Environmental Education at Work: The Case of Kalymnos, Greece

Constantinos Yanniris

Department of Integrated Studies in Education

Faculty of Education

McGill University, Montréal

Québec, Canada

July 2020

A thesis submitted to McGill University in partial fulfillment of the requirements of

the degree of Doctor of Philosophy in Educational Studies

Abstract

Environmental education constitutes a form of experiential learning that seeks to create awareness about the functions and properties of natural ecosystems. This research aims to assess whether environmental literacy provides a viable framework for assessing the impacts and outcomes of outdoor experiential environmental education and, if so, how. The experimental design was inspired by the National Environmental Literacy Assessment (NELA) project, which was administered by the North American Association for Environmental Education (NAAEE) and concluded in 2014. The environmental education programs examined in this study took place on the Greek island of Kalymnos, where a group of students (N=143) from two local schools was exposed to multiple, independent, and mutually exclusive environmental education pedagogies over the course of six months. The Greek Environmental Literacy Instrument (GELI, Kyriazi, 2018), a culturally appropriate and locally validated instrument, was used to assess and compare participating students' environmental literacy levels before and after the outdoor and experiential environmental education interventions. The results showed that the educational interventions, dispersed over a six-month schooling period, had no significant impact on participating students' environmental science knowledge or environmental attitudes when compared to a control group. However, a significant improvement was observed in participating students' espoused environmental behaviours. These findings were compared to existing theory describing the development of pro-environmental behaviours. The theoretical framework of experiential education points to outdoor experience as an integral part of the process that leads to the improvement of pro-environmental behaviours. The findings suggest that the concept of environmental literacy provides a viable framework for assessing the impacts and outcomes of outdoor experiential environmental education. Further research is necessary to determine

the mechanism through which outdoor experience may enable the development of positive environmental behaviours.

Keywords: environmental education, evaluation of environmental education, environmental literacy, education for sustainability

Résumé

L'éducation environnementale constitue une forme d'apprentissage expérientiel qui vise à faire prendre conscience des fonctions et des propriétés des écosystèmes naturels. Cette recherche vise à évaluer si la littératie environnementale fournit un cadre viable pour évaluer les impacts et les résultats de l'éducation environnementale expérientielle en plein air. La conception expérimentale a été inspirée par le projet Évaluation nationale de la littératie environnementale (NELA), qui a été administré par l'Association nord-américaine pour l'éducation environnementale (NAAEE) et a pris fin en 2014. Les programmes d'éducation environnementale examinés dans cette étude ont eu lieu sur l'île grecque de Kalymnos, où un groupe d'élèves de deux écoles locales a été exposé à plusieurs pédagogies d'éducation environnementale indépendantes (mutuellement exclusives) pendant six mois (N = 143). L'instrument grec de littératie environnementale (GELI, Kyriazi, 2018), un instrument culturellement approprié et validé localement, a été utilisé pour évaluer et comparer les niveaux de littératie environnementale des élèves participants avant et après les interventions d'éducation environnementale extérieures et expérientielles. Les résultats ont montré que les interventions éducatives, réparties sur une période de scolarité de six mois, n'avaient pas d'impact significatif sur les connaissances ou les attitudes environnementales des élèves participants par rapport à un groupe témoin. Cependant, une amélioration significative a été observée dans les comportements environnementaux adoptés par les élèves participants. Ces

résultats ont été comparés à la théorie existante décrivant le développement de comportements pro-environnementaux. Le cadre théorique de l'éducation expérientielle fait de l'expérience en plein air une partie intégrante du processus qui mène à l'amélioration des comportements pro environnementaux. Les résultats suggèrent que le concept de littératie environnemental fournit un cadre viable pour évaluer les impacts et les résultats de l'éducation environnementale expérientielle en plein air. Des recherches supplémentaires sont nécessaires pour déterminer le mécanisme par lequel l'expérience de plein air peut permettre le développement de comportements environnementaux positif.

Acknowledgements

First, I want to thank my supervisor from DISE, Dr. Anila Asghar. Dr. Asghar had the patience and persistence to lead me through the complex landscape of funding proposals, ethics approvals and revisions thereof, changes in research design, and unexpected circumstances that I encountered during this study. I appreciate how, as a supervisor, she respected my academic freedom, supported my methodological choices, and backed me up when my research findings led me into unexplored waters. For all these, her human understanding and her high level scholarly and academic support, I feel indebted. I feel equal gratitude toward my co-supervisor, Dr. Ralf St.Clair, whose knowledge and experience have helped shape the present doctoral research from the very start. Dr. St.Clair never stopped believing in me, even in my most difficult times of self-doubt and disappointment. From Dr.St.Clair I've learned what hard, disciplined work really means, as I observed how he directed the progress of this project from the most abstract epistemological issues all the way down to the finest technical details. The contribution of my committee member Dr. Michael Hoover was essential for the completion of this treatise. As an experienced statistician and a deep thinker, Dr. Hoover was always there to explain to me what statistics can tell us, and what it cannot. For all the countless weekends that he went out of his way to teach me valuable research and life skills, I thank him immensely.

