A SYSTEM APPROACH TO ENVIRONMENTAL EDUCATION

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Abstract. A system approach to environmental education (EE) is developed. By making use of it the educators will be able to introduce successfully ecological principles and global environmental problems in the educational system for the development of environmental culture, consciousness and behavior. It embraces a long period of thinking, designing, experimenting and rethinking in the light of the new ideas, concerning humanity-nature relationships. The core of the system approach is represented by environmental consciousness, which is the driving force of environmentally responsible behavior. The system approach is concerned with constructing an innovative model of EE, which consists of three elements: didactical, conceptual and technological and six integrating concepts, uniting the studies of the different school subjects under the global movement for sustainable development. EE is regarded to be an essential part of the education for sustainable development (ESD).

Keywords: environmental education, education for sustainable development (ESD), system approach, conceptualization, contextualization, teaching and learning innovations

1. Introduction

1.1. Significance of EE. Every year the interest towards EE grows stronger as the conflicts with nature become more serious and more difficult to solve. Global environmental problems increase in number, depth,

complexity and interrelatedness. The reasons for the development of EE are summarized in Table 1. For these reasons EE is regarded as a new area in the pedagogical theory and practice. Students think that nature enriches them intellectually, esthetically, physically and morally (Kostova, 2003, p. 19).

1.2. History of EE. The analysis of the information given in UNESCO's newsletter *Connect* from 1976 up to now and many other publications in EE helps us to classify the history of EE into three periods: a) education up to 1972 when Humanity unites at the Stockholm UN conference for human environment and makes a decision to initiate IEEP (International Environmental Education Program); b) between 1972 and 1992 marked by the organized international and national activities for the development and introduction of EE in the educational systems of different countries; c) from 1992 up to now characterized by the rethinking and redesigning EE under the principles of ESD and as an essential part of the wholesome educational system (Kostova, 2003, pp. 20 – 35). On the basis of the outlined new trends in education and in the light of the UNESCO's decade of Education for sustainable development (2005–2014), we undertook revision of all theoretical and practical achievements and using system approach constructed an innovative model of environmental education that can correlate with the new state of the environment and the new requirements of social development[1)].

2. Philosophy of the innovative model of environmental Education (EE)

2.1. Interrelations and interactions between methodologies. The rethinking and reformulating the aims and contents of EE and the choice of teaching and learning strategies need a clear methodology – the science of structure and organization of all types of human activity, including education. In the development of the innovative model of EE the interaction of three types of methodologies were used – philosophical, interdisciplinary and proper (methodology of educational sciences). The philosophical methodology is represented by the general scientific concepts (matter, consciousness, movement, development, energy, time, cause, effect, etc.), principles (relativity, complexity, hierarchy, reductionism, holism, etc.), theories (interaction between society and nature, system theory, theory of evolution, etc.) and approaches (integration, interdisciplinary, inquiry, axiology, ontology, prognostic, etc.). The interdisciplinary methodology comprises the interactions between different branches of science (natural, social, technical, etc.),

Table 1. Reasons for developing Environmental Education (EE)

Reasons	Arguments
1. Studying nature	Every human being is closely connected with nature and has an inborn reflex of studying it. The environmental situation is reflected in our consciousness.
2. Solving environmental problems	Environmental situation is marked by many environmental problems which await expert approach to them. Further development of humankind is impossible without adequate environment and natural resources.
3. Understanding unity of nature	The system approach to nature shows that it is a wholesome unity build up of hierarchically connected systems starting with the atom and ending with the universe. But in schools it is studied by many different subjects. EE helps to solve that contradiction.
4. Introducing human values in the educational system	Only human beings create values and follow them. Human values system encompasses the value of nature and develops through it. Humans carry nature within their bodies and are part of it as well.
5. Ensuring social activity and capability of making decisions.	When students study real environmental problems and try to find solutions they acquire capabilities to communicate, to help one another for the benefit of all and to save nature for future generations.
6. Strengthening students' health	Contacts with nature help students become physically adept to weather changes and psychologically fit to difficulties in life.
7. Reforming education	Changes in life and science require changes in educational system. Education develops students' competences and nowadays new competences are in need – health and environmental competences.
8. Developing partnership	EE is the real connection between the present and the past. The movement fir sustainable development unites all human beings no matter of their nationality, ideology, religion etc.
9. Fulfilling Agenda 21	Chapter 35 of Agenda 21 of UN summit in 1992 in Rio de Janeiro motivates people to develop EE as part of ESD in order to guarantee sustainable development which leaves resources for future generations.

shared concepts (core, biosphere, nucleus, population, entropy, operation, etc.), common principles (of thermodynamics, limiting factor, etc.), as well as closely related scientific fields (chemistry, physics, biology, ecology). The proper methodology implies the use of theories, methods and concepts of the pedagogical and psychological sciences.

