

Educational Technology as a Teaching and Learning Tool in Environmental Education

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Abstract

In the following research paper, we discuss an educational action research that was carried out in order to investigate students' knowledge, attitudes and views in relation to understanding, managing and solving environmental problems in connection with recycling, before and after implementing an environmental education programme that utilised the "Recycle-Land" educational software. The objective of using this software application was to make students view waste management problems as genuine problems of the environment to which they themselves are related. Exploiting Information and Communication Technology (ICT) in education based on social constructionism, it becomes possible to approach environmental education in a holistic manner whilst avoiding to isolate students outside the general framework within which it take place. Student activities lead to concept formation, theory and practice come together, teaching, learning and evaluation become integrated and active problem solving is encouraged. This educational software application –through a user-friendly and familiar interface – makes it possible for students to realize the environmental and financial benefits of recycling and hence, as modern citizens, act to promote the viability and sustainability of the planet.

Keywords: ICT; environmental education; recycling; educational action research

1. Introduction

The rapid developments taking place in recent years in the fields of science and technology demand from the education system of each country to adapt to the new conditions. This continuous readjustment of knowledge is achieved by introducing corresponding innovations; the way in which these are implemented, plays a crucial role (Peters 1998). ICT provides the

ground for such innovations which emerge as teaching and development processes that depend on sociocultural factors and are directly related to the education system of a country. Integrating ICT into the education systems of developed countries creates the necessary conditions for the improvement of the educational process and for the right preparation of young persons in the face of the emergent Information Society (Roblyer 2004).

A new educational view is put forward that promotes not only novel, active and experiential ways to learn- mainly through play, but contributes to the development of new attitudes and skills (McNabb 1999). Multimedia and hypermedia technologies coupled with social constructionist tools constitute not only a field of study, a teaching aid, supervisory tool, means of communication and a cognitive and developmental tool (Raptis and Rapti 2006), but can be also utilized in education as an emancipatory tool .i.e. a tool to manage problematic situations in society by providing alternative ways to view, understand and solve these problems (Makrakis 2004).

The teachers that are called to teach classrooms using technological tools, are actually called to promote concepts like independence, responsibility, equality and action towards social change. This position is expressed in educational psychology by social (or critical-dialectical) constructionism (Vygotsky 1978) which emphasizes the importance of social and cultural elements upon which individuals belonging to a certain sociocultural environment base their ability to communicate and understand each other with the use of a common language. Knowledge gain is an active process of concept formation and meaning attribution which takes place within a social framework through language and participation of individuals in social groups which are characterized by common experiences and cultural practices. Learning results from actual activities that take place in real conditions (Nardi 1996) as opportunities for learning and restructuring knowledge rise from the processes of cognitive conflict, reflection and knowledge restructuring (Salomon and Perkins 1998).

Within this framework, education is called nowadays to play an important role in sensitizing individuals and social groups on environmental issues. In these uncertain times where global climatic changes will demand our attention, environmental education becomes responsible to help young persons realize the connection between humanity and environment, become sensitive about environmental problems, and finally become active through specialized programmes in order to contribute to the general effort to solve them (Palmer 1998).

Sustainable development is a term related to environmental education and reflects the new direction in the field worldwide. It emphasizes concepts like social justice, culture, civic structure, and economy. The necessity of this new model of development has been acknowledged by the international community as an opportunity to transform the traditional open economy model into a new, closed-loop economy one based on recycling, clean technology and the development of eco-friendly systems (Gao et al. 2006). As far as sustainability is concerned, environmental education aims to rock the boat of traditional environmental education as a field of study and to focus on decision making at the socio-political level as well as to expose and criticize social infrastructures. Thus, environmental education intends to transform social perceptions rather than reproduce current ones (Morrison 1994).

Nevertheless, radical changes are needed as in the Greek education system environmental issues are dealt with in extracurricular activities under teachers' individual discretion (Goussia-Rizou and Abeliotis 2004). At the same time the absence of teachers in environmental training programmes results in their avoiding to engage environmental education issues.

