

## CONCEPT OF A TEXTBOOK ON PHYSICS

*T. M. Zasyekina,*

*a Candidate of Pedagogical Sciences, a senior researcher*

In the article, the conceptual fundamentals of the Physics textbooks design for the secondary school (7<sup>th</sup>–9<sup>th</sup> grades) and for the future profession-oriented school (10<sup>th</sup>–11<sup>th</sup> grades) are covered. The main problem which is solved by us is the specification of such concept of Physics textbook which would promote the implementation of the competence-based, personality-oriented and activity-based approaches and respond to the double matter of the school Physics course at the same time. In the other words, it is the definition of the priorities in the functions, the common and the different features of the structure and the methodological apparatus of the textbooks on Physics for the secondary school (7<sup>th</sup>–9<sup>th</sup> grades) and for the future profession-oriented school (10<sup>th</sup>–11<sup>th</sup> grades).

We consider that such criteria are: 1) the correspondence to the pupils' age opportunities and the development tasks; 2) the correspondence to the purpose and the tasks of the physics education content; 3) the interrelations between the general and the certain educational aims and tasks as well as the requirements to the education outcomes.

Paying a special attention to the pupils' age peculiarities we concretize the feasibility of the aims and tasks set in the standards and in the curriculum; select those academic material that determines its content, structure, and methodological apparatus of a textbook in accordance with the most significant psychological growth of the corresponding age category.

Textbook functions can be provisionally divided into invariant ones which do not change during the whole period of creating a textbook and variant that change under the impact of the social and cultural factors.

For the secondary school, a textbook on Physics is a complex informational model which reflects four elements of the pedagogical system, namely, education goals, education content, didactic processes, organizational teaching forms; it allows implementing them in practice. In the high profession-oriented school, the role of such complex model must be played by an educational series: the main course book-manual and the variative handbooks-appendixes that demonstrate the content in correspondence to the chosen education profile.

Both for the secondary and the high schools, we define the following invariant functions of an educational book: informational, transformational, systemizing, motivational, acquisition, and self-control, developmental, and upbringing ones.

For the secondary school, the variative functions are the following: cognitive (cognition), communicative, prognostics (prediction), and modelling ones. For the high school, these are the self-education function, representative, integrative,

compensational, coordinative, and regulatory ones (for the professional self-determination).

**Keywords:** *the structure of two concentrers of the Physics course, functions and methodological apparatus of a textbook on Physics, academic series*

**Problem statement.** In the secondary schools, the updated standard of the basic and the secondary education continues to be implemented. The feature of the comprehensive standard is the fact that it is formed in order to provide the deployment of the educational process based on three defining approaches: competence-based, activity-based and personality-oriented ones [3]. Despite it, educational areas content, its components, the state requirements for the students' comprehensive education meet the challenge of the basic and the high school in their sequential relationship that leads to the double-centered structure of the most school subjects. Therefore, the high-school physics course is designed on two logically completed concentrers, the content of which is consistent with the structure of a comprehensive secondary education: in the secondary school (7-9 grades), the logically completed basic course of physics, which lays the foundation of physical knowledge is studied; in the high school, studying physics is dependent on the education orientation.

In accordance with the theory and the methodology of teaching physics, the problem of developing a new educational and methodological provision which would ensure the educational innovations implementation is faced.

**Analysis of the recent researches.** Nowadays in the homeland pedagogy, different aspects of the competence-based, personality-oriented and activity-based approaches are actively studied. We are going to consider the issues related to the impact of these approaches on the theory and practice of academic books development in detail.