Aside from the support of my doctoral research committee, I am especially grateful to Graduate Program Director Dr. Marta Kobiela, who supported me consistently in every step of my progress in this degree. I would also like to thank Dr. Carolyne Turner, who helped me to organize my thoughts at the early stages of this research project. Furthermore, I would like to express my appreciation to Dr. Ratna Ghosh for giving me helpful feedback on my funding proposals, and to Dr. Claudia Mitchell for her encouragement and advice. I would also like to thank DISE academic staff Dr. Caroline Riches, Dr. Sheryl Smith Gilman, and student

advisors Ms. Grace Wong-McAllister and Ms. Tina Schiavone for their help and support in reintroducing an undergraduate course on Education and Environment. The re-introduction of this course draws from an earlier initiative led by Dr. Elizabeth Wood, Dr. Caroline Riches, and Dr. Anila Asghar, who worked to establish Education for Sustainability learning communities. Teaching that course was an opportunity and a rich learning experience which has informed my study in many ways. Furthermore, I would like to thank Ms. Jacky Farrell from the Redpath Museum, who introduced me into Canadian outdoor learning and the undergraduate students who embraced the sustainability course, with a special reference to Mr. Antonio Giordano, Mr. Brandon Nancoo, and Ms. Jessica Giambagno. I would also like to thank lab technician Ms. Jennifer Wallace, who was always there to help me with technical and ethical support for my lab and outdoor teachings, and Graduate Student Affairs Coordinator Dr. Michael Lariviere, who showed extraordinary patience, as he helped me juggle the necessary arrangements between Greek and Canadian bureaucracies, importantly securing lifeline funds for this research project every time I showed up in front of him with just another impossible deadline.

I would also like to thank prof. Alexandros Georgopoulos and environmental education counsellors Dr. Evangelia Moula and Dr. Antonia Dardioti for helping me connect with environmental education groups from Greek schools, as well as school teachers Ms. Evdokia Platsi and Mr. Vassilis Kalogerakis for inviting me to collect data from their students. I also thank school principles Mr. Nikolaos Korfias and Mr. Pantelis Ellinas for granting the respective permissions. Lastly, I thank school teachers Ms. Eleni Adamopoulou and Mr. Anargyros Drivas for inviting me to collect data from their schools in Nafpaktos, Greece – in compliance to the initial approval by McGill Research Ethics Board III, REB File #: 67-0717 – even though data collection from these schools did not proceed due to institutional issues from the Greek side. I would also like to show my gratitude to all the

anonymous students who participated in this research in good faith, thus allowing me to obtain a census of all the students in their classes.

Importantly, I would like to thank Dr. Julie Kyriazi for giving me the permission to use the environmental literacy instrument that she developed in the context of her doctoral research, supervised by Dr. Evangelia Mavrikaki from the University of Athens. I was lucky enough to come across their newly developed instrument, exactly at the time when I was searching for a culturally appropriate method to capture the effects of Greek environmental education. Moreover, I would like to acknowledge the contribution of environmental education expert Dr. Tom Marcinkowski from the Florida Institute of Technology, who gave me valuable insights concerning the empirical findings of the study, at the final stages of the present research. My appreciation to data analyst Mr. Dimitris Katsaounis, who found the time and good will to show me how to tabulate the voluminous data of the present study into a digital format.

Additionally, I would also like to gratefully acknowledge the financial support I have received from the Stavros S. Niarchos Foundation, the Fonds de recherche du Québec – Société et culture (FRQSC), the [Greek] State Scholarships Foundation (IKY), the Department of Integrated Studies in Education, the Faculty of Education, and Graduate and Postdoctoral Studies at McGill University. Special thanks to the Dean of Graduate and Postdoctoral Studies Dr. Josephine Nalbantoglu and Dr. Stelios Vassilakis from the Stavros S. Niarchos Foundation for their interest in the empirical findings of this study.