The educational software Recycle-Land was developed to address these problems and assist in the practical achievement of aforementioned objectives pertaining to ICT and environmental education. This software application constitutes an integrated environmental education programme and presents students the opportunity to become involved in activities that lead to concept clarification, value formation, psycho-motor skills development and attitude adoption (Ernst and Monroe 2004). Students are provided with the opportunity to learn about new ways of waste management and to contemplate the causes and dangers of waste mismanagement. They're also assisted to realize the environmental and financial benefits of recycling and become conscious through activities that keeping their school, neighbourhood and district clean is a firstly a personal matter and secondarily a social one and that they should act in that direction.

2. THEORETICAL ISSUES RELATED TO EDUCATIONAL TECHNOLOGY AND ENVIRONMENTAL EDUCATION

The design of environmental education software using new technologies is based -directly or indirectly- on certain theoretical grounds. This theoretical basis provides the proper support for computer assisted teaching and learning and provides the guidelines for design and possibly evaluation of a software application. In the Tbilisi Declaration (UNESCO 1978) man is viewed as capable of transforming his environment. The Tbilisi Declaration refers to human social action which current sociological thought approaches with activity theory. Hence, the theoretical basis of school environmental programmes using new technologies comprises sociocultural theories of learning such as activity theory and distributed cognition theory.

According to activity theory, the basic subject of analysis is human activity. It emphasizes intentional activity of individuals or groups acting according to a set of rules and which use specific mental or natural instruments within a particular social framework. The constituents of an activity are usually not fixed and can dynamically change. The outcome of the activity emerges as a result of the interaction of individual subjects. This Activity System (Jonassen 2000; Engestrom 2000) has an outcome which in our case is learning. Tools which are found in a particular sociocultural framework, function as intermediates between subjects and knowledge and thus influence the final product of the whole activity, which is knowledge acquisition through active participation in the educational process.

The Distributed Learning model (Ackerman and Halverson 1998; Hutchins 1995) focuses - beyond individuals- on the social and natural environment (including available tools) within which activity takes place. Thus, knowledge is viewed as an outcome not solely of individual activity but as an outcome emerging from the interaction among individuals with the assistance of tools. Knowledge acquisition is therefore, a result of collaborative learning. Salomon, (1995) argues that humans think in connection and collaboration with each other, assisted by cultural tools and applications.

3. ACTION RESEARCH USING THE ENVIRONMENTAL EDUCATION SOFTWARE RECYCLE-LAND

Educational software is a cultural learning tool for groups and individuals. It is defined as a technological product which can be used to teach a field of study by implementing a particular educational philosophy and educational strategy.

Researchers studying educational technology aim to equip computers with capabilities that simulate as accurately as possible the way humans arrive at knowledge (Sebe et al. 2005). Educational software provides an educational environment that uses non-linear interconnections among various forms of information and knowledge (text, audio, video and animation) in order to greatly improve learning (Lewis et al. 2005).

Educational technologies and educational software in particular, could play a central and positive role in an environmental education programme. The Tbilisi Declaration made this clear as many of the guideline propositions emphasize the importance of modern ways of communication (Tbilisi Declaration, Propositions 7, 12, 19, 21, 24, 26, 27). These propositions do not directly mention new technologies, as in the 1970s-1980s these were not widely available. They emphasize though, the special importance of information transmission and information network creation.

In designing the environmental education software we intended to encourage student critical thinking and communication within the framework of the educational process. The software makes it possible for students to choose among recycling related issues that interest them, work on problems that result from waste mismanagement and seek information using various sources. We worked towards creating a tool that aids students to come up with answers both as individuals and collectively. The software was designed to trace trends and record behaviours, values and attitudes and does so through a critical educational approach.

3.1 The Research Question

The central question of the present research is whether “an educational software application based on constructionist principles can help students acquire knowledge, develop skills, capabilities, environmentally friendly attitudes and behaviors in relation to waste management issues”.

The examination of the software's effectiveness is complemented by the examination of the following questions: a) what was the initial student knowledge of waste management and recycling issues and how was this knowledge transformed after the educational intervention? and b) what were the initial attitudes of students towards waste management, buying eco-friendly materials and using eco-friendly packing materials, and how were these transformed after the educational intervention?

