Project-Based Ecology Learning in Vocational Training

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Abstract: The article discusses project-based learning of ecosystems, biodiversity and pollution in a vocational school in Bulgaria. The teaching strategy based on interactive methods, information communication technologies, out-of-school observations, experiments and Power Point presentations versus teaching strategy based on lectures and information communication technologies were comparatively studied and the results were analyzed. Difficulties met by students and strategies for overcoming them were dealt with and described. The ecological concerns of students were surveyed using revised New Ecological Paradigm scale. The theoretical framework was based on constructivism, theory of multimedia learning, zone of proximal development and guided discovery.

Keywords: Ecology, information communication technologies, out-of-school studies, project learning, Power Point presentations.

INTRODUCTION

The problem of our investigation was in the poor state of the environment and the disengagements of students from its improvement. They needed personal involvement, emotional dedication and determination to have ecological goals and to pursue them to the end. They did not experience personal responsibility and they passively imitated the neglect of their surroundings by adults. Besides, they more easily united in destructive activities than in nature conservation work. The reasons for this situation we saw not only in the bad example set by community, but also in the teaching and learning process mainly represented by lecturing of teachers and memorization of facts and ideas by students as well as in the lack of controversial intellectual communication in the class-room on real environmental issues [1]. Therefore the aim of the investigation was the effect of project-based learning and practical solving of local environmental problems on environmental literacy and environmental responsibility of students. The experimental teaching model was based on interaction of discovery learning, zone of proximal development and information communication technologies. The preparatory work was done in the following successive steps:

1. Theoretical analysis of academic literature on constructivism, advantages and disadvantages of its practical application in different teaching models;

2. Theoretical analysis of information communi-cation technologies and their challenges in project-based learning of ecology;

3. Analysis of types and structures of ecosystems around the experimental school and the ecological problems, created by town inhabitants.

4. Analysis of school curricula, achievement standards, textbooks and teachers' guides in order to construct a teaching model directed to development of environmental literacy and environmentally responsible behavior.

5. Construction of the teaching model and investigation of its advantages and disadvantages in the real educational practice of a vocational school.

THEORETICAL FRAMEWORK

Information technologies have penetrated into all aspects of life and have created a virtual environment in which many students spend a lot of time. Scientifically-based use of contemporary ICT in education is under investigation of many authors. Some of them study their capacities for mental development and enhancing achievements of students [2]. Others are interested in the use of ICT in the classroom [3], considering the development of personal strategy for successful learning [4-6]. Use of ICT in education is closely based on cognitive theory of multimedia learning [7], which explains how technology helps learners in acquiring of new knowledge. It is based on the understanding of information processing by means of two distinct systems – one processing visual and the other processing verbal information [8].

Principles of multimedia learning [9] increased the efficiency of the theory and gave impetus to new theoretical and empirical investigations [10-14]. The contributions of the theory authors see in various

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aspects: flexibility of learning allowing learners to study when they have free time from work, modular learning that gives a learner the ability to choose modules for study, parallel learning with professional development, use of wide range of information sources, economical use of time and money, etc.

Cognitive theory of multimedia learning is criticized for the dual coding approach. In learning a multisensory approach is more effective: besides eyes & ears, other senses as touch, smell and taste are also employed. The overloading of multimedia presentations with attractive details destructs their attention and reduces the effect of learning [15, 16].

According to constructivists, learning is an active process of constructing knowledge by learners rather than acquiring it. Learners interact with reality as they work with objects, discuss problems, reflect on contradictions and make experiments, which help them not only to understand the matter but also to remember it. Many models of learning are based on constructivism. They have common philosophy but differ in their nomination and technology of application, for example: discovery learning, problem learning, inquiry learning, scientific approach to learning, simulation learning, case or incident studies, zone of proximal development, etc. according to the dominant method [17-23].

Opponents of constructivism think that its shortcomings are due to the disability of human mind to process a large amount of information without cognitive loading of memory. Discovery learning suffers from attention deficit, didactic tension, lack of enough time for inquiry activities, etc. [24, 25].

Constructivists do not deny guided discovery. Students have no time to walk through all the difficulties scientists have passed in discovering new knowledge. They will have to do it in a limited span of time and learn simultaneously a proper ratio between science as a system of knowledge and science as a system of procedures. That can be put into practice in the classroom studies by means of team teaching, where the team is composed of students with different intellectual abilities.

PRACTICAL FRAMEWORK

The results from the theoretical analysis of the academic literature, concerning the proponents and opponents of multimedia learning, constructivism and discovery learning, we used for the construction of specific requirements to teachers, learners and context in a successful project-based learning with ICT

Modern understanding of teachers' role in education advocates the promotion of cozy environment and creative learning activities of students [26].