Analyzing the theory of creating textbooks, including the works of the scholars of the Institute of Pedagogy [1, 2, 3, 7, 8, 9], we can conclude that a textbook serves as a multifunctional didactic means the structure, content and analytical tools of which promote the academic goals achievement, are a carrier of the subject content and the teaching methods. Gradual or simultaneous changes of the targeted, the semantic and the procedural components of the education system have a significant influence on the concept of the textbook. For example, in the 70s of the XX century, the problematic learning idea has a direct influence on the restructuring of a considerable part of textbooks in the area of the organization of the pupils' active learning. In the 80s, the new trend in didactics is the development of the methods for the positive motivation towards the educational activity, avoiding the overload of the taught material, stimulating creative activities that appropriately define the procedural component of studying. In the 90's of the last century, in Ukraine, the modernization processes in the public secondary school is associated with the differentiation and individualization of learning. This is primarily due to the foundation of a new type of institutions (high schools, grammar schools, colleges and specialized schools, educational and industrial complexes, etc.), development

of curricula and varied programs. Correspondingly, it led to the change of the textbook concept. Common textbooks, the textbooks of the same type, universal textbooks are replaced with the new ones: variable textbooks (designed for the varied training programs or those ones which implement the content of the traditional curriculum in a new way), level textbooks (ordinary and advanced levels), differentiated (for the humanities and the natural sciences), two-level (those ones which are assigned for the different levels of studying the subject), authorial ones.

The search for the new textbook concepts, improvement of its models are ensured at present. In what way do modern education approaches have an influence on the concept of a textbook? In accordance with L. Neporozhnyia [6], from the standpoint of the competence-based approach, a textbook as a resource must perform the following functions: information and cognitive, developmental, synthesizing, research, practical, self-educational, educational functions, which are primarily aimed at the formation and the development of the key subject and the general subject competencies of the pupils. Each of these features predetermines the appropriate selection of the textbook components: text, tasks, and visual means. As it has been noted by M. Burda [1], a competency-oriented content of textbooks (for mathematics) should meet the following requirements: compliance of the school mathematics education with the socio-economic needs of the country; taking into consideration the peculiarities of the pupils' learning activities at the different levels of its content; strengthening the practical and the creative components of the educational content; the priority of the developmental learning function; the correspondence of the educational texts to the stage of cognition; the optimal combination of continuous and discrete mathematics; scientific and applied focus of the content.

Considering the current approaches to the textbook design, O. Pometun [7] points to its traditional functions: 1) it is a source of educational information that provides the content of educational standards for the pupils in an easy way; 2) a means of learning, through which the organization of the educational process, including the pupils' self-education is ensured.

By means of a textbook, the aims and the objectives of education are achieved. If the goal of education is to transfer the system of knowledge for the students, a manual gains the relevant features. If, except for the knowledge, we are interested in the development of the pupils' specific skills, these characteristics change. If we talk about the development of a child, particularly, about the personality oriented or the personality-centered learning, the textbook must include the elements that influence the emotional sphere of a child, his/her values, thought, culture and so on. There is no doubt that it is possible to combine or use different approaches in a textbook systemically [7].

We agree with the S. Trubacheva's opinion [9], who divides the textbooks functions into invariant ones that do not change in the process of creating textbooks and variable ones those functions that change under the influence of

the sociocultural factors. However, some traditional functions are modified or transformed and become the signs of variability. Therefore, the organization of the cognitive activity transformed into the motivational one, and then into the function of the pupils' cognitive abilities; the function of the pupils' homework organization became the self education function and, later, the function of the key competences formation; the systemizing function of a textbook transformed into the function of the pupils' orientation at their cognitive activity, and then into the function of the pupils' independent cognitive activity in the information space [9].

Developing the concept of physics textbooks, we pay special attention to the analysis conducted on a system of the requirements for a textbook in the history of the homeland physics didactics. A textbook on Physics reflects the priorities in the physics education and the educational goals that were set in the process of teaching physics at various stages of school physical education development. The role of textbooks in the educational system is conceptually represented primarily in the requirements that are put forward by theory and practice [2].

**Setting the purpose of the article (problem statement).** The main task that we must fulfill is to specify that physics textbooks concept, which would contribute to the implementation of the competence-based, the personality-oriented and the activity-based approaches and, at the same time, take into consideration the two-centered nature of the school physics course. In other words, it is to prioritize the functions, the common and the different features of the structure and the analytical tools in physics textbooks for the secondary school (grades 7–9) and the future profession-oriented school (10–11 grades).