4. Methods

Action research was the preferred procedure because it is based on participatory and collaborative methods and not only aims at identifying and construing educational practices, but mainly aims at detecting and reconsidering actual everyday problems. It also aims at taking measures, including discussing these measures with students and critical friends during every phase of the research process. Action research does not demand the creation of a control group since it is defined as a form of applied qualitative research that studies the activity of subjects and at the same time develops itself through the activity of subjects (Carr and Kemmis 1986). The researcher intervenes in the research process where the subjects occupy a central place as individuals under observation, as well as individuals that act and contribute to the development of the phenomena under investigation, participating in the evaluation of the research's progress and their own actions (Cohen, Manion and Morrison 2003).

4.1. Context of the Study

The present study took place in a Greek Primary School (ages 11-12). A class of 16 students (10 females and 6 males) was divided in four groups (A, B, C and D) each one of them comprising two pairs of students. Special attention was given in selecting the pairs of students in such a way that each group represented individuals of different levels of academic performance.

4.2 Tools

The research tools used to collect the data and the techniques used in the present research have as follows:

Questionnaire: a special questionnaire was created comprising questions relative to our research objectives.

Focus Group Interview (Vaughn et al. 1996): This is a powerful qualitative data collection tool. The interview focuses on a single issue each time but allows for a variety of opinions under the guidance of the researcher. Our aim was to encourage students to express different opinions.

Participant Observation (DeWalt and DeWalt 2001): This qualitative technique of data collection allowed us to record spontaneous behaviours of students, thus allowing us to answer the research question of whether interactive multimedia can be used to raise environmental conscience in future citizens. This method was applied when we were interested in studying the motives behind certain actions and behaviours i.e. how individuals themselves do interpret what takes place in their surroundings and how this affects their behaviour in turn.

4.2.1. THE “RECYCLE-LAND” SOFTWARE APPLICATION

The Recycle-Land interactive educational software was the tool for our educational intervention and was designed in such a way as to assure the optimum student engagement in activities leading to acquiring specific knowledge and developing certain attitudes. The educational scenario was based on studies by Pinelle and Gutwin (2002) on collaborative problem. The main objective during the design process was to develop an application that will lead students to develop positive attitudes and behaviors towards the environment so that they protect it and manage waste materials properly. The most important contribution to the solution of this problem can be expressed in four words: Reduce, Reuse, Recycle, Respond (Fenton et al. 1990), a method that can assist sensitizing individuals and help changing their consumer attitudes.

Individual objectives of designing this software can be grouped in three categories: cognitive, emotional and psycho-motor.

A) *Cognitive*: Understanding the main environmental problems of modern world and how these permeate every aspect of life. Getting acquainted with recyclable materials. Recognizing recycle signs and symbols. Realizing the value and usefulness of recycling and the benefits of changing human attitudes. Knowledge of the consequences of recycling. Information on managing eco-friendly materials.

B) *Emotional*: Sensitizing students on issues like recycling and over consumption. Realizing that reusing materials is a personal responsibility for everyone. Adoption of a collective ecological attitude. Building confidence and becoming responsible as related to environmental issues. Participation in social activities that aim to protect the environment and improve the quality of life.

C) *Psycho-motor*: Development of critical thinking. Developing imagination and creativity

through free expression and practice. Mobilization and action inside and outside school environment. Skill development contributing to ecological waste management.

Recycle-Land features three protagonists. Recyclette explains the secrets of recycling, Little Aluminum Guy introduces recyclable materials and Miss Pristine presents the good recycle guide. We adopted a comics style where images are accompanied by text.

Researchers argue that the problems that the users are called to solve have to be genuine ones based on realistic scenarios (Gutwin and Greenberg 2000). Thus, as a final task, students are called to solve their own school's waste disposal problem in collaboration with local authorities and are asked to create a model presenting their suggestion.

4.3. RESEARCH STAGES

The framework within which the action research progresses, was provided by answering the following questions: What is the current knowledge of students regarding the issue? What do they wish to learn and what do they need to learn? How can we satisfy their needs? How can we know that their learning needs were met? More analytically, the stages of the course of research are presented in the table 1.

