DEVELOPMENT OF ENVIRONMENTAL LITERACY BY INTERACTIVE DIDACTIC STRATEGIES

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Abstract. The purpose of this study was to find out the influence of interactive and on site teaching strategies on environmental literacy of students. Three kinds of interactive technologies were compared in the study. Some of the interactive techniques in them were similar; others differed between the experimental groups. Three main interactive technologies were compared: group work in the field and poster presentations, teem work on projects and power point presentations, demonstration and discussion on concept maps in the delivery of a lecture. The project work was the most effective and the presentation of concept maps was the least effective. Neither of them was used independently. They were accompanied by additional techniques, which enhanced their influence.

Keywords: environmental literacy, interactive teaching & learning, students' ecological research, river ecosystem, environmental quality impact

Introduction

Acute global environmental crisis faces the humankind this century due to exponential population growth, technological advancement and consumer demands. It can be coped with by environmentally literate and responsible citizenry. The alienation of the young generation from nature, spending lots of time in front of televisions and computers, does not help them in understanding the real complexity of environmental issues and makes them incapable of actively participating in their resolution [1]. The passive verbal interaction in the classroom feeds this situation and makes it worse. There are students who lack motivation for learning, achieve poor academic results, abandon school and once left on the street they become aggressive. All of the above motivated us to investigate the problem how to change the teaching practices in order to improve the environmental literacy and responsibility as well as environmental quality on local scale hoping that local action can change global thinking and vise versa.

Institutional and academic context

The problems of ecology and nature conservation require multidisciplinary approach [2] – all well represented in the Bulgarian school curricula and included in the Cultural Educational Areas (KOO in Bulgarian): "Natural sciences and ecology" and "Geography and economics" from 3rd to 12th grades of the secondary education. The State Educational Requirements (Table 1) presume inclusion of environmental and nature conservation aspects in school curricula and textbooks.

Table 1. Environment as presented in the State Educational Requirements

Cultural educational areas	Educational requirements: Students should be able to:
Geography and economics	Evaluate natural diversity and beauty of our planet. Explain the global problems, connected with nature conservation and rational use of natural resources and the environment. Explain the processes of global warming of the climate and the depletion of the ozone layer. Discuss the problems, connected with management of water, soil and biotic resources and solid wastes. Value the concept of sustainable development as a global strategy. Know the principles of ecological monitoring and understand its necessity. Plot maps of geographic and economic sites and phenomena. Develop school projects on geographic and economic topics.
Natural sciences and ecology	Use scientific approach when solving problems from different areas of life. Develop environmental culture and aspiration for nature conservation. Distinguish structural elements and processes in different biosphere levels of organization. Explain the state of the environment using natural ecological laws and human impact. Classify and compare ecosystems, populations and organisms. Anticipate the outcomes from changes in the environmental factors and human pressure on environmental equilibrium. Describe the application and biological impact of nuclear radiation. Understand the use of thermonuclear synthesis in production of nuclear energy and in nature conservation. Prove the necessity of recycling of materials and use of nature friendly technologies.

The school curricula [3] allow inclusion of environmental problems in three ways: implicit inclusion of some notions or data in the lessons; explicit inclusion of some concepts in appropriate topics (hazardous substances and health) and inclusion of ecology and nature conservation chapters (Table 2).

Table 2. Topics in the syllabus allowing inclusion of ecological and environmental concepts

Subject	Grade	Topic
The Human Being and Nature	3rd to 6th	Physical phenomena: "From the atom to the Cosmos", "Energy"; "Movement and forces", "Electricity", " Substances and their properties: "Classification of substances and nomenclature", "Structure and properties of substances", "Application of substances", "Chemical processes"; Structure and life processes of organisms: "Structure, life processes and classification", "The human organism", "Organism and Environment", "Observations, experiments and investigations"
Biology and Health Education	7th	"Structure, life processes and classification – plants and invertebrates", "Organism and environment", "Observations, experiments and investigations"
Biology and Health Education	8th	"Structure, life processes and classification – vertebrates", "The Human organism", "Organism and environment", "Observations, experiments and investigations"
Biology and Health Education	9th	"Biosphere", "The Cell", "Observations, experiments and investigations"
Biology and Health Education Chemistry & nature conservation	10th	"The Multicellular organism", "Biological evolution", "Observations, experiments and investigations" "Conservation of the surrounding environment"
Biology and Health Education Chemistry & nature conservation	11th	"The Cell", "The Multicellular Organism", "Observations, experiments and investigations" "Fundamentals of the Chemical Qualitative & Quantitative Analysis"
Biology and Health Education Chemistry & nature conservation	12th	"Biological Evolution", "The Biosphere", "Observations, experiments and investigations" "Fuels", "Chemistry & Nutrition", "Problems of Conservation of the Environment", "Analysis of the State of the Environment"

