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DESIGN AND ASSESSMENT OF AN INTEGRATED TEACHING METHOD FOR TEACHING ECOSYSTEMS

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Abstract:
The aim of this paper is to present and evaluate the Integrated Teaching Method (ITM) which is an innovative teaching model incorporating comprehensive teaching content, effective teaching strategies, and specifically-designed lesson plans. ITM was developed based on modern learning theories in conjunction with the latest findings in cognitive psychology and the neuroscience of the brain. ITM was implemented on Year 8 Greek secondary school students to teach the ecosystem and was assessed in comparison to Didactic Teaching Strategies (DTS), based on a traditional teaching method. The data collection tools were questionnaires on students' knowledge, comprehension, application and attitudes/opinions towards the environment. ANOVA and t-Test showed that students who were taught with ITM as opposed to those taught with DTS: a) achieved better results in knowledge, comprehension and application of the teaching content, and b) achieved equally good results in terms of attitudes/opinions towards the environment. The findings suggest that ITM had a greater impact and improved the level of student knowledge to a larger extent than DTS. ITM can thus be considered an effective teaching methodology and is proposed to be implemented in the multi-disciplinary teaching of biology, environmental education and Ecology; its effectiveness in the other science subjects should also be assessed.

Keywords: multi-disciplinary approach, Integrated Teaching Method, Aristotle teaching strategy

1. Introduction

The major objectives of contemporary education are that students should acquire both theoretical and practical knowledge as well as gain skills in cooperation, critical thinking, responsibility and autonomy. The educational process in junior High School (Gymnasio) in Greece today is still based mainly on traditional pedagogy. Nevertheless, in recent years a concerted effort has been made at modernization, either by updating the teaching methodology or by adapting the curriculum to the needs of modern society. In response to the fact that in Greece there has been little evaluation of multi-disciplinary approaches to teaching in both theory and methodology, a number of researchers have proposed that such studies be carried out (Kafetzopoulos et al. 2003 Soulioti & Pange 2004).

In the Declaration of Thessaloniki adopted at the International Conference on Environment and Society in 1997, it is stated that in order to provide environmental education to students aiming at environmental protection and sustainable development whose impact will be maintained throughout students' lives, the following need to apply: a) there should be a set of specific objectives and action plans designed with concrete targets and teaching strategies, b) the community of teachers and scientists need to ensure that the teaching content is based on sound knowledge and accurate up-to-date information, c) the teaching content must meet the needs of society and sustainable development, and d) knowledge and awareness of the environment must have the potential for incorporation into the existing school subjects so that through multidisciplinary teaching approaches, Environmental Education (EE) objectives are met (Knapp 2000). Mappin & Johnson (2005) argue that detaching EE from the other school subjects merely reinforces humans' separation from nature. An attempt needs to be made by both teachers and researchers to develop new creative approaches to EE, whose content will be clearly understood by all learners. By acquiring the basic principles and concepts, explanations of how phenomena function, students learn to apply them to and for their entire lives (Cole 2007).

Manzanal et al (1999), Hangerford & Volk (2003), Slingsby & Barker (2003) and Adamson et al. (2003) proposed that field work should play a central role in teaching EE because, among others, students are given the opportunity to enhance their critical thinking and evaluation skills through the analysis of a problem in their local community.

Fischer et al. (2007) believe that new discoveries about brain function require cautious interpretation to be followed by investigations that test their applications in the classroom. In addition, according to Stern (2005) there needs to be a review of teaching so that it is based on data of neuroscience of the brain, which uses contemporary methods that associate learning to the structure and functioning of the brain.

Therefore, there is a need for empirical research in Greece and worldwide, on the multi-disciplinary approach to teaching which is linked to the current findings of neuroscience.

The present study addressed the following hypothesis: The multi-disciplinary approach to the teaching of Biology, Ecology and Environmental Education with the Integrated Teaching Method (ITM), is more effective than the more traditional approach of Didactic Teaching Strategy (DTS) in terms of: a) increasing students' knowledge, comprehension and application of the new knowledge acquired about the ecosystem in a given situation, and b) improving students' attitudes and opinions towards natural ecosystems.