**The main body.** It is necessary to analyze the objectives and the main tasks of teaching physics in the secondary and the high school. As for the primary school, they are defined in the foreword to the physics curriculum for the grades 7–9 [5]. As for the future profession-oriented school, it is known that it will be the second center, the content of which is formed in accordance with the basic physical principles and theories and are comprehended at a higher level of generalization (compared to the basic one (7–9 grades). Therefore, mastering course content of Physics of the second centre, in fact, the pupils study the same phenomenon depending on the education profile. The difference is that in the secondary school it is mainly the qualitative description of them whereas in the high school, it is theoretical and applied.

It should be notified that the double-centered structure of the school year is current since 2007. What is more, in practice, in the textbooks on physics for the 10<sup>th</sup>–11<sup>th</sup> grades, some paragraphs, explanations, examples are almost verbatim. Of course, avoiding repetition is completely impossible in the double-centered structure; however, it is necessary to restructure the content and the methodological apparatus of a textbook.

We consider that the criteria of the differences in the structure and the methodological apparatus of the textbooks for the secondary school (grades 7–9) and the high school (grades 10–11) are the following:

- compliance with the pupils' age opportunities and development tasks;
- compliance with the objectives and the tasks of the corresponding physical education centre;
- the ratio of the general and the specific educational goals and objectives, as well as the requirements for the learning outcomes.

Putting the pupils' age features on the first place, we:

- specify the realistic nature and the opportunity to achieve the set standards as well as the curriculum goals and the objectives (sometimes these figures are unsubstantiated, vast, and vague);
- select that textbook learning material, which determines its content, structure and methodological apparatus according to the psycho-pedagogical requirements. The main of them are the following: taking into consideration the most important psychological neoplasms respective to the age category, interpretation of the educational content in an accessible form, namely, writing the textbooks in a language that is correspondent to mastering its content by the pupils of a certain age category at the appropriate level and at the established time avoiding the primitive simplification and the vulgarisation of the scientific content; selection of the system tasks that would be interesting and objectively feasible for the pupils, relevant for their development level, previous comprehensive training and life experience, encouraging self-development and self-improvement.

Besides, we take into account that the following issues are important for the textbooks on physics:

- the appropriate analogy used to explain complex processes, introduce new terms, their explanation and use;
- sufficient and accurate explanations, samples of the design and solving typical examples, guidelines for the experimental skills formation;
- appropriate emotional presentation, relying on experience, description of interesting facts and real life situations, research, examples of the application of knowledge in practice and so on;
- adequate ratio: didactic units provided for the pupils' one-time learning and cognitive capabilities, the amount of manual sections and the number of training hours defined by the program;
- clearly structured, systematic sequence of the schoolbooks, the rational division of the text into the principal and supplementary;
- the perfect orientation apparatus (headings, signals, symbols, signs, etc.), availability of material or instructions in the tutorial to help to work on a book;
- appropriate use of illustrations.

Let us specify the key moments of the concept of the textbooks for the secondary schools (exemplified by a textbook which we developed for the 7<sup>th</sup> grade). Each section begins with a separate page, before the text paragraph there are the short headings «You are going to learn» and «Remember,» which are aimed to help pupils to learn the basic issues that will be considered and state what they should remember from the learned issues to comprehend the new material better. A

distinctive feature of these headings and the text that precedes each section is that they notify what it is not «about», but the reasons for the pupils to learn the material.

Text paragraphs contain the descriptions of the real-life situations based on the pupils' life experience that allows them to understand the nature of the physical phenomena and the applied nature better, to demonstrate the knowledge in Physics, its significance and usefulness. Additional material is presented in the sections «Physics around us» and «Interesting facts», which illustrates the paragraph with the examples from the history of physics, modern production and reality.

As physics begins to be studied from the 7<sup>th</sup> grade, in these books, we consider it necessary to provide the pupils guidance on the new forms of work organization (educational projects, front laboratory work) and the formation of the appropriate skills whereas the ability to solve physical problems is primary. The textbook contains the category «How to conduct laboratory researches», «How to create educational projects, » «Rules of solving and filling out physical problems.»

