Article

Learning Ecological Concepts in Secondary Schools of the Northeast of Spain

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Abstract: Ecological concepts are not a recent matter; international organizations have already increased their efforts to provide better environmental education and ecological consciousness, although despite these efforts, a lack of attitudes and concepts were detected in the northeast of Spain. We evaluated the acquisition of concepts related to environmental education in the students as proposed by current legislation, as well as their relation to different parameters, such as geographical location, type of school, and gender. The result suggests that the students achieve a meaningful learning of the concepts proposed by legislation and that acquisition of this knowledge is related to gender and geographical location, but not to the type of secondary school.

1. Introduction

Following the recommendations by Eckins (2011) [1] and Ferreira (2009) [2], environmental (or ecological) consciousness is addressed in terms of the level of endorsement for the so-called new environmental (or ecological) paradigm. This paradigm associates environmentalism to a general eco-centric worldview that emphasizes humanity's need to establish a balance with nature, the existence of limits to the growth of human societies and questions humanity's right to rule over the rest of nature [3].

Environmental concern is not a recent quandary. For decades there have been many events that have highlighted how the overexploitation of socioeconomic activity is beyond the capabilities of the ecosystem to generate resources and absorb residues. One of the first pieces of evidence of ecological consciousness can be found in the early sixties, with the book of Rachel Carson, "Silent spring" [4]. In the 1970s, awareness of ecological consciousness grows exponentially with the creation of different associations and, as a result, different reports like "The limits to grow" [5] were published. Moreover, in this period, classic books related to environmental thoughts were also published, with two examples being "The Closing Circle: Nature, Man, and Technology" [6] and "The small is beautiful" [7], both of which expose, reflect upon, analyze, and criticize overdevelopment, the economic growth, and the little concern regarding the environment and ecological consciousness.

Different international institutions and organizations, such as the United Nations [8], since the early sixties have increased their efforts to achieve better environmental education and ecological consciousness by designing different programs and holding conferences and seminars in order to take decisions related to these subjects, as well as making these concepts and strategies available to all of society [9]. In recent years some authors have explored the implications of the shift of environmental education (EE) towards education for sustainable development (ESD) in the context of environmental ethics [10–12].

In Spanish institutions the development of conferences and programs started in the 1970s. Two books are the turning point in regards to ecological consciousness, "El bosc de Santiga" and "Ecología y educación ambiental" [13]. The Spanish history of environmental education is summarized in the "Libro blanco de la educación ambiental en España" published in 1999 [14]. The efforts made by the Spanish government in relation to ecological consciousness were not in vain, since the Spanish population is aware of the need to protect the environment beyond economic development as proven by the fact that consumer behavior of the Spanish population can be defined as pro-ecological [15]. Within this perspective of respect and awareness of our environment, we should work, teach and educate our younger generations inside and outside the classroom, to foster ecological consciousness as reported by Boyes and Stanisstreet [16].

1.1. Theoretical Framework: Ecological Consciousness in Secondary Schools

Environmental education is comprehensively analyzed in Spain and all over the world. In Spain, some studies analyze the initial background of secondary education professors [17], others detect the beliefs and limitations of primary school teachers regarding environmental education as a critical point to be implemented in the syllabus [18] or the evolution on the teacher's work, method and background over time [19]. Some studies focused on the students and their knowledge of nature such as the study proposed by Jaén and Barbudo [20] where they studied the evolution or changes in the perceptions regarding the environment in an academic year based on the ENV scale—which measures the environmental perceptions, both in attitude and behavior, as proposed by Bogner and Wilhelm in 1996 [21]—where no differences were detected; other work studies the evolution in the students' attitudes towards the environment as a result of working on a monographic assignment [22]. Other work compares the different strategies in order to have a wide view of socio-scientific issues (SSI) in science education [23] and others study the decision making in sustainable development and improves the strategies for decision making [24]. Some studies analyze the teaching model and suggest a proposal for environmental education [25], whereas other works compile different strategies for environmental education [26] and other studies examine the motivation of students—from 14 to 16 years of age—to learn science and how the Advanced Placement Program (AP) and collaborative-learning science can change the student's motivation to do so [27]. In addition, other documents analyzed include the Programme for International Student Assessment (PISA) reports, where the attitudes and responsibility of the teenagers towards the environment were tested (Organización para la Cooperación y el Desarrollo Económico [OECD], [28,29], as well as others where the data of the PISA reports were used in order to quantify the engagement in science of 15-year-olds [30].