Three versions of textbooks were prepared and published for each grade and although authors used one and the same syllabus the textbooks differ. We decided to use the textbook [4] and the corresponding workbook for the ninth grade because it is the only one that discusses the problem of biodiversity and factors threatening it. The other topics are the same in the three versions: ecological factors and environment, basic interactions of organisms with their environment, populations, biocoenoses (communities), ecosystems, biomes, biosphere, behavior and health.

Theoretical background

Conceptions on environmental education, scientific approach to biology teaching and interactive teaching techniques constituted the theoretical background of our investigation. In the 21st century environmental education continues to expand and gain in scope, depth and significance [5]. Education for sustainability under the environmental crisis needs increased attention and citizens should "be prepared to participate in problem-solving throughout the use of the best from traditional, innovative, effective and adaptive" approaches, knowledge and techniques within the field [6], that is, to fuse selectively traditional and innovative. Innovations in environmental education are expressed by activities in nature: in the schoolyard [7,8], in natural and human-engineered systems [9-12] and in the classroom: guided essay writing [13], ecological concept mapping [14], modeling [15], outreach techniques [16], multidisciplinary frameworks and place-based education [2] as well as assessing outcomes such as environmental or ecological literacy [17-19], decision making and critical thinking [20], environmental concerns [21], etc. The global call for environmental education in periods of educational conservatism and financial crisis can be answered by integrated curriculum programs and technologies [22], research at "the intersection of education and ethics as a means to explore controversy, dissonance, unconventional ideas and to imagine new possibilities" [23], trans-disciplinary cooperation and knowledge integration [24], etc. Historical and contemporary analysis of the scientific approach to teaching from philosophical, psychological and didactic aspects since its first introduction by Henry Eduard Armstrong at the end of the XIX century up to now, as well as from data of its practical implementation, gave us a sound base for using it in environmental education [25]. Conceptualization of environmental education throughout its history up to the present days helped us outline the main concepts, ideas, principles and theories and construct a model for its practical application [26,27]. Studies of constructivism and concept mapping opened new possibilities for structuring knowledge and facilitating learning in environmental education classes [28]. Computer assisted learning (CAL) enabled us to use Web-based GIS maps and Google Earth visualizations to understand the geographic nature of the watershed. Studies on environmental literacy and interactive methods [29,30] for its development direct us also to widening the meaning of the concept *classroom* including nature itself, addressing communication and interaction between teachers and students, students and students, students and community and students and science as a worldwide endeavor.

We tried to shape the main characteristics of traditional versus innovative teaching (Table 3) by analyzing pedagogical theory and practice in order to choose proper teaching techniques for the experimental design of our study [6,31].

Table 3. Characteristics of traditional and interactive teaching in environmental education

Traditional teaching	Interactive teaching
Memorizing definitions of core concepts, listening, writing, rehearsing, observing, reproduceing, imitating; resources of information – textbook, workbook, teacher, copy-paste from internet sources. Individual aims, objectives and abilities are not considered, students' cognitive activity and initiative are suppressed. Reproductive thinking becomes a priority. Assessment *of* learning meets basic standards. Routine studying keeps students at a slow pace and does not give pleasure.	Active learners` participation, using work groups, formulating cognitive problems, designing and carrying out experiments, registration, processing and interpretation of data, handson experience, conceptual mapping, drawing conclusions, constructing, presenting, and sharing knowledge, ideas. Individual aims, objectives and abilities are suppored and guided; students' cognitive activity and initiatives are encouraged. Creative thinking, problem solving and decision making are given priority. Assessment *for* learning meets basic standards and above them, pushing students forward and upward and bringing them cognitive personal satisfaction.