2. The Integrated Teaching Method

2.1 The value of teaching about the ecosystem

The ecosystem was chosen as the teaching content for this study because besides having great importance in and of itself, it also comprises core curriculum content in the school subjects of ecology, biology, Environmental Education and others. Furthermore, pedagogical research on modern education has confirmed that it is important for students to have basic knowledge in the understanding of how complex systems operate (Resnick, 1994) and a number of researchers have proposed various teaching approaches that promote systems thinking (Draper 1993, Lannon 1994). The knowledge of the functioning of ecosystems leads to an understanding of how all systems in general operate, which can be transferred to other sciences, as well as to situations and problems of everyday life. Therefore, focusing on ecosystems comprises suitable teaching matter to help learners develop essential knowledge and skills required for analyzing complex systems. Needless to say, students must also have awareness and possess the necessary skills in order to enhance their attitudes, opinions and behaviour towards the global ecosystem. If students do not understand the structure and function of ecosystems, they will not be able to fully comprehend the world which they live in and which they are so closely and deeply connected to. Chances are that they will not be environmentally literate global citizens and will not be able to make informed personal and social decisions on managing the environment or dealing with environmental issues at either a global or local level.

The objectives and curriculum of the present study were compiled having taken into account research showing that the concept of ecosystems is not easily understood by students (Leach et al 1995, 1996, Hellden 1998, Carlsson 2002, Eilam 2002, Grodzer &

Basca 2003, Brody & Koch 1989, Munson 1994 and others). They were included in detail in a Student's Workbook which was given to both the ITM and the DTS groups. The reasoning behind the workbook lies in that recent studies have shown that in order to achieve cognitive objectives; it is more effective to provide high schoolers with content that is concise and comprehensive rather than general and abstract. Detailed teaching content coupled with the precise teaching strategies used has indicated higher success in cognitive goal attainment (McNeill at al 2006).

2.2 The teaching models of the study

The Integrated Teaching Method (ITM) is a combination of specific course content, effective teaching strategies and an innovative teaching model. While inspired by both Ausubel's (2000) intelligent learning and Illeris' (2004) holistic modern learning theory, the latest data of the neuroscience of the brain, which is about how people learn and remember (Anderson 1997, Ball 2001, Byrnes 2001, Jensen 2005, Stern 2005) played the most important role in the formulation of ITM. The general framework for ITM was Kolb & Fry's (1975) experiential learning cycle.

As Siegler (2005) explains children use both passive and active learning mechanisms, whose interaction releases the capacity of functional memory that promotes learning. When children use active learning strategies they are able to solve problems, think about their accomplishment or their mistakes and learn from them. However, they also learn by identifying prototypes, such as examples, analogies, metaphors, and by associative learning (e.g., relating their experiences to the theory).

It has been extensively shown that there is great diversity in people's learning styles. Not only does each student have a different learning style but also a different level of development (Heffler 2001, Kolb 1981, Judson 2013). Gardner's (2006) theory of multiple intelligence states that each person has several ways of learning and processing information at different levels that are independent from one another. In addition, Sternberg & Grigorenko (2000), claim that three distinct elements comprise successful intelligence in people. Thus, it is advocated that teachers use a wide variety of approaches when instructing learners during the lesson, in order to ensure that the greatest number of students benefit (Anderson 1997, Heffler 2001, Kempa & Martin-Diaz 1990, Willis 2007, Pimentel & McNeill 2013).

From the perspective of Environmental Education, qualitative EE programmes should be based on pedagogical approaches that incorporate students' theoretical and practical learning experiences (Orr, 2006). In their meta-analysis of earlier studies, Kirschner et al. (2006), found that teaching strategies based on the minimal guidance of pupils are less effective in achieving the learning objectives than strategies with clear and concise instructions. It has been shown that teaching with no or little guidance may actually have negative effects on learning because students could acquire misconceptions or misguided attitudes, as well as incomplete or disorganized knowledge (ibid.). Mayer (2004) had similar findings in a study conducted on students in Californian schools.

The Integrated Teaching Method (ITM) proposed in this study was developed by taking the extensive literature referred to above into consideration, along with the most effective teaching strategies put forward by a number of prominent educationalists, such as Burden & Byrd (2007), Karten (2005) and Kinchin (2006), Marzano et al (2001) and Atherton (2005). The three types of teaching strategies selected for ITM were as follows:

A. Direct strategies: the teacher-designed instructional activities guide the students in the acquisition of skills and knowledge. More specifically, the strategies applied were: a) setting clear objectives, b) power point presentation, c) demonstration and direct application (during research on the ecosystem), d) asking appropriate questions, and e) immediate feedback.

B. Inductive strategies: exploratory activities that help students to understand concepts, to generalize, to expand one's knowledge of the subject, and to acquire skills. Those used were: a) construction of concept maps, b) discussions with note taking, and c) problem solving with field research.

