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**SOFIA UNIVERSITY "ST. KLIMENT OHRIDSKI"**

***FACULTY OF BIOLOGY***
***Department "Teaching Methodology in Biology "***

**MAYA IVANOVA GACHEVA**

# CONTENT OF BIOLOGICAL EDUCATION IN THE BULGARIAN AND CALIFORNIAN EDUCATION SYSTEMS – COMPARATIVE ANALYSIS

# ABSTRACT

**of a doctoral thesis for awarding the scientific and educational degree "Doctor" in professional area 1.3 Pedagogy of teaching in... (Methodology of teaching in biology)**

## Supervisors:

**Assoc. Prof. Nadezhda Raycheva**
**Assoc. Prof. Iliana Petkova**

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## STRUCTURE AND GENERAL CHARACTERISTICS

The structure of the dissertation work is in accordance with a derived methodological framework for conducting comparative pedagogical research. The dissertation has a total volume of 176 pages, with the content structured as follows: introduction, four chapters, contributions, recommendations and conclusion, followed by a list of used references. In the exhibition 16 tables and 37 figures are included within the exhibition. The cited literature includes a total of 77 resources and 50 archival documents and Internet resources.

The dissertation work has been discussed and referred for defense by the Faculty Council of the Department of Teaching Methodology in Biology to Faculty of Biology at Sofia University "St. Kliment Ohridski", held on 16.04.2024 with protocol No. 508.

The defense of the dissertation will be held on ……..from …… at …… hall of the Faculty of Biology at the Sofia University "St. Kliment Ohridski", 8 Dragan Tsankov Blvd. The materials for the defense are available to those interested in the Faculty of Biology at the Sofia University "St. Kliment Ohridski", 8 Dragan Tsankov Blvd., room ...

**CONTENTS**

# INTRODUCTION

Achieving success is always at the forefront of life's goals, and human beings are directed toward this pursuit throughout life. This purpose motivates and drives humanity forward. Success, in turn, is the result of the efforts made and the innate and acquired abilities, skills and knowledge of a properly built, full-fledged and harmonious personality, which is also the purpose of education and upbringing in its modern form. The same applies with full force to natural science and especially - biological education, which for a number of reasons are, to put it mildly, neglected in Bulgaria, and through it some of the most valuable professional personnel, sometimes vital for humanity, are prepared and motivated, which fact has been painfully proven, unfortunately in the conditions of the recent global pandemic that has befallen us.

Achieving personal progress requires many qualities that must be nurtured from early childhood. Understanding that it is achieved with a lot of work, effort, perseverance, persistence and above all a good education is basic in the list of values that every person should possess.

In the last 20 years, the alarming trend of the "drainage of young intelligence" from the borders of our country has been constantly discussed, which practically leaves huge gaps in the personnel base of these areas. The obvious and already seriously noticeable lack of medical workers, pharmacists, teachers, professors and scientists, in the field of natural sciences, ecology, and narrow specialists in all fields of science. In this line of thought, interest in natural sciences should be nurtured and developed in the early stages of school education.

The present research was dictated by my long-term experience as a biology teacher in both the Bulgarian and the Californian education systems. We looked for opportunities to improve the content of biological education based on a comparison with foreign experience.

The dissertation project follows the classic structure and includes an introduction, four chapters, contributions and recommendations, conclusion, references and appendices. My interest in the issue and its significance is justified in the introduction. The first chapter presents the research methodology. The second chapter contains a presentation of the study documentation related to education. Emphasis is placed on the Bulgarian and American regulations. In the third chapter, the funds related to the implementation of the training content in the USA and in Bulgaria are described. In the fourth chapter, the results of the biology training of students who were trained simultaneously in the Bulgarian and Californian education systems are presented and analyzed. The appendices contain samples of ongoing assessment, standardized tests, and more. At the end of each chapter (except the first) and at the end of the dissertation, the results of the comparative analysis are presented as summaries and conclusions.

## CHAPTER ONE

## RESEARCH METHODOLOGY

In the framework of empirical pedagogical research, three research approaches can be summarized in general - qualitative, quantitative and mixed. B. Gospodinov notes that there are no sharp boundaries between these three approaches. Empirical research can be positioned on a continuum bounded on both sides by pure qualitative and quantitative research, but between these two extremes there can exist mixed research in which the qualitative or quantitative element predominates to varying degrees. (Gospodinov, 2016: 100-101) The present study can be defined as mixed with dominance of qualitative characteristics.

### 1. Research methods.

The research methods that were used in the present work are:

*Theoretical analysis and synthesis* - when achieving the theoretical goals of research and deriving generalizations, bearing in mind that through analysis and synthesis, objective trends can be determined in the studied objects and phenomena, inconsistencies and real contradictions can be "caught", contours of concepts can be found ( Danilov & Boldyrev 1971: 132-134) **.**

*Collecting data* on the results of the application of the two content concepts of biology education;

*Statistical methods* - for mathematical assurance of the reliability of the results.

### 2. Object and subject of the study.

The object of the science Teaching Methodology in Biology "includes teaching and learning as relatively independent, but inextricably linked activities with certain motives, goals, methods, subjects, means, processes, methods, conditions and products, of the two key subjects: teacher and learner. " (Tsanova & Raycheva 2012: 24).

In the context of the object thus defined, the specific **object** of the present study is *the content of biology education in the Bulgarian and Californian education systems.*

The subject of the science Methodology of teaching biology "at the modern level of development of this science, existing or newly created integrative models of the activity teaching biology enter, from the angle of the modern level of development of the knowledge system, with the aim of establishing regularities and deriving basic rules, principles in the implementation of this activity." ( Tsanova & Raycheva 2012: 25 )

In accordance with these theoretical statements, we formulated the subject of the present study.

**The subject** is presented by *an analysis of the acting ones models for the content of biology education in the Bulgarian and in the Californian education system to derive a summary of common characteristics and differences, as well as opportunities for improving the Bulgarian model for the content of biology education.*

**3. Research objectives and research questions.**

**The main purpose** of the dissertation research is *comparative analysis of the concepts of the content of biology education, described through a number of documents and materialized through state-approved resources for implementation (textbooks, study notebooks, books for the teacher, electronic resources)*

*The main research questions* of the present study as follows:

*What are the main similarities and differences in the concepts of the content of biology education in the Bulgarian and Californian education systems?*

*What opportunities for improving the Bulgarian concept are found as a result of the comparative analysis of the two models?*

**4. Tasks of the research.**

Answering the stated research questions requires solving the following tasks:

- Analysis and interpretation of literary sources to determine the content of the main concepts - content of teaching, content of education, competence approach to content;
- Comparative analysis of normative documents in which the concepts of the content of biology education are reflected;
- Comparative analysis of established resources for the implementation of the content concepts of biology education in the Bulgarian and Californian education systems - textbooks, workbooks, teacher's editions, electronic resources;
- Collection of data on the results of the biology education of the same students, taught in the two educational systems - the Bulgarian and the Californian;
- Processing and analysis of the data for the results of the training on both systems .
- Bringing out similarities and differences between the two concepts and opportunities to improve the Bulgarian model for the content of biology education.

In the context of the two main functions of the teaching methodology in biology, which N. Tsanova and N. Raycheva bring out (Tsanova & Raycheva, 2012: 22 - 23) - heuristic and theoretical, it can be said that the design of the present study is related -soon with the theoretical functions of science. Placed within the objectives of the science teaching methodology in biology, this research is directly related to the descriptive-explanatory goals, which are "related to the description of accumulated experience in the activity of teaching biology and the explanation of facts related to this activity." (ibid.) It is also partly related to the reflexive-corrective goals, which refer to "comparing the described new facts and newly discovered dependencies with the already established ones and, if necessary, revising the system of knowledge in accordance with the newly discovered characteristics of reality." (ibid.). In essence, comparative analysis has descriptive purposes, and deriving opportunities for improvement of the concept of the content of biology education belongs rather to the reflexive-corrective research goals of the science methodology of biology education.

**5. Stages of the research**

According to N. Popov, the preliminary phase, which can also be called methodological, is of particular importance in comparative studies. Here the subject of comparison is outlined and aspects are

differentiated. The next phase is related to data collection and the mentioned author calls it the information-foreign phase. Last is the comparative phase, in which the differences and similarities found during the comparison are outlined and explained. (Popov, 2014: 108-111) In the present study, the indicated phases have their own different, but still close appearance to the methodological process described by N. Popov:

**First stage – methodological**, related to determining the subject and aspects of the study.

This stage only begins with the formulation of the research subject. Here, its boundaries are once outlined in relation to the separate scientific field - biology and the realization of the educational model in this field through relevant subjects in the two selected systems - Bulgarian and American (Californian). This territory cannot yet be considered methodologically clear enough. The next level of specification is done by detailing documents and information resources that will be included in the study as tools through which the content of biological education is implemented. The next question arises - which aspects of these information resources will be analyzed and compared. In response to this question, the following aspects (levels of comparison) were derived - conceptual, structural and *The conceptual level* refers to what basic educational idea is embedded in the studied elements. *The structural level* refers to the way in which the respective element is built, and *the content level* refers to the internal information elements and connections between them. (fig. 1)

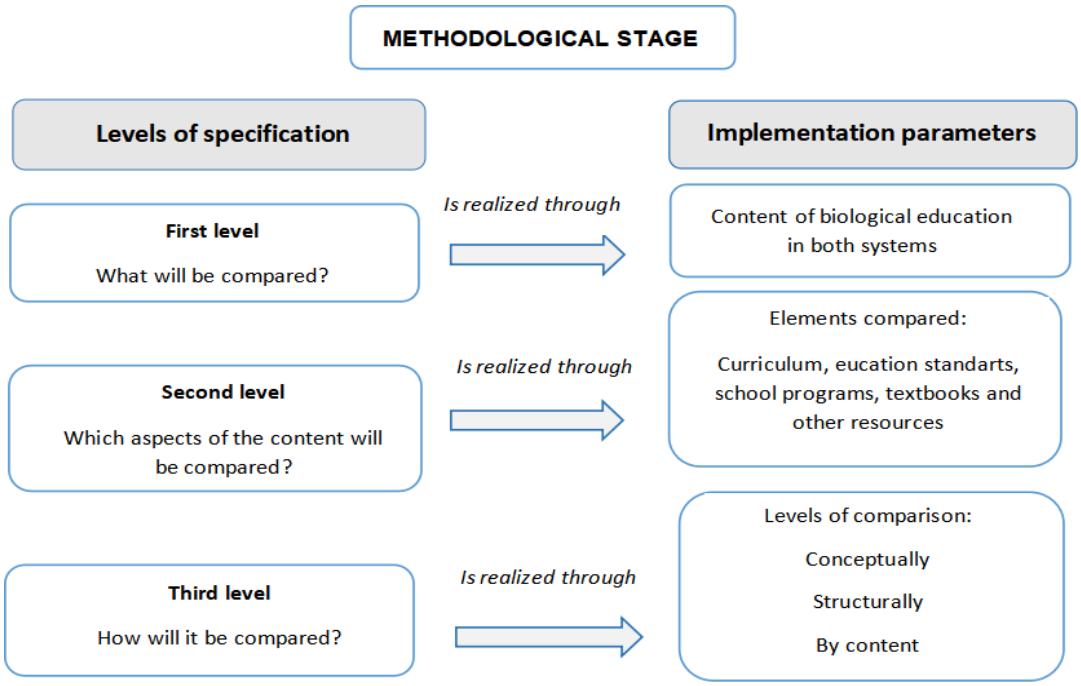


***Fig. 1.*** *Content of the methodological stage of the research*

**Second stage – information provision of the comparison**

Includes detection of the compared elements (and their variants). Collection of data on the results of training in both systems of the same persons (Bulgarian students, trained simultaneously in both systems).

**Third stage - actual comparison**

It includes the discovery of similarities and differences in the two studied educational systems in the compared elements on the differentiated levels of the comparison.

## CHAPTER TWO

## COMPETENCE APPROACH AND STUDY CONTENT

### 1. The competence approach – theoretical foundations and practical dimensions

In the last few years, competences have taken center stage when talking about the preparation of the younger generation. With the development of the European Qualifications Framework for Lifelong Learning (EQF), the combination of knowledge, skills and competences is required. What do the concepts "knowledge, skills and competences" mean and why exactly these terms are used - the answer to these questions can be found in Appendix 1 to the EQF. For example, "competence" means " a proven ability to use knowledge, skills and personal, social and/or methodological givens in work or study situations and in professional and personal development ", and explanatory notes to the same document describe the relationship between knowledge, skills and competencies, taking into account that knowledge is part of skills, and competencies are expressed through certain skills .[1]

In the scientific literature, a distinction is made between the concepts of "competency" and "competence". A number of Bulgarian authors V. Gyurova, Ya. Merdzhanova, V. Naydenova, I. Petkova and others. have contributions in clarifying the essence of the two main concepts "competency and competence". Separately, for the subjects included in the educational content, there are also authors who specify the competences that must be formed.

Ya. Merdjanova characterizes them as "two interconnected internal-external aspects of human professional activity. We use competence when we need to characterize the professional-personal profile of the specialist and the quality of his attitude towards the subject of his professional work. While the competency fixes the professional powers for certain professional activities and functions, which are attributed to the specialist with exactly this certificate and exactly this job position in the professional hierarchy. (Merjanova, 2010: 249)

According to V. Naydenova, "competencies are manifested through the corresponding action in a certain practical manifestation, based on the acquired set of knowledge, skills, experience and legal powers of the person in some limited area...competency as a concept is more comprehensive, has a larger volume and more rich content." (Naidenova, 2004: 65)

I. Petkova classifies the professional competences of the teacher on three levels: meta-, mega- and personal/individual level, specifying that "each one of them includes a different type of competences, characterizing the personality in different situations and in a different way. " (Petkova, 2012: 59)

When clarifying the competence approach, it is appropriate to analyze the book "Competence and Education" [2], which can be found on the pages of the Ministry of Education and Science. According to its authors, "competencies are defined as a dynamic set of knowledge, skills, attitudes and attitudes that are acquired in the learning process. They are mainly related to the behavior of the individual – not knowledge or skills per se, but appropriate behaviors demonstrated in specific learning situations and necessary to

[1] https://europa.eu/europass/system/files/2020-05/EQF-Archives-BG.pdf

[2] Available on the website of the Ministry of Education and Culture - https://www.mon.bg/bg/100770 , page 3

achieve results in a specific activity or in a specific professional role." They are associated with abilities and are developed throughout life in the learning process or through social experience.