Table 1: Five-Component Model of Ecological Consciousness = Environmental Literacy

Cognitive component
Consciousness of the need to be informed: basic knowledge of natural systems**,** ecological knowledge and knowledge for protection of human health and quality of the environment (facts, concepts, laws and relationships, unifying ideas, hypotheses, theories, prognoses, scientific picture of the world), knowledge of contradictions between society and nature (SSI – socio-scientific issues), global and local environmental problems, knowledge of the structure of the biosphere as a unified planetary organization of life;
Value component
Consciousness of the need to be able to arrange values in priority: foresee the consequences from a given activity; understand personal and societal environmental value systems; look at nature as a system of its own value; ecological equilibrium and health as values; human needs, values and goals; environmental ethics; world outlook of society; human moral categories and behavioral norms. Values of natural objects: ecological, scientific, historical and cultural, esthetic, recreational, healing.
Normative component
Consciousness of duty and responsibility: readiness for experimentation and analysis of alternative solutions; personal and social activities for protection of natural harmony and beauty; self-evaluation of activities from the point of view of moral values and ecologically rightful behavior; obeying the role of laws and religion; overcoming the wrong understandings of the unlimited power of humans over nature; keeping regulations and standards for ecologically sound and healthy behavior; taking into account ethical and responsible solutions, having trans-boundary consequences.
Action component
Consciousness for capacity of action: effective participation in team activities and solution taking for preventing the occurrence of environmental problems and for solution of existing problems; obeying and spreading the global humanity understanding of human being-nature and society-nature relationships; interdisciplinary understanding and action with respect to modern environmental crisis; participation in environmental activities in a risky society, suffering from economic, social and value crises.
Control (feedback) component
Consciousness for capacity of management: cognitive, intrapersonal and interpersonal skills; self-control skills; skills for making good influences on other people; effectiveness of nature conservation and environmental education activities; control and self-control (feedback), self-reflection; internal and external assessment and evaluation of students achievements in environmental education.

Discussions of educators on the advantages of learning through concept construction *vs*. memorizing definitions have not found strong practical solutions yet. Both textbooks and organization of educational process favor declarative learning. The use of ICT in a didactic system that gives priority to construction of knowledge and development of cognitive capacities proposes solution to the problem.

Theoretical analysis was necessary for studying and summarizing the views on environmental consciousness and for constructing a working model (Table **1**).

Environmental education (EE) is well situated in the Bulgarian educational system with the development of the new State Educational requirements. Biology is most suitable for teaching fundamentals of ecology and environmental principles. A whole chapter is dedicated to ecology and nature conservation in 9th grade biology. Environmental problems are introduced in all school subjects, having priority in the Cultural Educational Area “Natural sciences and ecology”, (KOO in Bulgarian), using the infusion and interdisciplinary approaches [27-29], whose shortcomings we tried to diminish when constructing the teaching module.

The biological courses of both 9th grade (population and species level of biodiversity) and 10th grade (genetic level of biodiversity) are compulsory and develop the basic ecological and environmental concepts. In the 11th and 12th grades only some students choose biology courses. Therefore the efforts in the development of interactive-enhanced and project-based studying of ecology using ICT were preceded by content analysis of the biology programmes and textbooks of the 9th grade (Table **2**). The concept structure was studied and concept maps of each topic of the ecological chapters were developed. Then the opportunities of the context, provided by the school resources and the neighbouring environments for involvement of students into active studies and solutions of real environmental problems were analysed.

Local background of the experimental school:

Students involved in the investigation, lived and studied in the town of Dupnitsa, situated in southwestern Bulgaria in the valley of the river middle Struma along the river Djerman. All types of ecosystems are at a glance: river ecosystems, river bank ecosystems, forest and mountainous ecosystems, meadows and marsh ecosystems. The beautiful mountainous and hilly scenery is severely affected by pollution and floods, especially in periods of heavy rains. The capacity of draining shafts is not enough to absorb all the rains water, which runs into people′s

Table 2: Contents of the chapter “Biosphere” in the 9th grade biology syllabus for compulsory (first figure) and extended biology studies (figure in brackets). The figures indicate the school periods allocated for studying the topic. Each school period lasts 45 minutes

Core	Topics and school periods	Opportunities for introducing biodiversity concepts and problems
Biosphere – 9th grade	1. Levels of biological organization: 1 (2)	Constructing the meaning of biodiversity concept on three levels: genetic, species and ecosystem.
	2. Ecological factors - theory: 3 (4) and practical exercises (2)	Distribution of biodiversity in time and space. Ecological significance of biodiversity. Direct significance of biodiversity to humans. Local and regional state of biodiversity and factors reducing it.
	3. Populations – theory: 2 (4) and practical exercises 1 (4)	Populations’ structure in space, age, sex, and behavior. Population properties and dynamics. Genetic diversity, adaptations and stability. Methods of studying. Threatened populations. Factors causing extinction and methods for protection. Local populations near the critical minimum for extinction.
	4. Biocoenoses – theory: 5 (6) and practical exercises 2 (4)	Species diversity, positive and negative intra and interspecific interactions and ecological equilibrium. Ecological niche. Morphological and physiological structure. Ecological pyramids. Methods of studying biotic factors (interactions).
	5. Ecosystems – theory: 3 (10) and practical exercises 2 (4)	Ecosystem diversity. Significance of the evolutionary process. Cycles of matter and flow of energy. Productivity, succession and climax. Biodiversity and ecosystem stability. Methods of studying ecosystems. Habitats protection.
	6. Behavior – theory: 2 (4) and practical exercises 1 (2)	Ecological aspects of behavior. Individual and social behavior of animals. Methods of studying it. Environmental imperatives for human behavior.
	7. Biosphere – theory: 5 (8) and practical exercises 3 (4)	Structure and boundaries of the biosphere. Biomes. Ecological equilibrium and anthropogenic impact. Sustainable development. Place of humans in the biosphere – biological and cultural diversity. Humans’ health. Stress and adaptation. Population numbers. Human population growth and environmental consequences. Biodiversity as a global environmental problem.