2.2. Basic organizing ideas and concepts for the construction of an innovative model of EE. Using the method of content analysis more than 362 literature sources were analyzed and the following basic organizing ideas were outlined (Kostova, 2002, pp. 3–5):

• **Ecology** has a methodological and value role and significance in the system of national and global culture. It is a metascience, concerning human-environment interactions and environmental education. Ecology is no longer an isolated brunch of biology, concerned with description of species and their surroundings. It is the study of life in its interaction with culture, the study of our common home. The scope of ecology changes in correspondence with the change in the meaning of the term environment, which is regarded as nature, biosphere, system, problem, home, living place, resource, and a place for collaboration as well as)[2)].

• **Biosphere** is a wholesome planetary organization of life, under the influence of Space organization and a result of billions of years of co-evolution of non-living and living matter. Our biosphere is a part of the Universe and life receives information from Space radiation in the form of electromagnetic waves not only from the Sun but also from other stars. The biosphere incorporates all bio-systems. Space now is influenced and changed by human beings.

• Intensified and global interference of *Homo sapiens* on the biosphere creates **eco-crises**. The present day crisis is **anthropo-ecological** and for its solution a change in human behavior is urgently needed. **Environmental problems** are generated as a result of changes and problems in human souls and in human values. Humans should protect nature outside their bodies and inside them. Because of that health education and environmental education should be developed as a unity (Kostova, 2003, pp. 12–14).

• **Concept** and **context** are complementary and in the light of the system analysis they help to convert the anthropo-ecological situation into a pedagogical situation. **Conceptualization** of knowledge starts with conceptualization of pedagogical situation that simulates real life situation. Conceptualization means assimilation of knowledge at different levels – from the level of reproductive knowledge to the level of values and participation. It means incorporating each concept into a conceptual scheme, which is used for the development of a scientific picture of our common home (Our Planet). Conceptualization has a priority role in organizing, structuring and giving meaning to information. It is a process by means of which information becomes knowledge (Kostova, 2003, pp. 43–45; Kostova, 2003b).

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2.3. Research program. The *object* of inquiry is the EE as a unity of structural and functional components in secondary schools of Bulgaria in the light of the new theory of humanity-nature relationships and new trends in teaching and learning. The *subject* of inquiry includes the constructs of an innovative model of EE in the context of biology as a model of science in the system of culture, i.e., the interaction of biology with other branches of culture. *Assumptions* involve that if we expect to make changes in the culture, consciousness and behavior of students so that to develop their personality and help them successfully integrate in society preserving the ecological equilibrium, then it is of utmost importance to uncover the numerous interactions of the basic characteristics of environmentally oriented educational process, to ensure the investigation and discussion of global environmental problems from different theoretical and practical aspects and to open the perspectives of further improvement of the model to keep it in correspondence with the new requirements of life.

Studied problems (Kostova, 2002, pp. 5–9):

1. What are the parameters of environmentally organized educational process that can be extracted from historical and contemporary studies and from careful analysis of advantages and disadvantages of educational theory and practice?

2. What basic constructs can be essential in developing an innovative model of EE in order to ensure the accomplishment of the expected educational outcomes?

3. What are the basic integrating concepts that can unite the subjects in studying humanity-nature interactions and help construct conceptual schemes of the studied problems?

4. What is the context of EE that makes it agreeable and easy to understand by students?

5. What are the methods of objective evaluation of EE?

One of the basic obstacles in organizing an effective environmental educational process (EEP) is the lack of theory for uniting the fragmentary nature of EE in a wholesome dynamic model. Environmental Education (EE) has a long history (Kostova, 2003, pp. 20–36), but it has not reached a unified wholesome state yet. There are many reasons for that: the environmental problems are very complex and dealt with by different specialists. Every specialist interprets them from his or her point of view (usually one-sided) and interpretations very often do not take into account the principles of sustainable development (Kostova, 2003, pp. 52–56). The lack of unity in EE is responsible for lack of confidence and for inadequacy in interpretations of ecological concepts. It is also responsible for the vague definition of the context of EE not

taking into account the modern understanding of biology as a bridge between the different cultural and educational dimensions of knowledge in health and environmental perspective (Kostova, 2003, pp. 62–76).

The knowledge and the activities in EE are spread throughout school subjects without unifying ideas that can integrate the facts into a wholesome picture. The multidisciplinary approach has many advantages as it helps to discuss the many aspects of the environmental problems but it also has some shortcomings. Ecological and environmental concepts are subordinate to the concepts of the subject studied. They follow the structure of the branch of science, modeled in the subject (for example the structure of chemistry, physics, biology, history, geography etc.). This is an obstacle in developing the conceptual unity of EE (Kostova, 2003, pp. 152–183).

The research is carried out by means of two kinds of methods (Kostova, 2002, pp. 11–12):

a) theoretical methods: *system analysis* of the problems and main concepts, *content analysis* of: educational documents, resolutions of the Ministry of Education and Science, literature in ecology, biology, psychology, didactics, teaching of different subjects, teachers' and students' papers, *system modeling* and *constructing mind maps* as conceptual models of contents in ecology and nature conservation, *brainstorming* in generating new ideas in order to solve the arising problems;

b) empirical methods: *observation* of students' and teachers' work, *pedagogical experiment* to assess the effectiveness of the model, *surveys* to collect data using questionnaires (for information, opinion, evaluation), *method of associations* for assessing the cultural model of environmental consciousness, *comparative analysis* of tests, questionnaires, workbooks, reports, projects, scientific papers, data, in order to find out the level of environmental consciousness, *discussions*, *interviews, lectures* and *consultations* to teachers, applying the model, *expert evaluation* of the system of criteria for evaluation and for assessing the reliability and validity of tests., *statistical methods* for assessing the reliability of the results were also used.