C. Social strategies: students work together to collect in groups and to process information, as well as to acquire knowledge and skills. Instead of providing direct knowledge, the teacher facilitates its transmission as students help each other in the learning process. Those used were: a) cooperative learning, and b) a game of cards.

In addition, a new strategy was developed and applied based on Categories the philosophical work of the ancient Greek philosopher, Aristotle. In the study, this is referred to as 'the categorization of the ten modes of objective being of Aristotle'. The ten categories are: substance, quality, quantity, relation, location, time, position, possession, acting, and being acted upon. More specifically, the teacher has students examine and define the ecosystem which they investigated in accordance with Aristotle's categorizations, a poster of which is displayed on the blackboard. The students are asked to record on it the results and conclusions of the discussions that they have on the basis of the 'categories' and the questions asked in each. This strategy serves as a reference point that helps students answer the hypothesis set at the beginning of their study by providing evidence and thus reach substantiated conclusions and solutions.

Having the 'categories' as a starting base, the student groups verified the study hypothesis, using the data they collected in the field and combining them with the knowledge they gained. A more detailed report can be found in the lesson plans.

The 90-minute lesson plans were designed based on the suggestions of Jensen (2005) who believes that the lesson should be divided into a number of phases based on goals set by the teacher. The lessons are underpinned by the three following general principles: 1) marine ecosystems function in the same way that all ecosystems and systems generally do in our world; 2) energy plays an essential role in the functioning of the ecosystem; and 3) all the components of a system are interconnected and interrelated either directly or indirectly on the basis of cause-and-effect.

The teaching was designed and implemented based on a new teaching model, which indicates general teaching guidelines. The theoretical background was based on the works of Sousa (2001) and Donovan & Bransford (2005), whose proposals contribute to effective teaching by setting aims and objectives that enable students to gain a deep understanding of the concepts and the functioning of the ecosystem.

2.3 The teaching model consists of the following stages:

A. Engagement-presentation. Enhancement of functional and semantic memory and linking it to positive emotions

1. the teacher provides emotional anchors and sets the learning goals
2. the teacher discusses the teaching process and the students' responsibilities, engaging them in and committing them to the educational process
3. the teacher presents the new knowledge and connects it with that already held by students
4. the students ask, answer questions, discuss, write, observe and focus their attention

B. Guided collaborative research. Enhancement of episodic and procedural memory and its link to positive emotions

1. the teacher together with the students pose a real-life problem and make a case study
2. the teacher demonstrates skills and links knowledge to the possible solution of the problem
3. the students apply skills under teacher supervision

C. Guided knowledge construction. Strengthening and linking episodic and semantic memory

1. the teacher presents new knowledge, elaborates, elicits existing knowledge and provides feedback
2. the teacher together with the students associate the knowledge to the results of the students' research
3. the students find causal relationships, explain and evaluate

D. Independent knowledge construction. Development of positive feelings and long-term memory

1. the students check their hypothesis and draw conclusions
2. the students formulate proposals for the solution of the problem

The student learning objectives for each stage are:

1. a) awareness of the problem, b) acquisition of essential knowledge over time.
2. a) acquisition of experience in scientific field research, b) acquisition of scientific knowledge and skills, c) developing cooperative spirit.
3. a) acquisition, enhancement and construction of new knowledge, b) transfer from the specific to the general or to abstract, c) use of new knowledge
4. a) awareness of the ability for action and problem solving, b) in-depth concept consolidation, c) development of cognitive skills.

The Didactic Teaching Strategies (DTS) was based on eight of the eleven teaching strategies, mentioned above, of which the following were not applied: the demonstration with immediate application, the solution to the problem through field research, and the categorization of the ten modes of being of Aristotle.

3. Research Design

3.1 Study sample

The target population of the research were Year 8 Greek public secondary school students. The total sample consisted of 239 students enrolled in four junior high schools in Thessaloniki. The schools were selected on the basis of meeting the following criteria: a) the availability of computers and a projector in the classrooms for teaching with power point presentations, b) the availability of money to carry out research on the ecosystem, and c) the availability of time required to carry out the educational intervention.

In education, a difference of about 0.40 (40%), corresponding to Cohen's d = 0.80 (Cohen 1988) in the sample before and after the educational intervention is considered statistically significant. Based on this assumption, the minimum sample size for this study was determined at 104 students for the desired statistical power, i.e. a mean of 24 students per group. In addition, using Cochran's (1977) formula at a significance level of a = 0.005 the adjusted sample size was determined at 216 students (for a total population size of approximately 150,000 Year 8 secondary school students per annum in Greece). Thus, in the end, 239 students participated in the educational intervention, to ensure that the sampling error was small.

