented by works on the factorization of polynomials, on issues of equivalence of equations and inequalities, on methods of extracting roots and solving equations of the 3rd and 4th degree, on the coverage of elementary techniques for the study of functions with one and two variables , on the theory of approximate calculations (see articles by *P. Sveshnikov* (No. 238), *P. S. Florov* (No. 664–665), *D. Yefremov* (No. 170, 171), *I. O. Kleiber* (No. 103, 104, 106), *V. G. Von-Bool* (No. 205, 207, 210) and others). Articles dedicated to the analysis of infinitesimally small quantities occupied a special place in Bulletin (see the works of *P. Sveshnikov* (No. 130), *R. Dedekind* (No. 191, 192). A voluminous block of articles in Bulletin was devoted to the problems of the Methodology of Teaching Mathematics. A significant problem, which became the subject of discussions on the pages of Bulletin, was the proposal to start transfer exams in schools, which was clearly aimed at the maximum dropout of students from schools. A rational approach to solving this problem was demonstrated in the article by *R. V. Przyshikhovskyi* (No. 189). General issues of the methodology were analyzed in the articles of *E. K. Shpachynskyi* (No. 26, 109, 110, 113), problems of Algebra teaching methods – in the works of *V. P. Yermakov* (No. 102), *E. K. Shpachynskyi* (No. 217), *B. A. Gern* (No. 197), methods of teaching Geometry – in the article by *S. Zhitkov* (No. 133, 134, 141). Reports on the activities of the International Commission on Teaching Mathematics became important materials of the Bulletin (see reports by *K. A. Posse* (No. 907), article by *D. E. Smith* (No. 570, 572–573). 1912–1914 on the pages of the Bulletin *V. F. Kagan* and *D. M. Syntsov*, the work of the 1st and 2nd congresses of Mathematics teachers (No. 553, 554, 556, 603) was covered. Materials on the features of the reform of Mathematics education posted on the pages of the Bulletin (articles by mathematicians *K. Shcherbina* (No. 658, 659–660), *A. Kiselyov* (No. 649), mathematicians *A. Shaposhnikov* (No. 418, 421), *K. Lebedyntsev* (No. 513), *S. Vinogradov* (No. 509*), A. K. Arndt* (No. 655–656), *I. I. Aleksandrov* (No. 204, 650–651) and others) played an important role in changing the guidelines in the mathematical training of the younger generation.

The editorial staff of Bulletin paid due attention to articles from various sections of Physics and Technologies of its Teaching. This became especially relevant for the creation of conditions for Physics and Natural Sciences in general to acquire the necessary meaning and scope of study in secondary schools of the late 19th and early 20th centuries. Thus, more than 500 articles were devoted to Physics issues, in which the problems of mechanics were covered (see, for example, articles by *H. Florinskyi* (No. 31), *B. Hern* (No. 217–224), *P. V. Shepelev* (No. 493), molecular physics (see articles by *K. Chernyshov* (No. 163, 165, 171, 173, 174, 176–178), *F. Shvedov* (No. 362), *I. Husakovskyi* (No. 15, 19, 26, 29, 33, 36), *B. Golitsyn* (No. 65, 67, 69, 71, 74, 76, 80, 86, 87), electricity and magnetism (see articles by *P. Bakhmetyev* (No. 31, 34, 36, 58, 59 , 70, 89), *H. Poincare* (No. 185, 186), *L. Mandelshtam* and *N. Papalleks* (No. 521), optics (see articles by *E. K. Shpachynskyi* (No. 58), *A. L. Korolkov* (No. 106), atomic and nuclear physics (see articles by *K. Sluzhevskyi* (No. 231, 232),

*N. Pylchykov* (No. 286, 289), *B. P. Weinberg*, *Z. P. Weinberg* (No. 335, 336, 338), *A. Rigi* (No. 409, 411, 412, 417). The magazine also published an original article by *A. Einstein* on the problems of the theory of relativity (No. 596). Problematic issues of physics teaching technology were highlighted in articles by *E. K. Shpachynskyi* "To the reform of the physics textbook" (No. 97), "On a new explanation of the doctrine of Electricity and Magnetism" (No. 153), "On the Methodology of Physics. To the question of the Basic Principles of Electrostatics" (No. 344), *F. Shvedov* "Introduction to the Methodology of Physics" (No. 172), *A. Wolfenzon* "Practical works on Physics in secondary school" (No. 320), *K. Posse* "On coordination of programs in secondary and higher education" (No. 555), "Issues of school teaching of Physics. Summary of lectures by Professor *P. Volkmann*" (No. 619) and others. Thus, in the articles of famous domestic and foreign physicists, the author's current views on the ways of development of university and school Physical Education were revealed.

The domestic and foreign congresses and congresses of natural scientists and mathematicians at that time became an important phenomenon for the formation of the views of scientists and teachers on the development of technology for teaching natural sciences and mathematics. It was here that new ideas were expressed and models of optimal organization of education for high school students in mathematics, physics, biology, chemistry, and geography were formed. A detailed description of the disclosure of the Bulletin of the peculiarities of holding scientific and educational gatherings of naturalists and mathematicians was made by us in (Pasichnyk, Rizhniak, & Deforzh, 2023).

An important role in the organization of experiments in the study of Physics was played by the "Experiments and Devices" section of the Bulletin. In the articles of *P. Bakhmetyev* (No. 146), *V. Obolenskyi* (No. 301, 306, 311), *I. Tochidlovskyi* (No. 314, 316, 318), *E. K. Shpachynskyi* (No. 329, 349, 351), *V. A. Kachok* (No. 364), *V. Lermantov* (No. 367), *A. Yanitskyi* (No. 550), *I. Haber* (No. 602, 604, 609, 613), *P. Smirnov* (No. 644–645) and other Methodist physicists the questions of the methodology and technique of the school physical experiment were revealed.

The organization of reviewing new Literature on Physics and Mathematics for secondary school was also a regular phenomenon for Bulletin. More than 200 textbooks, manuals, and problem books on Physics and Mathematics were reviewed during the magazine's publication period. For example, Algebra and Geometry textbooks by *A. Kiselyov* (No. 149), *Nikultsev's* algebras (No. 652), *V. Shidlovskyi's* book on differentials and integrals (No. 243), collections of problems in Geometry by *N. Rybkin* (No. 364) and arithmetic were reviewed *Shpakovich and Tereshkevich* (No. 169). The following were also reviewed: a Physics textbook by *S. Kovalevskyi* (No. 33, 35, 39), a course in Experimental Physics by *A. P. Shimkov* (No. 53), Physics Methodology by *F. Shvedov* (No. 199, 200), Physics course by *O. D. Khvolson* (No. 261), a collection of problems by *R. D. Ponomaryov* (No. 339), Manual for School Physical Experiment by *M. S. Lukyanov* (No. 375), a concentric Physics textbook by *I. I. Kosonogov* (No. 475–476) and other books. It should be noted that reviews of publications in Geography, Chemistry, Biology, Astronomy, and the History of Science also found a place on the pages of the Bulletin.