During this journey, I was lucky enough to find people who have supported me through their warmth, kindness, and friendliness. I am grateful to Ms. Christina Nassiou and Mr. Xenofon Nikolopoulos for helping us settle in Montreal. To Peter Paproski, Dr. Ehaab Abdou, Dr. W. Y. Alice Chan, Dr. Costas Gavrilakis, Aristofanis Soulikias, prof. Dimitris

Vouliouris, and Vassilis Melidis for advising me, for giving me practical and ethical support and, above all, their friendship. To DISE colleagues and friends Sylvie Wald and Adrien Bourdon-Feniou, Dr. Sara Hashem, Dr. Nazeeha Khoja and Mohammed Obaidullah, Dr. Arzina Zaver and Alim Fakirani, Dr. Ying-Syuan (Elaine) Huang, Dr. Eun-Ji Amy Kim, Dr. Casey Burkholder, Dr. Mehdi Babaei, Ashley DeMartini, Felipe Méndez Alvarado, Mona Makramalla, Dr. Lauren Halcomb-Smith and Grant Smith, Désirée Rochat, Dr. Chloe Garcia, Dr. Megumi Fujio, Dr. Khishigbayar Tsogbadrakh, Maria Chiras, Dr. Heather McPherson, Dr. Neerusha Gokool, Zachary Parker, Dr. Shujiao Wang, Dilmurat Mahmut, Mustafa Ramazan, and Dr. Terry Wan Jung Lin for creating a warm and supportive learning environment and for introducing me to diverse and interesting new ways of thinking.

This dissertation would never have been written without the important people in my life who have supported me throughout my graduate study. In particular, I am grateful to my parents Vassiliki Papagianni and Elias Yanniris, who have taught me to love reading and learning and setting high standards for my efforts. To my older sister Myrto and her family, who paved the way for our Montreal life and graduate studies. To my younger sister Lemonia and to my father's partner Electra Strovilidou, who visited us in Montreal and gave a helping hand with our babies. To my maternal uncle Kostis Papagiannis for keeping me alive with homegrown food upon my retreat in the solitude of rural Greece in order for me to complete this treatise. Importantly, to my ex-spouse Panagiota Ntaltagianni for her support and her decision to move our young family in Montreal for six consecutive years full of learning, new friends and experiences, but also times of self-doubt and hardship. Lastly, to my two daughters, Drosia and Eliana, who gave me the chance to rediscover the world through their young eyes. To participate in their upbringing has given me a new sense of purpose and meaning in my life, and spending time with them gave me the most relaxing and replenishing breaks from my studies that I could ever have hoped for.

Table of Contents

Chapter One: Introduction

Today, a growing global population demands the allocation of ever more natural resources to meet a seemingly insatiable desire for consumption. This demand strains the availability of natural resources and increases competition over their use. As a result, humanity may face a future of irreversible environmental damage and perpetual conflict over access to dwindling environmental resources (IPCC, 2014). Education can play a significant role in developing people's understanding of critical environmental issues, shaping positive attitudes toward the environment, and inspiring pro-environmental behaviors. At the same time, environmental education can help in creating awareness about (a) the impact of environmental issues on the health and resilience of human societies and (b) the effects of our civic and economic choices on the state of the natural environment (Orr, 1992). Since the late 1970s, international organizations have successively called on Environmental Education, Education for Sustainable Development, and Education for Global Citizenship to introduce these complex socio-environmental issues in mainstream education. Below, I discuss the historical origins of these often overlapping educational approaches.

In 1977, the world's first intergovernmental conference on Environmental Education was organized under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Programme (UNEP) in Tbilisi. The declaration adopted in the context of this first international conference on Environmental Education describes the field as "interdisciplinary and holistic in nature and application…an approach to education rather than a subject" (Palmer, 1998, p. 98). The Tbilisi declaration expounded that "Environmental Education must adopt a holistic perspective which examines the ecological, social, cultural and other aspects of particular problems. It is therefore inherently interdisciplinary" (UNESCO, 1978, p.12). Following the introduction of the term 'sustainability' into the public discourse by the Brundtland Commission Report

(1987), Education for Sustainable Development was presented at the United Nations Environmental Conference in Rio (1992). Sustainable development was defined as "development which meets the needs of the present without compromising the ability of future generations to meet their needs" (Brundtland, 1987, p. 41). Drawing on this definition, the political demand for Sustainable Development is viewed as a synthesis between environmental theory (the interest in conserving natural resources) and justice theory (a concern for the needs of present and future generations) (Le Grange, 2013). Hence, Education for Sustainable Development placed a renewed emphasis on the economic, social and political aspects of the environmental problem.

In the next decade, efforts to integrate environmental and sustainability themes into diverse educational curricula continued with initiatives such as the 2005–2014 UN Decade of Education for Sustainable Development (UNESCO, 2002). More recently, UNESCO (2015) introduced Global Citizenship Education, a form of civic learning that involves students' active participation in projects that address global issues of a social, political, economic, or environmental nature. In 2016, UNESCO recommended that "(i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in: (a) national education policies, (b) curricula, (c) teacher education and (d) student assessment" (p.50).