The research is pursued in three stages (Kostova, 2002, pp. 13–15):

a) 1972–1987: the basic components of EE were worked out, the foreign experience was analyzed, national experience was accumulated, the possibilities of school subjects' contents for introducing environmental education were analyzed, interactions between school subjects were worked out, the system of ecological and nature conservation concepts were defined, the philosophy of EE was developed (aims and objectives, principles, approaches, organization and methods of teaching, learning environments and etc). Programs and

materials for students' EE and for teachers' training were developed and introduced. Teaching was introduced in experimental schools in different towns in Bulgaria. The first variation of the model of EE was worked out and its effectiveness was assessed.

b) 1988–1992: the research program and its methodology were improved and enlarged, more researchers, schools, teachers and students were involved. Priority was given to system and wholesome EE and to development of environmental consciousness. Doctors' dissertations were developed and assessed. The history of EE in Bulgaria and abroad was studied. The first trial of creating school EE standards was carried out. The value aspects of EE were probed. The aims and objectives and the conceptual structure of EE were further developed. New textbooks, teachers' guides were prepared and put into practice. The pedagogical experiment continued in the experimental schools.

c) 1992–2004: The general theory of EE was discussed and improved as well as the theory and practice of EE in biology education for the development of environmental culture, consciousness and behavior. Innovation methods of teaching and learning were developed and published and special training courses in EE for teachers were organized. New methods of research were introduced (content analysis, semantic differential, intellectual concept mapping, force-field analysis, strategic planning, brainstorming etc.). The experience of other countries and the new social, economic and ecological situation in our country were studied. The ecological and health crises were comparatively analyzed and a united basic health-environmental competency outlined. Interactive methods of teaching for EE contextualization were also developed and introduced. Priority was given to values development by construction and application of corresponding strategies and studies of attitudes fluctuation were undertaken. New textbooks, workbooks, collections of assessment materials and teachers' guides were prepared and introduced in schools. The adequacy and effectiveness of the different constructs of the EE model were assessed in the different types of schools. The conceptualization of all research data led to the development of an innovative model of EE and six integrating concepts as its core.

Throughout the three stages 144 teachers and 12 489 students took part in the experiments and in the evaluation studies. In 1985 a survey of teachers' competency in EE was undertaken in which 826 teachers of different school subjects were examined. The results were used for the construction of programs for teachers' environmental education. Periodically EE evaluation was carried out in 1981, 1982, 1985, 1988, 1992, 1995 and 2001 (Kostova, 2004). After

that the EE model was used and evaluated by teachers doing investigations for new approaches to teaching, such as projects, case studies, role playing etc.

3. Basic constructs of the innovative model

The innovative model of EE incorporates three constructs – Didactic, Conceptual and Technological (Kostova, 2003, pp. 184 – 199), which combined together help to organize an effective modern educational process, provide possibilities for unified personal development and open contemporary education. It should answer the needs and abilities of the learner – social and the perspectives for further improvement in correspondence with social, scientific, economic and environmental changes.

3.1. Didactic construct of the innovative model of EE. This construct has nine components. It can be visualized as a pyramid with the learner at the top and all the other constituents at the base (Kostova, 2003, p. 42). EE should contain all the necessary ingredients of a modern educational process (Fig. 1). It can be effective if it answers the basic nine questions of a good personal development comprising interaction of a person with himself, with other people and with nature. That puts the priority on styles and methods of communication as EE needs partnership and collaboration between people.

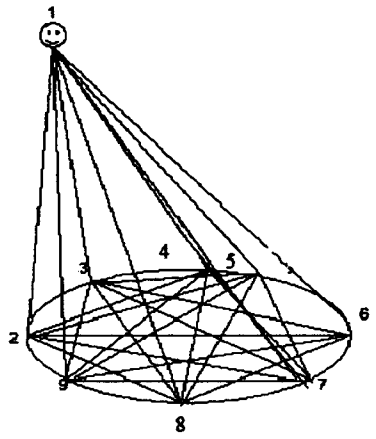

Fig. 1. Interaction of factors in a modern well organized educational process (didactic construct). 1 – learner, 2 – aims, 3 – contents, 4 – methods, 5 – teacher, 6 – teaching aids, 7 – credits (teaching hours), 8 – teaching environment, 9 – evaluation.

