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EPISTEMOLOGICAL RESEARCH AND DEVELOPMENT OF CONTENTS OF PHYSICS EDUCATION IN UKRAINE

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Abstract

In the present paper, the historical perspective of the complex problem of the formation and development of the contents of physics education in Ukraine as an integrated socio-probabilistic process is considered. Objective criteria of periodization of the history of school physics education in Ukraine during the XVIII century - beginning of XXI century is scientifically grounded and developed on the base of the synergistic approach, identifying eight periods. A method for multilevel forecasting development of school physics education has been developed and validated, which allows to create a model for such a process and to formulate the general principles of its construction.

Keywords: content of physics education, epistemological research, historical and methodological context, periodization, scientific prediction.

Prólogo

La historia de la formación y el desarrollo de los contenidos para la enseñanza de la física, considerando el hecho de que cada país tiene particularidades únicas las cuales lo relacionan con una cultura nacional específica, inevitablemente se incorpora al flujo de la historia general de la humanidad. Esto es natural puesto que los contenidos para la enseñanza de la física tienen información que refleja de una manera más o menos completa y precisa el conocimiento establecido por la ciencia, la cual es internacional.

La colaboración con los colegas de la Benemérita Universidad Autónoma de Puebla (BUAP, México) se ha dado en la forma de: seminarios científico-metodológicos conjuntos con investigadores y estudiantes del Instituto de Física, las Facultades de Ciencias Físico-Matemáticas, Química, y Ciencias de la Computación; seminarios metodológicos con maestros de física y matemáticas de las escuelas Preparatorias de la BUAP; proyectos científico-metodológicos conjuntos con el Cuerpo Académico de Materiales Avanzados del Instituto de Física, cuyo responsable es el Dr. F. Pérez Rodríguez, y con el Dr. J. Slisko del Cuerpo Académico de Enseñanza de las Ciencias de la Facultad de Ciencias Físico-Matemáticas. Estas actividades han permitido definir una serie de problemas actuales de la Teoría y la Metodología de la Enseñanza de la Física.

Entre los problemas que más sobresalen podemos mencionar: la investigación epistemológica de la formación y el desarrollo de los contenidos para la enseñanza de la física; los cambios en los enfoques teórico-metodológicos para la elaboración de los contenidos para la enseñanza de la física a nivel medio superior y superior; elaboración de libros de texto de física de gran calidad como medios fundamentales para la enseñanza; reconocimiento de la esencia del libro como modelo del proceso de enseñanza en cierta etapa del desarrollo a nivel escolar considerando el desarrollo mismo de la física, la acumulación de conocimientos, la formación del sistema de conocimientos, y los conceptos físicos fundamentales; aplicación de tecnologías innovadoras para la enseñanza de la física, en particular las informático-computacionales; predicción científica y elaboración de los planes y programas académicos correspondientes de física para las escuelas de educación media superior y superior.

1. Introduction

Development of Ukraine in the third millennium by the general context of European integration is defined with a focus on the fundamental cultural values. Entrance of Ukraine to the Bologna process is caused by a number of factors: embracing globalization, which influences the radical changes, forcing higher education of European countries for immediate and radical reform; transformation of the information revolution into a powerful accelerator of the social changes and, consequently, the creation of the world communication network, through which information transfer and exchange of knowledge become general; the dynamic development of science, engineering and technology; consistent and confident transformation of science into a direct productive force of society. Therefore, the reform and renewal of secondary education in Ukraine, on the way towards European and global integration, involves the conceptual changes as of methods and the content of teaching, the principles of organization of new educational standards and pedagogical approaches to learning, innovation, adapted to the social needs of technology. In this context, the physics education as one of the fundamental components of comprehensive education of personality requires new ways of development, improvement of content by historical and methodological achievements, introducing the new concepts, standards and alternative education programs, advanced technologies of the educational process, methodological reorientation on the individual. Accordingly, the main areas of updates of content of physics education is the orientation on individual, the priority of universal and national values, taking into account the latest science, technology, culture achievements and social practices.