The sections «Examples of solving problems» and «Exercises» help to teach pupils to solve physical problems. Exercises include qualitative and computational tasks of varying complexity. The problematic situations collected under the heading «Explain» encourage pupils to search for the answers independently, to promote the opportunities to express their opinion, to evaluative judgments, that is to show their competence.

The pupils will be able to check the level of the comprehension of the achieved knowledge, acquired skills to apply that knowledge, explaining the essence of physical phenomena and processes by means of control questions and tasks headings «Tasks for knowledge control» (at the end of each section), «Quiz» (in end of each chapter). Among the control tasks of the topic there are complex ones that require the identification and the application of knowledge both from the areas related to physics and for other subjects (mathematics, biology, chemistry, etc.).

The equipment description and the brief instructions will help the pupils in preparing and conducting frontal laboratory researches. After each laboratory work there is a heading «My physical investigations», where pupils are offered some homework experiments and observations, which they can conduct on their own.

An effective means of forming the subject and the key competencies of pupils in learning physics is training projects. The textbook's how to implement educational projects section helps pupils to master this kind of work.

Developing V. Bezpalko's definition of the school textbook, we believe that a textbook on physics for the secondary school is an integrated information model that reflects the four elements of the educational system, namely, learning objectives, learning content, teaching processes, organizational learning, and, therefore, it allows to implement them in practice. Thus, physics textbook for the secondary school:

- implements the content and the objectives of the physical components of the State Standard of the basic and the full education («Natural Sciences» area) and curriculum in physics by means of the functions that are peculiar for it;

- provides the pupils' organization of teaching and learning and their intellectual activity;

- ensures the organization of the educational process at its main stages (perception, remembering, application, evaluation), has an effective tool for the organization of comprehension (questions, tasks, instructions, instructional materials, etc.);

- promotes the organization of various activities and communication between the participants of the educational process, differentiation, individualization and personalization of pupils' learning activities according to their cognitive abilities;

- ensures motivation for learning, stimulating cognitive interest, development of the pupils' intellectual and creative activity,

- promotes self-esteem and self-awareness skills, mastering the techniques of the pupils' mental activity (analysis, synthesis, comparison, generalization, etc.), formation of their ability to learn;

- contains the tasks for the organization of the teaching and research as well as the project work of pupils; inspection and self-monitoring of the teaching material; provides opportunities for the application of knowledge in different situations, the formation of pupils' key and subject competencies;

- forms the semantic reading skills, develops critical thinking, ability to express estimated opinions reasonably and the ability to use terminology;

- ensures the consideration of the basic psychological characteristics of this age group in the materials of a textbook; among them, the most important issues are such psychological neoplasms as «self-concept» and the feeling of being adult.

The key functions of the textbook on physics for the secondary school are the following: invariant functions, namely, informational, transformational, systematizing, motivational, comprehension and self-control, self-developmental and educational ones and invariant functions such as cognitive, communicative, predictive (forecasting) and modeling ones.

As for the concept of physics textbooks for the high school. Taking into consideration that the main task of the high profession-oriented school is to provide conditions for the qualitative education of the high school pupils in accordance with their individual inclinations, abilities, skills and needs, providing the pupils some vocational counseling for the future activities and capabilities of the constant spiritual self-identity, the studies are carried out differently, depending on the profile the pupils have chosen; it comprises the in-depth and the professionally oriented study of the cycle of the related subjects.

We consider that teaching physics in high school must take the compensatory function of the content correction to align it with the requirements of the rational professional choices of young people and a certain academic ability, which is found in learning the physics fundamentals.

In this case, the most effective didactic tool is not a separate textbook, but the educational series of two levels: ideological and profile-professional where the unifying criterion is useful knowledge. The criterion of the knowledge usefulness

provides not the educational material expansion, but the augment and the enrichment of the content by improving the knowledge systems; including methodological knowledge and the methods of the scientific cognition in it comprising the tasks that require research and development aimed at the subject and key competencies; the proper representation of the applied aspects of the subject in the content, in particular, the ones which apply to the occupational preferences of those who have chosen a certain study profile.