The didactic construct of the model takes into account the innovative wholesome approach to education. The education process should satisfy the requirements of the student, of the society and of science. The priority is given to *the student* as it is the object and the subject of educa-

tion. *The aims* are directed at its personal and social development in such a way as to help him or her successfully integrate in society. *Contents* of education deal with the basic integrating concepts that show the ways human beings brake ecological laws and disturb the ecological balance. *Methods* of teaching are innovative giving priority to communication and partnership, to scientific approach and project development, to the use of information technologies and integrated teaching of subjects, and to the analysis and discussion of real life problems (biodiversity degrading, global warming, ozone layer depletion, etc.). *Teaching aids* are very reach nowadays. The use of information technologies creates a whole new virtual world, which is challenging and absorbing. Nature and environmental problems are the real context for environmental education. The computer, the multimedia and the hypermedia are new techniques with not yet completely understood and used capacities in education. *Time of teaching* is determined by the curricula but its flexibility gives the school some freedom in organizing modular environmental teaching and learning. *The teaching environment* is very broad – the classroom, the school environment, the community, natural objects and phenomena, the home environment, etc. *Teacher competences* are of great value and teacher qualification is life-long. Because of that, special courses are needed for teacher qualification in EE and in education for Sustainable development (ESD). EE should be regarded as an essential part of ESD. *Evaluation* is a feedback for students and teachers. It helps them to find out the personal shortcomings in teaching and learning and to overcome them. Evaluation is stimulating when it is done on time, with new techniques, and when it is objective and helping students to develop their own objective self-evaluation.

3.2. Conceptual construct of the innovative model of EE. It is build up of five basic components (Fig 2), which are closely connected and shape the whole personality of the individual. In one entity are unified the cognitive, affective and psychomotor aspects of the personality model. Each component is closely connected with the others.

Components of the conceptual construct are based on environmental consciousness (Kostova, 2002, p. 31):

1. What system of knowledge of ecology, health and nature conservation is necessary for society and for everybody? This component is concerned with consciousness of the need of information and of knowledgeable citizens.

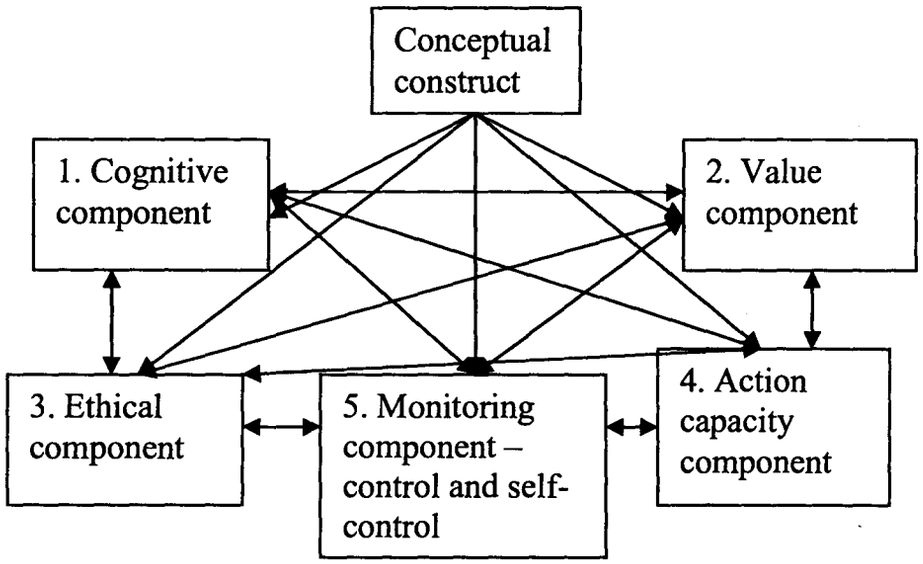

Fig. 2. Components of the conceptual construct of the innovative model of EE

2. What should we value? Nature, environmental equilibrium, health are values. Which is the priority value in our value system? This component is concerned with consciousness of value priority and with the environmental values as part of the system of human values.

3. What is right to do in order to preserve nature for next generations? What are the criteria for right and wrong? This component is concerned with consciousness of responsibility and duty to other people and to future generations, with standard consumption of natural resources.

4. What should we be capable of doing in order to evade or solve environmental problems? This component is concerned with consciousness of capacity for action, with environmental competences for ecologically, socially and economically effective interaction with the environment and with natural resources in order to maintain the ecological equilibrium.

5. How to monitor change? What capacity for regulation of the environment and of human interaction with it should we have? This component is concerned with consciousness of capacity for monitoring and regulating the change in the environment and for self-regulation as well, for control and self-control.

The five components are interconnected and interdependent. If anyone is missing, the model of EE will not be successful. Knowledge, values, moral rules, action capacities and self-control are the cornerstones of EE and ESD.

3.3. Technological construct of the innovative EE model

This construct is based on three variables: non-dependent, intermediate and dependant.

The *independent variables* are those that can be changed by the teacher, by the school or by the Ministry of education. They can be developed and modified in such a way as to predetermine the dependent variables. The teacher can formulate new aims and objectives in connection with the new necessities of the students, the new state of the environment and its understanding and the new requirements of society. The aims are formulated in the national educational standards, in the new curricula and school programs of teaching, and in the teacher's strategy for the lesson to be taught. The teacher chooses the textbook to use, the classroom organization, the teaching and learning methods, teaching aids, means of evaluation etc. Students change and teachers as well.