The European Council and UNESCO started the development of language competences and it gradually reached December 2006, when the European Parliament adopted the so-called A framework for key competences for lifelong learning. There are eight such as: 1) communication in native language; 2) communication in a foreign language; 3) basic skills in the field of mathematics, natural sciences and technology; 4) digital competences; 5) learning skills; 6) public and civil competences; 7) initiative and entrepreneurship; 8) cultural awareness and creativity and cultural competences.

Along with these key competencies, the so-called additional, «"soft" skills such as (initiative, risk assessment, creativity, critical thinking, controlling emotions, teamwork, problem solving, taking responsibility) that provide connectivity between the personal, social and professional expression of the modern person .» (ibid: 7)

Subsequently, each country member of the European Union had to adopt and specify them. "Ten years later, within the framework of the Bulgarian Presidency, with the Recommendation of the Council of the European Union of May 22, 2018, these key competencies have already been updated..." (ibid.: 8) In the revised recommendation, the key competencies are: 1. linguistic literacy; 2. communicative competence; 3. mathematical competence and competence in the field of natural sciences, technologies and engineering; 4. digital competence; 5. personal competence, social competence and learning competence; 6. civil competence; 7. entrepreneurial competence; 8. cultural awareness and performance competence.

Thus, the competence approach began to require pedagogues, methods and teachers to measure and prove which competence is developed with the specific knowledge that is embedded in the curriculum.

These competences are laid down in the legislation. In Ordinance No. 5 of November 30, 2015 on general education (Official Gazette No. 95 of 8.12.2015, last amended and supplemented by Gazette No. 79 of 8.09.2020) it is stated, that the competences that the young person must master are: "1. competences in the field of the Bulgarian language; 2. communication skills in foreign languages; 3. mathematical competence and basic competences in the field of natural sciences and technologies; 4. digital competence; 5. learning skills; 6. social and civic competences; 7. initiative and entrepreneurship; 8. cultural competence and skills for expression through creativity; 9. skills to support sustainable development and for a healthy lifestyle and sports. (art. 2, paragraph 1). They are formed during the study of the main subjects from grades 1-12.

Thus, over the years, the transformation from the subject-centered approach, based on the subject and the knowledge gained from it, to the competence-oriented approach was reached.

## 2. The content of the teaching/learning as the main construct of the didactic issues

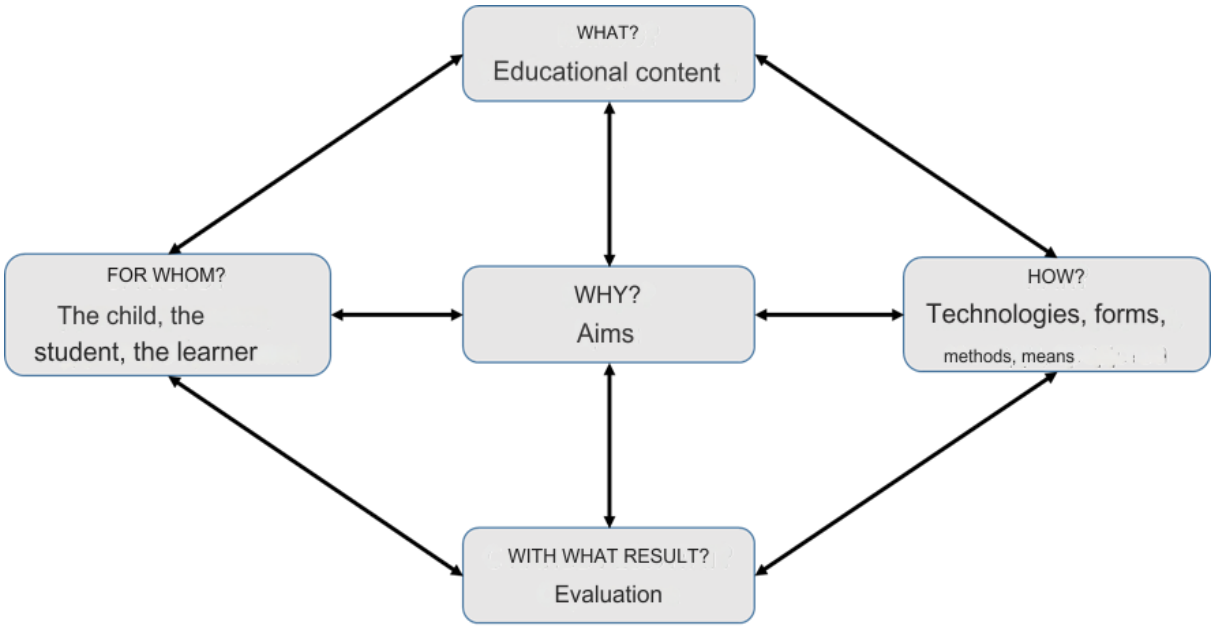


***Fig.2*** *Structure of G. Mialare's didactic problems (after M. Andreev, Didaktika, 1986)*

The entire process of learning, whether it takes place in the formal, organized or informal, non-institutionalized environment, is guided by several basic questions. They were formulated by Gaston Mialaret, mathematician, educator and psychologist. His didactic construct, presenting the entire learning process and subsequently adopted by M. Andreev and other didactic educators in our country, includes five basic questions - Why?, For whom?, What? How? and with what result? (fig. 2).

The interconnectedness of all elements shows that the learning process must be seen as a whole, and although G. Mialare poses these questions as referring only to the learning process, they can be transferred to education as a whole, because successful education starts from the correct answer to the question "why", to what goals should education, and training be subordinated. For this purpose, we have developed strategies, and the goals of education are found at the beginning of the Law on Preschool and School Education (LPSE), in section III. It is also of fundamental importance to whom this education and, in particular, training is directed. Its organization and implementation technology must be tailored to age specifics. In one way it is organized in kindergarten, in another way in school, in a third way – in higher education, in a fourth way when it is aimed at adults. It is not by chance that in pedagogical science there are separate branches, separate scientific directions that take into account these specifics and features, developing the educational content. It is the third important element of didactic problems. The educational content will also be one of the main focuses of the current dissertation research. After determining what will be studied at a certain age, in the specific class comes the answer to the question of how this learning content should be taught. And this is precisely where the mastery of the teacher lies. The forms, methods, means he uses make him unique, makes him a virtuoso teacher. Finally, after completing the training process, it is time to "see" the result. Knowledge, skills, competences, everything that is at stake in the education system must be evaluated.

As noted by B. Gospodinov, "due to its indisputable significance for the theory and practice of training, the problem of the content of training is one of the most discussed and permanently debated problems..... That is why, along with the questions "Who are we teaching?" and " Why are we teaching them?', the question 'What should the student learn?' is equally essential, both socially and personally." ( Chavdarova-Kostova et al. 2018 : 300)

Learning content is the essence, the heart of the learning process. It is a reflection of educational needs, of the ideal that a society wants to embody as knowledge, skills, values and attitudes in its young generation. That is why "if we look at the essence of educational reforms in recent decades, not only in our country, but also abroad, we will inevitably find that the core or the most essential part of them turns out to be the changes in the content of education and its improvement and modernization." ( Andreev, 1996: 157)

Didactics specialists distinguish between the concepts of "educational content", "learning content", "teaching content" and "curriculum". For the purposes of the dissertation research, the opinion of B. Gospodinov was accepted that "the concepts of "learning content" and "educational content" do not coincide. According to the author, the content of the teaching "consists of the procedural-activity, organizational-functional, technological features of the teaching along with the educational content and more precisely with those components of it that are the direct object of teaching and learning". (Chavdarova-Kostova et al. 2018: 304).

The English term "curriculum" is examined in detail by M. Andreev. He makes a deep analysis of the essence of the concept and comes to the conclusion that "Curriculum" is **the content** (italics - M. Andreev), (what should be learned), and teaching is **the process** (again) in which this content is digested. That is why the thesis that the "curriculum" is the educational content (the educational subjects and activities), and the process, means and methods of its acquisition are the essence of the education" (Andreev, 1996: 140) is becoming more and more indisputable.

In the present study, the structural-functional relationship between the listed concepts related to the construction of a model of the content of education in a certain area of human cognitive experience was sought . (fig.3)

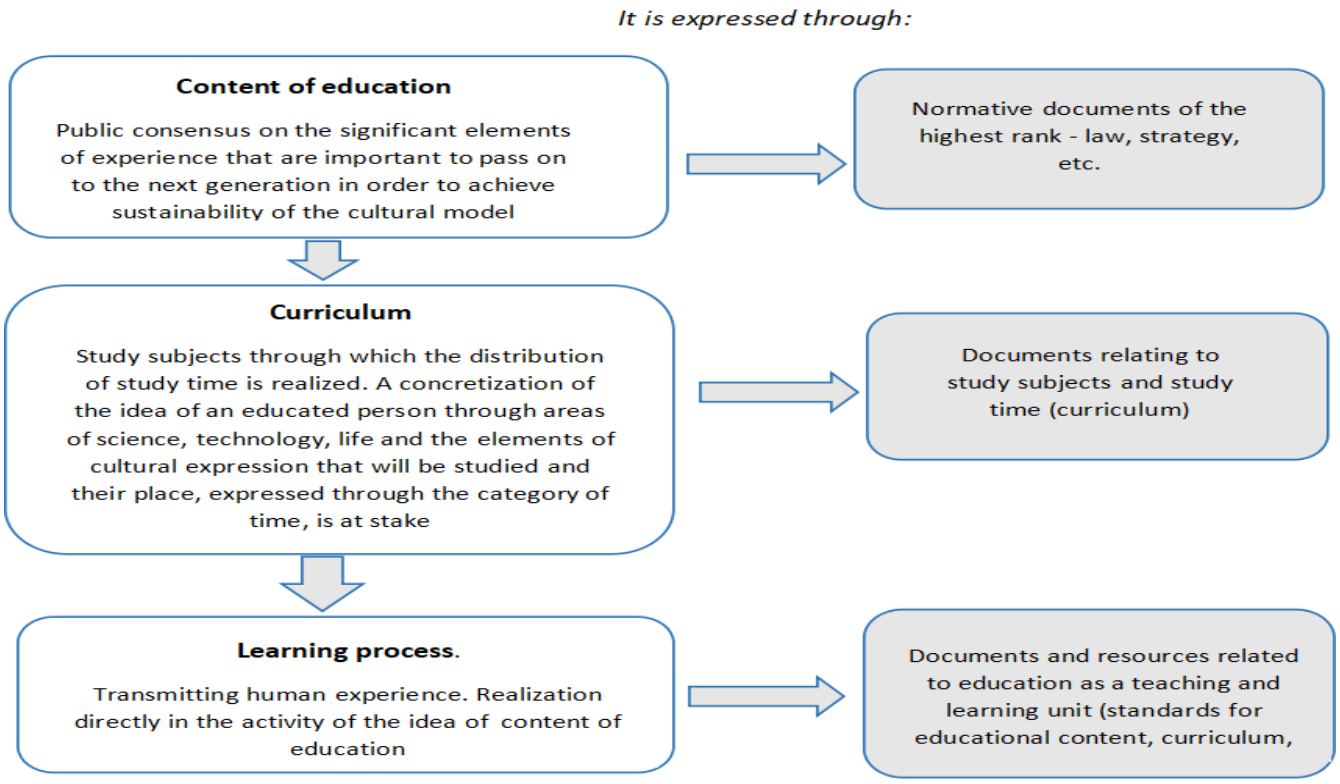


***Fig. 3.*** *Structural and functional relationships between connected elements with the realization of the content of the education*

## 3. Documentation related to the content of the education

### 3.1. Curriculum - essence and manifestation in the Bulgarian educational system

The main normative document, which "determines the content structure of the educational system and in this sense is relatively stable over time, is the curriculum. It is developed in accordance with the goals and vision for the development of the educational system". (Tsanova & Raycheva, 2012: 66 )

M. Andreev defines the curriculum as "an official state document that confirms the main content of education" (Andreev 1996: 176). In his 1996 textbook on didactics, he emphasizes that "No one can change or disobey the requirements of the curriculum. Considering the time in which the textbook was written and the highly centralized system of governance, the mandatory and unquestionable nature of the curriculum is understandable.

Now, the drive towards decentralization of the Bulgarian education system makes it possible for every school to make changes in its curriculum. This is regulated by Art. 82 of the Preschool and School Education Act.

In the curriculum, the educational content from the scientific field of biology is implemented through elements of the subject **"Human and Nature"** (3rd - 6th grade) as well as through a separate subject **"Biology and health education"** , in the period of mandatory preparation from the 7th grade up

to 10th grade ( *Table 1).* (Ordinance amending and supplementing Ordinance No. 4 of 2015 on the curriculum (Government Gazette, No. 94 of 2015)

| **Main subjects of study** | **Number of classes 5-7th grade (total)** | **Number of classes 8-10th grade (total)** |
|---|---|---|
| Bulgarian language and literature (one subject) | 554 | 360 |
| Foreign languages (two subjects) | 312 | 864 + 144 |
| Mathematics and Information Technology (2 subjects) | 520+156 | 288 + 90 |
| Social studies - history and geography (2 subjects) | 208+208 | 270 + 162 |
| **Human and Nature** | **170 (grades 5 and 6 only)** | |
| **Biology and Health education** | **72** (grade 7 only) | 162 |
| Chemistry and environmental protection | 54 (grade 7 only) | 162 |
| Physics and Astronomy | 54 (grade 7 only) | 162 |
| Music | 190 | 54 |
| Art | 190 | 54 |

***Table 1.*** *Main subjects and general time in the curriculum.*

Table 1 shows that there is an obvious emphasis on language competence in native and foreign languages. At the same time, foreign languages are allocated slightly more than 400 hours of study time over the study time allocated to native language learning at the lower secondary level. However, if the initial stage is also taken into account (the data is not reflected in the table), then the balance is about 240 hours more in favor of native language learning. In general, the data on language literacy and communicative competence, to which all other subjects naturally contribute, show a serious presence in the content of Bulgarian education. Mathematical competence, with just over 800 hours in total for middle school and first high school stage, is the next most important, according to the curriculum. A total of 246 hours are allocated to information technology at the middle school and high school level, and together with the other study subject related to technology - Technology and entrepreneurship (138 hours at the middle school level), the "share" of technology is 384 hours. Natural sciences in total for junior high school and high school stage are 836 hours. Thus, mathematical competence and competence in the field of science and technology have a commensurate share of study time compared to linguistic and communicative competence. But here it should be noted that information technology is directly related to digital competence. In total, the four subjects related to natural sciences have a number of hours that are comparable to the single subject of mathematics. This puts each of the three natural sciences – physics, chemistry and biology – at an extremely disadvantageous position. This is a trend that is also observed in comparison with the social studies, where there are two study subjects correlating with two sciences and with a total number of hours of 848, that is, slightly more than the total hours of the three natural sciences and the four study subjects. They are followed by the subjects related to cultural awareness and performance competence - with two subjects and 488 hours in the lower and upper secondary stages, but there is a significant amount of study time devoted to these areas of culture and art in the primary stage -

a total of 454. All these considerations show that the natural sciences are greatly underestimated as a presence in the content model of education in Bulgaria.