The system of physics education has a dual temporal orientation: to the past and to the future. Therefore, beyond a broad historical perspective, the underlying mechanisms remain unsolved, which were formed in the distant past, but which are objectively present and determine the future of the modern physics education. You cannot appreciate the perspective and even logical structure of any methodological theory without mastering its genesis. Only on the basis of knowledge of specific historical facts of modern teaching methodology we can not only obtain new knowledge about the nature of the didactic phenomena and processes, reveal their patterns, but also make some predictions about their future. In this context, the development of modern didactics of physics should be based on historical and methodological (epistemological) studies of the formation and development of the physics education and the methodological basis should be an axiomatic-deductive methodology - the methodology of cognitive modeling [1].

2. History of Physics Teaching

According to Ref. 2, the history of development of content of physics education can be analyzed within:

- The systematic approach that combines a number of paradigmatic and methodological guidelines for the study of physics education as a system with a large number of elements, where structural levels combined with numerous tasks and functions with considerable complexity and the different indications due to a very large variety of relations between components;
- The structural approach, the main direction of which is the selection of the structural aspects of the system of physics education, paying attention to this particular aspect of the problem, the realization that coexisting structures - it's kind of the different "slices" of multistructural system, internal projection from different points of view;
- The functional approach, whose essential requirement is to determine the behavior of the content of physics education as a combination of its own functioning and interaction with information technology environment, which is generated by the practice of using high technology industry;
- The informational approach, the essence of which is the selection and research of information aspects of teaching physics. Modern physics didactics gradually aware of the fact that knowledge of the evolution of the content of physics education cannot be considered even relatively complete and adequate information without studying the "cuts" of historical and educational reality, which is due to the multiple information processes;
- The probabilistic approach, which occupies a prominent place in the arsenal of the theory and methods of teaching physics, because the evolution of content of physics education is considered as a complete historical phenomenon that is not strictly deterministic, but flexible and labile, subordinated by stochastic effects of many factors;
- The modeling approach, which is the study of properties, connections and correlations of one object by means of the other – its model;
- The genetic approach points to the origin, development, research method, based on an analysis of the genesis and development of the content of physics education;
- The historical and methodological approach as an indispensable kind of epistemological reflection in modern methodical science has an important heuristic function in determining the basis and preconditions for its further evolution, which leads to the development of effective research strategies

and determine the general directions of didactics of physics as a scientific field of study and design content of physics education as its major component.

Methodological basis for determining the dynamics, direction and trends of school physics education is its periodization. We created the periodization of the development of school physics education, based on a synergistic approach to the analysis of scientific information space [3, 4]: the first period (XVIII century - 60th of the XIX century) - emergence of physics as a school subject, the appearance of the first domestic textbooks of physics, which reflected the content of education, the second period (60th - end of 90-th of the XIX century) - formation of physics as a school subject, the development of the first program in physics, and the third period (end of the XIX century - 1917) - a radical change in physics and trends of school physics education in the context of national revival, the fourth period (1917 - 1920) - forming the content of physics education in the period of Ukrainian statehood and school, fifth period (1920 - early 30's of the XX century) - search for new approaches to the design of school physics education in the context of the revival of the Ukrainian school and didactics of physics: the sixth period (30th of the XX century - 1945) - forming the content of physics education through the use of advanced domestic methodics, the seventh period (1945-th - 80-th of XX century) - development of school physics education in the scientific and technical progress on the basis of dialectical epistemology, eighth period (90th of XX century - present) - the development of school physics education based on new methodological principles and innovative processes in the didactics of physics.