Table 2. Variables of the teaching-learning process (the technological construct)

Independent variables	Intermediate variables	Dependent variables
Aims and objectives Organization forms Methods of teaching and learning Teaching aids Teacher Learner Time of teaching Context Evaluation – pedagogical monitoring	Learning by imitation or learning by inquiry. Dimensions of learning, types of thinking, ways of information searching, Use of high order intellectual skills and competences	Expected achievements: Declarative knowledge (know and understand): facts, concepts, relationships, unifying ideas, hypothesis. theories, scientific picture of the world; culture Procedural knowledge (able to do): skills (high order intellectual skills, thinking, planning, experimenting, modeling, etc), competences Values: convictions, attitudes, consciousness, behavior

The dependent variables comprise the expected results of teaching and learning and show the degree to which the aims are achieved.

The intermediate variables show the psychological state of learning, the type of thinking which is developed in learning, the learning strategy of the student, the ways in which information is gathered and interpreted, etc. These variables are not easy to observe. Usually we understand what is going on in the head of the student from his or her external behavior – expression, interaction, communication, visualization etc.

This construct is very essential when we look for shortcomings and want to improve the model of teaching as well as when we use scientific approach to objective evaluation of EE. The construct helps to introduce innovations in teaching and reform educational system.

The technological construct is concerned with the experimental pedagogical activity, directed at developing new didactic technology, teaching aids, applying new dimensions of learning. This kind of work is usually done by teachers involved in research or by other pedagogical researchers. It helps to analyze the factors involved in education, to isolate the studied variables and to evaluate the new improvements.

4. Integrative environmental concepts

They are very essential in overcoming the fragmentary structure of EE. The integrative environmental concepts are those that show how and which ecological laws are broken by human beings and how ecological equilibrium is disturbed. Each of the proposed integrating concepts discovers the contradiction between natural phenomena and human activity (Kostova, 2002, p. 36; Kostova, 2003, p. 141). The integrative environmental concepts are based on really existing contradictions between human activity and ecological equilibrium and they are interrelated between themselves (Fig 3).

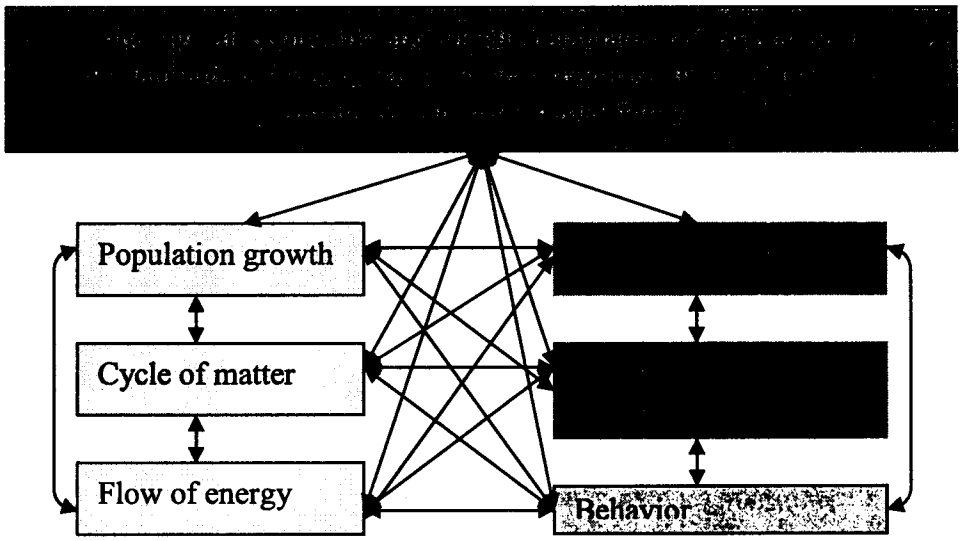

Fig. 3. Integrative environmental concepts and their interrelationships. They unite facts, notions and ideas of different school subjects as well as different scientific and cultural fields. Our sustainable living is based on them.

The integrative environmental concepts show the ecological laws broken by human activity:

1.1. Population growth deals with one of the basic contradictions between ecological laws and human development. It is connected with the pyramid of biomass. In the upper levels of the pyramid the biomass of the organisms is decreasing. Human beings make an exception. The biomass of human beings which are usually at the top of the pyramid is increasing. It is connected with birth control and family planning.

2.2. The cycle of matter is also connected with an ecological problem created by human activity. In nature the cycle of matter does not end with wastes, while in society lots of wastes are produced. The concept integrates all school subjects around the topic of technologies that do not produce wastes, waste treatment and waste control. It directs to sustainable living which diminishes waste production.

2.3. Flow of energy involves the difference between flow of energy in ecosystems and transformation of energy by human activities. Organisms use radiant energy while humans use conserved energy in fossil fuel, which is in limited amounts. Most environmental and social problems arise from the ever rising need of fuel and continuously diminishing fuel resources.

2.4. Ecosystem monitoring and regulation is connected with concepts such as ecosystem productivity, succession, climax, environmental equilibrium, etc. Human beings are regarded as consumers in an ecosystem. The resources consumed should not exceed the biomass produced, i.e. the ability of the ecosystem to recover and to sustain its own life. The human society deliberately holds agricultural systems in disrupted balance in order to use the ecosystem productivity.