Table 1. Research stages, objectives and tools

ACTION RESEARCH STAGES	OBJECTIVES	TOOLS
Design, development and summative assessment of Recycle-Land software.	To create an educational intervention in order to raise environmental conscious citizens. Determination of software effectiveness on end users.	Software tools and programs (Multimedia Builder)
Initial examination and recording of student knowledge and attitudes in relation to environmental problems and recycling.	To record possible ignorance and misunderstandings in relation to environmental issues. To record also, their attitudes towards environmental problems.	Questionnaire, Focus group interview.
Critical reconsideration and redesign of Recycle-Land.	To redesign the educational software in order to meet the needs of this particular group of students	Software tools and programs (Multimedia Builder)
Student activities involving the educational software as well as practical assignments.	To equip students with necessary knowledge and skills as stated in the software design objectives. To observe whether the use of interactive software can contribute to raising environmental conscience.	Educational intervention using Recycle-Land, Participant Observation
Examination and recording of new attitudes and behaviors.	To examine the effectiveness of the educational intervention.	Questionnaire, Focus group interview.

4.4. QUESTIONNAIRE DESCRIPTION

In the present research we compared questionnaire results before and after our educational intervention. If we were to describe in detail the data we wished to collect, we could place them in two groups and five subcategories. The first group comprises data collected by subjective evaluation of facts, ideas or individuals. In this group, the subcategories pertain to attitudes of students towards various situations, student opinions on a series of problems related to the environment and finally the ambitions they express for the future. In the second group, we place issues relate to student knowledge about waste management and the environment, both in the case of their immediate surroundings (home, school, neighborhood) and their wider surroundings (country, Europe, planet).

Since we expected to use students' answers to determine their environmental orientation, i.e. their level of knowledge and their attitudes, we had to: a) examine whether their knowledge was substantial or superficial (e.g. by asking them to rate the importance of various environmental problems), b) examine whether their information came from random sources (TV, radio, publications) or resulted from some form of educational process, c) examine whether they could answer more specialized questions. To this end, some of the questions were expressed in ecological terminology, and d) examine whether their answers were reliable and honest especially so on issue where they had to express personal opinions e.g. how would they act in certain situations.

The questionnaires were filled in directly using special forms provided by the researchers. The more structured a question is, the easier it is to analyze. For this reason, the final questionnaire comprised only two open ended questions. These were deemed necessary because of the usefulness of the data provided by their answering. Based on the seven question types (Youngman 1986) we used -besides the aforementioned open ended questions- four closed ended ones and two questions in the form of short stories (50-70 words in length) which were used to elicit student attitudes towards waste management and voluntary action. These stories were created especially for this research and we made sure that they were simple and comprehensible by the students. In the end, we asked them to choose the character closer to their own attitude and behavior. The remaining questions took the form of Likert items. The table 2 presents the created items.

Table 2: Questionnaire Description

SECTIONS	DESCRIPTION	QUESTIONS
Knowledge	About various issues in general, especially about waste materials	Q3: Technology can solve every environmental problem. Q5: If there are problems with landfills, incineration plants should be built. Q6: Glass damages the environment as much as plastic. Q7: The planet can hold all human waste. Q8: Fires can start at landfill sites. Q18: If we change our consumer behaviour the problem of waste disposal will be alleviated. Q19: The problem of waste management come down to insufficient legislation.
Attitude 1	Economy and the environment	Q4: The environmental as well as waste management problems stem from the insatiable thirst for profit. Q5: Waste materials of trourist regions should be kept far away from it or in other towns.