The editors of Bulletin considered providing students with historical information about the specifics of the development of Mathematics, Physics, Biology, Chemistry, and Geography as an important component of the organization of Science and Mathematics Education (see articles on the history of arithmetic by *I. Kleiber* (No. 34), on the History of the problem of squaring the circle by *V. Kagan* (No. 126, 127), from the History of the development of the doctrine of the foundations of geometry by *V. Kagan* (No. 380–403), from the History of spherical trigonometry by *V. Shidlovskyi* (No. 389), from the History of mathematical physics by *Henri Poincare* (No. 406–408), from the History of determining the speed of light by *B. Weinberg* and *Z. Weinberg* (No. 335, 336, 338), from the History of wireless telegraphy by *Gibson* (No. 616), from the History of the study of the physical state of gases by *I. Husakovskyi* (No. 15, 19, 26, 29, 33, 36 and others). A voluminous source of historical knowledge about the development of Natural Science and Mathematics is Scientific Biography, which occupied a significant volume in the materials of the Bulletin. We carried out a detailed analysis of the biographical and prosopographic materials of Bulletin about famous mathematicians and natural scientists in the article (Rigi, 1910).

"Mathesis" Publishing House specialized in publishing scientific and popular science works in the fields of natural and mathematical sciences, as well as in Philosophy, Technology, Astronomy, Meteorology, Spectroscopy, Geodesy, and the History of Natural Science and Mathematics. The largest number of books was published by the publishing house on Mathematics and Physics. "Mathesis" took an active position in supporting the reform of teaching Mathematics in secondary school, which originated from the initiative of the German mathematician *Felix Klein*. The essence of the reform was to strengthen the applied orientation of the mathematics course, as well as to implement the idea of introducing students to the beginnings of higher mathematics. Promotion of the reform was manifested in the publication and popularization of books written for its implementation by *E. Borel* (Borel, 1911, 1912) and *F. Kleyn* (Kleyn, 1912). *A. Filipov's* book (Filipov, 1912) was also valuable in the context of the implementation of the reform. In addition to books of a methodological nature, the publishing house published textbooks on various sections of mathematics for higher schools: "Course of Analytical Geometry" by *O. Dziobek* (Dziobek, 1911, 1912), "Introduction to the Calculus of Infinitesimals" (Kovalevskiy, 1909) and "Fundamentals of Differential and Integral Calculus" by *G. Kovalevskyi* (Kovalevskiy, 1911), "Theory of Geometric Constructions" by *A. Adler* (Adler, 1910), "Calculus of Finite Differences" by *A. Markov* (Markov, 1910), "The beginnings of the theory of determinants" by *E. Netto* (Netto, 1912), "Elementary textbook of algebraic analysis and calculus of infinitesimals" by *E. Cesaro* (Chezaro, 1913, 1914), "Paradoxes of the Infinite" by *B. Boltsano* (Boltsano, 1911). The publishing house produced the following mathematics publications for secondary school teachers and students: "Volume of a Sphere and Spherical Segment" by *V. Cimmerman* (Tsimmerman, 1908), "Continuity and Irrational Numbers" by *R. Dedekind* (Dedekind 1909), "Algebra of Logic" by *L. Couture* (Kutyura, 1909), "Encyclopedia of Elementary Mathematics" by *H. Veber* and *I. Velshteyn* (Veber & Velshteyn, 1911, 1910), "What is Algebra?" *V. Kagan* (Kagan, 1910), "Theorem of Pythagoras" by *V. Littsmann* (Littsmann, 1912),

"Terminology in an Elementary Course of Mathematics" by *K. Shcherbina* (Shcherbina, 1923). The publishing house also paid attention to "mathematics lovers", offering readers popular scientific publications: "Games with Matches" by *S. Tromgolt* (Tromgolt, 1907), "Geometric Exercises with a Piece of Paper" by *S. Rou* (Rou, 1910), "Mathematical Entertainment and Games" by *G. Schubert* (Shubert, 1911), "The Nature of Mathematics" by *F. Jourdan* (Zhurden, 1923) and others.

The formation of Physics teaching technology as a branch of science was associated with socio-cultural changes at the end of the 19th and the beginning of the 20th centuries, which sharpened society's attention to the state of school physical education. This is what led to the formation of the program for the publication of books on physics at the "Mathesis" Publishing House. Textbooks for higher education were also published: "Physics Course" by *H. Lorenz* (Lorents, 1910a, 1910b), "Modern Theory of physical phenomena" by *A. Rigi* (Rigi, 1910), "Corpuscular Theory of Matter" by *J. Thomson* (Tomson, 1910), "Course of theoretical mechanics" by *P. Appell* and *S. Doteville* (Appell & Dotevill, 1912a, 1912b), "Course of electricity and magnetism" by *G. Mi* (Mi, 1912, 1914). To organize practical and laboratory classes in physics in secondary schools, the publishing house offered the "Collection of Elementary Experiments in Physics" by *H. Abraham* (Abraham, 1905a, 1905b) and "A Short Guide for Practical Lessons in Physics" by *F. Kohlrausch* (Kolraush, 1914). As popular scientific literature on physics, "Mathesis" offered a wide list of publications: "Physics of the Sky" by *S. Arrhenius* (Arrenius, 1905), "Modern Development of Physics" by *V. Vetgem* (Vetgem, 1908), "Liquid Crystals and Theories of Life" by *O. Leman* (Leman, 1908), "Rotating top" by *J. Perry* (Perri, 1908), "Origin of spectral colors" by *P. Zeeman* (Zeyeman, 1909), "Wireless telephone" and "Attenuation and resonance of electric waves" by *A. Slaby* (Slabi, 1909a, 1909b), "Paradoxes of nature" by *V. Hampson* and *K. Schefer* (Hampson & Shefer, 1910). "The theory of relativity and its influence on scientific thought" by *A. Eddington* (Eddington, 1923) and others.