Despite the presence of consistent institutional support by international organizations, the introduction of these interdisciplinary pedagogies into actual educational settings proved challenging. Indicatively, four decades after its celebrated inauguration at the UNESCO conference in Tbilisi (USSR) in 1977, the integration of Environmental Education into K-20 educational curricula has been relatively slow (Saylan & Blumstein, 2011). Even in countries (and states) where a favorable political climate has led to the implementation of policies in support of educational initiatives linked to environmental concerns, the integration of environmental and sustainability education into the schooling system has not proceeded at the pace that many of us would have hoped for (Louv, 2008; Brügger, 2004). The subsequent introduction of Education for Sustainable Development was also

accompanied by criticism that teachers and practitioners were left without guidance in a discourse that was becoming increasingly abstract and decontextualized from pedagogy and contexts of practice (Blum et al., 2013; Stevenson, 2013, 2008).

The UN Sustainable Development Goals constitute a collection of 17 global goals, announced in December 2014 and adopted by the United Nations General Assembly in September 2015 (UN, 2014). With respect to education, Sustainable Development Goal 4 aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by the year 2030 (Madeley, 2015, p.33). The Sustainable Development Goals were deemed as 'unachievable', and the organization was criticized for 'cockpit-ism', the "illusion that top-down steering by governments and intergovernmental organizations alone can address global problems" (Hajer et. al., 2015, p.2). In response, UNESCO acknowledged this criticism and proceeded to specify the implementation and monitoring policies on UN Goal 4 pertaining to education (2016, p. ii).

Environmental and sustainability education have encountered a number of challenges which have hindered their adoption as mainstream pedagogical practices. One of the ongoing challenges in environment-related education is the development of a valid and reliable framework for program evaluation. Since the first evaluation of the World Wildlife Fund's global educational programs, researchers have pointed out that evaluation in environmental education has been "immature" and largely "neglected", and noted a "lack of a widespread culture of evaluation in environmental education" (Fien, Scott & Tilbury, 2001, p. 379). More recently, Carleton-Hug and Hug (2010) reported that most environmental education programs worldwide have failed to incorporate high quality, systematic evaluation into their programming. As a result, there is a dearth of documented factors leading to programme success in the fields of environmental and sustainability education (Jacobson & McDuff, 1997). Developing and implementing a comprehensive evaluation approach thus needs to be a key focus of current efforts to promote environmental education.

Context and Purpose of Study

This dissertation analyses the application of an evaluation perspective based on environmental literacy to environmental education programs in Greece. In many ways, Greece shares the challenges that environmental education program evaluation faces worldwide (Yanniris & Garis, 2018, p. 126). Environmental education in Greece is school-based and is offered to students as an elective, interdisciplinary activity supported by a dispersed network of Environmental Education Centres and supervised by environmental education counselors who report to the Greek Ministry of Education. The pedagogical goals of the Greek environmental education program are defined by the Environmental Education curriculum of 2003 and the Environmental and Sustainability Education curriculum of 2010 (Pedagogical Institute, 2003; 2010). In the 2003 Environmental Education Curriculum, a number of criteria are set for the evaluation of environmental education, including the degree to which environmental education projects meet the goal of developing students' knowledge, skills, values, stances, and behaviours towards the natural environment (Pedagogical Institute, 2003). However, the Greek curricula and ministerial directives lack specific guidelines on how institutions, schools, and teachers can actually measure the aforementioned qualities in order to assess the quality of environmental education programs. As a result, the standard practice in Greek secondary education is that environmental education projects are self-evaluated through questionnaires completed by participating students at the end of the term, the results of which are rarely announced (Kalathaki, 2012).

The lack of a systematic evaluation framework for environmental education in Greece has exposed the field to criticism from the highest political level. In 2010, deputy Minister of Education Efi Christofilopoulou criticized environmental education practice in Greece and claimed that "recently, most Environmental Education Centres have evolved into excursion

centres that serve trade unions but not the students" (Christofilopoulou, 2010). Shortly after her statement, the Ministry of Education enforced the closure of forty per cent of the EECs and abolished a number of staff positions related to environmental education (Greek Ministry of Education, 2011). The decision by which specific Environmental Education Centres were closed was based on their seniority and geographical location. In each of the country's 54 administrative districts, only the most senior Environmental Education Centres were allowed to operate, and the more recently opened Environmental Education Centres were merged under the senior ones. It seems that these uniform criteria were used to abolish these centres in lack of evaluative information on the educational impact of these centres on students' learning. Arguably, the presence of a reliable evaluation framework, based on learner's educational outcomes to assess their performance, could have averted this indiscriminate loss in educational programs, projects, and materials. As is discussed below, a reliable evaluation system could serve in a) improving the accountability of environmental education, and b) pointing to effective environmental education practices.

The international literature suggests that environmental education programs can be evaluated based on their demonstrated capacity to improve students' environmental literacy (Ardoin & Merrick, 2013, p.3). Recently, the National Environmental Education Advisory Council [NEEAC] in the US declared that "environmental literacy is the intended outcome of environmental education" (NEEAC, 2015, p.8). According to its classical definition, environmental literacy is an observable quality:

> Environmental literacy is essentially the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems . . . Environmental literacy should be defined . . . in terms of observable behaviors. That is, people should be able to demonstrate in some observable form what they have learned—their knowledge of key concepts,

skills acquired, disposition towards issues, and the like. (Roth, 1992, as cited in St.Clair, 2003, p.70.)