### 3.2. Specifics of the US curriculum.

The 5-7th grade curriculum and instructional time are determined based on California Education Code requirements, California Department of Education recommendations, and national subject area association recommendations . In California, there are both required and recommended courses of study and instructional time required for elementary and secondary students to study.

California Education Code Section 46201 requires all students in grades 4 through 8 to receive a total of 54,000 minutes or 900 hours of instruction per year for the middle school level and 64,800 minutes or 1080 hours per year for the high school level. Equated in school days, specifically for the state of California, this equates to 180 school days, with the length of the school day varying - 4-8 grades to 5 astronomical hours per day, with school hours paired for 30 minutes, and from 9 to 12 class up to 6 astronomical hours daily. This includes all classes in all subjects, with the length of the school day depending on the educational stage. Education Code Section 41601.1 specifies that a district may receive funding to offer an "extended" day if students in grades 4 through 8 attend 300 or more minutes per school day (5 astr. hours). This is usually interpreted as 300 minutes of actual studying. Lunch breaks and breaks longer than 5 minutes are excluded from the 300 minutes.

The state (USA) sets minimum requirements for graduation from secondary education, which are considered part of the information contained in the so-called curriculum, which in itself is not a unified document and in its structure and essence is quite different from the similar curriculum existing in Bulgarian education.

The California State Education Code sets minimum course requirements from the public school system, such as: three years of English and history/social studies; **two years each** of math **and science** and one year each of visual or performing arts, foreign language, or profiled technical education. The state encourages local districts to set their own requirements, but requires them to include these courses. The new Next Generation Science Standards, however, require at least 3 years of training, so the training is aligned with this requirement.

According to the high school science curriculum, (according to the California Department of Education) expressed in terms of minimum state requirements for high school graduation in the state of California, USA (grades 8-12, high school) science education 1 through 12 class should not exceed one astronomical hour per day, or it is two 30-minute class hours, including alternating laboratory exercises.

UC (University of California) and CSU (California state university) admissions criteria exceed the state's high school graduation minimums. Both the University of California (UC) and California State University (CSU) require all high school students to complete a so-called AG system, with a grade of at

least C (equivalent to Good 4) in each subject. A – G consists of year-long courses in seven areas, from History ("A") to Preparatory Elective ("G"), which must be approved by UC and CSU[3] [4]

Examining the two systems in a comparative plan, in terms of the content model of biological education, reflected in the curriculum shows that in the middle school stage, almost twice as much study time is allocated. (Table 4)

| | **Middle school stage BG** | | | | **Middle school stage AP** | | | |
|---|---|---|---|---|---|---|---|---|
| | Grades | | | **Total** | Grades | | | **Total** |
| | V | VI | VII | **V - VII** | V | VI | VII | **V - VII** |
| **School weeks** | **34** | **34** | **36** | | **38** | **38** | **38** | |
| *School subjects:* | | | | | | | | |
| Human and nature | 85 | 85 | | **170** | | | | |
| Biology and health education | | | 72 | **72** | | | | |
| Science | | | | | 180 | | | **180** |
| Earth Science | | | | | | 180 | | **180** |
| Life Science (biology) | | | | | | | 180 | **180** |

***Table 4*** *Comparative number of classes per year in Biology and Health Education and Human and Nature in the Bulgarian and the Californian (American) educational system at* ***the middle school stage***

In high school, Environmental Science is studied (which includes knowledge of geography and economics, chemistry and biology related to environmental protection and natural resources).

| | **I high school stage BG** | | | | **I high school stage AP** | | | |
|---|---|---|---|---|---|---|---|---|
| | Grades | | | **Total** | Grades | | | Total |
| | VIII | IX | X | VIII – X | VIII | IX | X | VIII – X |
| **School weeks** | **36** | **36** | **36** | | **36** | **36** | **36** | |
| *School subjects:* | | | | | | | | |
| Biology and health education | | 90 | 72 | **162** | | | | |
| Biology | | | | | | | 180 | **180** |

***Table 5*** *Comparative number of classes per year in Biology and health education in the Bulgarian and the Californian (American) educational system in the first high school stage*

Summarizing the aspects of comparison at the content level of the education, the following conclusions can be drawn: (Table 6)

[3] https://www.calstate.edu

[4] https://www.universityofcalifornia.edu/

**Content of teaching and studying**

| | ***Bulgarian system*** | ***American (California) system*** |
|---|---|---|
| ***Conceptually*** | Emphasis is placed on language literacy and communicative competence. Natural sciences, including and biology are at an extreme disadvantage in terms of allocated study time. There is no direct connection between the study time in which a given subject or field is studied and the application to university. | Education in natural sciences is on an equal footing with other fields – mathematics, social sciences, etc. The study time with which the specific fields were studied is a limiting factor when applying to a university. |
| ***Structurally*** | Study subjects are fixed with study time reflected in study hours (40 min.) | Study time is given as hours per day and is measured in astronomical hours (60 min.) |
| ***By content*** | Hours are disproportionately few compared to other subjects (applies to biology and other natural sciences). At this stage, there is no fixed study time for experimental and laboratory work. | The hours are almost twice as much in middle school, and in high school with about 2 hours a week compared to those in the Bulgarian system, and there is a requirement for the number of hours of laboratory exercises. |

***Table 6*** *Summary presentation of the result of the comparison at the curriculum level*

### 3.3. State standards for educational content in the Bulgarian educational system

The state educational standards allow seeking an answer to the question "With what result?" the given goal was achieved and whether the learning content was mastered through all these grades and stages. This is also stated in Art. 22 of the LPSE, where it is said that: State educational standards are a set of mandatory requirements for the results in the system of preschool and school education, as well as for the conditions and processes for their achievement." State educational standards regulate 19 activities in Bulgarian education . However, we will focus only on those related to the educational content and more precisely those on the curriculum and general education preparation. The curricula were developed on the basis of these standards.

According to "Art. 1 (2) The standard for general educational preparation (Ordinance 5 of 30.11.2015 on general educational preparation Promulgated - SG No. 95 of 08.12.2015, in force from 08.12.2015 ) is a set of requirements for the results from the teaching in each general education subject at the end of each stage of the relevant degree of education and determines: 1. the goals, content and

characteristics of the general education preparation; 2. general education subjects; 3. the requirements for the results of the teaching in each general education subject for the acquisition of the general education preparation. "[5]

The standard for Human and Nature is in Appendix 13 of the document and includes the areas of competence and the knowledge, skills and attitudes for the end of the education in the subject in each of the stages - in the case of primary (3rd and 4th grade) and middle school stage (5th and 6th class) where the study of this subject is intended. At the beginning, the general objectives of the teaching in the subject are given. For each of the given knowledge, skills and attitudes, it is noted which key competences it contributes to the development. Biology and Health Education standard in Appendix 14 of the document is structured in the same way. Again, there is a section for middle school stage (7th grade) and first high school stage (8th – 10th grade). The standards for the second high school stage are listed in another document - the state educational standard for profiled preparation. (Ordinance No. 7 of August 11, 2016 on profiled training, in force since August 26, 2016). The structuring is similar, but it is modular and does not have a fixed relationship with the key competencies.

### 3.4. Educational Standards in the United States

The differences in standards in the Bulgarian and California educational systems are minor, but they are regulated differently. It is well known that in the Bulgarian education system there are uniform state educational standards regarding the preparation of a curriculum, general education preparation, profiled preparation, etc., which are valid and must be applied in all schools throughout the country. (LPSE, ch. 3, art. 22). The story of the transformation of educational standards in the American education system in general is quite interesting and dynamic. All educational standards for training in the main subjects - in this case English language and mathematics are described in the so-called *common core* document, or this corresponds to a certain extent to the Bulgarian educational standard for general education, but covers children and students from kindergarten to 12th grade inclusive .

In 2010, the so-called Common core state standards initiative took place in the United States, which was sponsored by a national institution - the National Governors Association, and sought to establish consistent and sustainable educational standards for all states, as well as to ensure high school graduates a good preparation for further study in a two- or four-year college course or to let them into the market as a workforce. Twenty years earlier a movement had emerged in the United States to establish national standards that clearly explained what students were expected to know and be able to do at the end of each grade and to implement assessment methods designed to literally measure whether and how much students meet these standards. In 2004, employers began to feel the growing need for employees with education. It is established beyond doubt that successful high school graduates do not possess the necessary skills and knowledge that will help them succeed in further education or in a given career, regardless of the belief that the degree corresponds to adequate intellectual preparation in real life, it in fact, it falls short of that necessary goal at all. Following this logic, in 2009 the National Government Association organized a group of people to develop the above standards. Clear goals are set for the standards - "to provide a consistent and clear understanding of what students are expected to learn so that

[5] https://cioo.mon.bg/wp-content/uploads/2014/07/nrdb5_30.11.2015_obshtoobr_podgotovka.pdf

their teachers and parents know what to do to help them" [6]. In addition, “the standards are designed to be sustainable and relevant to the real world, reflecting the knowledge and skills our young people need to succeed in college, university, and careers, which should position America's students to compete in the global economy. [7]". By 2010, 41 states had adopted the Common Core standards and began working according to their rules and requirements. By 2015, all other states are encouraged to adopt these standards. As already noted above, the Common Core standards cover only the basic subjects, but since they do not cover the natural sciences and social studies, in 2012 the so-called science standards of the next generation or Next Generation Science Standards, were created which were immediately adopted by many of the states, including the state of California, whose educational system is the subject of the present study. The final draft of the standards was published in April 2013.

### ✓ Educational standards in natural sciences

The Next Generation Science Standards (NGSS) are based on the "K-12 Educational Science Framework" (kindergarten through 12th grade) created by the National Research Council. They have three dimensions that are integrated into learning at all levels. For this reason, science and engineering education according to these standards is called 3D education. The first dimension is core ideas, which consists of specific content in subject areas – in this case, the key ideas in the natural sciences that have broad relevance within one or across science or engineering disciplines. These core ideas build on one another as students progress through the grade levels and are grouped into the following four areas: Physics and Chemistry, Biology, Geology and Astronomy, and Engineering. The second dimension is the sciences and engineering practices. Students are expected not just to learn the content, but to understand the methods used by scientists and engineers. The third dimension is precisely cross-curricular concepts: key underlying ideas that are common across a range of topics. NGSS give equal emphasis to engineering design and scientific research. These concepts help students explore connections across the four fields of science, including physics, biology, geology, and astronomy, as well as engineering design. When these concepts, such as "cause and effect," are sufficiently clear to students, they can help them develop a coherent and scientifically based view of the world around them. [8]In addition, they are aligned to the Common Core standards in the main subjects, by grade and level of difficulty. The standards describe the "performance expectations" of students in science and engineering.

The goal of the California Next Generation Science Standards (CA NGSS) is to prepare students to become full participants in public relationships, and some of them future scientists, leading to a specific vision for science education. Science learning depends not only on the accumulation of facts and concepts, but is about developing competent science students with the motivation and interest to learn more. Such formation is valuable not only for a limited number of students who will realize themselves as scientists or engineers, but also for the majority of students who will not follow this professional path. What is learned at school forms citizens with the confidence, ability and inclination to continue learning throughout whole their life, not only in matters related to the natural sciences, but also in others that affect life in society in general. (National Research Council [NRC] 2012a, ch. 11).

[6] http://www.corestandards.org/
[7] http://www.corestandards.org/about-the-standards/
[8] https://www.nextgenscience.org/

In science education, the initial emphasis is on observable phenomena that students are likely to have experience in their daily lives or in the classroom. Macroscopic phenomena and processes are explored in greater depth, including modeling of processes and systems that are not visible. Moving on to microscopic phenomena and introducing concepts – atoms, molecules and cells. Moving to the subatomic level and to complex interactions within and between systems at all scales.[9]

According to **the California Science Standards**, at the end of the specified period (grade), students should have the following knowledge and skills:

- **5th grade: LIFE SCIENCE**

Matter and energy in organisms and Ecosystems
5-LS1 From molecules to organisms: structures and processes
5-PS3 Energy
5-LS2 Ecosystems: Interactions, energy and dynamics
5-PS3-1. Use models to describe this energy in animals

- food (used for body repair, growth, movement and to maintain a constant body temperature) was once energy from the sun.

[i.e. Use diagrams or charts to show the connections. Note:food chains and webs]
5-LS1-1. Support the argument that plants obtain materials necessary for growth mainly from air and water.
[i.e. Focus on the idea that plant matter comes primarily from air and water, not soil. Note: collect data from experiment growing plants in water only vs. soil and water option]
5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
[Focus on the idea that plants change matter from the air, water, and minerals from the soil into carbon matter, which is food].