1.2. The Present Study

The concepts related to environmental education in the secondary schools in Spain are defined by the government. The legislation for the work presented is the "Ley Orgánica de Educación 2/2006" (Boletín Oficial del Estado [BOE], [31], a law which outlines the skills and capacities that a student in secondary education (ages comprised between 12 and 16) has to acquire. The capacities are defined and collected in the "Real Decreto" 1636/2006 (BOE) [32] on a national level and by the Diario Oficial de la Comunidad Valenciana (DOCV) 112/2007 (Generalitat Valenciana) [33] on a regional level. If the legislation is analyzed, it can be observed that the concepts related to ecological consciousness are scattered throughout secondary education. This is indicative of the cross-curricular nature of these

concepts and the effort involved in the introduction of a cross-curricular matter within a consolidated syllabus structure [34]. Nevertheless, biology is the subject that contributes the most to the learning of ecological concepts. Within the defined framework, the aim of the present work is to analyze the learning of ecological consciousness-related concepts by the students of the secondary school in the northeast of Spain, specifically in the province of Castellón, which is divided into eight districts (Figure 1).
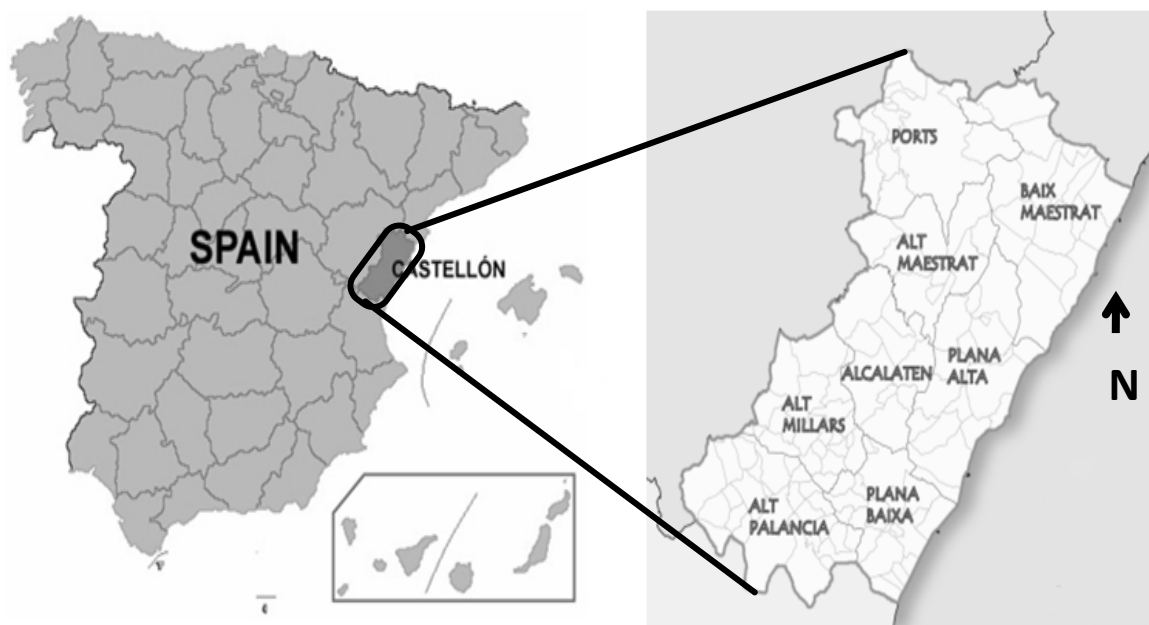

Figure 1. Geographical location and districts of the province of Castellón (Northeast Spain).

2. Objectives

Ecological consciousness is part of the curriculum of compulsory secondary education in Spain. These capacities and competences are the following: know the scientific knowledge as an integrated knowledge, know and apply methods to identify the problems in the different fields of knowledge and experience; critically assess social habits related to consumption, care of living beings and the environment, contributing to their conservation and improvement.