Two dozen titles of literature were offered to readers to study the problems of astronomy (see "Astronomy for all" and "Theory of the Moon's motion" by *S. Newcom* (Nyukom, 1905, 1910), "Formation of worlds" by *S. Arrhenius* (Arrenius, 1908), "Evolution of the solar system" *F. Moulton* (Multon, 1908), "Halley's Comet" by *K. Graff* (Graff, 1910) and others), more than 15 names – from chemistry (see "Exercises in inorganic chemistry" by *H. Biltts* (Biltts, 1910), "Introduction to the study of physical chemistry" *V. Ramsay* (Ramzay, 1910), "Stereochemistry" by *M. Mamlok* (Mamlok, 1911), "Introduction to Inorganic Chemistry" by *A. Smith* (Smit, 1911), "Introduction to Colloid Chemistry" by *V. Poshl* (Pyoshl, 1912), "Chemical Experiments for Youth" by *K. Sheid* (Sheyd, 1907) and others), about 10 titles – from biology (see "Lectures on bacteriology" by *N. Ushinskiy* (Ushinskiy, 1908), "Dynamics of living matter" by *Zh. Loeb* (Loeb, 1910), "Unity of vital phenomena" and "Biology cells as the basis of the teachings on embryonic development and reproduction" by *B. Verigo* (Verigo, 1912, 1913), "Human Biology" by *P. Saksl* and *K. Rudinger* (Saksl & Rudinger, 1915) and others). We should also note important natural history works – "Centuries and tides" by *R. S. Boll* (Boll, 1909), "Snow, frost,

hail, ice and glaciers" B. P. Veynberg (Veynberg, 1909), "The Picture of the World in the Light of Modern Natural Science" by *K. Snayder* (Snayder, 1909), as well as geography publications – "Modern Geography" by *M. Newbigin* (Nyubigin, 1923) and "Research of Polar Countries" by *K. Hassert* (Hassert, 1912).

In addition to the named books, two series were added to the treasury of publications. In the "Successes of Science" series, two issues of "Successes of Physics" were released, as well as publications revealing the latest achievements in the fields of modern Technology, Biology, Chemistry, Astronomy, and Geography. In a series of books on the History of Science, the works of *A. Ladenburg* on the History of Chemistry (Ladenburg, 1917), *F. Cajori* on the History of Elementary Mathematics (Kedzhori, 1910), *A. Clark* on the History of Astronomy (Klark, 1913), *F. Dannemann* on the History of Natural Science (Dannemann, 1913) were published. *E. Fourier* on the History of Elementary Geometry (Furre, 1912), *F. Rudio* on the History of the Quadrature of the Circle (Rudio, 1911), *P. Lacour* and *J. Appel* on the History of Physics (Lacour & Appel, 1908).

Thus, the content analysis of the publications "Journal of Elementary Mathematics", "Bulletin of Experimental Physics and Elementary Mathematics" and the volume of publications of the "Mathesis" Publishing House, which were printed on the territory of the Dnipro region at the end of the 19th – at the beginning of the 20th century, shows the wide coverage of the topics of the articles in the journals and books. Training in secondary school in subjects of the natural and mathematical cycle. In addition, the editors of both magazines and the management of the publishing house paid due attention to the publication of publications of a pedagogical nature, in which problematic issues of the technology of teaching natural and mathematical subjects were revealed.

*Quantitative analysis.* "The Journal of Elementary Mathematics" was published in 1884–1885. A total of 36 issues of this publication were published. "Bulletin of Experimental Physics and Elementary Mathematics" had 674 issues during the 30-year period of its publication. From the editions of "Journal of Elementary Mathematics" and Bulletin, we selected for analysis those materials that were directly related to the content of science and mathematics relevant for high school and to the technology of teaching these disciplines. Thus, we divided the materials of the "Journal of Elementary Mathematics" into the following categories: "Articles on Mathematics", "Articles on Physics", "Pedagogical Articles", and "Problems".

In the course of our research, we will use the median values for all indicators, and not the average, since the distributions in the samples differ from the normal distribution. It should be noted that the median values of the distribution of the volume of publications by the numbers of the "Journal of Elementary Mathematics" in the correspondingly defined categories are as follows: "Articles on Mathematics" – 10, "Articles on Physics" and "Problems" – 5, "Pedagogical Articles" – 0. Total volumes of articles the specified categories and the number of publications during the two years of publication of the magazine are presented in fig 1.

When analyzing the publications of the Journal of Research Physics and Elementary Mathematics, in addition to the aforementioned categories of the Journal

of Elementary Mathematics, we identified three more: “Experiments and Devices”, “Mathematical Trifles”, and “Inventions and Discoveries”. The total volumes and number of articles of the specified categories of the Bulletin during all years of its publication are presented in fig. 2.