Drawing on this definition, St.Clair (2003) suggested that environmental literacy requires "knowledgable, critical engagement with environmental issues and the ability to form judgements about the likely impact of human activities upon the environment" (p.15). In a similar tone, the NEEAC has more recently described environmental literacy as "the extent to which a person is concerned about the environment, equipped to make informed decisions about it, and has the skills and motivation to take environmentally responsible actions" (NEEAC, 2015, p. 8). Environmental literacy is generally considered as a multifaceted concept that consists of environmental knowledge, competencies, skills, dispositions and preparedness to act (McBride, 2011; Hollweg et al. 2011; Green, Camilli & Elmore, 2012).

A number of researchers have sought to evaluate the effectiveness of environmental education programs based on the environmental literacy performances of participating students (McBeth et al., 2011; Maulidya, Mudzakir, & Sanjaya, 2014; Igbokwe, 2012, 2016). According to their rationale, effective environmental education programs should be those whose beneficiaries display improved environmental literacy performances. Their work opens the way for a more systematic evaluation of environmental education programs, as appropriate to the objectives, goals, and priorities of each national context.

The purpose of this study is to examine the pertinence of an environmental literacy approach as a means to assess the effectiveness of environmental education programs in Greece. In order to meet this general purpose, the research objective of this study is specified below:

1. To explore whether, and how an environmental literacy approach can provide a viable framework for assessing the impacts and outcomes of the type of environmental education programs that are applied in the Greek context.

In order to meet this objective, this research applied an environmental literacy framework aiming to capture the effects of outdoor environmental education programs. Specifically, a quasi-experimental research design was used to study the impact of environmental education on high school students' environmental knowledge, attitudes and behaviours. The environmental education programs that were observed took place on the Greek island of Kalymnos, where a group of grade 9 and 10 students (N=143) from two local schools took part in outdoor and experiential environmental education pedagogies over the course of six and a half months in addition to the standard curriculum. A control group of students from the same grades followed the standard curriculum. The Greek Environmental Literacy Instrument (GELI), a culturally appropriate and locally validated instrument, was used to assess and compare participating students' environmental literacy levels before and after the environmental education treatment (Kyriazi, 2018).

The study methodology and findings are presented in Chapters 4 and 5, respectively. The results contribute to the international body of research that addresses the challenge of environmental education program evaluation. Improvements in the evaluation of environmental education programs can entail improvements in both the quality and accountability of environmental education. Moreover, a minimal agreement on what environmental education is expected to achieve can pave the way for the identification of effective environmental education practices in Greece and elsewhere.

Situating the Researcher

My interest in environmental education stems from five years of professional involvement in Environmental Education Centres in different parts of the Greek countryside.

My professional responsibilities included the design and implementation of environmental education programs as a member of multidisciplinary teams. As part of this experience I also had the opportunity to work with educators from different countries in the context of international environmental education programs. Connecting with educators from different parts of the world helped me understand that the promotion of environmental and sustainability is a collective, international cause. However, I saw that each one of us was having difficulty in working our way against long-established mentalities in order to convince local stakeholders of the necessity and urgency of environmental education.

Ten years ago, I was sitting in front of a selection committee headed by the regional director of primary and secondary education in the provincial capital city of Lamia, central Greece. Earlier, the Greek Ministry of education had delegated to the regional boards of education the responsibility of selecting the personnel for the country's Environmental Education Centres. At that point, the board was evaluating my application for a vacancy in an Environmental Education Centre. The position was for the Environmental Education Centre of Karpenisi, a small town of central Greece situated at an altitude of 970 meters, in a narrow valley surrounded by imposing, forested mountains. Concluding the interview, the regional director asked his last question to me in an austere tone, something like "So, what do you think that environmental education has to offer to the students? What does it do?". With no conscious intention to provoke him, I replied "I think that the most important thing that environmental education does, is that students learn how to get themselves dirty, they gain in experience through their contact with the soil and the mud." This was *casus belli* for the regional director of education, who became apparently agitated at the idea that a novice teacher would be sent out there (his salary paid by the Greek state) with a mission to teach our children how to get their clothes dirty. Eventually, I did not get that job, but I think that I now understand his reservations and where they were coming from.