The main objective of this study is to evaluate if the contents marked by the Spanish law of education, relative to the ecological awareness, are assimilated by the students of secondary education in a selected studies area.

To reach the main goal, two complementary or secondary objectives were designed. On one hand, to compare the differences between concepts students knew beforehand and those they acquired thereafter, whether in the same academic year or during a different one, in order to assess the status of the concepts related to the environmental education within the secondary school. On the other hand, to correlate these concepts to different parameters, such as geographical location, type of school, and student gender.

3. Methodology

The methodology used in the present research is related to science education from the point of view of the social sciences, mainly experiment and statistics. The methodology used in this work is summarized in Figure 2.
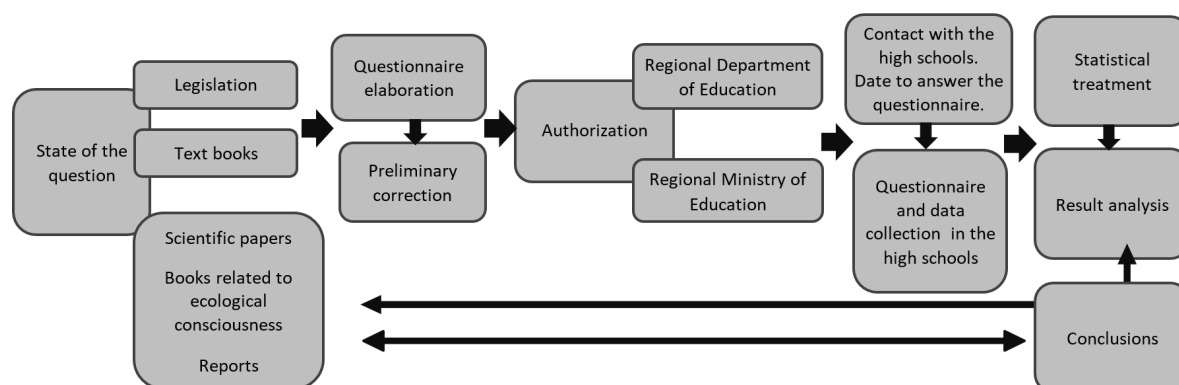
Figure 2. Flow diagram of the methodology followed for this research.

First of all, an extended bibliographic research was carried out in order to establish the state of the matter (theoretical framework). The first phase to be developed in the proposed methodology is a further bibliographic review, both of current educational standards and textbooks, to prepare the questionnaire in which the knowledge proposed by the current education law related to education ecological awareness is evaluated.

Secondly, a questionnaire to evaluate the background in ecological concepts of students of the secondary schools was created. We proceed to the correction of these questionnaires in a preliminary way by the experts (professors and researchers of Experimental Sciences Didactics and Methodology of educational research), to verify a validation of both the contents and the design and methodology. After receiving comments and constructive criticism, the final questionnaire is prepared. Next, the survey is carried out in the centers and, finally, the data is processed following Gil and Carrascosa methodology [35]. Due to the nature of the studied population, the authorization by the Regional Ministry of Education was required. After contacting the secondary schools, and once the date to carry out the questionnaire among their students was established, we proceeded to do so, after which the data was collected, and then the results were processed and analyzed, leading to the conclusions of this study.

3.1. Questionnaire

In order to collect the data from the studied population, in this case, secondary school students, the answers from a questionnaire were collected from September 2013 to May 2014. Its elaboration must be reliable with the purpose to obtain, in a systematic and objective way, all required information from the studied population related to the variables under investigation [36].

For the creation of the questionnaire, different bibliographic sources were analyzed with the aim of establishing a real framework of the treatment of ecological concepts in the secondary schools. These sources were scientific papers, books and reports related to the ecological concepts and the legislation of the period during which this study was carried out. In addition, the textbooks that the teachers used in their classrooms were also analyzed. These books were from different editorials (Vicens Vives, Edelvives, Oxford University Press, McGraw-Hill and Ecir) in order to have a comprehensive view and understanding of that which was proposed by the legislation. The questionnaire consisted on multiple-choice questions with a number of questions that varied according to the level of the students. The main reason to choose this type of questionnaire is because it is the most objective way to obtain the information, because it is a method where personal experiences do not influence the analysis of the data. Finally, the questionnaire consisted of 47 questions and has been adapted to the different educational levels of secondary school. The different issues address is related to climate change, ozone layer, pollutants, greenhouse effect, renewable energies, exploitation of resources, lithological, zoological and botanical concepts, ecosystems, and natural resources, among others.