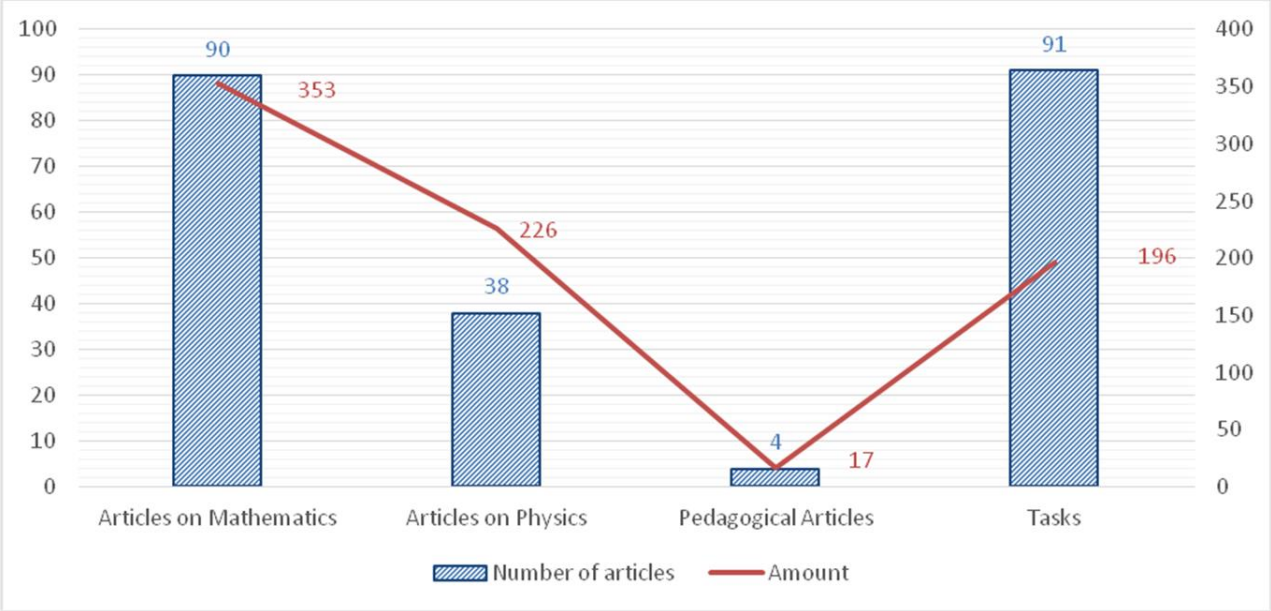


**Figure 1.** Total volume and number of articles of the “Journal of Elementary Mathematics” by category.

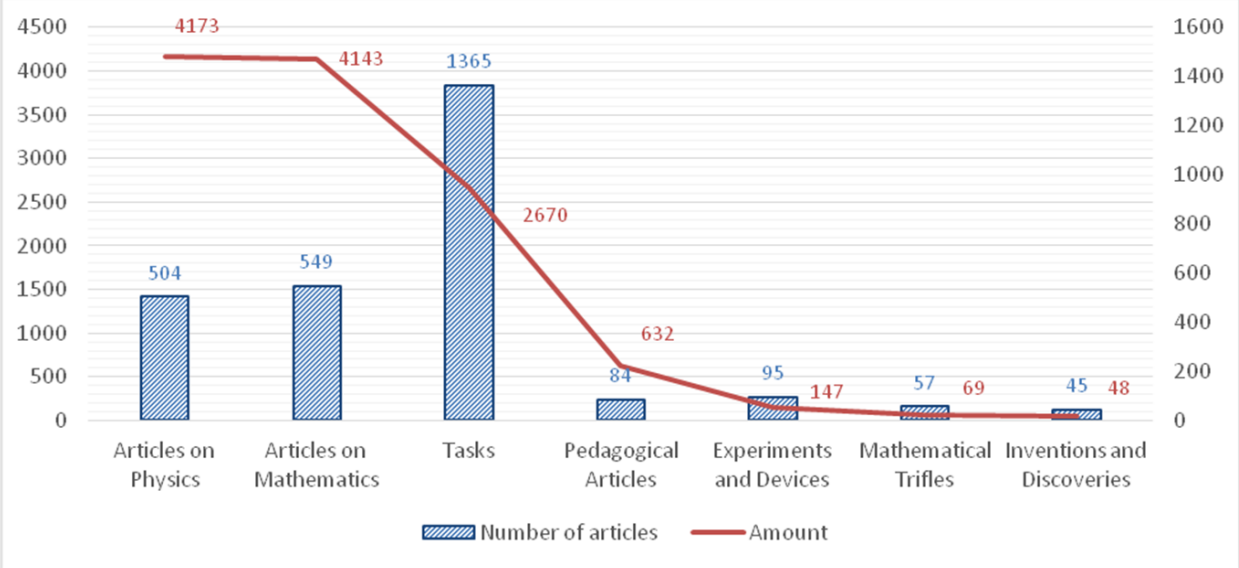


**Figure 2.** Total volume and number of articles of the Bulletin by category.

The median values of the distribution of the volumes of publications by the years of publication of the Bulletin according to the specified categories of articles are as follows: “Articles on Physics” – 147, “Articles on Mathematics” – 143, “Problems” – 89, “Pedagogical Articles” – 10, “Experiments and Devices” – 2, “Mathematical Trifles” and “Inventions and Discoveries” – 0.

The time series of changes in the total volume of publications of natural and mathematical materials and the technology of their teaching in the "Journal of Elementary Mathematics" (1884–1885) and in the "Bulletin of Experimental Physics and Elementary Mathematics" (1886–1917) is shown in fig. 3.

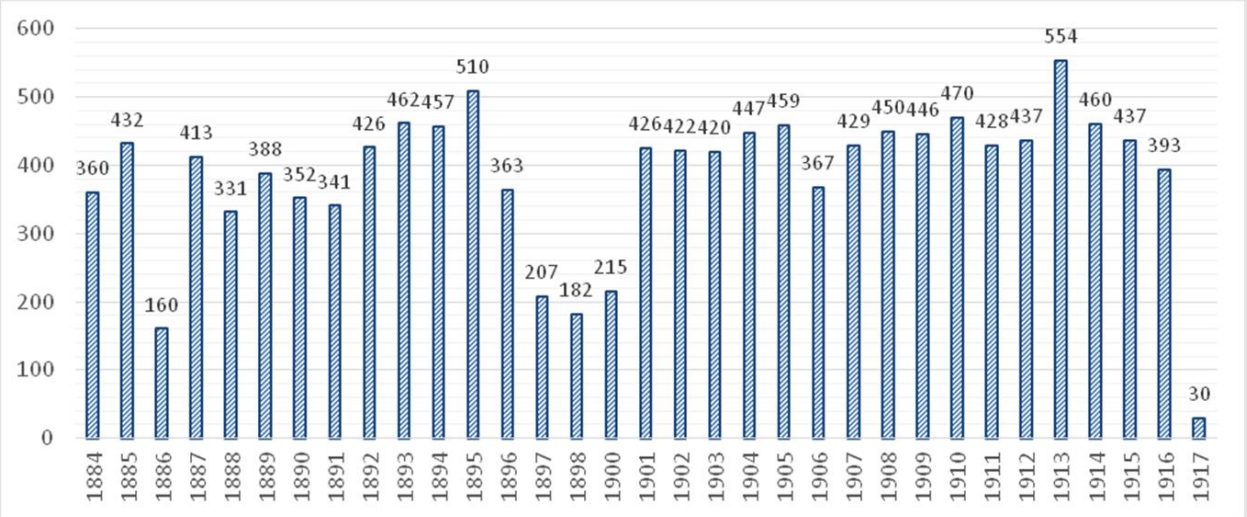


**Figure 3.** Time series of the dynamics of changes in the volume of natural and mathematical materials in the "Journal of Elementary Mathematics" and in Bulletin (1884–1917).

The time series of the dynamics of changes in the number of articles on natural and mathematical disciplines and the technology of their teaching in both magazines is shown in fig. 4.

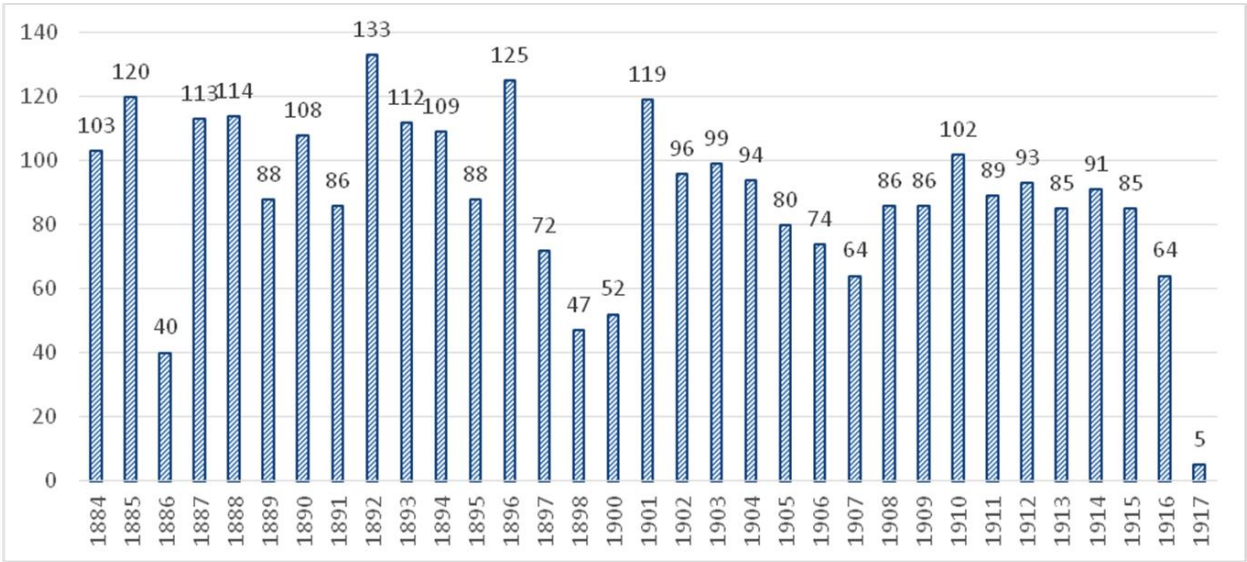


**Figure 4.** Time series of the dynamics of changes in the number of natural and mathematical materials in the "Journal of Elementary Mathematics" and in the Bulletin (1884–1917).