3. Educational Prognosis

The content of education is a major component of the educational prognosis. Therefore, the development of scientific prediction of school physics education allows to create a content model that would permit the use of the objective mathematical forecasting methods. One of the traditional models, presenting the content of a discipline and scientific material is structural schemes. Generalized hierarchical structural and logic scheme presents the content of physics as a discipline as follows: the first level determines the sections (lines of content), second - units, the third – themes, fourth - training elements (concepts, definitions, laws, etc.). The data about the development of school physics contents at four levels - sections, subsections, topics and educational elements - allowed the strategy for forecasting. To realize the possibility of systematic analysis of mutual influence levels of content we offer a systematic strategy of multilevel forecasting of the content of the discipline "physics", the essence of which is in predicting

changes of content at each level of the hierarchy and the ability to analyze its mutual influence. The basis of this strategy is the method of mathematical description and prediction based on time series [5,6].

We use the system Statgraphics for the correlation analysis of numerical relationships of elements of content as sections (SECTIONS), subsections (SUB-SECTIONS), theme (TOPICS), and educational elements (ELEMENTS). Based on the results of the correlation analysis in the Statgraphics we made prediction of the content of school physics with four levels of hierarchy.

1. Level - learning elements (ELEMENTS). Analysis of prediction (fig. 1) shows that with the probability of 95% in the next five years the number of training elements will increase to 746, in 10 years - up to 762.

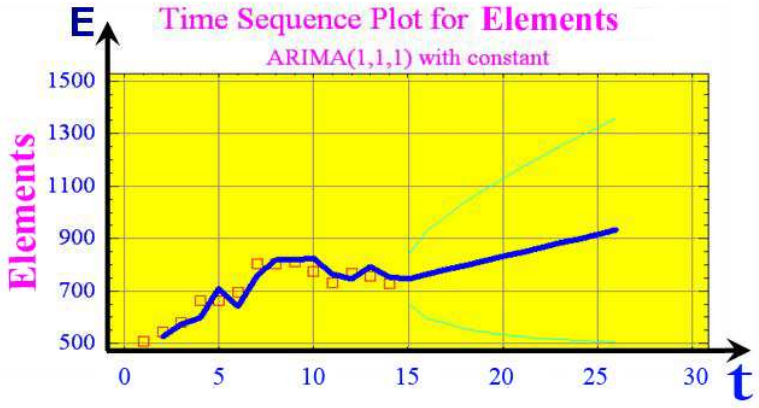

Fig. 1. The prognosis of change of the studding elements

2. Level - Topics (TOPICS). The resulting prediction (fig. 2) shows the probability of 95% of increasing the numbers of topics in 5 years to 338, in 10 years - up to 382.

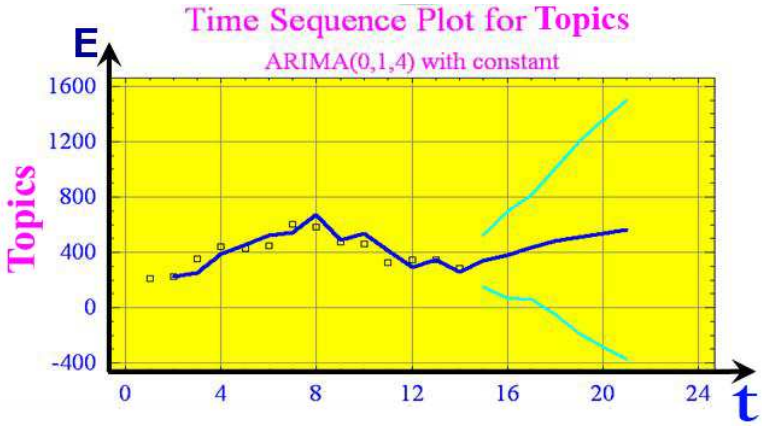

Fig. 2. Using graphic time series TOPICS for the forecast.

3. Level - units (SUBSECTIONS). According to the forecast (fig. 3) it is expected, that with a probability of 95% the number of units in the school physics course increases in five years to 32 and in the ten years - to 34.