For example, we show two different questions with multiple choices that appear in the questionnaire:

1. The water resources are:

(a) The waters of the oceans.
(b) All the waters on the earth.
(c) The available fresh water in our planet.

2. Climate change consists of:

(a) The rise in daytime temperature and nighttime descent.
(b) The difference between the temperature of the water and the rocks.
(c) The variation of the climate due to atmospheric modifications.

The students answered this questionnaire at the beginning and at the end of the academic year, allowing us to compare and analyze the number of correct questions answered in the different periods. With the information collected it was possible to obtain different types of information: previously known concepts, which students acquired during previous courses, specific concepts, which students acquired during the year that the questionnaire was created and the total amount of concepts that the student acquired. The questionnaire was reviewed and validated by a group of experts in the field of teaching. This information is collected in the Table 1.

Table 1. Type and number of questions from the questionnaire for each course of secondary education.

Year of Study	Type of Questions		
	Previous	Specific	Total
1st	- - - - - -	19	19
2nd	19	8	27
3rd	27	9	36
4th	36	5	41

3.2. Characteristics of the Studied Population

The main characteristic of the population being studied is that they are secondary school students (aged between 12 and 16), or juveniles under 18, which means they are protected by existing legislation. For this reason, the authorization by the Regional Ministry of Education is a mandatory requirement. Taking this into account, and in order to protect the personal information of the students, the questionnaire and the data collected is dealt with anonymously.

Data for this research was obtained by polling the secondary school population in the province of Castellon (Spain) with a questionnaire. When dealing with children, approval by the corresponding centers is necessary. Therefore, due to the characteristics of the population under study, a convenience sampling was carried out among those centers that volunteered to participate in the study and to obtain the corresponding permission from the tutors and the local government.

A total 7260 students who study in the 69 high school that there are in the province of Castellon were surveyed. Data was collected in the academic year 2012–2013. Although the sampling was carried out for convenience, the percentages of the population have been respected with respect to the sample used. In order to preserve their identity, both the questionnaire and the data collected are dealt with anonymously.

3.3. Systematization of the Data

In order to preserve the objectivity, impartiality and coherence of the data, accurate systematization is needed. The first step to achieve this objective is to properly elaborate and improve the questionnaire. Then, the students wrote their answers in a template, which was identical for all students, reaching optimal standardization and systematization of the data collected.

3.4. Statistical Analysis

Once the data has been collected and systematized we proceeded to analyze the results. This analysis is a statistical approach under the point of view of social sciences [37]. In this study

two statistical packages were used: The Statistical Package for Social Sciences (SPSS) [38] and the R programming language [39]. SPSS is a broad system, flexible, user-friendly and useful for descriptive statistics. The R programming language offers a wide range of statistical and graphics tools and allows the user to define their own functions [40]. R is more robust than SPSS and offers more guarantees in the hypothesis contrast.

4. Results and Discussion

4.1. Statistics

Statistics is defined by the Medical Subject Headings (MeSH) thesaurus as the science and art of collecting, summarizing, and analyzing data that is subject to random variation. The two broad categories of summarizing and analyzing data are referred to as descriptive and inferential statistics [41]. Descriptive statistics are used to estimate characteristics of the population in question, while inferential statistics are used on a sample to obtain conclusions based on descriptive statistics of the sample [8]. Both types of statistics and different statistical programs were used for this study.

4.2. Descriptive Statistics

To describe the population studied, the students of the province of Castellón (Spain), the program SPSS, version 21.0 was used.

The province of Castellón is divided into eight districts, and a total of 35 and 19 secondary schools were surveyed at the beginning and at the end of the academic year, respectively (Table 2). A total 4740 and 2520 students were surveyed at the beginning and at the end of the academic year, respectively, and can be classified according to different parameters: the type of secondary school—state, private and state-sponsored secondary school (which is regulated and financed by the public administration) (Table 3)—by the year of the secondary school—from first to fourth year—(Table 4) or by the gender—male or female—of the students (Table 5).