The time series of changes in the total volume of the "Pedagogical Articles" category in the "Journal of Elementary Mathematics" (1884–1885) and in the "Bulletin of Experimental Physics and Elementary Mathematics" (1886–1917) is shown in fig. 5.

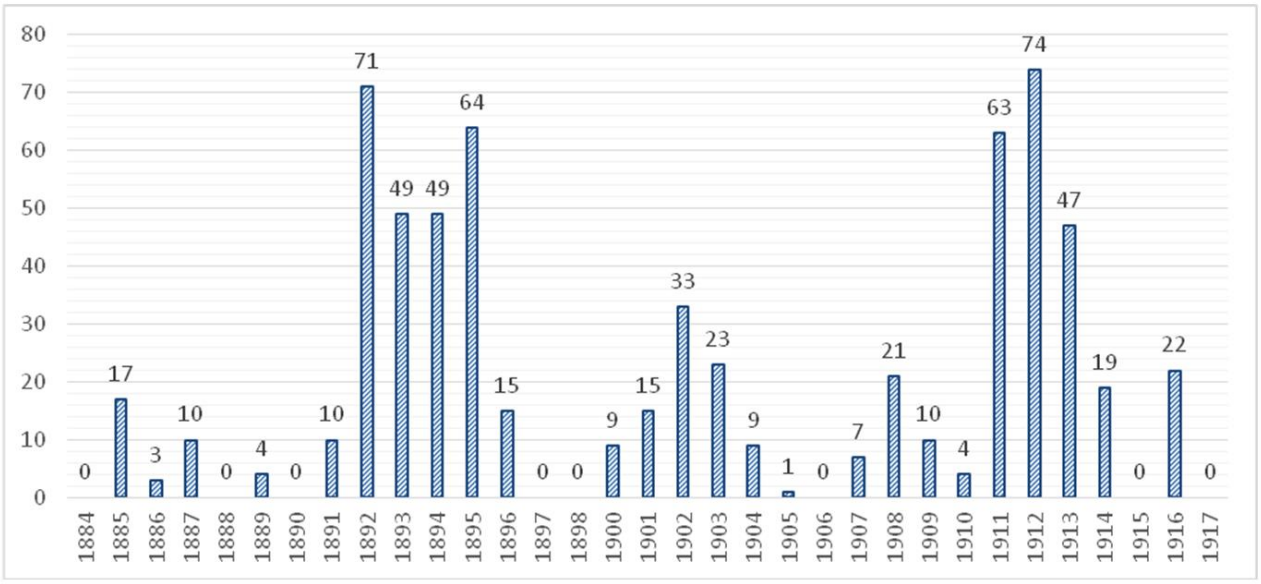


**Figure 5.** Time series of the dynamics of changes in the volume of materials in the "Pedagogical Articles" category in the "Journal of Elementary Mathematics" and in Bulletin (1884–1917).

The time series of the dynamics of changes in the number of materials in the "Pedagogical Articles" category in both journals is shown in fig. 6.

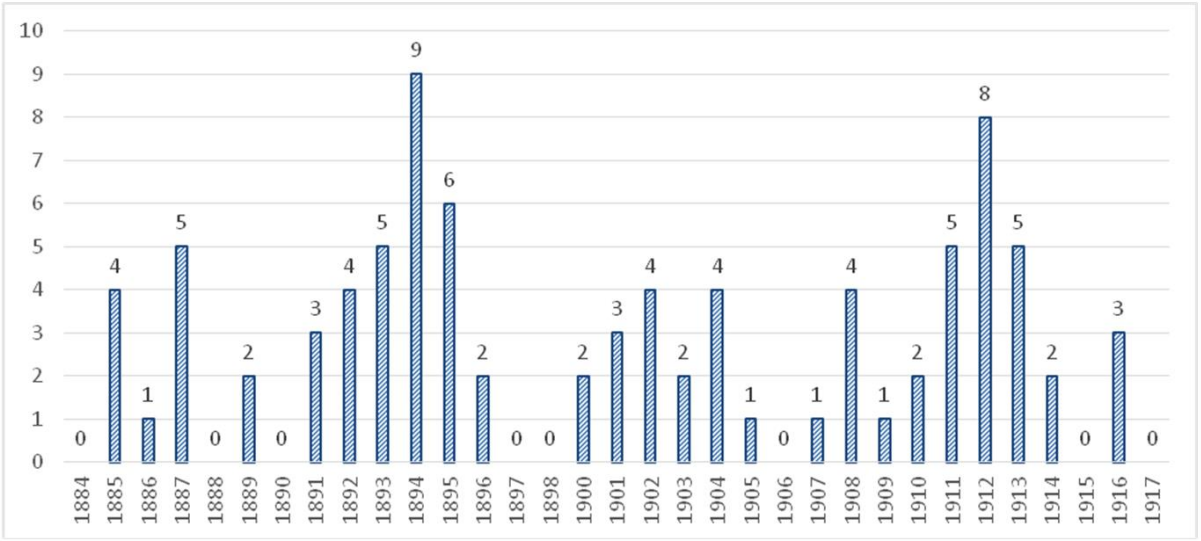


**Figure 6.** Time series of changes in the number of materials in the "Pedagogical Articles" category in the "Journal of Elementary Mathematics" and in Bulletin (1884–1917).

Almost 190 books (including reprints) were published by the "Mathesis" Publishing House during the 20-year period of its operation. We divided the entire volume of his book production into categories: "Mathematics", "Physics",

"Astronomy", "Biology", "Chemistry", "Geography", "Natural Science", "Philosophy", "Technology", "Meteorology", "Geodesy", "Spectroscopy". The number of published books and their total volumes by defined categories are shown in fig. 7.