Research design and methodology

The experimental work was concerned with developing successful interactive strategy for teaching ecology in the course of biology aiming at developing environmental literacy. The chapter of ecology, named "Biosphere" involved 35 topics, planned to be covered in 35 school periods, each lasting 45 minutes. Three different teaching strategies were employed in the experiment (Table 4):

Table 4. Number of school periods for each teaching strategy in each E group

Experimental groups	EG1	EG2	EG3
Punctuated lectures	18 periods	12	25
Interactive learning	6 periods field trip	12 project work	
Discussion	6 periods	6 periods	5 periods
Practical work	5 periods	5 periods	5 periods

The sample involved three groups of 80 urban students in 9th grade (16 years of age) from professional gymnasium in the town of Dupnitsa (Table 5).

Table 5. Sample of students participating in the experiment

School year	No of students	Experimental groups	Experimental classes Specialties (learning future profession)
2008/2009	20	EG1	9b " Economics and management"
	20	EG2	9a " Industrial electronics"
	20	EG3	9c " Electrical equipment"
	20	EG3	9d "Auto transport technique”

Preliminary work: formulating the problem for students` learning (How does human activity affect interactions of organisms in 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 (ecological factors, populations, communities, ecosystems, biosphere, biodiversity and pollution), 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 internet sites for on-line information, recommended by the teacher[1-8]. Students were divided into three groups: EG1 – interactive teaching on a field-trip and in the computer room, EG2 – interactive teaching during on-site project work, in the laboratory and the computer room and EG3 – interactive teaching in the computer room (Table 6 and Fig 1).

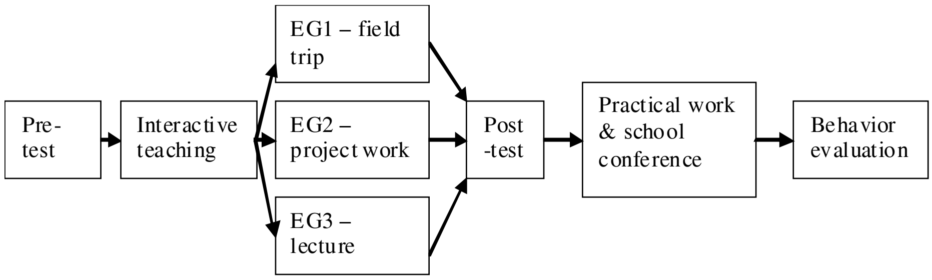

Fig 1. Design of the experimental work on interactive teaching in ecology

Table 6. Interactive educational strategy in each experimental group

Experimen-tal groups	**EG1**	**EG2**	**EG3**
Materials [31]	Work sheets, pencils, work books, rulers,	Diaries, ropes for the method of quadrates, laboratory equipment for the investigation (glassware to collect specimens, chemicals for water analysis, string nets, petri dishes with sterile agar medium etc.).	Work books, pens and colored pencils, rulers,
	Topographic charts of the river, lenses, binoculars, flora and fauna keys, cameras, tape-measures,		
Specific instruction technology	Field trip and observation, work sheets filling, poster presentation, photo-session,	Project team work, ecological experi-ments, team work, role playing, inter-view, survey, Power Point Pre-sentation, group report, multimedia company, commu-nity outreach [16]	Lecture, delivering concepts, presentation of concept maps, Web-based GIS maps and Google Earth visualization, incident processes, asking questions, think-pair-share, peer support

Shared instruction technology	A participatory lecture format, question-and-answer session, computer assisted learning (CAL), surfing the internet, using recommended list of sites, group and class work, partnership and participatory learning		
Final activities	Practical work – cleaning the river banks and afforestation [32]; School conference: exhibition of students' materials (concept maps, posters, Power Point Presentations), reports of experimental groups to share achievements with other students from the school and with representatives from the community.		
Data collecting technology	Pre- and post- tests, a closed questionnaire designed to measure students' environmental concern, assessment of posters, projects and concept maps		
Achievements	Ideas evaluation, support views based on facts, ecological observation skills, data collection of first hand evidence and interpretation, poster presentation and communication	Problem identification and problem-solving, making hypothesis, collecting first hand evidence, ecological experimental skills, data interpretation and critical thinking, PP presentation and communication	Internet surfing as homework, content analysis of information, conceptual understanding, concept map analytical reasonning
Common skills	Teamwork skills, internet surfing, bibliographical skills, ICT skills		