Table 2. Schools surveyed at the beginning and at the end of the academic year for each district.

	Academic Year	
Counties	**Beginning**	**End**
ELS PORTS *	1	1
ALT MAESTRAT *	3	2
ALCALATÉN *	4	2
ALT MILLARS *	1	1
ALT PALANCIA *	3	2
BAIX MAESTRAT **	3	1
PLANA ALTA **	8	5
PLANA BAIXA **	12	5
TOTAL	35	19

Note. * inland district, ** coastal district.

Table 3. Students surveyed at the beginning and at the end of the academic year for each type of school.

Type of School	Students Surveyed			
	Beginning		**End**	
	Freq	Pct	Freq	Pct
STATE	3113	65.7%	1268	50.3%
STATE-SPONSORED	1527	32.2%	1136	45.1%
PRIVATE	100	2.1%	116	4.6%
TOTAL	4740	100%	2520	100%

Note. Freq means frequency and Pct means percentage.

Table 4. Students surveyed at the beginning and at the end of the academic year for each course of secondary education.

Year in Secondary Education	Students Surveyed			
	Beginning		End	
	Freq	Pct	Freq	Pct
1st	1429	30.1%	792	31.1%
2nd	1315	27.7%	664	26.7%
3rd	1198	25.3%	621	24.6%
4th	798	16.8%	443	17.6%
TOTAL	4740	100%	2520	100%

Note. Freq means frequency and Pct means percentage.

Table 5. Students surveyed at the beginning and at the end of the academic year sorted by gender (male or female).

Gender	Students Surveyed			
	Beginning		End	
	Freq	Pct	Freq	Pct
MALE	2276	48%	1195	47.4%
FEMALE	2464	52%	1325	52.6%
TOTAL	4740	100%	2520	100%

Note. Freq means frequency and Pct means percentage.

As can be observed, the sample from the studied population has all the characteristics from the population, which shows that the sample is representative. Therefore, the present work represents a beginning for statistical, descriptive, or inferential analyses of other population with similar characteristics.

4.3. Hypothesis Contrasts

To achieve the objectives proposed, several hypothesis contrasts were designed and tested with the R programming language. Before testing them, the sample was analyzed in order to ensure that it met the applicability conditions required by the hypothesis contrast. The means were compared using independent *t*-tests and were statistically significant when the *p*-value < 0.05 [27,42].

The first contrast was designed to answer this question: is the mean of correctly answered questions at the end of the academic year greater than the mean of correctly answered questions at the beginning of the same academic year? This designed hypothesis contrast, is a unilateral contrast where all types of information that can be extracted from the questionnaire—previously, the specific and the total concepts acquired by the student were tested. In coherence with the results (Table 6), we have enough statistical evidence to reject the null hypothesis in most cases. This means that the mean of questions answered at the end of the academic year is greater than the mean of questions answered at the beginning of the same academic year. Therefore, the students of the secondary schools in the northeast of Spain (Castellón) achieve a meaningful learning of the concepts related to environmental education proposed by legislation in the same academic year. This result is consistent with the PISA report [29], which indicates that the main source of information related to the natural environment is the school. In this study, this information is quantified and verified by statistical methods, and It shows that for students of the secondary school in the northeast of Spain, it is at their secondary school where the students learn concepts and information related to ecological consciousness.

Table 6. Results for the unilateral hypothesis contrast where μ_1 is the mean of the beginning of the course and μ_2 is the mean of the end of the course. This table indicates the course, the type of questions (total, previous and specific), the *p*-value of the *t*-tests and if this is greater or less than the *p*-value established.