SECTIONS	DESCRIPTION	QUESTIONS
Attitude 2	Individual participation and volunteering	<p>Q23: Would you like to participate in paper, glass and aluminum collection so that these can be recycled?</p> <p>Q24: As Yannis and Giorgos were watching a TV programme concerning the value of forests and how paper is made from trees, Yannis started putting old newspapers and magazines, paper packings and old notebooks in a large box. Giorgos asked: "What are you going to do with this stuff?" Yannis answered : "I'm collecting this stuff to recycle it". George said "But you're messing up your room and that problem can't be solved by you...". With which do you agree?</p> <p>Q25: Every year the school organizes a recreational trip to a seaside tourist region. This year, a teacher proposed that they should altogether clean some part of the beach. Half the teachers agreed with her. The rest said that this concerns the local authorities and that children are not waste collectors. With which group do you agree? a)with those that wanted to clean the beach, or b) with those that argued this was a local authorities concern and children are not waste collectors?</p> <p>Q26: If you were city mayor how would you deal with the waste disposal issue?</p>
Attitude 3	Consumerist model and waste materials	<p>Q9: The soft drinks you consume come in what type of packaging? a) aluminum b)paper c) glass d) not concerned</p> <p>Q10: The notebooks you use are made of a) regular paper b) recycled paper c) don't know</p> <p>Q13: When you want to get rid of something and you find yourself away from home you a) litter the street b) find a waste container c) it depends on the circumstances</p> <p>Q14: Some people use for note-taking and calculations sheets of papers that are already used on one side. Do you agree?</p> <p>Q17: In many foreign countries shoppers have to pay extra money if they want a plastic bag for their shopping.</p>
Attitude 4	Local and national government and waste materials	<p>Q11: Attica prefecture decided to displace waste materials to a neighboring country, after an agreement was made, because no agreement could be reached about where should they build a waste collection site within Attica.</p> <p>Q2: For which reasons would you oppose the building of a landfill in your borough?</p> <p>Q16: City Council decided to fine three owners of fishing boats a large amount of money for throwing damaged fishnet in the sea.</p> <p>Q20: The state is solely responsible for waste disposal problems.</p> <p>Q21: If someone's litters public places would you propose to a) receive jail sentence b) receive a fine c) do compulsory community service d) have no consequences</p> <p>Q22: Waste disposal problem has reached a dead end in big</p>

SECTIONS	DESCRIPTION	QUESTIONS
		cities. Hence, waste materials should be moved to neighbouring districts.

5. RESULTS

Questionnaire analysis took place before and after our educational intervention. Questions were grouped in five sections. One of them involves knowledge and the remaining four comprised questions recording attitudes. A qualitative and quantitative analysis took place for every question except for the two questions in narrative form which were analyzed qualitatively only.

The analysis of the questionnaire before and after the intervention yielded the following. Each section of the questionnaire was scored separately. The score for each section corresponds to the percentage of correct answers. Only closed ended questions in each sector contributed towards scoring.

The average score for student knowledge of environmental issues in general and recycling in particular before our educational intervention was 0.54. The average for male subjects was 0.57 and for females 0.51. After our intervention the average rose to 0.79 (males: 0.76, females: 0.82). The average of correct question rose by 52%.

The average score for the general - environmentally friendly- attitude was 0.76 (males: 0.79, females: 0.72) before our intervention. This is higher than the score recorded for knowledge which is not surprising as attitudes are influenced by knowledge but there is no absolute correlation. After the intervention the score rose to 0.78 (males: 0.70, females: 0.85). This is an increase of 12.5%

The four attitude sections of the questionnaire (table 2) contributed separately to the general attitude score mentioned above. The details for each section are presented in table 3.

Table 3: Average scores for each section of the questionnaire

	BEFORE			AFTER		
	Total	Males	Females	Total	Males	Females
Knowledge	0.54	0.57	0.51	0.79	0.76	0.82
Attitude 1	0.67	0.84	0.50	0.65	0.50	0.80
Attitude 2	0.83	0.83	0.83	0.89	0.92	0.85
Attitude 3	0.64	0.66	0.61	0.70	0.66	0.77
Attitude 4	0.88	0.83	0.92	0.85	0.73	0.96
General Attitude Scores	0.76	0.79	0.72	0.78	0.70	0.85

Qualitative analysis

At this point we shall discuss the qualitative analysis of interviews and participant observation in order to pinpoint and interpret individual issues that were studied and to determine the influence of the educational software on changing perceptions, attitudes and behaviours and thus confirm or disprove our research hypothesis.

Student Knowledge about recycling and natural resources

There is an important change, before and after our intervention, in relation to the understanding of the concept of recycling and relative signs and symbols. Initially, students associated recycling with reusing packaging (45%). The very low percentage of students that correctly understood the Green Dot recycling symbol is worth noting, as 34% of them did not know whether the symbol refers to the packaging or the content itself. This ignorance is attributed to the young age of the students since the effect of age on knowledge about environmental issues has been noted by other researcher as well (Brody 1994).

Only a small percentage of students understood the meaning of the EU eco-label logo (8.6%). Many of them noted that they had never seen it before. Their ignorance could be the result that this symbol is rarely found on products.

Waste management problem

A large percentage of students were not familiar with the size and the importance of the problem. The percentage of students answering correctly after the intervention increased.