More specifically, four classes were taught with ITM and four with DTS, and two classes comprised the control, having no intervention.

3.2 Data Collection Tools

The data collection tools used in the research where two types of questionnaires with closed-type, multiple choice questions:

The first questionnaire was based on Bloom's taxonomy (1956): knowledge, comprehension and application. This was distributed to students before and after the teaching instruction to determine if and when there was an increase in knowledge, critical thinking and problem-solving abilities. It had 15 knowledge, 11 comprehension and 9 application questions.

The second was a questionnaire based on attitudes/opinions which had 16 five-point Likert scale questions and was distributed to students before and after the teaching instruction to detect and assess any changes in students' attitudes and opinions on issues of environmental protection.

The questions were formed on the basis of: a) the study hypotheses, b) the content and objectives of the subjects, c) questionnaires used in other similar studies (Morrone et al, 2001, Adamson et al, 2003, Brody 1996 and others), d) questions used by researchers to examine student misconceptions (Leach et al 1996, Tartaris 1997, Hogan 2000, Carlsson 2002, Grodzer & Basca 2003 and others), and e) the literature which refers to questionnaire design and evaluation (Kassotakis 199, Papanastasiou 1993, Bloom & Krathwohl 1991).

To ensure construct and concurrent validity of the questionnaires, factor analysis of principle components was applied to both the pilot study and the main research. The analysis showed that: a) the total knowledge questionnaire consists of six main parts, which consist of: knowledge, comprehension, application, General knowledge, General comprehension and General application and have concurrent and construct validity, b) in the questionnaire on attitudes/opinion the questions are divided into three main components with values and common charging factorial variance of the questions above 0.50 (heavy significance) and over 0.30 respectively. Thus, the attitudes/opinions questionnaire has concurrent and construct validity. With the Pearson discrimination index it was checked if there are correlations between the mean of each question and the mean of each part of the questionnaire. Index values for the pre- and post-tests were found to be above 0.20, which means that there is sufficient correlation between questions and thus the questionnaires have construct validity.

Questionnaire reliability was assessed with Cronbach's alpha for each part of the questionnaires, as well as for the overall scales. The index values are 0.864 and 0.931 in the pre- and post-tests, the overall knowledge questionnaire. The attitudes/opinions questionnaire takes values 0.842 and 0.814 in the pre-and post-tests, respectively.

3.4 Research Procedure

A quasi-experimental design that examines the cause-effect relationships between two variables was implemented. In the present study, the education of the students was the independent variable. This was divided into students receiving educational intervention with the application of either the experimental ITM or DTS.

The dependent variables that measure the results in the present study where the students' scores in the questionnaires of knowledge, comprehension, and application, as well as the total scores in the questionnaires on knowledge and attitudes/opinions. In the present study, three types of quasi-experimental design were used based on Cook & Campbell (1979), furthermore, there were two experimental groups and two control groups.

Therefore, the results of those students taught with ITM were compared on the one hand with those taught with DTS and on the other with the students who did not receive any intervention, i.e., the control groups. Firstly, the students answered the pre-test questionnaire one week before the educational intervention. The educational intervention was then implemented, over a three-week period. And one week later, the students responded to the post-test questionnaire. Questionnaire completion lasted 50 minutes and took place in the classroom in the presence of the researcher. At the start of the procedure the researcher gave instructions, as well as clarifying any queries so that the students would have a clear understanding of the questionnaire items and to avoid any misunderstandings. The three-week educational intervention was conducted as follows: in the first week, there was a 90-minute lesson in the classroom; in the second week, there was field research that lasted for five hours; and in the third week there was another 90-minute lesson in the classroom. Prior to the implementation of the educational intervention a pilot experiment was conducted, in the same year at the same school but in different classes of the same grade consisting of a sample of 106 students. The purpose of the pilot study was to check and assess the educational process and the questionnaires. The questionnaires: a) were timed in order to ascertain the time required for completion, b) the questions that were either very difficult or very easy were identified and adjusted, and c) the students' queries on some questions were clarified and the wording changed. Finally, the questionnaires were refined to meet the requirements of the study objectives prior to the main research.