homes, underground garages and cellars. The situation becomes worse because of erosion of river banks, silting and throwing solid wastes in the river basin. Pollution from business, industry and households also increases. Trapped cars in the flooded areas block roads and cause traffic jam, which threatens human lives.

The state of nature in the vicinity of the town of Dupnitsa is deteriorated. The most acute environmental problem is pollution of water, soil and air. Main industrial buildings are situated in two areas – north and south outside the residential area except two of them concerned with textile and shoe production. Each factory is equipped with a pure water source and waste water purification system, but some small factories throw their waste waters directly into the river that flows through the town. Thus different solid and fluid wastes go into the river: oil substances, organic solvents, plastic materials, etc. River pollution is aggravated by wastes from residential areas. Thermal, chemical and physical pollution threatens agriculture, human health and biodiversity of the local ecosystems.

Environmental values have been seriously neglected lately. The heavy environmental problems could be solved only by means of integrated actions of leaders, businessmen and the rest of the community. Students and their parents are a strong part of the makers, sufferers and managers of pollution problems. We were guided by the idea that students could understand ecology and ecological problems if they experienced them on their own lives, if they became aware of their personal dependence on them and saw the consequences of human activity in their own habitat. We expected them to become convinced in the negative human impact on nature and stimulated to take actions in protecting and improving it. Because of that, project-based studying of ecology on the background of local environment and community created problems, we considered very important.

METHOD AND MATERIALS

Information skills that students should possess were: Internet, Microsoft Word, Microsoft Power Point and Microsoft Excel. Technological requirements to the classroom: computers, access to internet, LCD projector, list of recommended web-sites, equipment for outdoor ecological experiments.

The school was chosen for its significance in vocational training and for the complex ecological and environmental resources in the close vicinity. Most of the students go straight to work after finishing school and exercise direct interaction with nature and its resources. If they possess poor environmental literacy, they will damage the environment. Besides, they have to know how to prevent the environment from human impact and how to cope with already created environmental problems.

All the students (Table **3**) were involved in the experimental learning, but the students for assessment were chosen by chance.

Students' environmental literacy was assessed before the experimental teaching (Figure **1**). Students were divided into two groups – one experimental (E) and one control (K) group. Experimental teaching occupied 35 school periods, each of 45 minutes, followed by interactive school conference on local environmental problems at which students from the experimental group presented their findings using Power Point Presentations and photo-sessions. Students from the experimental group organized practical work for cleaning river banks and planting trees. All students attending the school conference were invited to participate in the nature conservation practical work voluntarily. Then students' achievements were assessed using achievement tests, attitude questionnaires, checklists and observations.

The experimental model of ecology learning (Table **4**) was based on the 9th grade biology syllabus (Table **2**) with reorganization of school periods and introduction of interactive strategies, represented mainly by project field work and ICT.

Preliminary Work

Formulating the problem for students` learning (How does human activity affect interactions of organisms in

Table 3: Sample of students from the experimental vocational school "Acad. S. P. Corolev", town of Dupnitsa, Bulgaria; E – experimental group (project-based learning & ICT); K – control (ICT), N – number of participants; n – number of assessed students chosen by chance

Years	N	n	Groups	Experimental classes in vocational training (Future professions)
2010 - 2012	104	80	E	9^{d} Information technologies in economy; 9^{b} Economics & management
	104	80	K	9^{a} Industrial electronics; 9^{c} Electronics equipment