**Life Science (Human and Nature, Biology)**

*Plants and animals have structures for respiration, digestion, waste disposal, and material transport. As a basis for understanding this concept* :

- Students know that many multicellular organisms have specialized structures to help transport substances.
- Students know that and how blood circulates through the heart, lungs and body and how carbon dioxide ($CO_2$) and oxygen ($O_2$) are exchanged in the lungs and tissues.
- Students know the sequential steps of digestion and the role of the teeth and oral cavity, esophagus, stomach, small intestine, and large intestine in the function of the digestive system.
- Students know the role of the kidney in removing waste from the blood and turning it into urine, which is stored in the bladder.
- Students know how glucose, water and minerals are transported through the conduction system of plants. Students know that plants use carbon dioxide ($CO_2$) and energy from sunlight to build glucose molecules and release oxygen.
- Students know that plant and animal cells break down glucose for energy, which results in the release of carbon dioxide ($CO_2$) and water (respiration)

- **Grade 7: BIOLOGY**

[9] https://www.cde.ca.gov/pd/ca/sc/ngssstandards.asp

✓ **Cell Biology:**

*All living organisms are made up of cells, from as few as one to trillions, whose structure is usually only visible through a microscope. As a basis for understanding this concept* :

- Students know that cells function in a similar way in all living organisms.
- Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.
- Students know that the nucleus stores genetic information in eukaryotic plant and animal cells.
- Students know that mitochondria release energy for the work cells do and that chloroplasts capture energy from sunlight for photosynthesis. For example, students know that cells divide to increase in number through the process of mitosis, which results in two daughter cells with the same number of chromosomes.
- Students know that as multicellular organisms develop, their cells differentiate.

In a similar way, standards were formulated in the 7th grade from the areas: **Genetics, Evolution, History of the Earth and Life (Earth Sciences), Anatomy and Physiology of Plants and Animals, Physical Principles in Living Systems, Research and Experimentation.**

The standard for the high school stage covers the period 9-12th grade and it is planned to be studied in one school year. The way of formulation is analogous:

- **Grades 9-12: BIOLOGY / LIFE SCIENCES**

✓ **Cell biology**

*The basic life processes of plants and animals depend on various chemical reactions taking place in specialized areas of the body's cells. As a basis for understanding this concept:*

- Students know that cells are enclosed by semipermeable membranes that regulate their interaction with their surroundings.
- Students know that enzymes are proteins that catalyze biochemical reactions without changing the equilibrium of the reaction and that the activity of enzymes depends on the temperature, ionic conditions, and pH of the environment.
- …
- Students know how eukaryotic cells receive shape and internal organization from a cytoskeleton or cell wall or both." (California Department of Education, Reissued June 11, 2009)

The standard continues with formulations similarly aimed at students' knowledge in the areas of: **Genetics, Ecology, Evolution, Physiology.**

Californian standards are part of the NGSS and are detailed on their site. At the beginning of each textbook, the numerical codes of the relevant standards by class and subject are indicated, and at the beginning of each topic, the objectives are written.

### 3.5. The curriculum in the Bulgarian education system

✓ Essence - Curricula are official state documents that are drawn up and approved by the Ministry of Education and Science, and which specify the content of each subject intended for study in the curriculum. It precisely indicates the knowledge, skills, attitudes of the students and ways of knowing about the specific subject for the school year. (Regulation 5 on general education, section 4)

✓ Structure - Each curriculum contains an introduction, in which it characterizes the place of the relevant subject in the entire system, the main objectives of learning the subject in the relevant class. The didactic structure of the study programs contains the same components that are indicated when

justifying the didactic structure of the study subject. In fact, the structure of the subject is built on the didactic structure adopted in the curriculum.

✓ Functions – the first and main function of the curriculum is to fix the content of education at the level of a subject, and the whole set of programs must reflect the content of education in its entirety. The second function of the curriculum consists in the fact that, by its very nature, it is a normative document, guiding both the teacher and the student, and determining the actions and work of the compilers and authors of textbooks and teaching aids on the subjects for the respective classes of the respective educational stages. It is also a means of control in the education system, because it fixes specific goals of learning in the subject, which can be used as benchmarks, criteria for evaluating the academic achievements of students.

✓ The Human and Nature curricula in middle school for the 5th and 6th grades, as a continuation of the study of this subject in the primary educational stage and more precisely from the 3rd and 4th grades, include basic topics of the three types of natural sciences, namely - physics, chemistry and biology. Here we will look at the curricula that cover only the 5th and 6th grade biology field.

**The program for the 5th grade is divided into the following parts:**

I. Physical phenomena; II. Substances and their properties; III. Structure and life processes of organisms; IV. Unity of nature.

The first three parts correspond to three natural directions - physics, chemistry and biology, and the fourth part provides an opportunity to build a complete picture in the minds of students about nature in its unity and diversity. The biological part includes basic topics that affect the structure and life processes of organisms, the human organism, with a view to prevention of its health and the relationship between the organism and the environment.

**The program for the 6th grade** is divided again into the following 4 parts, in which case the knowledge imparted in the 5th grade on the same topics is supplemented and expanded: I. Physical phenomena. II. Substances and their properties. III. Structure and life processes of organisms. IV. Unity of nature. In the fourth part, the main life processes and the role of man as a part of nature are studied. The integration of educational knowledge is realized through the idea of mutual dependence between objects and processes in nature. It is embedded in all elements of the program, being emphasized and summarized through the fourth part.

The Biology and Health Education (BHE) program **in the 7th grade** complements the knowledge acquired in the subject Human and Nature in the 5th and 6th grades and is divided into the following main topics: 1. Diversity and classification of organisms; 2. Unicellular organisms (Kingdom Monera, Kingdom Protista); 3. Multicellular organisms (Kingdom Plants, Kingdom Fungi, Kingdom Animals); 4. Sustainable development and a healthy lifestyle.

**The 8th grade** health and wellness program is divided into the main topics: 1. Levels of organization in the human body; 2. Metabolism; 3. Movement and support of the body; 4. Reproduction, growth and development; 5. Regulation and homeostasis.

The BHE program in **the 9th grade** is divided into the following main topics: 1. Chemical composition of living matter; 2. Supramolecular complexes; 3. Cell structure and processes; 4. Cell reproduction; 5. Application of knowledge about the cell.

**The 10th grade** BHE education is organized into the following global topics: 1. Multicellular organism (Heredity and variability; Reproduction, growth and individual development); 2. Biosphere (Population, biocenosis, ecosystem; ecological factors); 3. Biological evolution (Origin and development of living matter; Origin and evolution of humans; Evidence for biological evolution).

In the American education system, textbooks are written based on the standard.

As mentioned above, California's middle and high school curriculum provides three years of science education each. Unlike the Bulgarian system, in the American (Californian) system, knowledge of a certain natural science is not upgraded and supplemented year after year. In the middle school stage, one year of studying only biology is planned in seventh grade. Interestingly, in the fifth grade, the curriculum includes the blended study of natural sciences, with the material with topics from biology, chemistry, physics, geology, oceanology, geography, astronomy and even engineering.

The part related to biology includes basic knowledge of the scientific method in general, cell biology, genetics, human anatomy, classification of organisms, unicellular and multicellular organisms - classification, structure, behavior and life processes and ecology. Examples of lab exercises and hands-on activities are varied, including more applied arts-related and hand-on activities, for example, designing and making different models from clay, making a model of a muscle, making different animal adaptations, making an ecosystem model, etc. Laboratory activities include familiarization with the rules of work and safety in laboratory conditions, with materials, devices, glassware and basic microscopic observation of animal and plant cells, microorganisms and various tissues in the order in which the relevant topics are taught.

In the seventh grade, the biology study is called Life Science and is studied 5 hours a week throughout the school year. The curriculum includes biological knowledge of all major divisions of biology, starting again with a reminder of the idea of the scientific method, studying some scientific models and laboratory rules and materials. The main topics are: 1. Presentation of biology as a science, 2. Cell biology and biochemistry, 3. Genetics, 4. Evolution, 5. Classification of organisms, 6. Microorganisms - protists, bacteria and viruses. 7. Fungi, plants and animals - structure, behavior and life processes, 8. Ecology, 9. Human anatomy, 10. Health education.

Laboratory exercises and hands-on activities, as in 5th grade learning, include activities related to the applied arts and are intended to provide students with fun and enjoyment, learning through play. Practical exercises often use materials at hand, paper, stationery and even different foods.

In the high school stage, the only year in which biology is studied is in the 10th grade, respectively in the 11th grade of natural sciences only physics is studied, and in the 12th grade only chemistry or vice versa. In general, in the curriculum, the material, which is studied again 5 hours a week, includes the same sections of biology as in the seventh grade, but expanded and supplemented and, accordingly, at a higher level. Topics include: 1. Biology in the 21st century, 2. Biochemistry, 3. Cell structure and function, 4. Processes in the cell, 5. Cell growth and division, 6. Mendelian genetics, 7. From DNA to proteins, 8. Frontiers of Biotechnology, 9. Principles of Evolution, 10. Evolution of Populations, 11. History of Life, 12. Principles of Ecology, 13. Interactions in Ecosystems, 14. Biosphere, 15. Human Impact on Ecosystems, 16. Classification of Organisms, 17. Viruses and prokaryotes, 18. Fungi and protists, 19.

Plants - diversity, structure, functions and life processes, 20. Invertebrates, 21. Vertebrates, 22. Animal behavior, 23. Human anatomy and physiology- organ systems.

Sample lab topics and hands-on activities include such to develop critical thinking, laboratory skills, model making, hypothesizing and inferring, predicting, examining samples, classifying, dissecting, comparing, interpreting graphs and charts and others. Some of these include working with a microscope and observation of cells and other biological objects; modeling of: chemical bonds, cell membrane, replication, genetic deviations, etc.

Summarized at this level of specification of the content of the training on the aspects of comparison, the following findings can be made (Table 7):

**Content at the level of the learning process - standards for learning content and curricula**

| | ***Bulgarian system*** | ***American (Californian) system*** |
|---|---|---|
| ***Conceptually*** | Curriculum content standards are for educational stage and subject.<br>They are the basis for developing relevant curricula for subjects and classes. The standards were developed as a tool for centralized system management. | The standards are a document that determines the development of textbooks.<br>Functionally, it can also be said that they are an attempt to unify the expected learning results and, as a meaning, process management in a decentralized educational system. |
| ***Structurally*** | Areas of competence and corresponding groups of skills are indicated in the formulations. Emphasis is placed on skills and the knowledge included in them | The wordings include general topics corresponding to areas of competence, but there are codes that fit into the corresponding topics in the textbook and so the connection between the standard and the content in the textbook is visible. The expected results are descriptive and with an emphasis on the knowledge and skills of the students. |
| ***By content*** | Areas of competence are tied to the levels of organization of living systems and large parts of biological science. A spiral upgrade is set. There is a specific area of competence related to practical skills and methods of research - observation, experiment.<br>In the curriculum there are elements related to teaching and assessment methods, types of forms of organization, sample topics for laboratory exercises, activities for the development of key competences. | Areas of competence are tied to large parts of biological science - ecology, evolution, genetics, cell biology, etc. The structuring is spiral, as the standards for the high school stage are for the entire stage – up to 12th grade. There is a separate section on the nature and application of the 'scientific method'. |

***Table 7.*** *Summary presentation of the result of the comparison at the level of standards and curricula*

## CHAPTER THREE

## THEORETICAL ANALYSIS OF EDUCATIONAL DOCUMENTATION RELATED TO IMPLEMENTING THE CONCEPT OF CONTENT IN THE EDUCATIONAL PROCESS

### 1. Nature and characteristics of the training documentation related to the implementation of the training content

The teaching-methodical complex includes a textbook, a workbook, a teacher's edition textbook, study aids, multimedia resources.

#### Concept of the textbook and teaching aids in Bulgarian education

State requirements for textbooks and study aids in Bulgaria are described in Ordinance No. 10 of 2017 on reference books, textbooks and study aids, which defines the state educational standard of the Preschool and School Education Act. The document presents the main provisions and requirements for the content, graphic design, polygraphic and electronic implementation of knowledge books, textbooks and teaching aids and a list of knowledge books, textbooks, teaching kits and teaching aids. Requirements such as compliance with the curriculum, text, non-textual components, structuring, language of the textbook are considered, as well as whether its content fully meets the relevant curriculum in terms of learning content (topics, competences as expected learning outcomes for the relevant topics, new concepts). This also applies to the content of the e-textbook in the relevant subject.

In the current modern times filled with numerous technologies that have become an integral part of the lives of the generation of students who will be educated in the current century, it would be unacceptable if there was no digital version of school education textbooks. The electronic textbook, as a modern technological product, is extremely convenient to use anywhere and at any time and an irreplaceable assistant in distance online learning, which is required recently. In addition to the modern digital versions of textbooks, they contain a copy of all pages from the original paper copy, as well as many additional products, such as multimedia presentations, image galleries, Internet links, animations, interactive tasks with a variety of illustrative material, visualizations - videos, photos, diagrams, tables, charts, worksheets.

According to the author of "Textbook Expertise", Prof. Yana Merdzhanova, the main tasks of the modern school textbook extend to the cognitive, affective, sensory sphere and the sphere of self-knowledge of the person and motivates them, with which action it contributes to mastering the objects of academic knowledge. According to the same author, the complex functions of the textbook derive from this, namely: - informative - translator of knowledge, beliefs and attitudes; formative and developing - of abilities and competences, consolidating what has been learned, exercising, evaluating and self-evaluating, integrating and translating, bibliographic - recommending various information sources and offering social and cultural education. "The textbook must be complete (cover all types of objects and cognitive activities: diverse (offer adequate cognitive tasks and exercises, systematic (organize and hierarchize the objects, activities and tasks both logically sequentially and graded by difficulty. Hardly with this, it turns from a scientific (or simple) book into a didactic tool in the learning process" (Merdzhanova 2009)

Modern biology textbooks are structured according to the two elements established in the literature, performing the main functional tasks, namely – a textual and non-textual component. The text component includes main, additional and explanatory text. The non-textual component includes an apparatus for organizing learning, illustrations, an orientation apparatus.

The workbook is an integral part of the teaching-methodical complex (TMC) and is intended for joint work with it, supplementing it with various worksheets and tasks for each lesson topic. In the latest variants of workbooks, developed for the purposes of the newly introduced curricula, the study content is presented in a new balanced way, and at the beginning of the lessons for new knowledge, a place is provided for taking notes and plan of the lesson topic. Each topic includes a variety of tasks that are interesting, clearly formulated, illustrated and with a practical focus, stimulating curiosity and discovery among students. Such as to develop various skills and support students in expanding and deepening their knowledge of natural sciences (in particular biology), to help them learn independently, to develop their critical, logical and creative thinking, to support the acquisition of the planned key competences and to form criteria for self-assessment of what has been achieved.

The teacher's edition textbook aims to support teachers in their daily work as a guide in the new curricula regarding the goals, tasks and technology of teaching and learning activities, in which the students have a priority place. This book helps to build the teaching methodology by the teacher, putting his personal understanding and attitude.