3.5 Data Collection and Analysis

The evaluation of ITM was the statistical analysis of the questionnaires, which derived from the pre-test and the post-test. These were corrected and the students' responses were encoded and transferred to the computer as a score. Then they were mapped in pairs: pre-test questionnaire with the post-test questionnaire for the same student. To describe the characteristics of the questions and the sample individuals, descriptive statistics was applied. Variations in students' knowledge and attitudes/opinions due to the educational intervention were evaluated with t-Test based on the scores of the pre- and post-tests. Cohens'd effect size was calculated, to assess the educational intervention's magnitude of effectiveness. A general linear model repeated ANOVA was conducted to compare group results. The level of statistical significance (a) was set at 0.05. The statistical processing and analysis was performed using SPSS (Statistical Package for Social Sciences).

4. Results

In the present study, for the correlation of the demographic characteristics two indices, the Monte Carlo method for index computation and Cramer's V were applied. The correlation that was found was that between gender and participation in the EE programmes. More specifically, 50.8% of girls took part in EE as compared to only 13.6% of boys.

Chi-squared/χ^2 test was implemented to compare all the groups in their demographic characteristics and found that they do not differ. The variables knowledge and attitudes/opinions in association with the educational intervention were evaluated with the t-Test. The results are presented in tables 1-4 below.

In tables 1, 2, 3 and 4 the means that are followed by a different letter (a or b) have a significant statistical difference (p <0.001) according to the Bonferroni test.

Note: In all the tables that follow M stands for the mean and SD for significant difference.

Table 1: Comparison of students' level of knowledge, comprehension and application before and after the educational intervention

		Knowledge		**Comprehension**		**Application**	
Group		**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
ITM	**M**	0.69 **a**	4.07 **b**	0.56 **a**	3.31 **b**	1.02 **a**	2.31 **b**
	SD	0.82	1.39	0.76	1.28	0.97	0.82
	p	0.000		0.000		0.000	
DTS	**M**	1.41 **a**	3.55 **b**	1.09 **a**	2.91 **b**	1.07 **a**	1.98 **b**
	SD	1.35	1.85	1.55	1.71	1.02	1.15
	p	0.000		0.000		0.000	
Control group 1	**M**	1.14 **a**	1.17 **a**	0.60 **a**	0.57 **a**	1.45 **a**	1.38 **a**
	SD	1.35	1.34	0.66	0.70	1.19	1.13
	p	0.908		0.913		0.649	

Control group 2	**M**	0.85 **a**	0.93 **a**	0.44 **a**	0.20 **a**	1.04 **a**	0.78 **a**
	SD	1.21	1.33	0.89	0.51	1.20	1.06
	p	0.761		0.098		0.283	

Table 2: Comparison of students' level of general knowledge, general comprehension and general application before and after the educational intervention

Group		General knowledge		General comprehension		General application	
		Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
ITM	**M**	2.64**a**	6.27**b**	1.16**a**	2.78**b**	1.73**a**	3.91**b**
	SD	1.82	2.10	0.93	1.28	1.54	1.76
	p	0.000		0.000		0.000	
DTS	**M**	2.57**a**	4.89**b**	1.25**a**	2.55**b**	2.30**a**	3.48**b**
	SD	2.38	2.35	1.20	1.47	2.15	1.85
	p	0.000		0.000		0.000	
Control group 1	**M**	2.50**a**	2.55**a**	1.21**a**	1.19**a**	2.64**a**	2.45**a**
	SD	1.76	1.77	0.84	0.83	1.64	1.48
	p	0.857		0.901		0.363	
Control group 2	**M**	2.73**a**	2.51**a**	1.08**a**	1.15**a**	1.62**a**	1.98**a**
	SD	1.90	1.82	1.15	1.09	1.82	1.71
	p	0.576		0.768		0.333	

In tables 1 and 2, it was found that p value was always less than 0.001 for all the questionnaires (knowledge, comprehension, application, general knowledge, general comprehension, and general application) for both the ITM and DTS groups. Therefore, there was a statistically significant large increase in all the categories for both of these groups.

Table 3: Comparison of students' total knowledge before and after the educational intervention

Group		Total knowledge	
		Pre-test	**Post-test**
ITM	**M**	7.80**a**	22.64**b**
	SD	4.30	6.55
	p	0.000	
DTS	**M**	9.68**a**	19.34**b**
	SD	7.68	8.69
	p	0.000	
Control group 1	**M**	9.55**a**	9.31**a**
	SD	5.12	4.51

	p	0.756	
Control group 2	**M**	7.75**a**	7.54**a**
	SD	5.90	5.21
	p	0.856	

In table 3, it can be seen that p value was always less than 0.001 for the ITM and DTS groups which indicates that students' total knowledge increased significantly.