Ecological and educational conceptions: Human activity changes the quality of water and affects the interaction between organisms, threatening some of them to extinction. Industrial, public and tourist pollution have an increasing negative effect on biodiversity of river ecosystems. The concept of biodiversity includes genetic, species and ecosystem biodiversity. *Genetic biodiversity* builds the foundations of adaptation of organisms to their living environments; *species biodiversity* is essential for biogeochemical cycles of matter and flow of energy and stabilizes ecosystems. *Ecosystem biodiversity* is indispensable for ecological equilibrium and sustainable development of the biosphere and of humanity as part of it. Definitions of environmental literacy differ due to the theoretical bases upon which they are built, but some of its components accepted by many authors are: ecological and environmental knowledge, skills, attitudes and behavior [7,13,14,17,18,33].

Teaching methodology in EG1

Preparation

A school session was organized and carried out for explaining the organization and cognitive tasks of the field trip in spring time. Students were divided into smaller groups of 5 people and were given work sheets with questions and blanks to fill in when visiting the river ecosystem. End products of the investigation, criteria for their evaluation and rules for team work were adopted.

Work on the site, data collection, registration and interpretation

The working teams investigated solid waste pollution, eutrophication, pH, temperature and oxygen demand of the river water at two places – before and after the town. They collected data about organisms from three kingdoms (plants, animals and fungi).

Work in the school laboratory

Students made food webs with 10-15 organisms from all trophic levels, each team identified one environmental factor having most serious impact on the organisms in each ecosystem and worked out recommendations to remedy its influence. They prepared posters with uniform structure including: topic, authors (names of the team) and problem of research, short summary, materials and methods of investigation, results, interpretations and conclusions, recommendations, bibliography, and expressing thanks. A photo session was prepared using the photographs they took. Communication of results was done by poster presentations in a class session.

Teaching methodology in EG2

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, articles) of the investigation, criteria for their evaluation and rules for team work were discussed and accepted. Students were divided into groups of 7 people, each one being assigned a role to play in the group: ecologist, botanist, zoologist, hydro-biologist, microbiologist, chemist and sociologist. Then new teams were organized with people for each role: a team of ecologists, a team of botanist, etc. Students in each team studied their role and prepared for it, using consultations with teachers and experts and internet surfing. 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.

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 [31,33], 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 collection and clarification

Specimens of water were investigated, identification of organisms was completed using keys, samples and photographs were taken; food webs were prepared, environmental problems identified and proposals made. "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 articles 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 EG3

Preparation

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

Lectures on river ecosystems took place in the computer room and started with posing the problem of water ecosystem pollution. In the course of the lectures the teacher used concept maps, Web-based GIS maps [1)] 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 for sharing information about pollution of local ecosystems, including the river Djerman, and ideas 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. The students copied the concept map in their workbooks. 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 three groups – EG1, EG2 and EG3. Later on joint activities among the three groups were organized:

1. School conference: presentation of posters, power point slides and concept maps and explanation of the key concepts and findings, presentation of a list of recommendations for the improvement of the state of the river ecosystems and their sustainable use.

2. Practical work for the improvement of the river banks seeking help from the Municipality and the two Regional centers of forestry and the national park "Rila" in the town of Dupnitsa: students participated in the cleaning of the solid wastes along the banks of the river in the area of the town and planted trees bought by the Municipality.

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

Assessing students' learning achievements

All students` products were assessed and evaluated: post-tests, posters, photo session exhibition, food webs, Power Point presentations, concept maps, participation in the group work, responsibility and productivity in the practical work, behavior and participation in the preparation and performance of the conference. Each group 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.

Results and interpretations

1. Students` achievements on the pre- and post-tests

The test contained 16 multiple choice questions including the main concepts of ecology and encompassing the six levels of Bloom`s taxonomy of educational objectives (Table 7). The students from EG2 achieved the highest results. Food webs, ecosystem stability and pollution were best understood from students in EG1 and EG2 groups. The students from EG3 group were best acquainted with structure of ecosystems, succession and population dynamics.