In the ideal version of the Teacher's edition textbook, for each lesson, which appears as a copy in the student textbook, along with a copy of the corresponding page for the lesson from the textbook, the goals to be achieved after studying a specific topic are indicated, the new concepts are brought out, an option for introductory motivation, by recalling previous knowledge on the subject, a story or an interesting scientific fact, the expected results after the end of the lesson unit, such as knowledge and skills, are indicated. The cross-curriculum connections, if any, are indicated, the different activities in the textbook are also listed, options for differentiated teaching according to the level of the respective students are set, such as basic, intermediate and advanced. Last but not least, additional tasks on the topic are available to the teacher in the form of methodical notes. ( Shishinova, M. , etc. 2020 )

## 2. Textbooks and teaching aids in the USA

In general, providing an overview of curriculum content for the United States in each area is very difficult, as each of the 50 states retains the authority to establish its own guidelines. Although in most cases there are many similarities between the states, there are examples of where some of the states are very different. California and Texas, for example, are the two states that most often have a different approach to curriculum content issues. The issue of textbooks is also difficult in the United States, as each state approaches textbook selection differently. In some states, the state education agency adopts a textbook (or set of textbooks) for the entire state. So in these states, every school district will use the same biology textbook. In other states, like Missouri for example, each school district (there are 518 school districts in Missouri alone) decides which biology textbook to use. So, from district to district, it can be found that everyone is using a textbook of their choice.

Biology textbooks are created based on existing ones, being reissued depending on the needs of the state and/or if any significant changes in the content of the old ones are required. The specifics and basic requirements for their content, volume and layout are specified in the Education Act ( California Department of Education )[10].

Scientific standards are those that determine what material will be studied in the respective class and they generally replace the function of a study program, which should correspond to the Bulgarian ones. The Next Generation Science Standards (NGSS) are based on the Education of Science K-12 framework (kindergarten through grade 12 inclusive) created by the National Research Council.

According to the California content science standards (which were described in detail above), at the end of the specified period (grade), students must possess certain knowledge and skills, which in Bulgaria are described in detail in the study program.

California has selected about 30 textbooks it says are aligned to the Next Generation Standards. The State Council is committed to supporting teachers with quality teaching materials that undergo a rigorous screening process beforehand. The standards, published in 2013 largely modeled after NSF's 2012 framework, have been adopted by 19 states and the District of Columbia. They place much greater emphasis on "doing" science through the process of hypothesis generation and data collection than on simply memorizing concepts.

California is also one of the first states to adopt materials that claim to be NGSS (New Generation Science Standards). Publishers of such instructional materials continue to tend to target state educational frameworks and then modify them for different states [11].

**NGSS Science Textbook Review**

California materials go through a three-step review, by panels of outside reviewers, then by the state's Commission on Instructional Quality, and finally for approval by the state board of education. By endorsing most series of textbooks and teaching aids, California also gives its contiguous districts many choices of materials. This offers flexibility on the one hand, but also raises questions about which are really appropriately applicable. According to Matt Krehbiel, director of science at Achieve, the problem with state textbook assessment in general is that raters are often limited to correlational analysis of a portion of the information to each standard. This nonprofit organization currently assists individual states in establishing NGSS and provides tools to their districts to evaluate and implement their alignment.

## Structure of American Biology Textbooks and Teaching Aids and Resources

In its modern versions, the means of teaching science (Science) for **the 5th grade**, for example, are structured according to the new standards, and the entire TMC consists of 4 components: a combined

[10] https://www.cde.ca.gov/

[11] https://www.edweek.org/teaching-learning/california-approved-nearly-30-science-textbooks-but-are-they-truly-aligned-to-standards/2018/11

textbook with a workbook, a teacher's edition textbook, a test book, inquiry flipchart (book with practical activities), etc.

The textbook is a combination with a write-in workbook, i.e. – it can be written on. It is structured into 15 separate units that include certain basic topics from divisions of biological and other sciences such as cell biology, human anatomy, classification, genetics, zoology, botany, ecology, oceanology, astronomy, paleogeography, physics, and even engineering. An analogue in the Bulgarian teaching of natural sciences is the subject Human and Nature for the 5th grade, and the wider range of sciences that are studied in the American program is obvious. Each unit of the textbook, in turn, is structured into several chapters that cover topics from the same field. Its interactivity is manifested by the fact that after the presentation of each part of the topic, the corresponding questions and tasks follow, usually depicted with blank spaces to be filled in by the student, in various graphs, diagrams, pictures. For comparison, in the Bulgarian versions of Human and Nature textbooks, the questions and tasks are usually located at the end of the lesson unit, often presented as a separate rubric. The textbook is interesting and easy for the student to use also due to the fact that it is multi-colored and the information in it is presented almost entirely through visual means. Each page of the textbook is also semi-perforated on the inside, so that it is convenient and easy to tear from it for easy handing in to the teacher.

In this case, this interactive version of a science textbook is not only the main source of information, but also turns the student into an active reader, allowing him to write down his ideas, answer questions, take notes, record the results of various activities in the same place, allowing him to learn concepts and acquire skills through his interaction with each of its pages.

At the end of each chapter of the unit there are usually 3-4 pages of exercises, which both serve as a summary, revision and self-assessment. They contain tasks for the development of logical, and critical thinking. They are usually related to tasks to apply concepts and ideas, which include tasks to compare, to connect, to describe a diagram, etc. A favorite of the students is the so-called Brain Check, which is a full page of crosswords or word puzzles involving all the scientific concepts, theories and ideas studied in the corresponding chapter. Often, after the end of the chapter or section, short texts or parts of articles about scientists in the scientific field presented in the unit are inserted, which motivate students through their example to develop an interest in the sciences, further develop their motivation for learning and guide them indirectly to a possible future profession in the field of science. Each individual chapter contains at least one laboratory experiment or research topic. It is brought out in a separate tool for practical activities, which was discussed above - Inquiry Flipchart, or in other words, it is a tool that contains experiments and assignments for research and inquiry for each chapter.

The Teacher's edition textbook is a set of 15 separate booklets of about 70 pages each, one for each section. This division is made in order to lighten the volume and weight of a paper version of the teacher's textbook, since otherwise it would be heavy and bulky, containing more than 750 pages. It is an extremely useful aid in the work of the teacher, as it contains all the pages of the textbook, with explanations, descriptions, ideas for student motivation, as well as additional exercises structured in different rubrics. Examples of this are the rubrics *"Generation of ideas", "Active reader", "Development of scientific vocabulary", "Development of scientific concepts", "Development of research skills", "Summarization of ideas", "Differentiated teaching"* (for the different levels of students, or their different learning styles),

*"Interpreting visual images"* etc. In addition, the teacher's teaching support booklets also include all answers to questions, exercises, tasks, and questions.

As an additional aid and part of the TMC, there is also a so-called *assessment guide*, which contains all types of assessment tasks, quizzes for each lesson, long tests for each unit, questionnaires, assessment sheets for practical activities , student self-assessment tests, as well as an answer key to all of them. At the top of each page of the handbook is a designated space for the student's name and number, as well as the date of the test. Each page of the manual is also semi-perforated on the inside for convenient and easy tear-off and easy photocopying and reproduction for student testing , as well as an answer key.

Last but not least, an online textbook containing digital lessons for the 5th grade, as well as virtual laboratories for each lesson unit of the planned curriculum, has been developed for modern science education and the effective application of all components of the TMC. The 6th grade science curriculum in California education does not include a *biology section* and therefore it will not be considered and analyzed in this study.

Similar to the set for the 5th grade, in the Bulgarian education system, the TMC for the 7th grade also includes a textbook, a workbook and a teacher’s edition textbook.

The Life Science textbook for the 7th grade, which is used in the American system, contains 780 pages, of which the last 70 pages are devoted to the so-called a lab journal, appendices and a glossary containing all the longer experiments that follow at the end of each chapter, answers to some questions after the topics, study skills, a table of world metric units, skills for measuring different quantities, scientific methods, temperature scales, diagramming and graphing skills, applications of related knowledge in mathematics and physics, microscope skills. The glossary contains all the new concepts used in the textbook, explained and arranged alphabetically, with the page on which the term is mentioned indicated.

Topics include all major areas of biology such as: basic methods, principles and models of life science, cell biology, genetics, evolution and classification, microbiology, botany, zoology, ecology, human anatomy and health education. All topics are divided into 8 units, and each of them includes several chapters, which are 28 in total. Each chapter contains a different number of sections/topics. The distribution of the main, explanatory and additional text from the topic is very similar to that in Bulgarian textbooks. At the beginning of each of them, students can familiarize themselves with the learning objectives, i.e. what exactly they will know and be able to do after learning it, as well as a short glossary of the new terms. In addition, a rubric "Reading Strategies" has been added, where effective methods for reading with comprehension of the text are indicated, such as discussions, predictions, organizing, etc. The most important terms with their respective definitions are displayed on the side of the page, and in the text they are highlighted in bold and colored with an electric background. An explanatory text is attached to each image. On almost all pages, different activities, easy and quick experiments, connections of the topic with other subjects, for example mathematical exercises or social studies, etc. are proposed. At the end of each new lesson, a half page is added for summary and questions rubric. At the end of each chapter, depending on its content, there are three consecutive and different types of exercises, namely – a practical exercise or experiment, a revision of the material from the corresponding chapter, in the form of questions and tasks, and a sample test covering the same material, under the name "standardized test

preparation." As the last element to the relevant chapter, but not least, after the test, a variety of interesting material is published, supplementing the information from the text to the topics. For this purpose, 2-3 pages have been added for a section entitled "Science in Action", which contains parts from scientific articles, information bulletins with facts and discoveries related to the material. As part of the rubric and subcategory, a short biography with the career, life and achievements of at least one scientist in the field is included, under the name "People in Science".

The teacher's textbook is very similar to the student's textbook, since it contains all the fully developed lesson topics, which, in terms of pages and content, completely coincide with those in it. The book begins with a description of the content of the TMC, what it includes and what each of its units is used for. The method of working with the individual characteristics of the students is also described, as well as strategies for dealing with students with learning difficulties are indicated, and it is specifically indicated what task to give for an exercise, as the level of the exercise is lower. There are additional resources for developing reading comprehension skills in science texts as well as assessment tools. A special place is added to giving instructions in laboratory exercises, which are divided into several groups according to their type, complexity, time and place of performance, such as mathematical-based exercises, demonstrations, laboratory practices, environmental exercises and field activities, long-term projects and research ideas. The safety rules and rules for working in a laboratory environment are also briefly described, as well as the main safety symbols and guidelines that students should be informed about. In several pages, the connections of science with other disciplines are also indicated, among which a special place is allocated to mathematics, and the areas in which they are intertwined and help to develop certain skills, such as logical thinking, experimental skills, research are indicated and explained skills, communication skills, etc.

For each chapter of the textbook, a specific plan is also outlined, including teaching time, objectives, laboratory exercises, demonstrations and resources, as well as the method of assessment and correlations with the relevant standards. A list of required resources for the unit is also provided such as worksheets to facilitate teaching and assessment such as skills development, assessment, laboratory exercises and teacher-directed activities and resources. Last but not least, the national education standards are listed within a few pages, with the correlations of each section of the textbook with the relevant standard indicated.

Electronic resources at TMC for 7th grade include online resources in the form of a website and software resources in the form of a CD. The site is tailored to the needs and use of both teachers and students. A digital copy of the textbook containing all its pages is also included with it. In addition to it, the site also includes all resources suitable for printing, such as worksheets with various tasks, crosswords, puzzles, self-control and assessment tests, dictionaries, Internet links to various videos and activities, summaries and sample tests to each chapter. In addition, each chapter lesson includes guided reading worksheets, with options for different student levels, an interactive textbook, vocabulary and section summary, reinforcement worksheets, lesson summaries, and control and self-assessment. In teacher resources, in addition to those accessible to students, an answer key has been added to all worksheets, lesson plans, and demonstration materials such as videos, animated experiments, virtual labs, simulations, as well as assessment materials such as tests and quizzes (quizzes) for the three main levels of students – high, medium and for those with special learning abilities, to each chapter and topic with the answers to all of their tasks.

The CD is available for teachers only. Apart from everything mentioned above as available on the site, a test generator is also added to this software, which contains questions on the entire material. The value of this so-called generator is that, in addition to creating tests in seconds, based on information from a specified chapter, as an additional option, it can create test variants for several groups of students, by shuffling the questions, as and adding and excluding such. In general, e-resources are an invaluable aid to both teachers and learners as they alleviate the purely physical burden of carrying heavy textbooks and aids.

The 10th grade biology textbook consists of about 980 pages. TMC was created for the needs of individual and age specific students in high school, 10th grade and meets national standards for science education in California, USA. At the very beginning, after a description of the content of the textbook, two appendices follow, the first of which contains explanations to facilitate the analysis of data that help in conducting scientific research, and the second with explanations for conducting so-called quick experiments, accompanying topics from each chapter, described by type and page, such as - observation, modeling, classification, design, sampling, inference, prediction, graph interpretation, dissecting, comparing, etc.

The last 100 pages are devoted to the so-called a "lab manual" including symbols and safety rules for working in a laboratory setting, a table of world units and the metric system, and instructions for using a microscope, a manual of mathematics and data analysis, a manual of scientific vocabulary, a manual of keeping notes, and appendices containing partial information on classification of organisms, life cycle diagrams of some organisms, occupations related to biology, the study and analysis of ecosystems, and a glossary of all terms in the text by all definitions in English and Spanish translation. At the end of the textbook, within 23 pages, there is also an index with the localization of all new terms and concepts by pages, arranged in alphabetical order. The textbook ends with a periodic table of chemical elements, with explanations for the main elements that make up organic substances and biomolecules.

Topics include all major areas of biology, such as: basic life science methods, principles and models, biochemistry, cell biology, genetics, ecology, evolution and classification, microbiology, botany, zoology, human anatomy and health education. All topics are divided into 9 units, and each of them includes several chapters, which are 34 in total. Each chapter contains a different number of sections/topics. At the beginning of each topic, students can familiarize themselves with the upcoming introduction of new terms through a short glossary of concepts. In addition, a visual dictionary and a set of reading tools have been added. The most important new terms in the text are highlighted in bold and colored with an electric background. An explanatory text is attached to each image. On almost all pages, different activities, easy and quick experiments, connections of the topic with other subjects, for example mathematical exercises or social studies, etc. are proposed. At the end of each topic of a lesson for new knowledge, a space is allocated for questions and tasks, and in addition, a connection with other academic disciplines or other sections of biology is indicated, and at the end of the chapter there are 2-3 pages for summary and discussion, followed by exercises and a sample test for self-monitoring and assessment. Before the next section, for additional information, enrichment of students' knowledge and connection to real life, an article on the topic from an online journal related to the latest discoveries in the field of biological sciences is published. The magazine is also available online with a link to it, which is also part of the electronic resources at TMC.