Hypothesis Contrast			
H$_0$: $\mu_1 \geq \mu_2$ $\left.\begin{array}{l}\\\\\end{array}\right\}$			
H$_A$: $\mu_1 < \mu_2$			
Year in Secondary Education	**Type of Questions**	**p-Value**	**Greater/Less α = 0.05**
1st	TOTAL	0.003203	<
2nd	TOTAL	1.126×10^{-5}	<
2nd	SPECIFIC	2.2×10^{-16}	<
2nd	PREVIOUS	0.4877	$\geq$
3rd	TOTAL	9.933×10^{-9}	<
3rd	SPECIFIC	4.248×10^{-9}	<
3rd	PREVIOUS	1.247×10^{-5}	<
4th	TOTAL	0.02522	<
4th	SPECIFIC	0.6399	$\geq$
4th	PREVIOUS	0.0164	<

The second contrast designed answers this question: is the mean of correctly answered questions at the beginning of the academic year less than the mean of correctly answered questions at the end of the previous academic year? Based on the results (Table 7), we do not have enough statistical evidence to reject the null hypothesis. We cannot claim that the mean of the correctly answered questions by the students of the northeast of Spain (Castellón) at the beginning of the academic year is less than the mean of correctly answered questions at the end of the previous academic year. This result was not expected, as we thought that at the beginning of the course the students would correctly answer a lower number of questions than at the end of the previous academic year. The cause of this improvement may be due to two main factors: firstly, because the questionnaires were answered by some students one month into the school year and secondly due to the maturation of the students. In regards to the first factor, the teacher reviews all the concepts from the last course during this period, so the students that answered the questionnaire at the end of this period have increased chances of answering the questionnaire items correctly compared to the students surveyed at the beginning. In relation to the second factor, the maturity level of the students, these improved results could be due to the fact that their logic is greater than in the previous academic year and they answered the questions aided by logic, and by thinking and connecting concepts to previous knowledge. Both factors can bias the result.

Table 7. Results for the unilateral hypothesis contrast where μ_1 is the mean of the total questions answered at the end of the previous academic year and μ_2 is the mean of the questions answered for the previous concepts at the beginning of the academic year. This table indicates the course, the type of questions (total end or previous beginning), the *p*-value of the *t*-tests and if this is greater o less than the *p*-value established.

Hypothesis Contrast					
H$_0$: $\mu_1 \leq \mu_2$ $\left.\begin{array}{l}\\\\\end{array}\right\}$					
H$_A$: $\mu_1 > \mu_2$					
Year in Secondary Education	**Type of Questions**	**Year in Secondary Education**	**Type of Questions**	**p-Value**	**GREATER/LESS α = 0.05**
1st	TOTAL END	2nd	PREVIOUS BEGINNING	1	$\geq$
2nd	TOTAL END	3rd	PREVIOUS BEGINNING	0.753	$\geq$
3rd	TOTAL END	4th	PREVIOUS BEGINNING	0.9984	$\geq$

4.4. Hypothesis Contrasts: Correlation with Parameters

In order to correlate the concepts acquired at the end of the academic year with different parameters such as geographic area, type of center and the gender of the students, other hypothesis contrasts were designed. For these contrasts, the proportion of the total questions answered correctly by students of the four courses of the secondary school was quantified and studied. The proportion was between 0 to 1, where 0 indicates that the students do not answer correctly any question and 1 indicates that the student answers correctly all questions.

The first contrast correlates the acquisition of concepts with the geographical location (district) where the secondary school is located—whether on the coast or inland. The contrast proposed is unilateral and leads to the following question: is the proportion of correctly answered questions greater among inland students than among students in the coastal regions? The results (Table 8) show enough statistical evidence to reject the null hypothesis. We can, therefore, affirm that the proportion of the questions answered by the students of the secondary schools that are located inland is significantly greater than the proportion of questions answered by the students of secondary schools located on the coast. These results can be explained by the influence of the direct contact with nature and the fact that in the inland districts, the lifestyle is more related to and direct with nature compared to the coast, where the big cities are located—in this case. Moreover, the ecological consciousness is introduced and fostered in the early primary school in inland districts, so the students are aware of the direct dependence on nature earlier in life [43,44].

Table 8. Results for the unilateral hypothesis contrast. It shows the proportion of the questions answered by the students form inland (μ_1) or coastal (μ_2) districts, the *p*-value of the *t*-tests and if this is greater to or less than the *p*-value established.