2.5. Diversity is a phenomenon that applies to nature and to culture as well. Diversity in culture helps to preserve environmentally friendly technologies. Diversity in species, i.e. *biodiversity* means environmental equilibrium and **sustainable development.** Monocultures, which are characteristic for modern agriculture diminish biodiversity and brake ecological balance.

2.6. Ecologically sound *behavior* requires environmental culture and environmental consciousness. Animal behavior is in correspondence with natural laws and that is why it is adaptive. Human behavior is against the natural laws and is destructive. The aim of education is to make people become aware of their destructive behavior, to present a model for constructive adaptive behavior and to organize pedagogical situations that students can conceptualize.

The integrative environmental concepts unite all the school subjects and facilitate the development of a wholesome picture of society-nature interactions.

5. Learning environments for EE are multisided and very rich in contents, provoking activities

Every part of the environment around us is a good learning environment, because it is full of environmental problems or solutions that can be converted into pedagogical situations to be conceptualized by students. In the application of the EE model in practice we used varieties of learning environments in which students cooperated in identifying environmental problems and by discussion and analysis looked for reasonable solutions (Kostova, 2003, pp. 170–174).

1. Environmental studies (ES) in classrooms;
2. Environmental studies in the laboratories;
3. Environmental studies in the school yards;
4. ES in school buildings, at homes, in communities, in home gardens, in parks, in nature, in natural and artificial ecosystems, in eco-museums, in school gardens, in nature trails, in factories, in eroded territories, recreation sites, urban or rural environments, youth centers, eco-museums, natural history museums, industrial areas, NGOs, etc.

Using the provided possibilities by these learning environments, students can formulate problems and do experiments to solve them. They are very useful for project development.

6. Organizational forms and methods of EE

The type of activities and the way they are organized is very essential in EE as in every aspect of education. In the experimental application of the innovative model we used a combination of traditional and modern teaching, so as to direct system learning for acquiring system knowledge (Table 3). Innovative forms are mainly giving way to students studies based on inquiry approach.

Table 3. Organizational forms in EE

Traditional	**Innovative**
Lectures	Expert learning
Seminars	School conferences
Laboratory investigations	Ecological investigations and workshops
Practical work	Simulations
Competition	Out of school activities: clubs, members of nature conservation movements, etc.
Excursions	Expeditions

Each traditional organizational form gives priority to the teacher's speaking and doing and to the students' listening and task executing. Seminars open better possibilities for students to share their theoretical or practical findings by means of discussion and constructing meaning for declarative knowledge. Laboratory investigations, practical work and excursions are used to give a chance to students to observe, collect data, try to find answers to real problems, participate in nature conservation and improvement. Competitions are essential in developing the ability of students to make objective self evaluation and to acquire self-confidence.

Expert learning and school conferences provide learning environment in which students study from their peers and play the role of experts (teachers) on a given topic. They participate actively in the learning process and acquire knowledge, which they can use later as a tool in discovering new knowledge. Ecological investigations, expeditions are usually taking place out of school in the open and also favor individual or team work on environmental problems, leading to deeper understanding of the integrating concepts. Simulations involve case studies, role playing and computer modeling (multimedia and hypermedia) and are essential in developing skills for social integration and assertiveness in students. Out of school activities, concerning participation in nature conservation movements and clubs ensure possibilities for developing students' interests in this matter.

Traditional methods of teaching and learning are concerned with acquiring declarative knowledge and give priority to teacher's speaking and students' listening. The new model puts the stress on innovative methods, which transform the learner into an active and responsible participant in his or her personal development. They take their own learning progress into their

hands and seek knowledge instead of waiting to receive it. Our observations and surveys show that students are most interested in project work and concept modeling by means of intellectual maps. Team work helps students to socialize, to make friends and tolerate each others' differences (Table 4).

Table 4. Methods of teaching and learning of EE

Traditional methods	Innovative methods
Lecture, Explanation, discussion, reading	Content analysis of textbooks and books
Observation, self-observation, experiment, modeling, construction,	Visualization (different approaches) Brain storming
Drawing, Illustrating, photographing,	Computer modeling, Presentations of projects
Collecting, classifying, describing	Method of association, Intellectual maps (mind maps)
Cleaning, planting trees, rearing pets etc.	Team work, Project method

7. Methods of improving EE (constant adaptation to needs)

The innovative model of environmental education can serve the practice if there are ways of keeping it in correspondence with the changing requirements of the school system as well as the changing state of the anthropo-ecological crisis. For that reason most valuable proved to be the strategic planning and the force-field analysis.

Strategic planning (Kostova, 2003, pp. 82–91) is a process that is effective when it is well thought out (Table 5). In applying strategic planning in environmental education two approaches were used: planning from top to bottom and planning from bottom to top. The first approach was realized from the Ministry of Education and Science after an intensive research for the development of a National System of Environmental Education in 1989 and a Program for support of the introduction and strengthening of education for sustainable development in 2005. The second approach is taking place by means of post graduate qualification (life-long education). Teachers develop new programs to improve the EE in the classroom, carry out experiments to study their reliability and effectiveness and improve the school practice.