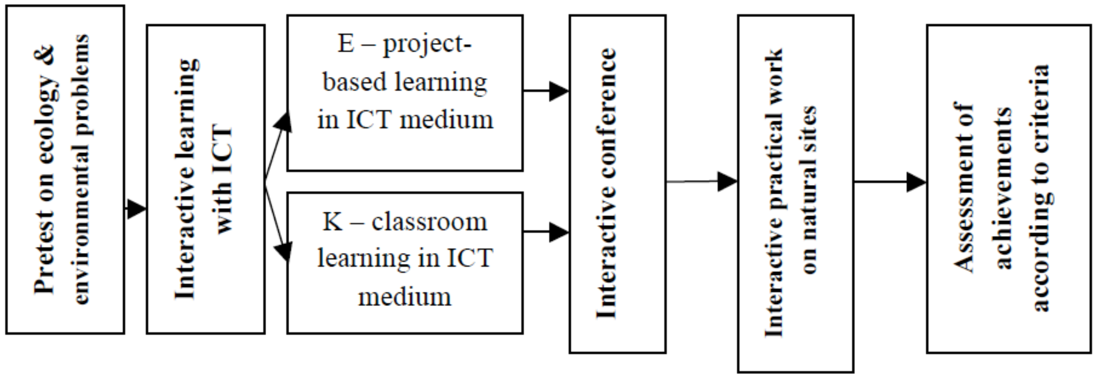

Figure 1: Design of the experimental studies.

Table 4: Allocation of school periods and activities in experimental and control groups

Interactive strategies	Interactive techniques	E	K
1. Interactive seminars	Discussions, multimedia presentations, concept mapping, questions and answers, reflexive communication.	9	19
2. Lectures	Punctuated lectures; brainstorming on the blackboard, demonstration of pictures of ecosystems, biodiversity and pollution,	2	10
3. Laboratory exercises	Biological, chemical and physical pollution tests	6	2
4. Project field studies	Field experiments & observations, briefing and debriefing, collaboration, team work, scaffolding, Power Point Presentations, data presentations, photo-sessions, reflection	14	
5. ICT learning & practice	Poster presentation, data processing, web-based learning, team work, concept map presentation	4	4
6. Interactive conference	Power Point Presentations, photo-sessions, discussions		
7. Interactive practical work	Planting trees and cleaning		

the local river ecosystems?), designing and explaining the objectives of learning based on State standards, performing content analysis of textbooks and constructing concept maps on basic ecological topics, designing the didactic technology with three basic elements: interactive educational technology, education for sustainable development and integrative ecological concept on biodiversity. All participants answered pre-test questions on ecology, river ecosystems and pollution and each of them received a list of recommended internet sites for on-line information from the teacher. Students were divided into two groups: E – interactive teaching during on-site project work, in the laboratory and the computer room and K – interactive teaching in the computer room.

Teaching Methodology in the Experimental Group. Preparation for the Project

Introductory session was held acquainting the students with the methods for searching and preparing a bibliography, making a plan and a timetable for the project development, clarifying the aims and objectives, working out the organization and technology of the study. End products (PP presentations, photo session, survey charts and diagrams, reports, concept map presentations) of the investigation, criteria for their evaluation and rules for team work were discussed and accepted. Students were divided into working teams of 7 people, each one being assigned a role to play in the group: ecologist, botanist, zoologist, hydro-biologist, microbiologist, chemistry specialist and sociologist. Then new teams were organized with people for each role: a team of ecologists, a team of botanist, etc.

Each team developed a work sheet: a list of the tasks, prepared and sorted out the needed materials and equipment, worked out a time table for the sequence of investigation. In a briefing session each team demonstrated and explained its role in the project development. The working groups visited two places – before and after the town for gathering the required data.

Work on the Site, Data Collection, Registration and Interpretation

Abiotic factors (dissolved oxygen, pH, biochemical oxygen demand, temperature, total phosphate, nitrates, turbidity and total solids) were investigated by *chemists*. *Microbiologists* studied fecal coli form, water and soil contamination. *Botanists* and *zoologists* investigated plant and animal biodiversity on the river banks. *Hydro-biologists* identified some hydrobionts and worked out food webs for water ecosystems. *Ecologists*, using the data from the other groups elucidated the interaction of organisms, evaluated the impact of pollution on biodiversity. *Sociologists* prepared questionnaires for studying the awareness of people living around these ecosystems or visiting them for recreation. All groups worked out the problems for preparing a multimedia company for river ecosystems sustainable use, in order to spread information and broaden the environmental culture of the population along the river.

Debriefing session was carried out after the first visit to the working sites. Students discussed the results and the problems of each team and formulated new tasks for collecting missing information. A second and a third visit to each site was executed each with an interval of one month and the investigations of the ecosystems were completed.

Work in the School Laboratory, Data Analysis and Clarification

Specimens of water were investigated, identification of organisms was completed using keys, samples and photographs. *Sociologists* analyzed and interpreted the results from the survey and made conclusions about people' susceptibility to and responsibility for the quality of the environment. Brief reports on the research, its results and conclusions of each team were prepared. A time table for the school conference was created. Sociologists made appointments with leading persons in the town (Mayer, municipality, experts from the regional institutions for water and environment monitoring, environmental societies, local newspapers, local radio and TV representatives) and invited them to the school conference.

Teaching Methodology in K Group

Preparation

The teacher prepared lectures on ecosystems, biodiversity and water pollution, using interactive techniques. Students received a list of checked internet sites and bibliography to look through at home and in the computer room. Rules for work in small groups and participation in lectures and interactive seminars were discussed and adopted.