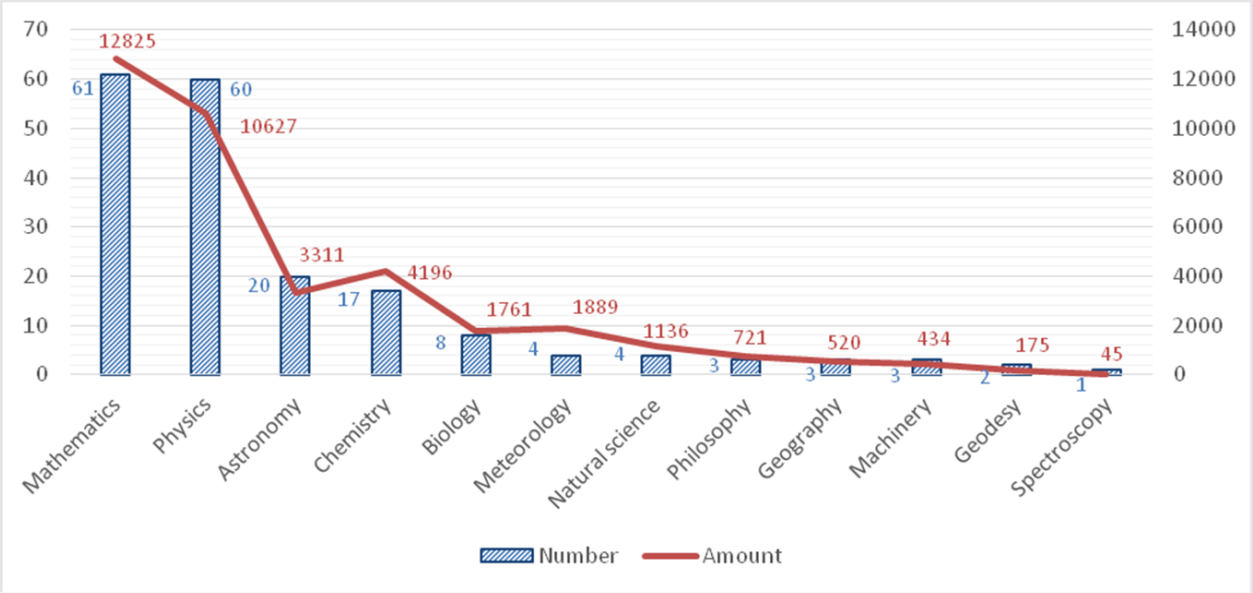


**Figure 7.** The number of books of the "Mathesis" Publishing House and their total volume by specified categories (1905–1925).

The median values of the distribution of volumes of books on natural and mathematical topics by years of operation of the publishing house according to the defined categories are shown in fig. 8.

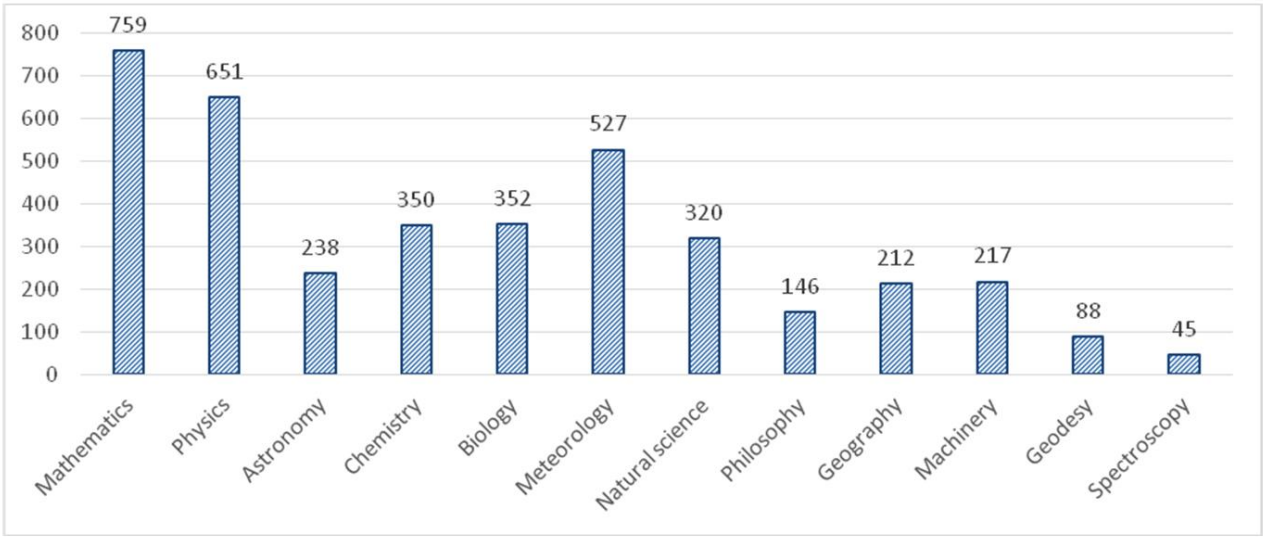


**Figure 8.** Median values of the distribution of the volumes of publications on natural and mathematical topics according to the defined categories ("Mathesis" Publishing House, 1905–1925).

The time series of changes in the number and corresponding volumes of publications in the field of natural and mathematical sciences and the technology of teaching natural and mathematical disciplines in the secondary school of the "Mathesis" Publishing House during the entire period of its operation is shown in fig. 9.

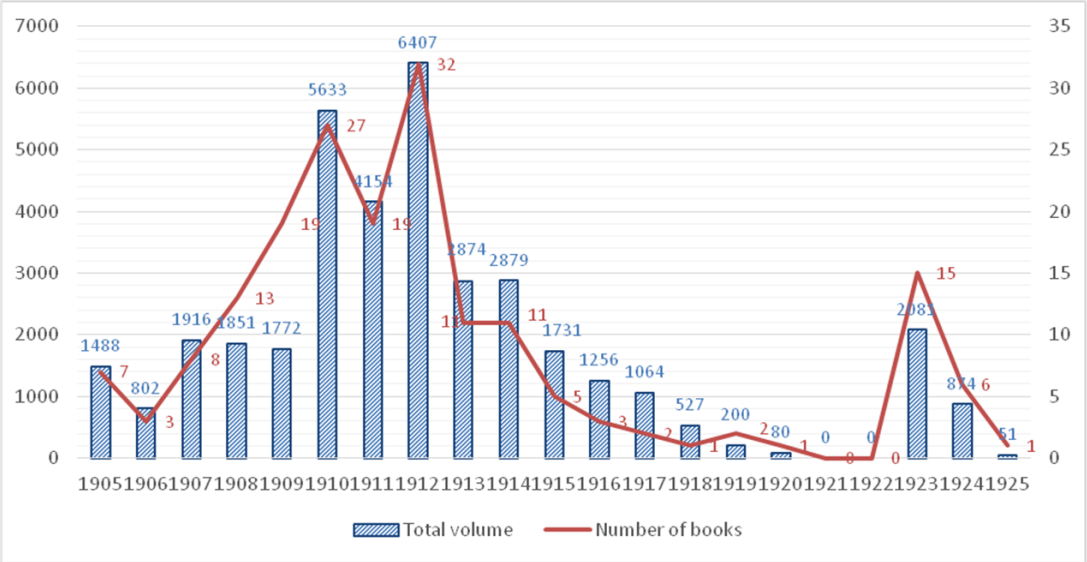


**Figure 9.** Time series of the dynamics of changes in the number and total volumes of publications on natural and mathematical topics of the "Mathesis" Publishing House (1905–1925).