Table 4: Comparison of students' attitudes/opinions before and after the educational intervention

Group		**Attitudes/opinions Score**	
		Pre-test	**Post-test**
ITM	**M**	49.22**a**	57.86**b**
	SD	7.77	7.77
	p	0.000	
DTS	**M**	48.32**a**	55.89**b**
	SD	6.71	8.79
	p	0.000	
Control group 1	**M**	50.22 **a**	53.69 **a**
	SD	8.39	9.12
	p	0.061	
Control group 2	**M**	48.57 **a**	53.34 **a**
	SD	12.12	7.40
	p	0.029	

In table 4 it can be seen that p value was always less than 0.001 only for the two groups (ITM, DTS) that received educational intervention, showing improvement in students' attitudes/opinions.

In all four tables above, there were no significant differences in the results for the two control groups in the pre-test nor does there appear to have been any improvement in their knowledge or in their attitudes/opinions in the post-test. All t-test results shown in the four tables illustrate that the p value of the two control groups is greater than 0.001. These findings indicate that the students in these groups during the intervention period were not affected by their other school subjects in regards to the knowledge and attitudes/opinions variables examined in the questionnaires.

Cohen's d was applied to provide a comparative analysis for the two types of educational intervention. For the ITM group, Cohen's d = 2.82, while for the DTS group d = 1.48. The high index values indicate the noticeable effect of both interventions on the improvement in the level of students' knowledge. However, there was a big difference between the two index values when these were compared. This indicates that the effect of ITM was greater than that of DTS. In addition, for both intervention groups together, Cohen's d = 0.43 for scores in the post-test for knowledge (educationally significant: d>0.25). The magnitude of the effect is significant and it indicates that ITM impacted and improved the level of students' knowledge to a greater extent than DTS.

The analysis of variance (ANOVA) based on Least Significant Difference (LSD) method was applied to the scores before and after the educational intervention to compare if there were differences in performance. There were no statistically significant differences prior to the educational intervention in all four groups.

Note: In tables 5 - 7 below the means that are followed by a different letter (a, b or c) have a significant statistical difference. When p≤0.05 the two groups differ statistically at the level a = 0.05.

Table 5: Comparison of the six students' categories for the groups for the post-test

Team		Knowledge	Comprehension	Application	G*Knowledge	G*comprehension	G*Application
ITM	M	4.07 **a**	3.31 **a**	2.31 **a**	6.27 **a**	2.78 **a**	3.91 **a**
	SD	1.39	1.28	0.82	2.10	1.28	1.76
DTS	M	3.55 **a**	2.91 **a**	1.98 **a**	4.89 **c**	2.55 **c**	3.48 **a**
	SD	1.85	1.71	1.15	2.35	1.47	1.85
Control group 1	M	1.17 **b**	0.57 **b**	1.38 **b**	2.55 **b**	1.19 **b**	2.45 **b**
	SD	1.34	0.70	1.13	1.77	0.83	1.48
Control group 2	M	0.93 **b**	0.20 **b**	0.78 **b**	2.51 **b**	1.15 **b**	1.98 **b**
	SD	1.33	0.51	1.06	1.82	1.09	1.71

ITM	DTS	Control 1	Control 2
P-values for comparison of knowledge in post-test			
	0.342	0.000	0.000
		0.000	0.000
			1.000
P-values for comparison of comprehension in post-test			
	0.445	0.000	0.000
		0.000	0.000
			0.858
P-values for comparison of in Application post-test			
	0.398	0.000	0.000
		0.027	0.000
			0.058
P-values for comparison of G*knowledge categories in post-test			
	0.004	0.000	0.000
		0.000	0.000
			1.000
P-values for comparison of G*Comprehension in post-test			
	0.000	0.000	0.000
		0.000	0.000
			1.000
P-values for comparison of G*Application in post-test			
	0.699	0.000	0.000
		0.019	0.000
			1.000

*G stands for General

In table 5 the statistically significant differences for the post-test can be seen between the experimental groups and the two control groups in all the questionnaires ($p<0.05$) and the positive effects of the educational intervention on student performance is clearly confirmed. Between the ITM and DTS groups, there were statistically significant differences in the categories of general knowledge (p=0.004) and general comprehension (p=0.000).

Table 6: Comparison of students' total knowledge for the groups for the post –test

Group			Total Knowledge
ITM	M		22.64 **a**
	SD		6.55
DTS	M		19.34 **b**
	SD		8.69
Control group 1	M		9.31 **c**
	SD		4.51
Control group 2	M		7.54 **c**
	SD		5.21
ITM	**DTS**	**Control 1**	**Control 2**
P-values for comparison of total knowledge in post-test			
	0.043	0.000	0.000
		0.000	0.000
			1.000

Table 6 shows that there were statistically significant differences for the post-test between the experimental groups and the two control groups in total knowledge ($p<0.05$). In addition, it can be seen that there were statistically significant differences between the two intervention groups, ITM and DTS in the comparison of total knowledge (p=0.043). These differences can be attributed to the fact that ITM was more successful in enhancing students' performance.