When my maternal grandparents were growing up in their native mountain villages, not very too from Karpenisi, they were practicing subsistence farming with their families, and toiled on the land. Their life was a constant struggle to keep their homes and clothes clean from dirt and mud. They had a drive (especially my grandmother) to better their lives, to educate their children, to escape from subsistence farming. Along with millions of internal immigrants, they moved to Athens after WWII and the Greek civil war, and settled on the outskirts of the city. In this new socio-economic environment, they saw their living standards improve dramatically through the 60s, 70s, and 80s. Their demand for social justice was grounded on their own lived experiences of social, economic, and political injustice. At the same time, they brought with them the ethos of the agrarian communities that formed them into who they were, and clung to their core values through the rest of their lives. For their generation, education was a class marker, and it went in tandem with being neat and proper, dressed with clean, well ironed clothes. To convince this old-school generation that education could be about familiarizing students with the soil and mud would require an inversion of their values and lived experiences.

However, we live in a different world today. Contemporary poverty is somewhat different than the kind of poverty that my grandparents experienced. These days, poverty is restrictive in a different way, it is about having no choice but living on polluted air, food and water. Today's poverty is to suffer from a deficit of nature because your parents don't have the luxury to afford (or to prioritize) a daytrip that would bring their children into direct contact with nature. In many parts of the world, natural landscapes are out of reach and even urban parks function as closed and gated clubs with no access for the urban poor. Environmental education ought to cater to this new type of poverty, for children whose families cannot afford to pay for access to natural settings.

However, the regional director's question deserves a substantiated answer. Reviewing his educational background as a mathematician with a PhD in the didactics of mathematics, I think that the essence of his question was: What evidence do we have that environmental education produces something significant? An important part of policy-making is to look out for measurable outcomes before concluding to a particular approach is effective or ineffective. I inevitably internalized these doubts on the effectiveness of environmental education efforts, which are being heard at all levels of the decision-making chain (Christofilopoulou, 2010). I could no longer trust my personal criterion that students appeared as being engaged and excited when participating in outdoor activities. I had to know, what were the students taking back home, and in what ways the delivered educational experiences were shaping their perceptions and attitudes toward environmental issues. Finally, I wanted to know how we could measure the effects and outcomes of our efforts in environmental education. These were the questions that spurred me to embark in this learning journey.

Structure of the Dissertation

I have structured this dissertation in seven chapters including this introduction. In the introductory Chapter One, I discuss the need for effective educational programs addressing the environmental and sustainability themes, and I point to the shortcomings that the literature has identified in relation to evaluation of these programs. In Chapter Two, I present a historical overview of the institutional and pedagogical evolution of environmental and sustainability education, and then I proceed to discuss the concept of environmental literacy and its problematic. Chapter Two closes with an overview of selected international examples of environmental and sustainability education, with a special emphasis on Greece, which has offered the setting for the empirical aspects of this research. Chapter Three lays out the theoretical framework of the present study, with an emphasis on the theoretical constructs that have been employed in environmental education program evaluation. The challenges in

environmental education program evaluation are discussed, as these are understood in the contemporary literature. Environmental literacy is revisited as a link between the outcomes of environmental education and empirical assessment.

In Chapter Four, the methodological framework of this study is presented, including the research question, research design, settings, population, sampling, instrumentation, and analytical methods. Chapter Five presents and elaborates on the study findings, as these are derived from analysis of the collected data. Chapter Five (Findings) also includes post-hoc analysis, which has been pre-emptively described in the previous chapter (Methods), in order to address potential threats to validity. Chapter Six contains a comprehensive discussion of the empirical findings, including analysis of their face validity. Lastly, Chapter Seven concludes the study by providing an informed answer to the research question, followed by detailed account of the study's limitations and implications, and suggestions for future research. Even if there is still much work to be done before proposing a consistent evaluative framework for Greek environmental education, the findings of this study support the potential of environmental literacy assessments as a means to understand the mechanisms that lead to the development of environmentally responsible behaviours.

I wrote the current dissertation in its entirety, and I conceptualized and carried out all aspects of the research, under the guidance of my supervisors and the advice of the doctoral committee.

Abbreviations / Operational Definitions/ Glossary

The use of acronyms and abbreviations was generally avoided in this thesis. Exceptionally, the following nine abbreviations are used in the body of this thesis, because their in-text full spread out would distract the flow of the text (Table 1). Except where noted

otherwise, the significance level (alpha level) for the findings presented in this thesis is set to the benchmark of .05

Table 1

Abbreviations

	Pre test measure (October 2017)	Post test measure (May 2018)	Post to Pre improvement (Change between Oct. 2017 and May 2018)
environmental Knowledge	preK	postK	ΔK
environmental Attitudes	preA	postA	ΔA
environmentally responsible Behaviour	preB	postB	ΔB

Chapter Two: Literature Review

A discussion of the current theoretical understandings of environment-related education is essential before proceeding to the research design, methods, and hypotheses of this study. Initially, this chapter reviews the historical development of environmental education, which emerged in its modern form in the second half of the 20th century. Then it describes the move towards Education for Sustainable Development, which started after the introduction of the term *sustainability* in the public discourse in the late 1980s. Finally, *environmental literacy* is presented as a construct that can be used to assess the effectiveness of both environmental education and Education for Sustainable Development. International experiences with education for the environment are discussed, with a focus on program evaluation.