Table 5. Stages in strategic planning

Basic steps	Detailed activities in strategic planning
Determining the goal	Analysis of the situation and taking into account of all variables. A clear picture of the situation towards we want to go and about the situation in which we do not want to stay. Control of all the variables and increasing the security. Building up of rules to reach the goals. Keeping the rules in order to minimize the uncertainty.
Taking measures against deviation from the goal	Keeping away from unwanted position and state. Passing through different stages in the movement to the goal. Checking at each state that we are nearer to the goal.
Zigzag movement towards the goal	The movement to the goal in the social practice is never straight. The negative feed back governs the zigzag movement towards the goal. Introducing a system of negative feed back in social planning.
Positive feed back	Increasing the deviation from the goal Escalation of the situation which moves us away from the goal.
Correcting the goal – feed in	The deviation from the goal may show a need of correcting the goal. Correcting the goal: leaving one goal and formulating a new more perspective goal Using a negative feed back in moving towards the new goal
Setting the boundaries within which the goal should be reached	Setting clear marks (activities) on the road the goal. Choosing a leader to lead the movement towards the goal. Giving power to the leader to ensure the right movement to the goal.
Keeping the new situation	Avoid disagreements after reaching the goal by keeping to the boundaries. Taking measures to ensure the stability of the new situation when the goal is reached

Force-field analysis (Kostova, 2003, pp. 196–198) was used at every step in development of the model of EE. It is done by analyzing the forces that drive EE further and the forces that hinder its further development (Kostova, 2004, p. 5). The forces are classified into four categories: social, organizational, inter-personal and personal. Force-field analysis was used at different levels: at the level of State monitoring, of research, of school monitoring and of teacher planning and monitoring.

9. Criteria for EE evaluation (Kostova, 2003, pp. 200–202)

Three types of main criteria were used – environmental culture, environmental consciousness and environmental behavior, each of which was decomposed to less generalized criteria that can be measured. Environmental culture was assessed by assessing environmental knowledge and environmental skills. Environmental consciousness was assessed by assessing the motives, convictions and notions, attitudes and values, self-control, self evaluation and competences. Behavior was assessed by means of verbal and real activities, concerning the environment. When the term environmental is used we mean ecological and nature conservation in the sense of education for sustainable development. For each criterion validated tests were prepared. For each test the following characteristics were determined: reliability, validity, task difficulty, discrimination power and distracters' analysis. Using the method of expert evaluation the level of tests was determined according to Bloom's taxonomy of educational objectives.

10. Results and their interpretation

Summarized results are presented here. The scale of marking students' achievements at the test examinations is done according to Bulgarian marking system from two to six. If a student receives a mark 'two', that means failure at the examination. Highest achievement is marked by six in the national system for evaluation, but lowest achievement is market by three. The mark 'three' means that the examination is passed.

Table 6 shows that students' achievements are good and that they have acquired the basic knowledge in ecology and nature conservation. The achievements are highest at the first level, which requires recall and lowest at the level of synthesis. We should expect that the level of evaluation is more difficult and the achievements of students to be lowest at this level. The repeated tests by teachers in different grades confirmed our results. Further analysis of literature, especially the papers dedicated to Strategic Leadership and Decision Making[1)] in the discussion of critical and creative thinking and Bloom's taxonomy of educational objectives (Bloom, 1956) point out that the highest two levels are not very well distinguished. The level of evaluation (6^{th} level according to Bloom) requires critical thinking according to predetermined criteria. This kind of thinking is convergent. The process of synthesis requires creative thinking (divergent in nature) which is

more difficult for students. Further research is needed to prove this conclusion. Graphic presentation visualizes the results (Fig 4).

Table 6. Summarized achievements of students in the cognitive domain

Levels	Meaning	Mean value
I	Knowledge	4.83
II	Understanding	4.69
III	Application	4.62
IV	Analysis	4.54
V	Synthesis	4.34
VI	Evaluation	4.38

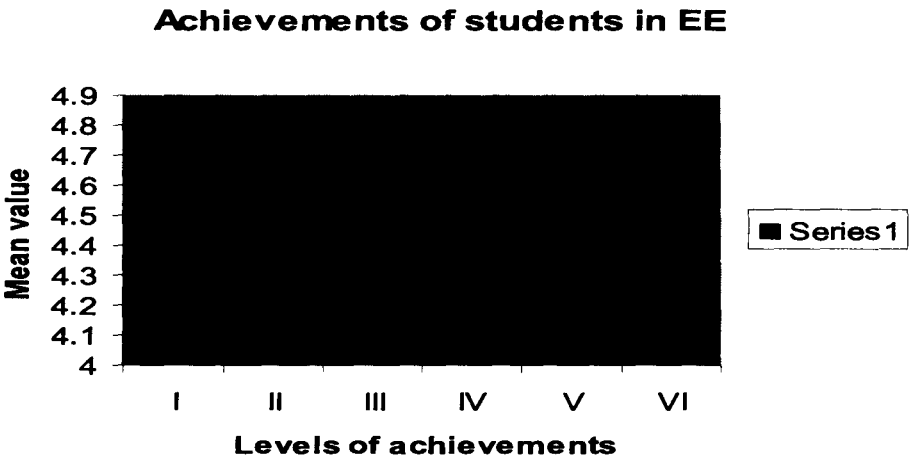

Fig. 4. Cognitive achievements of students in experimental EE according to levels of Bloom's taxonomy of educational objectives