The time series of changes in the number and total volume of books published by the "Mathesis" Publishing House, which were directly intended for the education of secondary school students (textbooks, manuals, pedagogical publications, popular science literature), during all the years of the publishing house's operation, is shown in fig. 10.

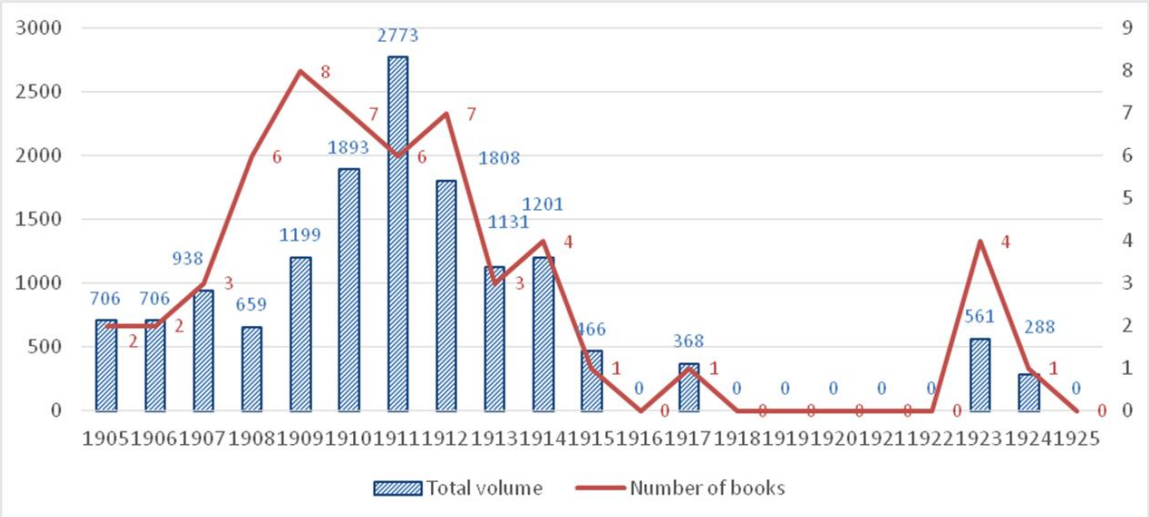


**Figure 10.** Time series of changes in the dynamics of the number and total volumes of books for teaching high school students ("Mathesis" Publishing House, 1905–1925).

**Discussion.**

Let's highlight some positions that arose in the process of conducting research. *First of all*, taking into account the peculiarities of the formation of learning technology, we will specify the positioning of the role of the publications analyzed in the article in the context of the generally accepted wording of the names and content of the stages, the passage of which ensures the formation of a body of knowledge into science. The global formation of the technology of natural and mathematical disciplines as a science went through several key stages, each of which had its own time frame and special meaning (Goncharenko, 2011):

1. At the initial stage (the middle of the 17th – the end of the 18th century), the main ideas and principles of didactics were formed (John Amos Comenius, "The Great Didactics" of 1657, the foundations of general didactics), the first attempts to systematize knowledge about learning and teaching natural and mathematical sciences appeared discipline, the study of mathematics and natural sciences is beginning to be integrated into educational programs.

2. The stage of the formation of methodological approaches (beginning – mid-19th century) is characterized by the active development of methods of teaching natural and mathematical disciplines (the works of Johann Heinrich Pestalozzi and Friedrich Froebel), the creation of the first textbooks and methodical guides in mathematics and natural sciences, the development of pedagogical education in European countries provided teacher training.

3. The stage of scientific substantiation of technology (late 19th – early 20th century) is characterized by the emergence of pedagogy as a science (the works of Herbert Spencer and John Dewey), specialized methodological schools appear, curricula, textbooks and methods of teaching mathematics and natural sciences are developed, the first empirical studies of the effectiveness of various teaching methods.

4. At the stage of institutionalization and development of technology (mid-late 20th century), the technology of natural and mathematical disciplines acquires the characteristics of an independent scientific field, departments and institutes are opened, scientific research is conducted, technology is integrated with other scientific fields, such as cognitive psychology, sociology of education, computer science.

5. At the current stage (late 20th – early 21st century), the role of information and communication technologies in education is increasing, new theoretical approaches to teaching are emerging, international cooperation in the field of technology of natural and mathematical disciplines is expanding, research is focused on adapting education to the needs of various groups of students, development of critical thinking and a creative approach to learning.

The educational system of the Russian Empire at the end of the 19th and the beginning of the 20th centuries was based on advanced European achievements. But, obviously, social cataclysms of this period, which were an integral part of imperial policy – wars with neighbors, uprisings, revolutions – had a powerful influence on educational processes. As a result, material support for educational reforms was implemented according to the residual principle. A clear proof of such a state policy is the actual complete lack of support for both periodicals and publishing houses, which

implemented the state policy regarding quality and comprehensive training of the young generation in the field of natural and mathematical sciences. The last thesis is confirmed by the results of the substantive analysis we conducted, as well as the circulation of publications (by the standards of the time, the circulation of the magazines analyzed in the work, which reached 500–700 copies (with discounted prices for educational institutions), was considered sufficient to meet educational needs, and the publishing house's circulation of 1 000–2 000 copies made it possible to distribute educational and popular scientific literature not only on the territory of the Dnipro region). That is why the advanced publishing activity of the publications "Journal of Elementary Mathematics" and "Bulletin of Experimental Physics and Elementary Mathematics" and the "Mathesis" Publishing House in the territory of the Dnipro region (and beyond its borders as well) can be assessed as creating the necessary conditions for normative, substantive and methodical ensuring the transition period from the stage of formation of methodological approaches to the stage of scientific substantiation of the technology of teaching natural and mathematical disciplines in secondary school.

*Second position.* Quantitative analysis of the research subject showed that the vast majority of the materials of both periodicals and the "Mathesis" Publishing House were focused on mathematics and physics. However, among numerous articles and books, there was also a large amount of materials that were meaningfully related to Astronomy, Biology, Chemistry, and Geography. Moreover, a popular phenomenon of many works was ideas and contents of an interdisciplinary nature. And this, in our opinion, vividly reflected the positions of both magazine editors and publishing house management regarding the integrative features of the world system, regarding the integrity of the laws of nature, regarding the mathematization of its descriptions. It is also interesting to note the fact that there is a large amount of problem-based material, in terms of the number of articles and their volumes in journals (see figs. 1 and 2), and the number and volume of problem books and publishing house workshops (see Physics – (Abraham, 1905a, 1905b; Kolraush, 1914), Mathematics – (Dzyk, 1914; Orbinskiy, 1919; Rou, 1910), Chemistry (Biltts, 1910; Sheyd, 1907), Technique (Venelt, 1923) and etc.) convincingly testifies to the editors' convictions (*V. P. Yermakov, V. P. Shpachinskyi, V. F. Kagan, E. L. Bunytskyi*) regarding the importance of the problem material as a crucial component of students' mathematical and scientific training.