Hypothesis Contrast			
$H_0: \mu_1 \leq \mu_2$ $H_A: \mu_1 > \mu_2$			
Mean of Proportion: Geographical Location		*p*-Value	Greater/Less
Inland	Coastal		
0.4755803	0.4552342	1.134×10^{-9}	<

In regards to the correlation with the type of secondary school (state- or non-state-run secondary school), the contrast proposed is bilateral and leads to the following question: does the proportion of correctly answered questions vary depending on the type of school the students attend? In coherence with the results, shown in Table 9, we do not have enough statistical evidence to reject the null hypothesis. We cannot affirm that the proportion of correctly answered questions (by the students) is statistically different according to the type of secondary school. Therefore, this means that the students acquire the contents related to ecological concepts in the same way, without statistical differences, in the different types of secondary schools.

Table 9. Results for the bilateral hypothesis contrast. It indicates the proportion of the questions answered by the students from the different type of secondary schools (state or non-state), the *p*-value of the *t*-tests and if this is greater o less than the *p*-value established.

Hypothesis Contrast			
$H_0: \mu_1 = \mu_2$ $H_A: \mu_1 \neq \mu_2$			
Mean of Proportion: Type of Secondary School		*p*-Value	Greater/Less
State	Non-State		
0.4627261	0.4552342	0.133	$\geq$

In regards to the correlation with the gender of the student (masculine or feminine), the contrast proposed is bilateral and leads to the question: does the proportion of question answered correctly by the students differ according to the gender of the students? Based on the results (Table 10) we have enough statistical evidence to reject the null hypothesis. We can affirm that the proportion of questions answered is statistically different depending on the gender of the students. If we observe the mean of both groups (Table 10), we can see that the mean proportion is greater in male students than in female students in this specific situation. Despite this result, there is data [45] that proves that 14% of men fail to achieve the basic level of reading, mathematics and science compared to 9% of the women. Men are better at mathematics and women are better at reading. About the relation of the gender with pro-environmental attitudes, the study by Lieflander and Bogner [46] reveals that the environmental attitudes are not influenced by the gender of the students.

Table 10. Results for the bilateral hypothesis contrast. It shows the proportion of questions answered sorted by the gender of the students, the *p*-value of the *t*-tests and whether this is greater o less than the *p*-value established.

Hypothesis Contrast			
$H_0: \mu_1 = \mu_2$ $H_A: \mu_1 \neq \mu_2$			
Mean of Proportion: Gender		*p*-Value	Greater/Less
Male	Female		
0.4674854	0.4532687	9.952×10^{-7}	<

Summarizing the obtained results, the students do learn the concepts related to environmental education proposed by the legislation. This study shows that this acquisition is related to the students' gender and geographical location but not with the type of secondary school they attend.

5. Conclusions

The present study is a pioneer in the region focused on high school students. It would have been of great interest to compare the results of this study with previous research and projects, mainly in the Valencian Community.

If we compare this study with previous ones focused on the acquisition or attitudes of high school students or teenagers [20], the work of Pérez [22] or the PISA reports (OECD) [28,29], we can see the difference between these works and the present study. While these previous studies analyze the attitudes, the perception or the changes in their behavior towards the environment of the secondary school students, this paper analyzes the learning of ecological consciousness-related concepts, proposed by current legislation, by the students of the northeast of Spain—the province of Castellón—with the purpose of answering the hypothesis: Secondary school students learn the contents proposed by the legislation related to ecological consciousness. Nando [18] detected factors that make a correct implementation of environmental education difficult due to social, infrastructure and curricular factors in elementary schools. These deficiencies have led to the development of various environmental education programs in the study area [26] focused on primary education. In the international context, a recent study [47] carried out in a German school of primary education in the Bavarian region measured different dimensions of students regarding environmental education with respect to their connection with nature and their pro-environmental attitudes, but the results cannot be compared with this study.

Although the study has been carried out focus in a small region of Spain, and with a reduce sample, this research has demonstrated that, in this particular context, the students successfully learn a significant number of environmental consciousness concepts as proposed by current legislation. This acquisition is related to the students' gender, as there are differences between female and male

students, and geographic location—greater in inland districts compared to coastal ones—but not with the type of high school—state or non-state. Due to this, it is essential to assess the learning of concepts related to the environment in secondary schools. Furthermore, it is essential to facilitate the evolution of society and its future generations, especially for those who depend on the future and the development of nature and the world.

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