Table 7. Results from the pre- and post-tests of the three groups expressed by the mean value

Task No	Assessed concepts and level from the Taxonomy of educational objectives (in brackets)	EG1		EG2		EG3	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
1	Abiotic & biotic factors, biotope, biocoenosis, transformation of matter & energy (understanding)	3.55	4.75	3.85	5.25	3.35	4.4
2	Ecological equilibrium, ecosystem stability, trophic levels, energy flow (analysis)	3.35	4.9	3.45	5.6	3.5	4.55
3	Open nature of ecosystems, immigration & emigration, exchange of substances between ecosystems, cycle of matter (synthesis)	3.65	5.05	3.35	5.4	3.7	4.6
4	Trophic levels, produces, consumers, reduces, autotrophs, heterotrophs, saprophytes, biosphere, (synthesis)	3.55	4.5	3.55	5.1	3.15	3.8
5	Food webs, food chains, trophic pyramids, trophic level (understanding)	3.8	5.3	3.55	5.75	3.2	4
6	Hydrophyte, mesophyte, xerophyte, (application)	3.6	4.3	3.35	5.25	3.55	4.05
7	Structure & functions of the ecosystem, biolope, biocoenosis (communities of populations), biogeochemical cycles, flow of energy (analysis)	3.5	4.5	3.4	5.1	3.65	4
8	Biotope, biocoenosis, abiotic factors, mineral salts, phytocoenosis, zoobiocoenosis, (application)	3.5	5.05	3.25	5.7	3.65	4.65

9	Ecosystem stability, climax, ecological equilibrium, (understanding)	3.3	5.2	3.1	5.8	3.35	4.55
10	Endangered species, habitat, ecological niche, land use, reservation area, sustainable development (evaluation)	3.75	4.5	3.3	5.35	3.55	4.3
11	Succession, evolution, alternation of generations, cycle of matter (knowledge)	3.4	4.25	3.3	5.35	3.3	4.15
12	Succession, primary, secondary, climax, ecosystem degradation (application)	3.95	4.85	3.55	5.45	3.35	4.8
13	Succession, climax, synusia, consortes, (Knowledge)	3.8	4.95	3.5	5.6	3.55	4.4
14	Birth-rate, deathrate, population density, producers, consumers, trophic levels, transformation of energy (synthesis)	3.85	4.75	3.6	5.6	3.55	4.75
15	Pollution, solid wastes, industrial wastes, environmental crisis (analysis)	3.7	5.1	3.55	5.7	3.3	4.45
16	Chemical pollution, physical pollution, biological pollution, recycling, waste management (evaluation)	3.7	4.85	3.45	5.65	3.55	4.45
	Mean value	3.65	4.8	3.44	5.48	3.45	4.36

The students from EG1 group were best at the level of understanding, analysis and synthesis, students from EG2 – at understanding, application, analysis and evaluation, and students from EG3 – at application, synthesis and evaluation (Table 8).

Table 8. Students` achievements on the pre- and post-tests assessed according to Bloom`s taxonomy of educational objectives

Bloom`s taxonomy of educational objectives	EG1		EG2		EG3	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
1. Knowledge	3.58	4.65	3.55	5.4	3.4	4.32
2. Understanding	3.55	5.25	3.33	5.78	3.28	4.28
3. Application	3.68	4.73	3.38	5.46	3.52	4.5
4. Analysis	3.52	4.83	3.47	5.46	3.48	4.33
5. Synthesis	3.68	4.77	3.5	5.36	3.47	4.38
6. Evaluation	3.73	4.68	3.38	5.5	3.55	4.36
Mean value	3.62	4.8	3.44	5.49	3.45	4.36

2. Students` achievements on the posters, projects and concept maps presentation

Criteria for posters evaluation (EG1): correct structure and presence of all key elements, clear and correct formulation of topic and problem of investigation, full list of materials and reliable method, well formulated tasks, convincing results, objective and correct interpretation, reasonable conclusions, cited bibliography, expressed gratitude to the persons consulted.

Criteria for projects evaluation and project presentation (EG2): contents, research planning and research methods, research questions and design, completeness, precision, compactness, organization (number and logical succession of slides per allotted time; tolerant and fruitful communication), argumentation (measurement and causality), visibility of text and illustrations, visualization, sources, technique, presentation and fulfillment of requirements.