*Third position.* All the time series of our research (see figs. 3–6, 9, 10) confirm the thesis formulated above about the colossal impact of social cataclysms and subjective conditions on the effectiveness of the creative activity of editorial teams of publishing institutions. The change of the editorship and name of the "Journal of Elementary Mathematics" to the "Bulletin of Experimental Physics and Elementary Mathematics", the relocation of the Bulletin's editorial office to Odesa, the revolutionary upheavals of 1905 and 1917, and the World War I – all this radically affected the number and volume of publications of the Bulletin and the productivity of "Mathesis". This caused a reduction in publications of educational literature, a decrease

in opportunities for organizational, substantive, and methodical support of the educational process. As a result, it led to educational losses.

There is no conditional form of statements in the story. But – if there were no obstacles, what would education be like, what would society be like? Would the forward movement really be powerful and decisive? Is it possible that losses are the payment for hope and the incentive for future accelerations?

**Conclusions.**

A meaningful and quantitative analysis of the results of the activities of the "Journal of Elementary Mathematics", "Bulletin of Experimental Physics and Elementary Mathematics" and the "Mathesis" Publishing House regarding their role in the formation of the technology of teaching natural and mathematical disciplines as science allows us to formulate the following conclusions.

1. During 1886–1925, on the pages of authoritative publications of the then Russian Empire, which functioned on the territory of the Dnipro region – "Journal of Elementary Mathematics", "Bulletin of Experimental Physics and Elementary Mathematics" and in the book editions of the "Mathesis" Publishing House, the ideas of science teaching technologies were actively developed – mathematical disciplines, the contents of textbooks and methodical manuals in mathematics and natural sciences were published and discussed, the peculiarities of teacher training were analyzed, methodical schools of prominent scientists and methodologists were started and fixed, curricula were reviewed. This shows that thanks to the activities of both magazines and publishing houses, real conditions were created for meaningful and technological provision of the transitional period from the stage of formation of methodological approaches to the stage of scientific substantiation of the technology of teaching natural and mathematical disciplines in high school in the global context of its formation as a science.

2. Social upheavals caused by the imperial policy of the state affected the productivity of both magazines and publishing houses. Moreover, neither the magazines nor the publishing house received state support. But the total volumes of publications, the total number of their articles and books, the quality of execution and the breadth of coverage of the content of natural and mathematical disciplines testify to the ability of the editors to carry out the planned measures for the production of meaningful and methodical support for teaching and the distribution of popular science publications to motivate a wide range of young people (and older members of the population) to study Mathematics, Physics, Astronomy, Biology, Chemistry and Geography. This is evidenced by the high level of activity of magazines and publishing houses during the "quiet" periods of their operation, median productivity indicators, as well as the total volumes of publication and distribution of literature.

3. Both journal editors and the management of the publishing house were aware of the important role of practice in the study of natural and mathematical disciplines. In general, for all analyzed institutions, more than a quarter of the volume of all publications was allocated for problem material and laboratory practicals.

4. Articles and books of a methodological nature became an important component of the publications, in which the peculiarities of the teaching technology were revealed, the subject terminology was clarified, discussions were organized about teaching models, the peculiarities of the speeches of famous mathematicians and natural scientists at various level congresses and congresses were highlighted, and the pedagogical and scientific heritage was disseminated famous scientists.

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The authors declare no conflict of interest.

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## Природничо-математичні видання Наддніпрянщини кінця XIX – початку XX століття: Становлення технології навчання як науки

***Анотація.*** *У статті визначена роль «Журналу елементарної математики», «Вісника дослідної фізики та елементарної математики» й видавництва «Матезіс» у трансформації сукупності знань про технології викладання природничо-наукових дисциплін у науку. При організації дослідження для змістовного аналізу його предмету використовувався аналіз інформації видань та узагальнення поданих у публікаціях елементів природничо-математичних знань і систематизація описів технології викладання природничо-математичних дисциплін. У процесі проведення кількісного аналізу використовувалися квантифікація тексту, збирання емпіричних даних, їх узагальнення та математико-статистична обробка. У результаті проведеного дослідження матеріалів обох журналів та продукції видавництва «Матезіс» протягом всього періоду їхнього функціонування автори дійшли таких висновків.*

*По-перше, протягом 1886–1925 рр. на сторінках авторитетних видань тодішньої Російської імперії, які функціонували на території Наддніпрянщини – «Журналу елементарної математики», «Вісника дослідної фізики та елементарної математики» й книжкових виданнях видавництва «Матезіс» – активно розвивалися ідеї технологій викладання природничо-математичних дисциплін, видавалися та обговорювалися змісти підручників та методичних посібників з математики та природничих наук, аналізувалися особливості підготовки вчителів, започатковувалися й фіксувалися методичні школи видатних науковців та методистів, рецензувалися навчальні програми. Це свідчить про те, що завдяки діяльності обох журналів і видавництва створювалися реальні умови для змістовного й технологічного забезпечення перехідного періоду від етапу формування методичних підходів до етапу наукового обґрунтування технології викладання природничо-математичних дисциплін в середній школі у глобальному контексті її формування як науки. Сумарні обсяги видань, кількість їхніх статей та книг, якість виконання та широта охоплення змістового наповнення природничо-математичних дисциплін свідчать про здатність редакцій виконувати заплановані заходи щодо продукування змістовного та методичного забезпечення викладання та розповсюдження науково-популярних видань для мотивації широких верст молоді (і старших представників населення) вивчати математику, фізику, астрономію, біологію, хімію та географію. Обидві редакції журналів та керівництво видавництва усвідомлювали важливу роль практики у вивченні природничо-математичних дисциплін – за всіма аналізованими інституціями більше четвертої частини обсягу всіх видань було виділено для задачного матеріалу та лабораторних практикумів. Важливим компонентом публікацій стали статті та книги методичного характеру, в яких розкривалися особливості технології навчання, уточнювалася предметна термінологія, організовувалися дискусії щодо моделей навчання, висвітлювалися особливості виступів відомих математиків та природодослідників на різного рівня з'їздах та конгресах, поширювалася педагогічна та наукова спадщина відомих вчених.*

***Ключові слова:*** *навчально-наукова періодика; видавництво; технологія навчання; природничо-математичні дисципліни; наука*

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