The new TMC Biology 10th Grade American Version options are designed to reinforce and emphasize vocabulary, reading comprehension, real-life connections, data analysis, differentiated instruction and online resources, using innovative technologies. Examples of such are: interactive summary games, interactive whiteboard resources, animations and simulations, links to web resources, etc. The textbook uses the 5 components of the educational model - engagement (inspiring students, through resources or activities to attract and hold attention), research (related to the use and collection of data), explanation (differentiated teaching), assessment (used, to guide teaching in the right direction), extension (to be relevant, related to real life).

The teacher's edition textbook is structured similarly to the others described above for grades 5 and 7.

Electronic resources at TMC for the 10th grade include online resources in the form of a website and software resources in the form of a CD. The site is tailored to the needs and use of both teachers and 10th grade students. A digital copy of the textbook containing all its pages is also included with it. In addition to it, the site also publishes all resources suitable for printing, such as worksheets with various tasks, diagnostic tests, self-control and assessment tests, dictionaries, internet links to various videos and activities, summaries and sample tests for each chapter. In addition, critical thinking worksheets, an interactive textbook, vocabulary and section summary, revisions and lesson summaries, and control and self-assessment worksheets are included for each topic in the corresponding chapter. In teacher resources, in addition to those accessible to students, an answer key has been added to all worksheets, lesson plans, and demonstration materials such as videos, animated experiments, virtual labs, simulations, as well as assessment materials such as tests and quizzes (short tests ) in two versions for the different groups of students, with an answer key to all of their questions.

The CD, like the 7th grade CD, is available to teachers only. Recently, it is noticeable that in the curricula of Biology and Health and Education, and in general in natural sciences, a greater percentage of topics for laboratory and practical work, as well as more topics for exercises, are included, compared to those for new knowledge. This was carried out precisely for the purposes of the new curricula with the aim of modernizing the teaching of natural sciences and its practical connection with life. In comparison, in the US this has been done for a long time. Much of the laboratory exercises and experiments in the 7th grade, for example, use materials available in every home. The creative and emotional approach to science (in the American curriculum) is actually the most significant difference when comparing it with the one in Bulgaria. Another significant difference is the direct linking of American paper textbooks, not only to a digital copy of the textbook in an online environment, but to fully developed teacher and student resource sites that have proven relevant to the needs of current distance learning. They contain a huge range of different sources for additional information and exercises, and electronic journals have been a tool for assessing and tracking student attendance for years and are by no means new and unfamiliar.

In summary, the result of the comparison of the identified aspects of the textbook and related resources is presented in the table. 8.

**Learning process level content - textbook and other resources**

| | ***Bulgarian system*** | ***American (Californian) system*** |
|---|---|---|

| | | |
|---|---|---|
| ***Conceptually*** | The textbook is structured according to the study program and is a resource for both the student and the teacher. Books for the teacher in most cases contain separate sample solutions and resources related to the work of the teacher - annual distributions of lessons and topics,theoretical,information on teaching methods, a sample structure of a teacher's portfolio, etc. Digital resources are unstructured and difficult to apply – some require corrections and further processing. | The textbook is structured according to the standards. The 5th grade textbook is not intended for multiple use, as it is in the Bulgarian system, and students can take notes - it has a more personal character. The Teacher's Book is actually a textbook with additional guidance on individual parts of each topic. The teacher mainly works with this book. There is a digital copy of the textbook and structured digital resources related to the textbook. |
| ***Structurally*** | The textbook is structured according to generally accepted requirements for the elements of the test and non-text component. There is a separate textbook for each class. | The textbook is structured in accordance with the generally accepted elements, but is richer in rubrics - for example, guidelines for effective learning, additional instructions for students with different needs, as well as many digital resources that are related to the textbook - worksheets, summaries, visualizations, etc. The textbook is one for high school level and is studied within one academic year. |
| ***By content*** | In grades 5 and 6, physiological processes are studied, in grade 7, classification of organisms is studied, but only 5 kingdoms, no domains. Sponges and echinoderms are not included. In 8th grade, human anatomy, physiology and hygiene are studied, starting with the organ systems - digestive, respiratory,excretory, followed by the intra-organismal transport system - cardiovascular without special emphasis on lymph and immunity, followed by the skeletal and muscular systems and ending with the regulatory systems – nervous and endocrine, skin is studied in the context of a sensory system. In the 9th grade, | The concept of classification of organisms is introduced in 5th grade and working with a dichotomous key. The concept of domain is also introduced (3 domains - incl. archaea and 5 kingdoms). In grade 5 there are mainly images and very short texts. At the beginning of each textbook is a section related to the "scientific method" - the essence of research and application methods. There are many ideas for activities - models, experiments. Already in the 7th grade, the concept of DNA, cell organelles - structure and functions, gene, heredity, dominant and recessive alleles of the gene, sex-linked traits are introduced, interactions between alleles of different genes are not studied, evidence of evolution, geological eras, animal behavior. In high school there is a section dedicated to research methods - e.g. genetic engineering, genomics and bioinformatics. The sections are connected |

| | | |
|---|---|---|
| | the structure of cells and processes in the cell are studied. In the 10th grade, the properties of heredity and variability are studied, incl. interaction between alleles of different genes, syndromes are studied, the next sections are ecology and evolution. | sequentially with cell theory, evolution, ecology incl. human interaction with the environment, classification of organisms incl. evolutionary relationships. From invertebrates, echinoderms and sponges are studied, animal behavior, human systems and homeostasis - systems start with regulatory - nervous and endocrine, followed by circulatory, respiratory, lymph and immunity, digestion and excretion, skeletal and muscular system and integumentary system-skin, reproductive system (with meiosis included). Standardized tests are also included in the textbook. |

***Table 8.*** *Summarized presentation of the result of the comparison of the highlighted aspects of the textbook and other resources related to it.*

## 3. **Rating scales and a method for equating values in Bulgaria and the USA**

Comparison of students' academic achievement expressed numerically is possible due to the equating of the grading scales used in the two programs. The Bulgarian grading system uses a six-point grading scale (from 2 to 6, in numerical expression), with the lowest value and lowest grade being Poor 2, and the highest - respectively - Excellent 6). However, in the American grading system, a percentage grading scale is used, which expresses the academic performance of students as a percentage (%). 60% is considered as a minimum value and a positive assessment, and 100% as a maximum, i.e. excellent performance of the student, respectively. Any value below 60% is considered Poor. The comparison of the values of the grades received by the same students in the subjects of Health and Biology for the studied period in the 9th and 10th grades are listed in the following table ( *Table 9.* ):

| **Grades - American system** | | **Grades- Bulgarian system** | |
|---|---|---|---|
| **Numeric value % (0-100)** | **Scale (A+ - F)** | **Numeric value (6-2)** | **Scale (Excellent-Poor)** |
| 100 | A+ | 6.00 | excellent |
| 93-99 | A | 5.75 | excellent |
| 90-92 | A- | 5.50 | excellent |
| 87-89 | B+ | 5.00 | very good |
| 83-86 | B | 4.75 | very good |
| 80-82 | B- | 4.50 | very good |
| 77-79 | C+ | 4.25 | good |
| 73-76 | C | 4.00 | good |
| 70-72 | C- | 3.75 | good |
| 67-69 | D+ | 3.50 | good |
| 63-66 | D | 3.25 | average |
| 60-62 | D- | 3.00 | average |
| Under 60% (0-59) | F | 2.00 | poor |

***Table 9** : Comparison table for the values of grades according to the Bulgarian and Californian evaluation systems.*

In addition, I will note that for not handing in a particular assignment, regardless of its type (homework, worksheet, written work in class, etc.) within the deadline, the teacher assigns a grade of 0%. This has a huge affect on the average annual or semester grade of the student, significantly reducing its value. Another rule in support of the previous one is that the student is not allowed to miss a test (long - between 25-35 questions) or quiz (short test - 5-10 questions). In case of absence on the day of the test (and regardless of the reason), the student must appear for the test on another day scheduled by the teacher. At the end of the grading period (in the case of the American system, this is done in quarters, with each term divided into two equal time periods, usually equal to two and a half months) the student is required to have a grade on all tests, quizzes and projects and the absence of such is unacceptable. If the student refuses or does not appear for these exams, the grade is again 0%. For comparison - in the Bulgarian system, when assignments, homework or classwork are not handed in, only a note is placed, which does not reflect the student's academic assessment, but rather an assessment of his behavior, and the students are not absolutely obliged to catch up with tests and controls if they missed them for some reason. All the facts listed above may be the reason for significant differences in the grades of the same students in the same subject compared in the two programs.

The number of grades required in Bulgarian education are regulated in Ordinance No. 11 of 01.09.2016 on the assessment of student learning outcomes and are listed accordingly in Section 2, Articles 12-16 thereof. In the American assessment system, the principle of assessment is used after the end of each section and chapter of the curriculum, after which an exam-test of about 20-25 questions, of which at least 10 are open questions, must be taken. Short tests (quizzes), homework exercises and those from class work, as well as project assignments, are assigned to students by the teacher's decision. The number of grades is not regulated. At the end of the academic year, a final test is held for each subject.

# CHAPTER FOUR

# ANALYSIS OF THE RESULTS OF THE STUDENT ASSESSMENT

## 1. Context of the analysis

Already in the first chapter, it was emphasized that according to the structure of didactic problems of G. Mialare, the assessment or the answer to the question With what result? is one of the most significant ones. It is the results of the student assessment that show whether the objectives have been achieved through the relevant learning content and the methods and techniques used.

The data collected from the annual assessments for a period of five consecutive academic years (in the period 2018/2019 - 2022/2023), in the subjects described above from the American and Bulgarian education systems, will highlight the differences and similarities between the two systems. Also, a comparison will be made between the academic results of students in middle school and high school, in order to track whether there is a difference between the achievements in natural sciences, in particular - biology, of the same students who are educated in both systems. The data from the grades of the studied students were taken from five consecutive years, namely - 5th grade Science (general), and respectively 5th grade Human and Nature during the school years 2018-2019, 2019-2020, 2020-2021, 2021 -2022, 2022-2023 and 7th grade Life Science and 7th grade Biology, respectively, as well as high school biology and health education - 9th and 10th grades, in the same five consecutive academic years. According to my personal professional observations over the past 9 years, students in middle school are more motivated to study biology, compared to those in high school. An exception is made for students who are targeting university majors that include this subject.

## 2. Results and analyses

The main research question to which the analysis of the results of the students' learning is subordinated is: *Is there a statistically significant difference in the achievements of the students simultaneously taught in the two compared educational systems?*

The analysis was done by grade and overall. A variety of tests and worksheets were used in the assessment of students under the Californian system. For teaching in the Bulgarian education system, tests published in books for the teacher and various study aids were used, taking into account to what extent the tasks correspond to the expected results according to the study program.

The average annual academic score rate of the students in Human and Nature, Grade V, taught in the Bulgarian educational system (BgES) is of the order of 5.5741, while the achievements in the Californian education system (CfES) is 4.9074 (Table 10). The results presented in Fig. 33. are the base for the following analyzes and comments: - the percentage of students with poor (1.85%), average (7.42%) and very good grades (35.18%) are more, taught in CfES; - there are more students with good (5.56%) and excellent grades (62.96%) taught in BgES.

It will be seen further that in all the studied grades, the scores obtained in the American program are relatively lower and in some cases there are even significant differences. This, I believe, is entirely due to the fact that students study different content in the subject at different times and sometimes with different teachers. This is the case with students who were in the 5th grade in 2018/2019. During the morning hours and until lunchtime, they studied Science with an American teacher using an American textbook and curriculum, with different requirements and assessment methods, and in the afternoon hours, during the Bulgarian program, they studied Human and Nature according to the Bulgarian curricula with Bulgarian teacher and Bulgarian textbook, according to the relevant requirements and assessment methods. The curriculum overlaps to some extent in meaning, but even so, it is taught at different times, often even in different school terms. For some students, the language barrier is also a factor, which affects the understanding of the new material, even when the topics coincide.

| | N | Statistical quantities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | X | Me | Mo | R | SD | V | Min | Max |
| **CfES** | 54 | 4.9074 | 5.0000 | 5.00 | 4.00 | 1.01440 | 1,029 | 2.00 | 6.00 |
| **BgES** | 54 | 5.5741 | 6.0000 | 6.00 | 2.00 | 0.60194 | 0.362 | 4.00 | 6.00 |

***Table 10.*** *Descriptive statistics results - V grade*

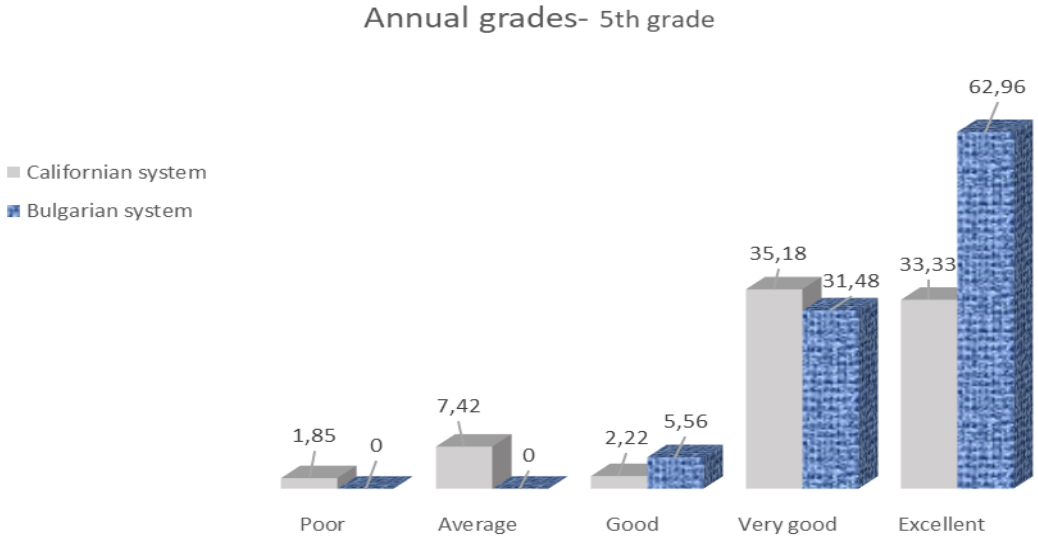


***Fig*** *. 33. Percentage distribution of annual grades in Human and Nature and Science V grade*

A similar discrepancy in assessment values is observed in the 7th grade. In my opinion, it is again mainly due to the different material learned at different time periods, as well as different teachers, in Life Science (LS) and Biology and Health Education (BHE) respectively. Leaving aside these and similar exceptions, there are no significant differences in overall grades in the study period, especially in the high school grades, 9th and 10th grades, respectively.