The features that distinguish these series is the fact that the worldview one is based on the integration and the professional-profile ones as well as the scientific knowledge differentiation.

One of the possible variants of the training series of the profiled-professional level is a set which consists of a reference book that contains the material of the whole physics course for the high school (the 10<sup>th</sup> and the 11<sup>th</sup> grades) as well as the variable appendixes to it, namely, the handbooks which implement the content of the certain special courses or the training modules. A set of such appendixes is determined by the specific profile. For instance, for the purely physical profiles, it may be some textbooks for the certain physics areas, the content of which is based on a combination of the phenomenological approach and the appropriate physical theories which are adapted to the studying the corresponding physical theories at the school level; the practical guides with the multilevel exercises and tasks; the handbooks that contain some non-fictional materials and the analysis conducted on the physical research, the topical news from the scientific laboratories, the descriptions and the tasks of the research projects and modern technologies, etc. For the profiles where physics is regarded as its basic subject (for example, for the technical, the technological, and the medical ones), such appendixes can be the applied handbooks (*A Collection of the Physics Tasks with the Biological Content*, *Physics of a Human*, *Physics of a Computer*, etc.). The educational content variability is determined by the degree of the pupils' independence, the appropriate selection of the content components that meet the cognitive needs of pupils as well as the focus of the content on the future professional activity and the formation of the professional thinking elements.

Both in the worldview and in the profiled-professional content of the physics course of the second concentre, the methodology of physics in its historical and contemporary perspective, reflection of the practical and the prognostics implementation of the physical (fundamental, integrated) knowledge of modern technologies must be laid.

We consider that the feasibility of this approach to the textbooks development will help to solve one of the hot-burning problems that is faced in the practice of the professional orientation of teaching physics, promote the improvement of the logic and the content representation, make it complete and integrate, avoiding unnecessary repetitions, which are caused by the two-concentered structure of the school physics course and ensure the fulfillment of the main tasks of the profession-oriented schools providing the conditions for the qualitative education of the high

school pupils in accordance with their individual inclinations, possibilities, abilities and professional preferences.

Therefore, the content, the structure and the methodological apparatus of an educational series on physics for the high school:

- must perform the compensatory function of the content correction for the purpose of making the content to meet the requirements of the rational professional choices of young people and have some certain academic inclinations, which are represented in the physics fundamentals studying;

- must correspond to the principle of the sequence between the education levels, expand the content ensure the more complex requirements for its comprehension and avoiding formal duplication;

- should facilitate the integrity of the formation of the fundamental (or philosophical) physical knowledge and professional self-determination of the high school pupils, form their training skills and the skills to solve problems in life, learning to learn;

- be aimed at the pupils' socialization, in other words, ensure those forms and methods in which students could realize their desire and intention (what I want), assess their personality features (what I can) and feel what the society requires from them (what I am required).

- take into account the basic psychological characteristics of this age group; among them, the most important ones is the ability to compare «image and me» with the requirements of the individual professions and the labor market situation, to design a professional plan and check it on this basis (by means of the «professional samples», the opportunities for the self-realization in various kinds of professional activities, etc.).

The key functions of a textbook on physics for the high school are the following: invariant ones, namely, informational, transformational, systematizing, motivational, comprehension and self-developmental as well as educational and upbringing functions and variant functions, which include the self-educational, representative, integrative, compensatory, coordination and regulatory (on the professional self-determination) functions.

We notify that the possibility of creating such educational kits is possible in case of making possible changes in the procedure of the textbooks competitive selection for the comprehensive secondary schools.

**Conclusions.** The development of the educational physics provision for the comprehensive secondary schools includes two conceptual factors: changes in the educational priorities and the two-concentered structure of the school physics course.

The criteria of the differences in the structure and the analytical tools of the textbooks for the secondary (7<sup>th</sup> – 9<sup>th</sup> grades) and the high (the 10<sup>th</sup>-11<sup>th</sup> grades) schools are the following:

- the correspondence to the age opportunities and the tasks of the pupils' development;

- the correspondence of the relevant physical education relevant to the goals and objectives;
- the ratio of the general and the specific educational goals and objectives as well as the requirements and the learning outcomes.