Table 7: Comparison of students' attitudes/opinions for the groups for the post-test

Group		Attitudes/opinions
ITM	M	57.86 **a**
	SD	7.77
DTS	M	55.89 **a**
	SD	8.79
Control group 1	M	53.69 **a**
	SD	9.12
	M	53.34 **a**

Control group 2			
P-values for comparison of attitudes/opinions in post-test			
ITM	**DTS**	**Control 1**	**Control 2**
	0.835	0.075	0.076
		0.712	0.962
			1.000

In table 7, ANOVA showed that there was not such a great difference between the mean scores of the ITM and DTS groups on attitudes/opinions (57.86 and 55.89 respectively). However, it can be seen that in comparison to both control groups (M ~ 53), the two educational interventions were effective. The ANOVA analysis showed that there were no statistically significant differences between all the groups in attitudes/opinions before the educational intervention. These findings reinforce the belief that students' attitudes/opinions were affected by the educational intervention, however, only to a small extent.

Table 8: Correlations of dependent variables with Pearson's (r) correlation for the post-test ($p \leq 0.001$)

Post-test		**Attitudes/opinions**
Knowledge	r	**0.371**
	p	0
Comprehension	r	**0.468**
	p	0
Application	r	**0.485**
	p	0
General knowledge	r	**0.404**
	p	0
General comprehension	r	**0.472**
	p	0
General application	r	**0.645**
	p	0
Total knowledge	r	**0.562**
	p	0

Table 8 shows the correlations between the values for knowledge and attitudes/opinions in the post-test. High correlation coefficients were found between the values for each of the knowledge questionnaires and the attitudes/opinions questionnaire. As can be seen, all $p < 0.001$ and Pearson's r is between 0.371 and 0.645, which clearly indicates a strong positive correlation between students' knowledge and their attitudes/opinions towards the environment.

5. Discussion and Conclusions

The individual characteristics of the sample did not influence students' knowledge level at all. The one point where a statistically significant difference was observed was in the attitudes/opinions between the male and female students who were in the group that had had ITM intervention. In addition, the proportion of girls who had previously participated in an EE programme was significantly higher to that of boys. In their study, Tikka et al (2000) also found female students to display greater responsibility for the environment than their male classmates. This then lends support to the importance of encouraging students to participate in Environmental Education programmes.

The data analysis showed a statistically significant increase in students' performance on the questions related to knowledge, comprehension and application in the two groups that had had educational intervention either in the form of ITM or DTS. Although it appears that both teaching methods yielded positive results which enhanced students' performance, the biggest improvement in knowledge was found in the ITM group. The proportion of correct responses in the ITM group was significantly higher than those of the DTS. It seems that students in the DTS group who were given a more traditional teaching method were not able to either generalize the knowledge they acquired about ecosystems or to comprehend it to the same degree that the students in the innovative ITM group. The latter were not only able to generalize particular knowledge but also to comprehend abstract concepts. Additionally, these students acquired more theoretical knowledge which they had an in-depth understanding of. ITM is justifiably a better teaching method than DTS as besides applying the most effective teaching strategies in accordance with the international literature (Marzano, J. R. et al., 2001), it was augmented with another three strategies - problem-solving with field research, demonstration by the teacher on how to use the scientific instruments with direct application by the students, and the categorization of the ten modes of being of Aristotle - the last being the present researchers' innovation. The main difference between the two forms of intervention of course was that ITM, apart from the classroom setting, which was where DTS was held, also used an ecosystem in the natural environment as a teaching space. It is often the case that students at this age (13-14 years old have difficulty in accepting or explaining complex relationships of causality as they do not always easily understand what they do not perceive with their senses (Piaget 1988). It could also be that as they are passing from the stage of actual thinking to the stage of formal deductive thinking it might be difficult for them to generalize the specific and to comprehend abstract concepts and principles related to the ecosystem. With the Integrated Teaching Method (ITM) that included a field study with a demonstration of the scientific instruments, as well as hands-on application, students were given the opportunity to collect specific data and information that were then related to the new knowledge (abstract concepts, principles and ideas) taught in the classroom, both before and after the field study. At the same time, in connection to the categorizations of Aristotle and the discussion that ensued on this basis, references to their observations, measurements and the knowledge gained in the field were made in conjunction to the new knowledge that the teacher had introduced to them in the classroom. Through discussion, the students exchanged information and knowledge, expressed their views and were encouraged to make associations which were perhaps difficult for their age. Students derived information and knowledge from their direct experience in the field which they integrated with the concepts they had been taught, for instance in their analysis and problem-solving of the issue of pollution. Students were in this way helped to better understand the complex relationships and principles governing ecosystems, as well as to consolidate the abstract concepts related to them. Duvall & Zint (2007) in their review of related work, also concluded that research on an environmental problem where the students lived and which contained hands-on activities contributed to: a) an increase in students' and their parents' interest in the environment, b) the promotion of deeper, more essential knowledge, c) positive change in attitudes and opinions towards the environment, and d) the encouragement in the search for solutions to problems in the local community. In a meta-analysis of the results of many studies from around the world, Dillon et al. (2006) found that field research has beneficial effects on the cognitive, emotional, social and behavioural aspects of the participants' lives. It is essential, however, that: a) the teacher prepares a lesson(s) both prior to and following the field study, b) the learning activities are well designed, to be implemented and followed up when back in the classroom setting, c) the local environment should be used for the acquisition of knowledge and raising students' awareness for the protection of the ecosystem, and d) to enable this to happen, reference needs to be made to the sustainable use of environmental resources (Dillon et al. 2006). These recommendations were implemented in the ITM-based teaching and they are considered to have been a contributory factor to its success.