Criteria for concept maps evaluation (EG3): correct concepts, structure, classification and hierarchy of concepts, clusters and logical connections between concepts in the clusters, level of completeness, visualization and compactness of information, accentuation and aesthetics [14] .

Posters, projects and concept maps of students were evaluated according to the adopted criteria and the quantitative results are represented in Table 9. Students were faced with difficulties and gradually developed their skills.

Table 9. Achievements of students on posters, projects and concept maps

Students` works	Experimental groups	Marks					Mean
		2	3	4	5	6	
Posters	EG1		1	6	8	5	4.85
Projects	EG2			3	9	8	5.25
Concept maps	EG1	2	3	5	7	3	4.3
	EG2			3	8	9	5.3
	EG3	4	12	18	4	2	3.7

Difficulties in poster preparation and presentations were observed in making the summary, outlining methods, and in drawing conclusions. Some students were not able to build and cite bibliography. Many of them forgot to include acknowledgements. There were shortcomings in visualization and aesthetics of the posters.

Project development and presentations exhibited difficulties of several kinds. There was not always a correspondence between text and illustrations. In some cases slides were more than necessary and in others – less, which did not give a comprehensive picture of the topic. Structure and color design were sometimes inappropriate. There were some mistakes in the scientific representation – concerning food webs, and structure of the communities. One visible problem was the shyness of some students to present their work. The fear of public presentation was a serious one and we decided to overcome it by organizing additional mini-projects and presentations within the team first as a well known social environment. In this way we managed to foster communication and relaxed attitude. The teacher had to explain styles of presentation; teach assertive ways of behavior and give personal support in order to strengthen their self-confidence.

Concept map construction and presentation proved to be difficult for all groups and they had to seek extra help from the teacher. It was not easy for the students to apply content analysis of the text – both in textbooks and internet sources. Some students did not like reading and preferred visual information. There was lack of consistency in associating pairs of concepts and hierarchy. Some found it difficult to outline the core concept. Few of the students were eager to revise their concept maps by rereading and analyzing the text. Some used color pencils for illustrations and accentuation. Few students prepared computer presentations. There were mistakes in concept explanations which had to be corrected using peer review and teacher explanation.

3. Interpretation of the results from the survey about student's abilities to make decisions

Students were given seven conflict situations and proposals for solving them including nature friendly and nature unfriendly decisions. Questions are classified on the basis of the NEP [34,35]. An example is given in Table 10.

Table 10. An example of conflict situations for decision making and results in percentage for each group

Situations	Possible decisions	EG1	EG2	EG3
Example: In the vicinity of the town of Dupnitsa there is a little lake surrounded by woods, which people use for recreation. Not long ago this area was bought by a businessman, who plans to destroy the lake, cut the woods and build blocks of flats. Which argument would you choose to use in order to save the area?	1. Anti-exemptionalism: People are living things and need recreation area for rest and active physical exercises (swimming, walking, etc.).	25%	15%	30%
	2. Ecocrisis and balance: The lake and the woods are habitats for endan-gered amphibian and bird species, included in the Red Data Book of Bulgaria and for migrating birds during different seasons of the year.	45%	70 %	35%
	3. Anthropocentrism: The animal species in the lake and in the woods provide game for hunters.	10%	5%	15%
	4. Anthropocentrism: The lake provi-des fish and the woods are good for timber and thus useful for people. (anthropocentrism)	20%	10%	20%
2, 3. 4. 5. 6.	Anthropocentrism	8%	10%	25%
	Exemptionalism	7%	5%	15%
	Balance	20%	30%	20%
	Ecocrisis	25%	20%	10%
	Anti-exemptionalism	15%	15%	5%
	Limits	10%	5%	15%
	Anti-anthropocentrism	15%	15%	10%

Students in EG2 group became concerned about water quality and quantity issues. The survey data of the students in this group revealed the inadequate concern of the inhabitants along the river about the river quality. They did understand the importance of water purity for water organisms but that did not stop them from throwing waste in the river giving a bad example to their children.

Sharing the result with students from other classes, not involved in the experiment, stressed the importance of the problem and increased the self-satisfaction and self-esteem of the participating students. Interpretations of the results from the conference and the practical work opened new possibilities for sharing data on key organisms in the river Djerman and for improving the recommendations for sustainable use of the natural environment.