Lectures on river ecosystems took place in the computer room. The teacher used concept maps, Web-based GIS maps and Google Earth visualization to attract students` attention and to help them understand better the concept maps. Oral clarification and visualization of each concept and its associations was done by asking questions and involving students in short discussions about pollution and about the solution of the problem. Students worked in group of two. After posing a question they were given one minute to share the answer between each other and then with the rest of the class. The concept map presented by the teacher contained 5 clusters of concepts on river ecosystems: 1) Types; 2) Characteristics of biotopes; 3) Characteristics of biotic communities and biodiversity; 4) Pollution; 5) Sustainable use. A final discussion summarized the conclusions from the lecture, and students were asked to broaden and re-enforce their knowledge using the textbook and on-line information as homework. They were encouraged to prepare their own concept maps after the example given by the teacher.

Then one and the same post-test was administered to the two groups – E and K. Later on joint activities among the two groups were organized and led by the experimental group:

1. School conference: presentation of power point slides and concept maps, made with the aid of computers, photo-session, presentation of a list of recommendations for the improvement of the state of the river ecosystems and their sustainable use.

2. Voluntary practical work for the improvement of the river banks. Participants in it sought help from the Municipality and the two Regional centers of forestry and the national park. They took part in removing solid wastes along the river banks and planted trees.

3. Students` were awarded certificates by the school administration and the Municipality.

RESULTS AND DISCUSSIONS

The achievements of students in the two groups were assessed using adequate criteria and methods (Table **5**).

All students` products were assessed and evaluated: post-tests, Power Point presentations, photo-session exhibition, food webs, concept maps,

Table 5: Criteria and Methods for Assessing Students' Achievements

Criteria	Indicators	Methods
Knowledge	Achievements according to Bloom's taxonomy of educational objectives	Achievement tests, verified for reliability and validity
Skills	Planning & performing outdoor experiments	Analysis of observations and assessment of results
	Power Point Presentations	Assessment of projects and concept maps and their presentation
	Collaboration	Analysis of observations
Attitudes	Verbal concerns for nature	Questionnaire of Dunlap *et al*, 2000;
	Real participation in nature improvement	Practical work in cleaning and planting

participation in the team work, responsibility and productivity in the practical work, behavior and participation in the preparation and performance of the conference. Each team received evaluation of its work from peer groups (peer review writing). The students wrote evaluation remarks on a blank poster. The teacher allotted individual mark for each work and for each student. Students' achievements were evaluated using 5-point scale: from 2 being the lowest and 6 as the highest mark Figure **1**.

Students' *knowledge achievement* was lifted at a higher level in both groups as a result of the teaching model (Table **6**). Project-based learning was more effective, the difference between pre- and post-tests of the E group was higher, 23.78 versus 20.03 for K group.

The results, analyzed according to taxonomy of educational objectives also proved the advantages of project-based learning of ecology. The trend from the first school year continued during the second year of the experiment (Table **7**).

Skills' developments were assessed in three ways. The skill for planning and performing outdoor experiments was analyzed using observations according to beforehand prepared checklist with the following rubrics: details of planning, precision of observations, correctness of experiments, data registration and presentation, and data interpretation. It was used only for the experimental group as with the control group outdoor activities were not carried out. The results were analyzed qualitatively and quantitatively. At the end of the school year 2011 the mean value of students' achievements (*M = 4)* was lower than the mean value at the end of school year 2012 *(M = 4.5),* the highest expected being 6. That was a sign of the need to rethink and improve the outdoor project-based learning by paying closer attention to the investigated problems and the degree of guidance. Internet connection using e-mail addresses and Skype was improve, so that students could send their questions by mail and quickly receive the answers.

The specific criteria for assessing presentations were: structure (successive and logical arrangement of all components), completeness (presence of all necessary components – topic, authors, summary, method, results, interpretations, conclusions, references), scientific correctness (correct formulation of the investigated problem, correlation between problem, tasks, experiments, results and interpretations, right interrelations between concepts), objectivity (results had to be obtained from experiments and observations) and proof support (conclusions should follow from experimental results). Those criteria were set in collaboration with students, so that they

Table 6: Statistical Analysis of the Results from the Pretest and the Posttest of both Experimental and Control Groups

Test	Groups 320 answers	Marks					Statistical analysis							
		2	3	4	5	6	*M*	*Me*	*Mo*	*S2*	*SD*	*V*	$S_{\bar{x}}$	T test.
Pre-	E	120	137	28	20	15	2.97	3	3	1.13	1.06	35.56	5.92	23.78
Post-	E	17	21	40	95	147	5.04	5	6	1.32	1.14	22.61	6.37	
Pre-	K	115	155	22	15	13	2.92	3	3	0.97	0.98	33.56	5.48	20.03
Post-	K	33	30	45	74	138	4.79	5	6	1.83	1.35	28.18	7.55	

Statistical differences between E and K from the pretest are insignificant: $t(120) = .61$, $p < .05$.
Statistical results between E and K from the posttest favor the experimental group: $t(120) = 2.52$ $p < .05$.