Gardner and Stern (1996) and Bartkus et al (1999) agree that educational intervention is successful in changing the attitudes and behaviour of the participants, so long as reliable environmental knowledge is taught and students are actively involved in the lesson. In the present study, the above are verified by the fact that only the two experimental groups showed statistically significant improvement in attitudes/opinions towards the environment, after the educational intervention. Furthermore, some researchers state that changes are achieved on an emotional level after a long-term process (Bloom & Krathwohl, 1991) and that the interventions should last at least 10 hours (Zelezny, 2000) for there to be significant changes. In the present study, there were nine hours of intervention, which is close to this length of time.

All the questionnaires between them presented significant correlations. More specifically, there is a strong positive correlation of each subcategory of knowledge with the questionnaire of attitudes/opinions and between total knowledge and attitudes/opinions after the educational intervention. It was noted that the increase of knowledge and their deeper understanding of the ecosystem, improved students' perceptions about the environment. This appears to have encouraged them to take more personal responsibility and they were willing to take future action in order to protect the environment. Although ITM was obviously superior to DTS in student knowledge enhancement, in attitudes/opinions, it does not appear to have had a stronger effect than that of DTS. The same results, namely that environmental knowledge -in whatever way it is taught- improved students' attitudes towards the environment, were had by numerous other researchers, such as Aini et al (2007), Bradley et al (1999), Siemer & Knuth (2001) as well as Kuhlemeier et al (1999) who conducted a study on 9,000 high schools in Denmark. In addition, Arcury (1990), Armstrong & Impara (1991) and Manzanal et al (1999) support that students who participate in EE programmes that last only for a few weeks, not only increase their knowledge of the environment, but also their attitude becomes more environmentally friendly. In a nutshell, having knowledge on the environment seems to be closely related to one's attitude towards the environment.

Since ITM and all its components increased the level of knowledge of students and strong correlations were found between all the categories of knowledge with students' attitudes/opinions, the method can be considered as being effective in enhancing the students' attitudes/opinions, thoughts, ideas and feelings towards the environment.

ITM provides an excellent opportunity for students to learn and apply scientific research methods in nature. Not only is it rational but essential that all students experience scientific methods at least once in their school life as only then will they be able to understand what modern technology is based on. In this way, they will gain first-hand knowledge on how human society works and progresses as well as its influence and/or interaction with the environment. In conclusion, this paper proposes that ITM be implemented as a teaching framework within an multidisciplinary approach for a variety of subjects involving the sciences and environmental education.

5.1 Study Limitations and Recommendations for Further Research

It needs to be stated that the results reported here are drawn from a limited study sample. If a research study were conducted at a national level, the findings could be generalised. In addition, another limitation was the length of intervention time. If it was for a longer period perhaps the findings would have been more conclusive between ITM and DTS on students' attitudes/opinions. Of interest would be research that assesses the implementation of ITM and the proposed teaching model in other school subjects. Furthermore, regarding the findings on gender differences, it would be interesting for further research to be conducted on whether females are more concerned about environmental issues than males and to examine the reasons why.

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