The practical work was taken seriously by all groups. After planting the trees and cleaning the area students were allowed to have physical exercises in the open.

Conclusions

State educational standards, school syllabi and textbooks created a valuable environment for studying ecology in the secondary schools of Bulgaria. Educators had studied and developed different didactic techniques for environmental education. Many of them are already introduced into the school practice, but the effect of complex interactive didactic technologies in different learning environments has not been investigated so far. A single method or technique could rarely be crucially effective in one period and in one class of study bearing in mind that students differ in aims, abilities, experience, expectations, etc.

Systematic use of well balanced interactive technique in correspondence with state requirements, goals, students, and local conditions and practices proved to be stimulating and very productive.

The didactic experiment addressed the cognitive, affective and behavior domains in response to different types of interactive teaching and proved to be very effective. Students developed a richer understanding of water ecosystems at multiple scales ranging from atomic-molecular level to large nature-society level.

The students in EG1 and EG2 demonstrated higher scores on skills, attitudes and behavior and expressed greater satisfaction from their studies than EG3 group. They acquired scientific skills for learning from and about the environment. Contacts with natural ecosystems had a great potential to enhance instruction and make students the center of the learning process. After-school program for urban 9th grade students that integrated instructional techniques to investigate a river ecosystem in the local surroundings was suitable for the school as it corresponded to the natural environment. Participation in the long-term river investigation enhanced environmental attitudes, promoted a sense of environmental stewardship and fostered responsible environmental behavior. Positive relationship between environmental knowledge, environmental attitudes and behavior was established in the process of experimental work.

Delivery of EE education both within and outside the classroom facilitated experiential learning and development of deep environmental concern, sustained increased care and responsibility for environmental protection.

Application of interactive techniques and experience-based learning in natural environment provided more appropriate and inclusive pedagogy integrating multidisciplinary methodology. Students showed preference to be acquainted in advance about what was required from them, what kinds of final products were expected from them at the end of the learning process and also what teacher's expectations were. They also demonstrated a need of exercises to learn communication skills and acquire self-confidence. On that basis they were able to shape their own goals and individual expectations. Productive pedagogies used in our experiment lead to authentic student engagement and learning. Students remembered knowledge that they had discovered by themselves and had understood well.

Team teaching proved to be very effective, especially for less able students. They felt the support of their classmates and were spared the knowledgeable and sometimes critical look of their teacher which could have made them feel uneasy.

Students increased their self-confidence realizing that their efforts mattered. The differential methodology provided rich interactive learning environment for all students and they were able to choose what suited them most. Cooperative work helped them communicate knowledge and understand effectively as well as behave responsibly not only to their studies but also to the environment. The assessment by peers, teacher, school leadership and Municipality sustained their motivation and confidence in learning. They showed patience and perseverance in learning, which helped them understand the significance of the acquired knowledge and attitudes for their future profession.

The model of the experimental educational strategy can be used on other topics and in other school subjects – geography, chemistry, physics, because integrative and interactive learning assures acquisition of fundamental concepts. Students became aware of very often irresponsible human behavior towards the environment, worsening its quality, and threatening present and future generations. Practical work by cleaning and planting trees was extremely stimulating because it helped students understand they could not only study and talk about the environment but they could be active and improve it. They were convinced that their work was important.

The introduction of project-based and computer assisted learning created good possibilities for interaction, saving data and correcting the produced material in a format clearly and easily accessible to other users. Students' environmental literacy was improved and strengthened. Those young citizens became more critical and responsible for their own behavior than the rest.

The results from this experiment guided us in formulating recommendations for the improvement of the school curricular and teaching methodology in giving some priority to environment-based studies.

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List of on-line sites, connected with the topic:

1. http://www.balwois.com/balwois/administration/full_paper/ffp-1067.pdf
2. http://www.az.government.bg/EFunds/AUPT/042006/Results/SBa-nja_LED.pdf
3. http://www.nug.bg/files/lup/107/DLDupnitza.pdf
4. http://www.bluelink.net/bg/bulletins/ecopolis11/tr1_1.htm
5. http://www.tourism-bg.net/obekti/29_skakavitza.html
6. http://www.sapareva-banya.net/index/history/
7. http://4coolpics.com/author_photo/202/15127.html
8. http://ivankiosev.snimka.bg/mountain/rila.79764.1606406

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