Table 7: Students' achievements analyzed according to Bloom's taxonomy of educational objectives and compared by the Mean *(M)* of the results

School year	Bloom's educational objectives	E		K	
		Pretest	Posttest	Pretest	Posttest
2010/2011	Knowledge	2.97	5.07	2.82	4.92
	Understanding	2.75	5.06	2.76	4.90
	Application	2.95	5.07	2.95	4.82
	Analysis	2.91	5.11	2.81	4.80
	Synthesis	2.90	5.05	2.75	4.90
	Evaluation	3.05	5.25	2.71	4.91
	Mean *(M)*	**2.92**	**5.11**	**2.80**	**4.87**
2011/2012	Knowledge	2.82	4.92	2.95	4.95
	Understanding	3.00	5.08	2.70	4.71
	Application	2.95	5.05	2.92	4.72
	Analysis	3.00	5.01	2.91	4.66
	Synthesis	2.83	4.93	3.00	4.78
	Evaluation	3.10	5.28	2.96	4.95
	Mean *(M)*	**2.95**	**5.04**	**2.90**	**4.79**

knew beforehand what was expected from them. Mean result for the experimental group for Power Point Presentation was lower at the end of the first year of experimentation *(M = 4.42; SD = 1.19)* than at the end of the second year of the experiment *(M = 5.20; SD = 1.08),* the highest expected result was 6.

Assessment of concept maps was done using the following criteria: correct structure, classification and hierarchy of concepts, logical connections between them, degree of finalization, clearness of visualization, compactness of information, esthetics. Concept mapping was used in K group and the results were *(M = 4.31; SD = 1.16)* and *(M=4.63; SD = 1.12)* for the successive years respectively.

The interactive learning allowed students to collaborate in the process of preparing the products of their interaction – PPP and concept maps. A longitudinal experiment is necessary to obtain firm results about skill development in the two learning strategies. Both skills proved to be difficult for students. Exercises and repetitions were needed. Both activities were new to the students and in spite of the difficulties, they met them with enthusiasm for two reasons – first for being new and second for being a real product from their work, a product they were able to see and use. Some of the difficulties for PPP were: formulation of own thoughts and writing them, distinguishing between materials and methods, registering and working out of data, preparing tables and diagrams. Drawing conclusions was not easy either. Nevertheless learning was overcoming of difficulties, which in their turn facilitated remembering. Working in teams proved to be very useful in coping with difficulties as students backed one another and felt more confident. To use and cite references and to express gratitude to consultants had to be learned as well.

Students constantly sought help from their teacher in informatics and thus developed their ICT skills. Outdoor experiments were time consuming and needed equipment. Each team kept a portfolio for documenting their work. Slide arrangement and writing concise and essential information for each one needed help and discussion. In some presentations slides were more than necessary, but in others – were not enough. The structure and colour design were a challenge. Mistakes in construction of food webs and structure of communities had to be corrected. Nevertheless project-based learning developed a realistic outlook of environmental problems.

Unexpected problem was the shyness of some students to present the products of their work. They experienced fear from publicity. So far we had not met studies dealing appropriately with this problem and we thought that it was simply overlooked. It was not correct just to accuse the student of experiencing this difficulty. Time and effort were spent to help those students to overcome it. First they were helped to share their thoughts and presentations in their team, then in front of the class and after that at the school conference. It was necessary to organize the development of mini projects and their presentation at a well-known public for the first time. The attended problems were the style of presentation, the practice of acquiring it and personal support for development of self-confidence. In this case coaching was indispensable. Project-based work was valuable in enforcing the ability of students to rely on their own and to develop their personalities.

In concept mapping other difficulties were challenging: analysis of the topic in the textbook in order to underline the concepts and look for relationships (students were not very fond of reading), analysis of information from internet sites (the sites had to be critically analyzed first by the instructor, students preferred to play computer games than to read and analyze verbal information). The trend in education to assess students using tests, requiring short answers, caused verbal skills to remain rudimentary. Extra help and motivation was necessary. Reading the textbook (more than once) and structuring the concepts by students was more effective than the use teacher's concept maps. The concept map provided schemata of structured knowledge [30]. The use of colored pencils stimulated interest and development of esthetic requirements. Some students constructed concept maps on the computer and looked for visual effects to make them dynamic. Concept map analysis with teacher participation disclosed misunderstandings that posed questions and provoked discussion for correcting them. Difficulties were met in determining the key concepts with which to start building the map. Concept mapping had a heuristic effect because students discovered new relationships between the concepts. The uncommon, innovative learning attracted attention.

Students' skills for collaboration were analyzed using a checklist with indicators (Table **8**).