Definitions and Institutional History of Environmental Education

The institutional history of environmental education at the international level starts from the UN Conference on the Human Environment (Stockholm, 1972), which created the UNESCO/UNEP International Environmental Education Program (IEEP) with a mission to develop, promote, and fund environmental education (McKeown & Hopkins, 2003). Over the following years, the IEEP collaboratively developed the theoretical foundations of environmental education, which appeared in the Final Report of the International Workshop on Environmental Education held in Yugoslavia in 1975, known as the Belgrade Charter (UNESCO, 1976). These efforts culminated in the Intergovernmental Conference on Environmental Education held in Tbilisi, USSR (now the capital of Georgia) in 1977 which ratified the Tbilisi Declaration for environmental education (UNESCO, 1978).

The Tbilisi declaration describes environmental education as "interdisciplinary and holistic in nature and application…an approach to education rather than a subject" (UNESCO,

1978). As an interdisciplinary practice, environmental education is not bound to a particular subject, discipline or domain of knowledge (Brügger, 2004). One distinguishing criterion for environmental education is that "the process of education is as important as the content" (St.Clair, 2003, p.71). The process of environmental education employs a variety of pedagogical methods including guided inquiry, place-based learning, experiential, and cooperative pedagogies in an effort to create awareness about the processes and properties of natural ecosystems (Stern, Powell, & Hill 2014).

The objective of environmental education is to demonstrate the dependence of human societies on the natural environment in order to emphasize our obligation to preserve and protect the availability of natural resources for the generations to come (Orr, 1992). Through environmental education, students are expected to develop their own positive stance and set of values towards the natural environment that will lead them to develop pro-environmental behaviors (Hollweg et al., 2011). The general aims of environmental education are to create aesthetic appreciation for the natural environment, to construct awareness on the impact of our social, political, and economic decisions on natural ecosystems, and to foster understanding about the unity and interrelatedness of all life forms. These are the elements that are expected to lead the students to the idea of personal responsibility for the natural environment (Palmer, 1998).

According to Palmer, editor of the influential book *Environmental Education in the 21st Century*, environmental education consists of four elements:

> 1) The "*empirical element"* which focuses on the direct contact and experience of nature based on the origins of science, observing, measurement, and analysis, 2) the "*synoptic element"* that aims to teach the complexity and interrelatedness of the various components of the environment, 3) the "*aesthetic element"*, which

> focuses on qualitative aspects, and 4) the "*ethical element*" that aims to introduce students to the idea of personal responsibility for the natural environment and the concept of stewardship. (Palmer, 1998, pp. 141-142.)

Environmental education combines empirical methods for the study of the environment (observation, measurement, analysis, interpretation) with the sense of aesthetic appreciation fostered by humanities and liberal arts education in an effort to cultivate empathy towards the natural realm. Environmental education aims to inspire an ethical attitude towards the environment based on a free choice of participants and not as a compliance to a code of conduct. Thus, the idea of stewardship towards the natural environment is promoted through a sense of personal responsibility (McKeown-Ice & Dendinger, 2000).

A recent definition describes environmental education as "organized efforts to teach about how natural environments function and, particularly, how human beings can manage their behaviour and ecosystems in order to live sustainably" (Palmer, 1998, as cited in Sata, Wongpho & Chankong, 2015, p.19). It should be noted that this definition could not have emerged during the first years of development of environmental education. According to the 1986 supplement of the *Oxford English Dictionary*, the use of the word sustainability in English dates only from 1972 (Le Grange, 2013). The following section discusses the introduction of sustainability as a construct in political, academic, and public rhetoric and its influence on the evolving notions of environment-related education.

The Move Towards Education for Sustainable Development

The term *sustainable development* was introduced into popular discourse after the publication of the World Commission on Environment and Development report (WCED, 1987). This influential document, which contains the most widely cited definition of sustainable development, is commonly referred to in both academic and general literature as

the Brundtland Commission Report (1987). Chair Gro Harlem Brundtland, a former Prime Minister of Norway, was appointed as the head of the intergovernmental committee in 1984 after being proposed for the role by UN Secretary General Javier Pérez de Cuéllar (Duraiappah & Muñoz, 2012). When her four-year assignment to the UN was completed, Brundtland returned to Norway to serve two more terms as a prime minister.

The Brundtland (1987) report offers the first definition of sustainable development as "development which meets the needs of the present without compromising the ability of future generations to meet their needs" (p. 41). Scholars have noted that in this definition, sustainable development is informed by both environmental theory (the interest in conserving natural resources) and justice theory (a concern for the needs of present and future generations) (Le Grange, 2013). The Brundtland report captures a moment of conceptual transition in which visionary policymakers understood that the *environment* and *development* could no longer be seen as antithetical priorities but there ought to be a formula to address both concerns in a comprehensive and sustainable manner. The discourse on sustainability is a warning that the needs of the people should not be served at the expense of the environment and vice versa.