For the secondary school, a textbook on physics is an integrated information model that reflects the four elements of the educational system, namely, learning objectives, learning content, teaching processes, organizational learning and allows implementing them in practice. In the high profession-oriented school, the role of such complex models should be played by an educational series: the main textbooks and variative handbooks-appendixes that implement the content according to the selected training profile.

Both for the primary and the high schools, we find the following invariant textbooks features, namely, informational, transformational, systematizing, motivational, comprehension and self-developmental as well as educational and upbringing functions.

Variable functions of a textbook for the secondary school are cognitive, communicative, prognostics (forecasting), modeling ones whereas for the high school, they are self-educational, representative, integrative, compensatory, coordination and regulatory (on the professional self-determination) functions.

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**Заскіна Т. М.**

### КОНЦЕПЦІЯ ПІДРУЧНИКІВ З ФІЗИКИ

У статті розглядаються концептуальні засади розроблення підручників з фізики для основної (7–9 класи) та для майбутньої профільної (10–11 класи) школи. Визначаються пріоритетні функції підручників, спільні та відмінні ознаки їх структури й методичного апарату залежно від цілей і завдань кожного концентру фізичної освіти й визначальних загальноосвітніх підходів.

**Ключові слова:** *двоконцентрова структура шкільного курсу фізики, функції й методичний апарат підручників з фізики, навчальний комплект.*

## КОНЦЕПЦИЯ УЧЕБНИКОВ ПО ФИЗИКЕ

В статье рассматриваются концептуальные основы разработки учебников по физике для основной (7–9 классы) и для будущей профильной (10–11 классы) школы. Главная проблема, которую мы решаем – это обоснование такой концепции учебников по физике, которая бы одновременно способствовала реализации компетентностного, личностно ориентированного и деятельностного подходов и учитывала двуконцентричность школьного курса физики. То есть установить приоритеты в функциях, общие и отличительные признаки структуры и методического аппарата учебников по физике для основной школы (7–9 классы) и для будущей профильной (10–11 классы) школы.

По нашему мнению, такими критериями являются: 1) соответствие возрастным возможностям и задачам развития учащихся; 2) соответствие целям и задачам каждого центра физического образования; 3) соотношение общих и конкретных образовательных целей и задач, а также требований и результатов обучения.

Поставив на первое место возрастные особенности развития учащихся, мы тем самым: конкретизируем реалистичность и достижимость поставленных в стандартах и учебных программах целей и задач; подбираем материал, соответствующий учебной программе и определяющий структуру и методический аппарат учебника, в соответствии с наиболее важными психологически новообразованиями определенной возрастной категории.

Функции учебников условно можно разделить на инвариантные, не изменяющиеся в теории и практике создания учебной книги, и вариативные, которые изменяются под воздействием социокультурных факторов.

Используя утверждение В. Беспалько, для основной школы учебник по физике рассматриваем как комплексную информационную модель, отображающую четыре элемента педагогической системы – цели обучения, содержание обучения, дидактические процессы, организационные формы обучения – и позволяющую реализовать их на практике. В условиях старшей профильной школы роль такой комплексной модели должен играть учебный комплект: основной учебник-справочник и вариативные пособия-приложения, реализующие содержание в соответствии с выбранным профилем обучения.

Как для основной, так и для старшей школы выделяем инвариантные функции учебной книги: информационную, трансформационную, систематизирующую, мотивационную, закрепления и самоконтроля, развивающую и воспитательную.

Вариативными функциями учебной книги для основной школы являются: когнитивная (познания), коммуникативная, прогностическая и моделирующая; для старшей – функция самообразования, репрезентативная, интегрируемая, компенсаторная, координационная и регулятивная (для профессионального самоопределения).

***Ключевые слова:** структура двух центров курса физики, функции и методический аппарат учебников по физике, учебный комплект.*