The graphic presentation (Fig 5) shows that students in 10th and 7th grades get better marks. Our interpretation is that the results are very much connected with the compulsory biology school program. In the 7th grade students study ecological topics, such as biomes and biodiversity as well as protection of endangered species. They also study adaptations of animals to their environment. The studies integrate biodiversity knowledge of plants, obtained in the sixth form. The 10th grade summarizes the ecological and evolutionary knowledge obtained in the 9th and in the 10th grades. 11th grade

is dedicated to biochemistry, which is not connected with ecology and nature conservation. The results show that environmental education is very much dependent on the obligatory school syllabus.

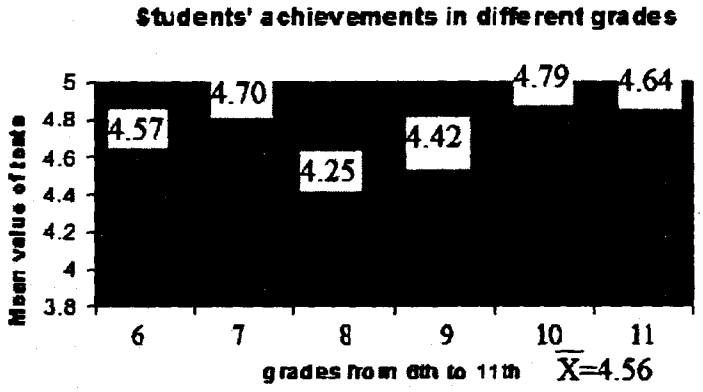

Fig. 5. Graphic presentation of achievements of students in experimental EE according to the obtained mean value of received marks at tests

In the 8th grade students study Biology of Man and the program is overburdened with facts, which hinder them in conceptualizing ecological knowledge and especially in connecting environmental and health education. No matter how seriously we try to organize integrated health-ecological education, the compulsory school program hinders the application of the EE model. The results from practical implementation of the model in facultative education show higher achievements of students (Table 7). We could not expect students to study only ecology and nature conservation because many other branches of science and human knowledge are also very essential but we would like them to be aware of the environmental situation and to care of it.

Table 7. Achievements of 8 grade students in facultative (optional) courses of EE

Cognitive levels	I	II	III	IV	V	VI	Mean value of levels
Mean value of results from all tests	5,86	5,36	5,06	4,80	4,76	4.86	5,11

In the course of experimental education students' skills were also assessed. We assessed intellectual as well as practical skills. The intellectual skills involved: decision making, providing evidence, description of habitats, giving opinion supported with arguments, use of intellectual maps, proving practical significance of knowledge, interpretation of tables and graphs, case analysis, generation of ideas, formulation of problems, formulating hypotheses, analyzing data, making conclusions, giving presentations, showing cause and effect relationships, giving proved answers, planning experimental investigations, evaluation of organism-habitat relationship, constructing prognoses about the consequences of human influence on ecosystems, etc.

The *practical skills* involved: identifying and classifying birds, conceptual map construction (intellectual maps), modeling, table presentation of data, plotting graphs, constructing experiments, using the stages of the scientific investigation properly, choice of conservation activity, explaining the relationship between organisms and their environment, determining the floors of a terrestrial ecosystems. Constructing food chains, food webs and food pyramids, constructing models of cycle of matter and flow of energy, taking care of animals and plants, making a botanical garden, cleaning the school and its surroundings, constructing bird homes, collecting recycled paper, etc.

The results from assessment of intellectual and practical skills are summarized in Table 8.

Table 8. Results from the assessment of students' skills in EE

Grades	6th	7th	8th	9th	10th	11th	Mean value of grades
Mean value of results from all tests	4.48	4.78	4.5	5.3	4.55	4.88	4.77

Conclusions

Environmental education is a new sphere of the pedagogical theory and practice with its own object, subject, methods and conceptual system. The innovative model of EE helps to redirect education to the values of culture and the interaction of philosophy, science, technology, ethics, aesthetics and pedagogy. The main conclusions of that paper should be:

1. The innovative model of EE has been applied in schools and evaluated;

2. Teachers use it to develop their teaching strategies using innovative approaches to EE;

3. The numerous tests and questionnaires in each grade prove its effectiveness in school practice;

4. The model is theoretically sound as it is based on modern pedagogical ideas and constructive arguments;

5. The model takes into account the new dimensions of learning and is directed to the development of the whole personality of students.

Notes

[1] Center for Strategic Leadership Studies, 2002. http://www.au.af.mil/au/awc/awcgate/ndu/strat-ldr-dm/cont.html

[2] Environmental Education: Possibilities and Constraints. *Connect* **27**, 1 (2002).

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