When asked, most students did come up with a reason for large waste material production and half of them could justify their reasoning; 49% reckoned over-consumption to be the cause of the problem and 16% attributed it to human irresponsibility and indifference towards the environment. Nevertheless, students appeared to have little knowledge about the issue of waste management, a finding confirmed by other researchers (Kuhlemeier et al. 1999). Students were under the impression that the majority of waste materials only comprised those of everyday use such as paper, aluminum, plastic, and food waste. Furthermore, the majority reckoned that waste materials end up in landfill sites exclusively and had never heard about sanitary landfills. After our intervention, students knew about the new waste management methods currently employed.

Human intervention on the environment

We found that students were familiar with the role people play in protecting the environment. Conversely, they ignored the repercussions of everyday activities and the way these contribute to the destruction of the environment. Following our intervention, a significant change occurred in their understanding of the role everyday activities play and their consequences on everybody's life.

Prior to our intervention, the percentage of full answers presenting the benefits of proper waste management to the environment and the ecosystem, was small. The majority noted general benefits to the environment (79%) while after the intervention they were able to state specific benefits like saving raw materials, space, energy and money. To the question of what packaging size should we prefer for products, students initially seemed to ignore the consequences of everyday personal choices such as our consumer habits. After the intervention, the percentage of correct answers rose to 71% and they were able to attribute responsibilities and propose solutions.

Participation in environmental actions

The percentage of students that participated or wished to participate in recycling actions before the intervention was small. The initial percentage of 20% became 90% after the intervention. It is important to note that the students could provide reasons for their decision and propose solutions. Following the end of the programme, students organized an exhibition titled "Love me and Hold me". The exhibits were made out of old or disused objects and

packaging. These were repaired or reused in a new way. Participant observation showed that the children developed critical thinking, collaborated and worked responsibly when asked to.

Effectiveness of the educational software

The implementation of computers in the educational process became an important factor and created an agreeable, positive and creative learning environment. Multiple representations – a distinctive feature of multimedia applications- reduced ennui and indifference. This was concluded as children denied taking a break and preferred to conclude their work uninterrupted. Students worked creatively and in collaboration with each other as they dealt with software activities and quickly managed to acquire clear understanding of concepts, detect problematic issues and actively participate in discussions and presentations of their activities while they expressed elaborative, critical and rational reasoning. A student interaction analysis was carried out for the duration of the programme and showed the contribution of educational software to the communication between groups. The verbal messages exchanged among students were recorded by critical friends (Participant Observation) and were later divided in three categories. These are: A) Strategy related, B) Related to the usage of tools, C) Related to participation in the activities (Table 4).

Table 4. Interaction Analysis

		VERBAL MESSAGES TYPOLOGY		
Groups	Pairs	Strategy	Tools	Participation
A	Pair 1	14	11	6
	Pair 2	8	18	3
	Total	22	29	9
B	Pair 1	9	13	7
	Pair 2	10	8	5
	Total	19	21	12
C	Pair 1	11	7	2
	Pair 2	13	9	5
	Total	24	16	7
D	Pair 1	12	12	5
	Pair 2	9	8	5
	Total	21	20	10

8. CONCLUSION

Published research place more emphasis on student knowledge acquisition and less on changing habits and attitudes (Boershig and De Young 1993; Kortland 1997; Smith-Sebasto and Semrau 2004). Nevertheless, there exist research papers evaluating environmental education programmes where the specimen shows a change of attitude towards certain environmental issues (Mangas et al. 1997) while the possibility of computer use to achieve this change is emphasized (Morgil et al. 2004). The application of the educational software Recycle-Land as an environmental education programme in a 6th grade Primary School showed an important increase of student knowledge about the waste management issue. The change of attitudes –a more demanding objective- was also achieved. Students seemed to deal with the waste management issue in a more environmentally friendly way and appeared to be in position to participate in environmental actions.

We found that technological tools can be utilized effectively in the educational process especially so in teaching environmental education. The high degree of interaction between the student and the educational software acts as a powerful incentive for learning. Within this new learning environment, students were able to reconstruct previous knowledge through critical thinking, form new concepts and develop social consciousness and environmental sensibilities. The development of inquiry skills and attitudes that is rarely achieved with traditional ways of teaching, was achieved easily, quickly and agreeably.

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