The characteristics "readiness" and 'activity" indicated that students were able to participate consciously in the studies organized by the teacher and the school. They responded positively and creatively in pursuing their goals. These two characteristics were essential for communication between participants – to associate together and communicate knowledge and propositions for work. The characteristics "precision" and "tolerance" indicated abilities of self-control, respect to others' opinion and responsibility for learning. They also showed ability to control emotions and give chance to positive feelings. The characteristic "behavior" showed ability to regulate activities concerning nature, learning and team participants [31].

Verbal concerns of nature were investigated using a direct self-report method. A self-administered survey questionnaire was offered to students to collect the necessary data. The survey questionnaire was revised NEP translation in Bulgarian [32] and has 15 polar statements of Likert items scale, measuring commitment to DSP and NEP.

Each student was allotted 30 minutes time to read the statements and to rate the extent to which they apply to him/her. The survey was repeated after a period of two months.

Higher score indicated pro-NEP view (Table **9**). Reliability of the scale was determined by Pearson correlation coefficient of test and retest. Means of pro-NEP (odd items) and pro-DSP (even items) were calculated. Each item was measured on a scale, ranging from 1 to 5. All pro-NEP responses were expected to be relatively high scores and all pro-DSP responses to be relatively low. The eight odd numbered items indicate pro-NEP attitudes and therefore responses were scored as 5 – strongly agree, 4 – mildly agree, 3 – undecided, 2 – mildly disagree and 1 – strongly disagree. The seven even numbered items

Table 8: Results from diagnostic observation using a checklist with beforehand accepted indicators

Groups	Indicators for observation					
	Readiness	Activity	Precision	Tolerance	Behavior	Mean *(M)*
K 2011	0.72	0.80	0.54	0.52	0.75	0.67
ЕГ 2011	0.77	0.86	0.73	0.64	0.80	0.76
Mean *(M)*	**0.75**	**0.83**	**0.64**	**0.58**	**0.78**	**0.72**
K 2012	0.88	0.89	0.86	0.77	0.88	0.86
EG 2012	0.90	0.95	0.92	0.86	0.89	0.90
Mean *(M)*	**0.89**	**0.92**	**0.89**	**0.82**	**0.89**	**0.88**

Table 9: Attitudes to nature showing students' concern for its state at the end of school year 2011

Dimensions of attitudes	Items	*M*	*SD*	Modal rank; positive
Limits to growth; r = .98	1,6,11	3.07 T 3.14 RT	1.19 1.08	34.13 SA + 27.80 A = 61.93 33.61 SA + 30.02 A = 63.63
Anti- Anthropocentrism; r = .78	2, 7, 12	4.20 T 3.83 RT	1.00 1.04	27.47 SD + 21.15 A = 48.62 26.82 SA + 23.25 A = 50.07
Fragility of nature's balance; r = .77	3, 8, 13	3.93 T 3.98 RT	0.86 0.91	29.31 A + 25.95 SA = 55.26 29.48 A + 22.65 SA = 52.13
Rejection of exemptionalism; r = .92;	4, 9, 14	3.31 T 3.39 RT	0.91 0.95	29.42 SA + 26.87 A = 56.29 29.92 A + 23.78 SA = 53.70
Possibility of an eco-crisis; r = .96	5, 10, 15	4.16 T 4.29 RT	0.98 0.94	45.77 SA + 18.95 A = 64.72 45.47 SA + 21.26 A = 66.73

Legend: T, test; RT, re-test; SD = Strongly disagree, MD = Mildly disagree, U = Unsure, MA = Mildly agree, SA = Strongly agree; *M* - mean Likert scores after adjustment for direction; *SD* - Standard Deviation.

indicate pro-DSP orientation; therefore the scores were reversed for them for the statistical analysis.

The students least understood the first dimension, limits to population growth. They did not accept that the human population growth is approaching the carrying capacity of the biosphere (Table **9**). One reason for that may be the fact that the town of Dupnitsa is underpopulated, another – because many people left the country as well as their houses empty and went abroad to earn their living, and still other, because the population growth curves and the carrying capacity concepts are not well represented in the ecology topics of the school curricula. The scarcity of natural resources was also unclear to students. Apparently they expected scientists to discover new ways of using nature (technocentrism). The model of the earth as a spaceship was unclear for them and difficult to grasp. The unintended side effects and domination of power, shaped by the globalization of capital and risks at the beginning of 21st century, were concepts beyond students grasping. They still had to think about the finite level of natural resources and the constraints of biophysical environment on human activity. But the inequity and inequality of human use of natural resources and other values of nature should also be considered as explanation of the results.

Mean scores for central tendency and frequency analysis for evaluation of distributions were used separately for each specialty and for the test and retest (Table **10**). Summary indexes were calculated in order to determine the overall environmental orientation. Two types of summary indexes were constructed: a) a summary distribution index for each item and for each of the four specialties; b) a summery distributions and means for each dimension of the scale.

The survey was repeated at the end of school year 2012 with students in 9th grade that underwent project-based learning throughout the school year and with students in the 10th grade that studied ecology the year before and in the school year 2011/2012 studied heredity and variation, evolution and origin of life. They continued their project-based learning on the problems of biodiversity. The results showed tendency to increased pro-NEP orientation (Table **11**).