In the analysis of the total annual grades of the students in the 7th grade in the two analogous subjects - Life Science and BHE, there are also differences. The average annual score rate of students from the target group of Biology and Health Education VII grade (Table 11) is again higher when they are taught

in BgES (5.1364), compared to CfES (4.6364). In support of the presented data are the results of fig. 34., from which it is clear that there are more students with very good (40.91%) and excellent grades (36.36%) when they are taught in BgES, compared to CfES (very good, 31.82%; excellent grades, 22.72%).

| | N | Statistical quantities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | X | Me | Mo | R | SD | V | Min | Max |
| **CfES** | 44 | 4.6364 | 5.0000 | 4.00 | 3.00 | 0.99044 | 0.981 | 3.00 | 6.00 |
| **BgES** | 44 | 5.1364 | 5.0000 | 5.00 | 2.00 | 0.76526 | 0.586 | 4.00 | 6.00 |

***Table 11.*** *Results of the descriptive statistics - VII grade*

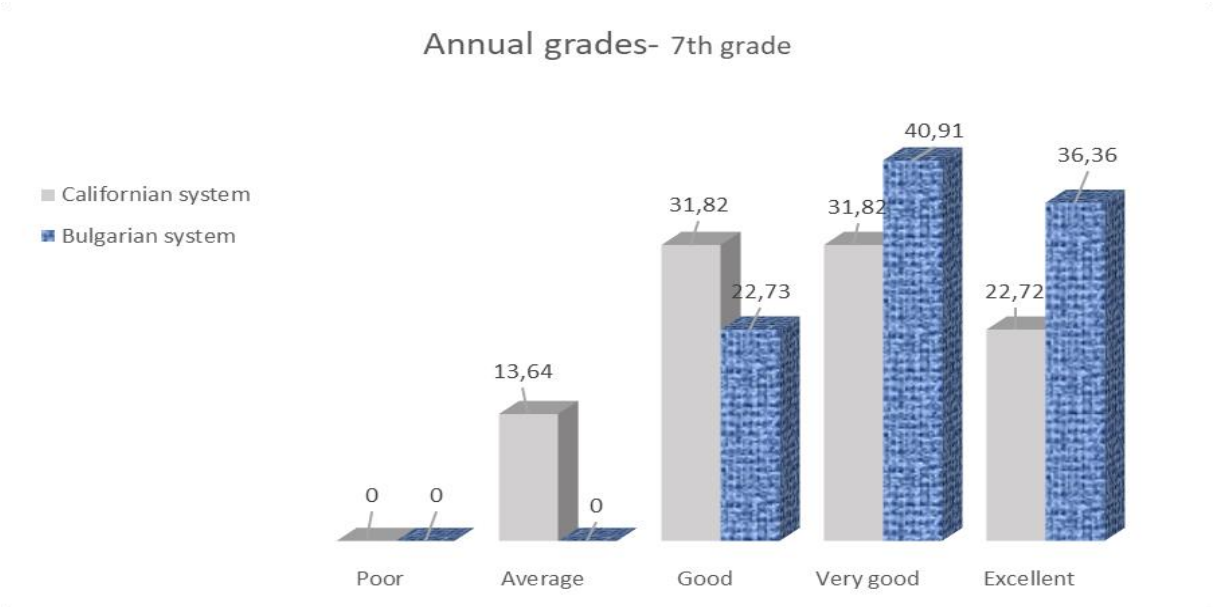


***Fig*** *. 34. Percentage distribution of annual grades in BHE and Life Science, grade VII*

An explanation of the results can be found in the curriculum - in the Bulgarian system it is mainly taxonomy of unicellular, colonial and multicellular organisms from the five kingdoms. In the American curriculum, however, one begins again with an introduction to the subject and a corresponding introduction to the scientific method, scientific models, then moves on to cell biology, genetics, evolution and classification, then moves on to the taxonomy of simple organisms, fungi, plants and animals, follows ecology and ends with human anatomy and physiology and health education. For this reason, even if they overlap, some sections of the textbooks in the two programs diverge in time, and in this case there is no way to rush one and slow down the others, just to coincide them chronologically. This also explains the result of the discrepancy in the evaluations in favor of the Bulgarian program.

In the high school stage, respectively in the 9th and 10th grades, there are much more insignificant differences in the final annual grades for the entire studied period. Here, however, the teacher is already the same and the material is taught and studied in English according to American textbooks, but following

the curricula of the Ministry of Education and Culture in Bulgaria for the content and chronological arrangement of topics.

| | N | Statistical quantities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **X** | **Me** | **Mo** | **R** | **SD** | **V** | **Min** | **Max** |
| **CfES** | 33 | 4, 5455 | 5.0000 | 5.00 | 4.00 | 1.06334 | 1,131 | 2.00 | 6.00 |
| **BgES** | 33 | 5.1515 | 5.0000 | 5.00 | 3.00 | 0.75503 | 0.570 | 3.00 | 6.00 |

***Table 12.*** *Results of the descriptive statistics - IX grade*

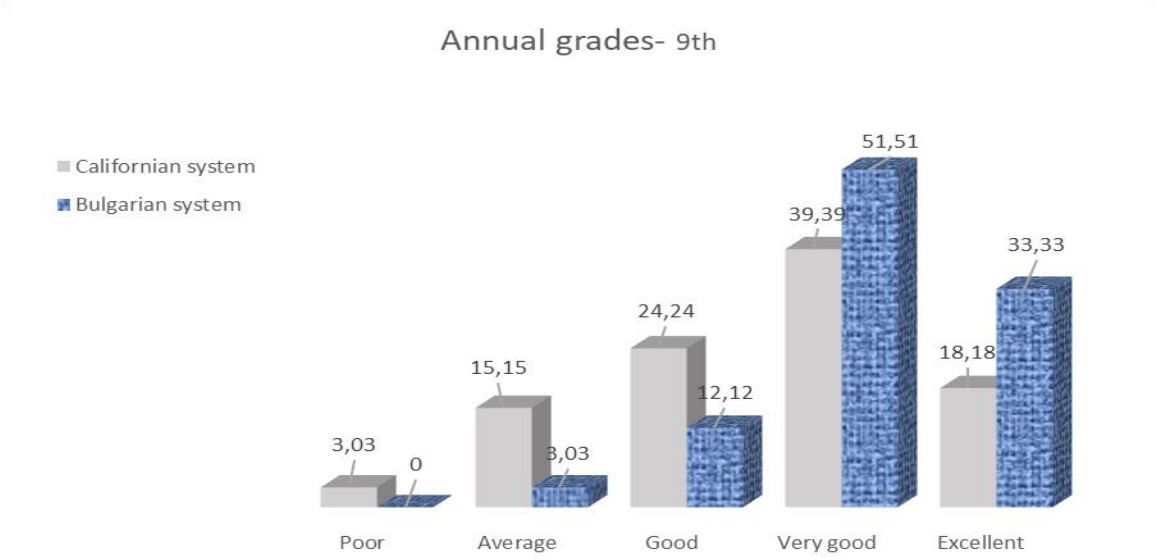


***Fig*** *. 35. Percentage distribution of annual grades in Biology and health education IX grade*

The percentage distribution of the annual grades in Biology and Health Education in grade IX (Table 12, Fig. 35.) illustrates that the percentage of students with a grade of very good (51.51%) and excellent (33.33%) is significantly higher when they were taught in BgES, compared to CfES (very good - 39.39%; excellent - 18.18%). The average annual success rate of students taught in BgES is 5.1515, and when they are taught in CfES it is significantly lower - of the order of 4.5455.

The results of the descriptive statistics in the 10th grade (Table 13) show that the average values describing the annual scores of students educated in both educational systems are almost comparable (CfES - 5.2069; BgES - 5.3793). The complete absence of students with low and average scores is striking (CfES - 0%; BgES - 0%). (Fig. 36) However, it is necessary to note that students with good scores are more distinctly represented when they are taught in CfES (24.14%), while very good and excellent scores is a characteristic of students studying biology in BgES (very good - 41.38%; excellent - 48.27%).

***Table 13.*** *Descriptive statistics results - Biology and health education, 10th grade*

| | N | Statistical quantities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **X** | **Me** | **Mo** | **R** | **SD** | **V** | **Min** | **Max** |
| **CfES** | 29 | 5.2069 | 5.0000 | 6.00 | 2.00 | 0.81851 | 0.670 | 4.00 | 6.00 |
| **BgES** | 29 | 5.3793 | 5.0000 | 6.00 | 2.00 | 0.67685 | 0.458 | 4.00 | 6.00 |

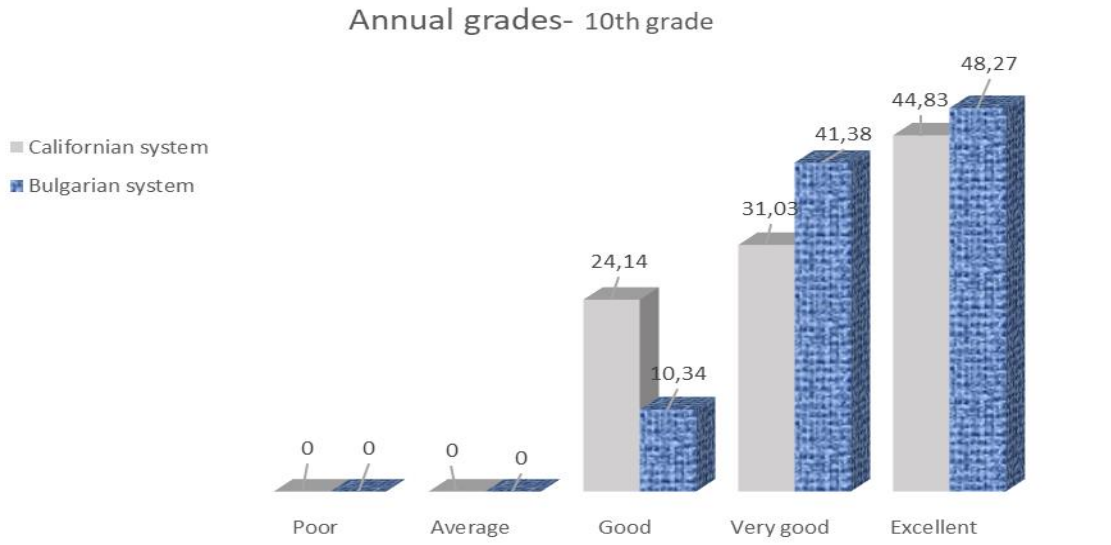


***Fig*** *. 36. Percentage distribution of annual grades - Biology and health education, 10th grade*

The overall ratio of all grades is in favor of the assessment of the Bulgarian program. The possible reasons for this have been mentioned above in the explanation of assignment grading methods.

The aggregated numerical data for all classes and the entire research period, shown in table 14, show that the average annual score of students educated in BgES (5.3313) is significantly higher than that of CfES (4.8125). The percentage distribution of the annual grades for the above-mentioned grades (Fig. 37.) is a reason to draw the following conclusions:

1. The percentage of students with grades poor (1.25%), average (9.37% -) and good (25.62%) are predominantly present in CfES;

2. The students with very good (40.00%) and excellent (46.87%) scores are significantly more when they are taught by BgES, compared to CfES .

| | N | Statistical quantities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **X** | **Me** | **Mo** | **R** | **SD** | **V** | **Min** | **Max** |
| **CfES** | 160 | 4.8125 | 5.0000 | 5.00 | 4.00 | 1.00431 | 1,009 | 2.00 | 6.00 |
| **BgES** | 160 | 5.3313 | 5.0000 | 5.00 | 3.00 | 0.71570 | 0.512 | 3.00 | 6.00 |

***Table 14.*** *Results of the descriptive (descriptive) statistics – all grades*

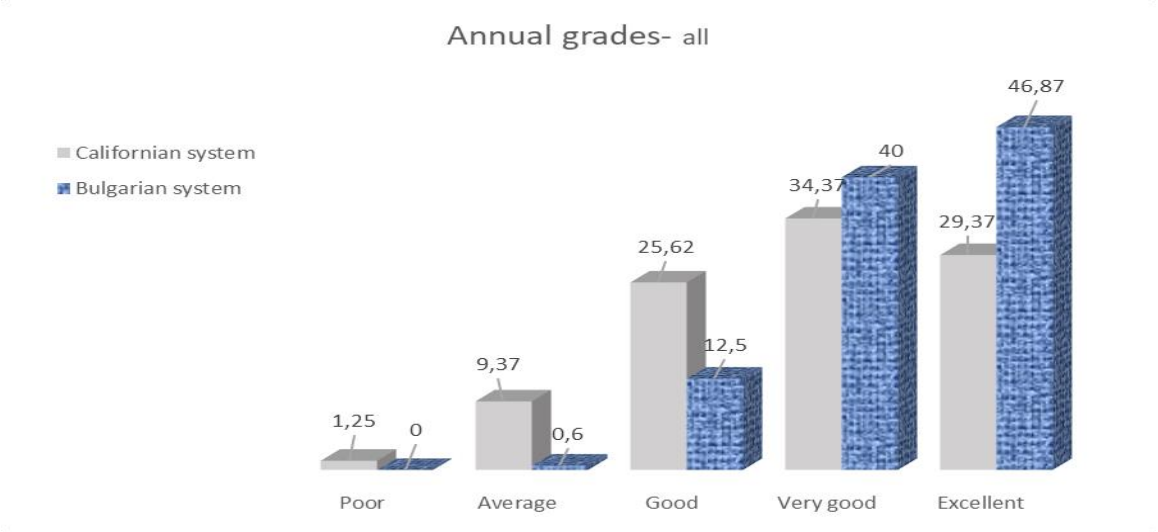


***Fig. 37.*** *Percentage distribution of annual grades in Human and Nature, V grade and Biology and health education VII, IX and X grades.*

The collected empirical material and the analysis of the results of the statistical research of the data from the conducted tests are focused on solving the following question:

*Is there a difference in the distributions of the random variables X and Y, which characterize with numerical values the achievements of the students taught in BgES and CfES* ?