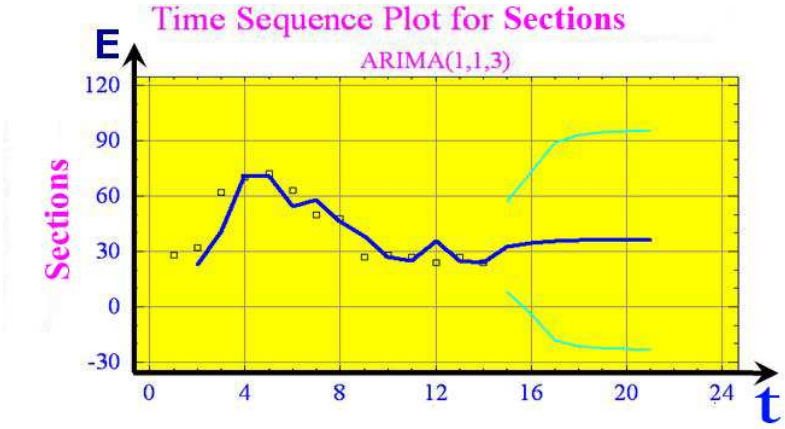

Fig. 3. Using graphic time series SUBSECTIONS for the forecast

4. Level - subsections (SECTIONS). The prognosis (fig. 4) shows that with the probability of 95% after five years, the number of sections in the school physics course will be 19, and in the ten years later - 17.

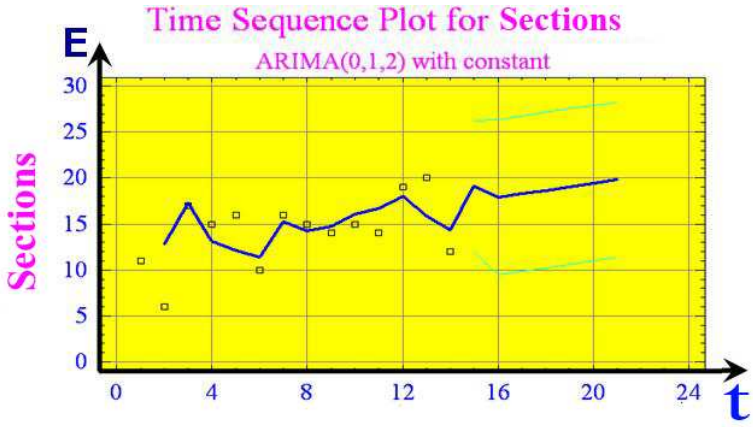

Fig. 4. Using graphic time series SECTIONS for the forecast.

These results of forecast revealed an objective deterministic-probabilistic process of the school physics course content development in the following areas: increasing the number of content elements at different levels of hierarchy (sections, subsections, topics, educational elements), decomposition of the content at the different levels of hierarchy, generalization of the content on different levels of the hierarchy.

5. Conclusions

- In the historical perspective, a comprehensive analysis of the problem of the formation and development of school physics education in Ukraine as an integrated socio-deterministic probabilistic process is considered. It is based on the synthesis of two groups of factors: external, by means of which the material characteristics of the historical development of the scientific process exist, and internal, by which the internal logic of the theory and methods of teaching physics exists;
- Theoretically proved that historical and information approach for designing the school physics education is a high priority in the current conditions of teaching physics;
- Scientifically proved and developed on the basis of objective criteria the synergistic approach for periodization of the history of the development of school physics education in Ukraine during the XVIII century - beginning of XXI century;
- On the basis of objective criteria of periodization and stages of development of school physics education in Ukraine, the socio-economic, the political and the cultural factors that have influenced the features of school physics education in Ukraine have been determined;
- The directions of the content of physics education at each historical period by correspondence with the national standards of physics with the possibilities of educational environments have been defined;
- The method of multilevel scientific forecasting of school physics education, which allows to create a model of content and formulate the general principles of its construction, has been developed.

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