There was not marked change in the pro-NEP orientation, although the positive trend was detectable. The attitudes to ecological crisis were markedly positive. They were and continue to be provoked by nature pollution, ecosystem degradation, resources depletion and biodiversity impoverishment. This situation stimulated students' attempt to do something good to natural balance. Greater pro-NEP orientation of

Table 10: Attitudes of students having different vocational training

Professional training	Electronic equipment (K)	Industrial electronics (K)	Economics and management (E)	Information technologies (E)	Mean *(M)*
Test	3.58	3.61	4.06	4.16	3.85
Re-test	3.62	3.52	3.90	3.93	3.74
Mean score *(M)*	3.6	3.56	3.98	4.05	3.79

Table 11: Attitudes to nature showing students' concern for its state at the end of school year 2012

Dimensions & statements: odd (pro-NEP); even (pro-DSP)	9th grade		10th grade	
	E	К	E	К
1. Limits to growth: 1, 6, 11	4,32	2,55	4,55	2,76
2. Anti- Anthropocentrism: 2, 7, 12	4, 34	3, 52	4, 58	3,3
3. Fragility of nature's balance: 3, 8, 13	4,19	3,43	4,44	3,45
4. Rejection of exemptionalism: 4, 9, 14	4,1	3,07	4,44	3,19
5. Possibility of an eco-crisis: 5, 10, 15	4,54	3,85	4,71	4,26
Mean score *(M)*	4,30	3,28	4,54	3,39
Mean score *(M)* for E and К	E = 4,42 ; К = 3,34			

students from Economics and management and Information technologies might to some extend be due to the professional training. Further studies are necessary in this respect.

The study has some limitations due to: the sample was small, the survey of students was carried out in the biology classroom, the assessment of attitudes was verbal and the questionnaire did not contain all attitudes to nature. Other instruments and scales could also be used for comparison of results.

In spite of the limitations, the results proved the advantages of the project method based on out-of-door experiments, team learning and using ICT technologies [33-35]. The study also disclosed the shortcomings and directed us to improvement of the teaching-learning strategy [36]. Big changes in environmental attitudes could not be expected in a society and humanity in which DSP dominates. Students tried to maneuver by replacing strong attitudes with uncertainty, acting on the side of caution. Nevertheless they demonstrated positive attitudes to their environment, which was due to the teaching model. Improvements of the school curricula, placing greater emphasis on the ecological concepts and their relations to everyday life as well as on the new interactive constructivists teaching strategies, proved to be very efficient.

Strategies of ecology learning should be changed so that students learn from real life and not only from textbooks and lectures [37]. Systematic assessment of students` attitudes and development of practical skills should also be taken into account.

CONCLUSIONS

The model of project-based learning of ecology using interactivity and ICT promotes ecological education, raises the level of ecological knowledge and helps in the orientation of students to NEP (New Ecological Paradigm). Interactive teaching in the control group also favors ecological education. The higher achievements in E group in comparison with the K group in respect to acquired structured knowledge, development of environmental attitudes and communication skills was due mainly to project-based ecology learning in the open through studying natural ecosystems. Learning in context and "reading from the book of nature" helped students to understand the real state of environmental problems due to the negative human impact. Participants in this group developed skills for performing ecological experiments and obtaining first-hand evidence.

Interactive ecology learning and solving complex real environmental situations proved that students should be trained for team work and productive cooperation with others. Ecology learning through constructing a real product (PP presentations, posters and concept maps construction) was met with interest, motivated students and engaged them in cognitive activity without any compulsion.

Public presentations following several mini projects presentations at a small and known audience helped students to cope with shyness and stress from publicity and to develop self-respect and confidence. This approach even made presentations emotionally rewarding. Learning in the two groups contributed to overcome learning by heart and remembering a large amount of information without understanding it.

Students' skills for cognitive collaboration were difficult to build up and required time and consistence in adequate learning environment. Integration of techniques for ecosystem studies in local environments proved to be valuable for productive learning. Students participated in long-term studies of the local river and developed responsible environmental behavior. Project-based interactive ecology learning using ICT promoted development of environmental literacy (Table **1**) and conscious responsibility in all its components: knowledge, skills, emotions, activities and management [38].

The questionnaire for studying students' ecological concerns proved to be easy to apply and effective to obtain reliable results. Using such a scale in schools gives information about the missing aspects of environmental education (EE), which should be attended properly on sound theoretical and practical grounds.

Practical work for cleaning the river banks and planting trees was important for improving the quality of the environment and for awakening the sense of social responsibility [39].

In project-based ecology learning students were able to: use different sources of information, prepare a list of references, surf in internet, visualize object and processes, label illustration, develop projects, construct posters and concept maps with a computer, work cooperatively and productively, prepare, present and defend presentations, make and arrange photo-sessions.

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