The resolution of this question is related to the empirical verification of the following statistical hypotheses formulated on the basis of the hypothesis of pedagogical research:

**Null hypothesis ($H_0$):** *The distribution of the random variable X (the results of the CfES teaching) does not differ significantly from the distribution of the random variable Y (the results of the BgES teaching)* .

**Alternative hypothesis ($H_1$):** *The distribution of the random variables X and Y describing the achievements of students in the two educational systems differ significantly* .

The comparison of the arithmetic mean values describing the annual academic score of students educated in the two educational systems was carried out using parametric and non-parametric tests for dependent samples: T-Test (One-Sample Statistics), Fisher's F-test (Repeated Measures ANOVA) and Wilcoxon's T-test (Wilcoxon Signed Ranks Test).

The verification of the statistical hypotheses is based on the empirically obtained data reflecting the annual score of students educated in both educational systems. The data from the descriptive statistics and from the applied tests (One-Sample Statistics, Repeated Measures ANOVA and Wilcoxon Signed Ranks Test) for comparing the students' achievements indicate that the average values characterizing the studied indicator for grade V, grade VII, grade IX, grade X and overall for all grades differ significantly in favor of BgES teaching, $p = 0.000$, $p < 0.05$, at a significance level $\alpha = 0.05$ (table 14). The obtained empirical

values from the applied tests are a reason to accept the alternative hypothesis - **($H_1$):** *The distribution of the random variables X and Y describing the achievements of the students in the two educational systems differ significantly* (table 15).

Only the mean values describing the annual academic score of X grade students for the two educational systems do not differ significantly (t = 1.361, p=0.184, p > 0.05; F = 0.764, p=0.386, p > 0.05; Z = (-1.508), p=0.132, p > 0.05) (table ). This requires accepting the null hypothesis - **($H_0$):** *The distribution of the random variable X (the results of the CfES teaching ) does not differ significantly from the distribution of the random variable Y (the results of the BgES teaching)* . (Table 15)

Again, an explanation of this fact can be sought in the different way of assessment and possibly the influence of the foreign language.

| Parametric and non-parametric tests for dependent samples | V grade | VII grade | IX grade | X grade | Total for all grades |
|---|---|---|---|---|---|
| T-Test (One-Sample Statistics) | t = 35,550<br>df - 53<br>p = 0.000<br>p < 0.05<br>**$H_0$ is rejected** | t = 31,051<br>df - 43<br>p = 0.000<br>p < 0.05<br>**$H_0$ is rejected** | t = 2,456<br>df - 32<br>p = 0.020<br>p < 0.05<br>**$H_0$ is rejected** | t = 1,361<br>df - 28<br>p = 0.184<br>p > 0.05<br>**$H_0$ is accepted** | t = 5.854<br>df - 159<br>p= 0 .0 00<br>p < 0.05<br>**$H_0$ is rejected** |
| Fisher's F-test (Repeated Measures ANOVA) | F = 17.250<br>Sum of Squares = 12,000<br>df – 1<br>Mean Square = 12,000<br>p=0.000<br>p < 0.05<br>**$H_0$ - is rejected** | F = 7.022<br>Sum of Squares = 5,500<br>df – 1<br>Mean Square = 5,500<br>p=0.010<br>p < 0.05<br>**$H_0$ - is rejected** | F = 7.127<br>Sum of Squares = 6.061<br>df – 1<br>Mean Square = 6.061<br>p=0.010<br>p < 0.05<br>**$H_0$ - is rejected** | F = 0.764<br>Sum of Squares = 0.431<br>df – 1<br>Mean Square = 0.431<br>p=0.386<br>p > 0.05<br>**$H_0$ - is accepted** | F = 28.310<br>Sum of Squares = 21,588<br>df – 1<br>Mean Square = 21.588<br>p= 0.000<br>p < 0.05<br>**$H_0$ - is rejected** |
| Wilcoxon Signed Ranks Test | Z = (-3.974)<br>Mean Rank = 13.00<br>Sum of Ranks = 78.00<br>p = 0.000<br>p < 0.05<br>**$H_0$ is rejected** | Z = (-2.462)<br>Mean Rank = 14.00<br>Sum of Ranks = 126.00<br>p = 0.014<br>p < 0.05<br>**$H_0$ is rejected** | Z = (-3.077)<br>Mean Rank = 9.50<br>Sum of Ranks = 38.00<br>p = 0.002<br>p < 0.05<br>**$H_0$ is rejected** | Z = (-1.508)<br>Mean Rank = 6.00<br>Sum of Ranks = 18.00<br>p = 0.132<br>p > 0.05<br>**$H_0$ is accepted** | Z = (- 5.465 )<br>Mean Rank = 3 9.50<br>Sum of Ranks = 790 .00<br>p= 0 .00 0<br>p < 0.05<br>**$H_0$ is rejected** |

***Table 15*** *. Parametric and non-parametric tests for testing statistical hypotheses*

We also subjected the research data to **correlation analysis**

***The research question that we formulated in connection with the application of the correlation analysis is:*** *Is there and what is the strength of the correlation dependence between the achievements of the students taught in BgES and CfES* ?

The resolution of this question is related to the empirical verification of the following statistical hypotheses:

**Null hypothesis $H_0$** : There is no correlation between the variables X and Y, which characterize with numerical values the achievements of the students in the two educational systems .

**Alternative hypothesis H $_1$** : There is a correlation dependence between the variables X and Y, which characterize with numerical values the achievements of the students in the two educational systems .

Since the variables are not rank-scaled and the distribution is not known, the Pearson Correlation *r* for simple linear correlation is applied.

Empirical values of Pearson's Coefficient (r) (Pearson Correlation) describe a moderate correlation dependence in IX grade and in general for all grades, while in X grade the correlation dependence is significant ( IX grade - r = 0.439*, p=0.011, p < 0 .05; X grade - r = 0.000, p < 0.05; total for all grades - r = 0.001, p < 0.05) (Table 16). They are the sufficient reason to accept the alternative hypothesis: H $_1$ : *There is a correlation dependence between the variables X and Y, which characterize with numerical values the achievements of the students in the two educational systems .*

| **Correlation coefficient** | **V grade** | **VII grade** | **IX grade** | **X grade** | **Total for all grades** |
|---|---|---|---|---|---|
| Pearson Correlation (r) | r = 0.150<br>N = 54<br>p = 0.277<br>p > 0.05<br>**H $_{0-}$ is accepted** | r = 0.006<br>N = 4 4<br>p = 0.971<br>p > 0.05<br>**H $_{0-}$ is accepted** | r = 0.439 $^{*}$<br>N = 33<br>p = 0.011<br>p < 0.05<br>**H $_{0-}$ is rejected** | r = 0.691 $^{**}$<br>N = 29<br>p = 0.000<br>p < 0.05<br>**H $_{0-}$ is rejected** | r = 0.253 $^{*}$<br>N = 160<br>p = 0.001<br>p < 0.05<br>**H $_{0-}$ is rejected** |

***Table 16*** *. Correlation analysis*

For grade V (r = 0.150, p=0.277, p > 0.05) and grade VII (r = 0.006, p=0.971, p > 0.05) the empirically obtained values of the correlation coefficient indicate that there is no correlation dependence between the variables (table 16). This is a reason to accept the null hypothesis: **H $_0$** : *There is no correlation between the variables X and Y, which characterize with numerical values the achievements of the students in the two educational systems.*

In general, the data from the analysis of the results show that the results of the students educated under the two systems differ significantly in favor of the Bulgarian education system. The difference in assessment method and the influence of the foreign language are the likely reasons for this difference. However, students also do well in their studies in the American (Californian) education system.

## CONCLUSIONS, CONTRIBUTIONS AND RECOMMENDATIONS

The dissertation is built on a clear and specific methodological structure (see fig. 1), which allows comparison on several levels:

- At a concrete content level, in which the content of biological education is compared;
- At the level of educational documentation - standards, study plans, curricula, textbooks and teaching aids;
- On a generalized comparative level - conceptual, structural and by content.

The content of the curricula and the specific learning content in the textbooks aimed to answer the two research questions:

*What are the main similarities and differences in the concepts of the content of biology education in the Bulgarian and Californian education systems?*

*What opportunities for improving the Bulgarian concept are found as a result of the comparative analysis of the two models?*

As a result of the comparative study of the content of biological education in the Bulgarian and in the American (Californian) education system, the following conclusions can be drawn, which are related to answering the first research question:

- There is a conceptual difference regarding the importance of biology and other natural sciences in the American and Bulgarian educational systems - there is a greater number of hours in the American and a connection between secondary and higher school. The number of hours spent studying the subjects is a limiting factor for applying to universities. The subjects of natural sciences in the high school stage are arranged consecutively in the American system, and in the Bulgarian system they are studied simultaneously throughout the entire period.
- The standards for educational content have similar functions, as in the Bulgarian system they are the basis for developing curricula, and in the American system - directly on textbooks. Content-wise, in the American system, the standards emphasize knowledge, and in the Bulgarian system, on skills (with the knowledge included in them). In both systems, the meaning of the essence of scientific research is derived through relevant standards.
- Textbooks in both systems compared are structured according to the main elements of textbook theory. In the American system, rubrics with an emphasis on students' cognitive activities, purposefulness and effectiveness of learning, practical application of knowledge and their connections with other sciences are richer. In the American system, more concepts are studied (eg, animal fungi, echinoderms, etc.) and all concepts are studied according to modern concepts (including the domain concept, the assignment of algae to the kingdom Protista, etc.) at each stage – including middle school. Adaptation, according to age characteristics, is in the style of the text and in the verbal-visual relationship. There is a much more significant presence of interdisciplinary knowledge - connections of biology with geology, oceanography, economics, etc.

- In the American system, there is a greater number of developed and textbook-related resources that greatly facilitate the teacher in preparing and implementing the overall learning process. In the Bulgarian education system, the teacher is free to develop his own solutions, but this takes more time.
- Grading according to the Bulgarian education system is more liberal - there is a requirement for a minimum number of grades, but not for grades from all types of activities for each student, there is no set pass-fail threshold for internal assessment. In the US system there is a threshold of 60% and standardized tests.

Based on the conclusions, the following recommendations can be made to the content of biological education in our country, which are related to answering the second research question:

- At a conceptual level, teaching can be harmonized through a more even distribution of learning time for the development of the various key competencies, incl. those in natural sciences.
- In terms of content, Bulgarian textbooks and resources could include clearer guidelines for the teacher on how to motivate students, realize cross-curricular connections, develop students' critical thinking and creative expression abilities. To have more ideas for cognitive activities, guidelines for successful learning and in general for an even more serious emphasis on student activity.
- In a structural sense, an attempt can be made to change established traditions in the hierarchies of concepts and their structuring in a vertical plan, but this must be done expertly and taking into account many factors - incl. the time factor.
- Regarding the evaluation in the Bulgarian system, it would be good to set a requirement for evaluations of different types of activities for all students and a common threshold value for the pass-fail boundary.

The contributions of the present study can be summarized on two levels as follows:

Scientific and theoretical level :

- For the first time, a comparative study is being done in the subject field of teaching methodology in biology.
- For the purposes of research, a methodological toolkit was derived and applied, which includes aspects of the comparison at several levels with a corresponding specification, which covers all the main elements of the didactic problematic.
- The methodological toolkit of this study is applicable for the purposes of future comparative studies in teaching methods in other subjects.
- As a result of the preliminary research, recommendations for the Bulgarian content model of biological education were made, some of them having a more general meaning.

Practical-applied level:

- A comparative analysis was made of the state educational standards, curricula and programs, textbooks and study aids of the two compared systems.
- A study was made of the achievements of students studying under the two systems for the period 2018/2019 - 2022/2023. It has been statistically proven that there are differences in the final results of the biology assessment under the two educational systems, in favor of knowledge and skills in the Bulgarian education system.

## CONCLUSION

In the present study, which in its essence has the characteristics of a comparative pedagogical study, we encountered the main difficulty of any such study of finding and accessing data from foreign educational systems. However, this is a study that we hope will be useful to at least start a discussion about some positive changes in the content of biology education in our country. Along with the possibilities for changes, we should note that our educational system in some respects has better solutions in the studied comparative plan. As such, we feel it is appropriate to mention:

- the centralized nature of the system's regulation and management model;
- the multilevel of specification of the teaching content;
- the simultaneous structuring of study subjects in the curriculum, which ensures the continuity of learning in the individual fields of science and a better basis for the durability of knowledge and skills.

There are probably other positive points to be made, but there will always be room for changes that can improve our education system as a whole.

The application of the competence approach requires more and more combining, breaking and going beyond stereotypes in the education of students. The rapidly changing reality leads to inevitable transformations in every sphere of public life, but the most urgent seem to be those in education. These changes, in turn, must be at all levels - philosophical-conceptual, normative, and methodological-content. And this is where comparative analyzes come to the rescue to show similarities and differences, strengths and weaknesses, opportunities and limitations. This was the basis of the design of the present dissertation study.

## LIST OF DISSERTATION-RELATED PUBLICATIONS

Gacheva M. (2022). The evaluation of biology in conditions of dual education according to the Bulgarian and California educational systems. *Science and High Technology Education,* 31 (5), 411 – 424.
https://doi.org/10.53656/nat2022-5.01

Gacheva M. (2022). The standards for general educational preparation in biology in the USA and in Bulgaria - a comparative analysis. *Science and High Technology Education,* 31 (4), 371 – 392.
https://doi.org/10.53656/nat2022-4.05

Gacheva M. (2023). Development of ideas for a biology textbook for grades V, VII and X (from the experience of the USA, state of California) *Pedagogy* 95 (4) 530-539 https://doi.org/10.53656/ped2023-4.08

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