As the concept of sustainable development gained traction, environment-related education started to move beyond the scientific study of the environment to include the economic, social and political aspects of the environmental problem. This development was reinforced by the discussion on Education for Sustainable Development, which was presented in the 1992 United Nations Conference on Environment and Development in Rio, revisited in the 2002 World Summit on Sustainable Development in Johannesburg and culminated in the 2005–2014 UN Decade of Education for Sustainable Development (UNESCO, 2002; 2016). The UN thematic decade was a notable initiative that gave global momentum to Education for Sustainable Development (Leal Filho, Manolas, and Pace, 2015). According to UNESCO (2016), Education for Sustainable Development incorporates "key sustainable development

issues into teaching and learning; for example, climate change, biodiversity, disaster risk reduction, poverty reduction, and sustainable consumption" (p. 2). To this end, teachers are expected to use "participatory teaching and learning methods that motivate and empower learners to change their behaviour and take action for sustainable development" (UNESCO, 2016, p. 2).

In December 2014, the United Nations (UN) Secretary General published a report on the Sustainable Development Goals, spanning the thematic scope of economy, society, environment, and education (UN, 2014). As noted earlier, the Sustainable Development Goals are a collection of 17 global goals set by the United Nations General Assembly in 2015 for the year 2030. Scholars have received the announcement of the Sustainable Development Goals with reserved optimism, noting that these goals have the potential to become a "powerful political vision that can support the urgently needed global transition to a shared and lasting prosperity" (Hajer et. al, 2015, p. 1651).

In the context of Sustainable Development Goal 4, pertaining to education, UNESCO recommended the integration of Education for Sustainable Development into Global Citizenship Education, a form of civic learning that involves students' active participation in projects that address global issues of a social, political, economic, or environmental nature. In 2016, UNESCO recommended that "(i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in: (a) national education policies, (b) curricula, (c) teacher education and (d) student assessment" (UNESCO, 2015, p.50).

At the level of objectives, environmental education and Education for Sustainable Development are committed to achieving the same goal: developing students' critical thinking and analytical skills so that they can challenge unsustainable practices in the society and actively participate in changing these practices (Gough, 2006). The difference is in their

strategies on how this goal can be achieved. According to Sauvé (1996), environmental education has traditionally been problem focused; that is, it has been grounded in the scientific study of the environment, and its learning outcomes have usually referred to the environment, its associated problems, and how to resolve these issues. At its early stage, environmental education employed a linear knowledge-attitude-behaviours (KAB) model which assumed that gains in environmental knowledge would lead to improved environmental attitudes, and eventually to the adoption of environmentally responsible behaviours (Colwell, 1976). However, this model was proven to be faulty: research has shown that in most cases, increases in knowledge did not lead to pro-environmental behaviour (Salmon, 2000; Loughland et al., 2003; Krnel & Naglic, 2009).

Since increased knowledge about environmental issues does not necessarily lead to changes in behavior, Education for Sustainable Development ventured to explore more complex models of precursors to pro-environmental behaviour (Kollmuss & Agyeman, 2002). People's behavioural intentions do not form in a vacuum, but are rather influenced by their social and economic choices. On these grounds, Education for Sustainable Development expanded the scope of environmental education and set out to explore the broader context of social and political issues vis-à-vis the natural environment such as poverty, democracy, and quality of life (UNESCO, 2016).

An overview of the literature on Education for Sustainable Development has shown that the means to achieve sustainable living are different in each sociocultural and socio-political context. As a result, it seems difficult to provide a universal framework for Education for Sustainable Development programs (Bell, 2009; Huang, 2019). In addition, many scholars have a fundamental disagreement with the phrase *sustainable development* in political discussions about global environmental issues. For example, O'Riordan (2008), a British environmental scientist, characterised the phrase as a contradiction in terms because he

considered environmental conservation and development to be contradictory issues. O'Riordan asks, what would sustainable societies look like in "a multi-national world of nine plus billion people demanding more and more from a stripped and stressed planet?" (p.153). For many scholars, the emphasis on development in a vote of confidence to an economic system that has brought humanity to an environmental deadlock (Latouche, 1993). As Neumann (1998) reminded us, "development will not take place without tears" (p. 70).

It appears that, despite the accumulation of extensive theoretical work on environment-related education, there is no consensus on the definitions and the conceptual borders between environmental education and Education for Sustainable Development (Stevenson, 2013). For scholars like Martha Monroe "EE [environmental education] and ESD [Education for Sustainable Development] have an overlapping and intertwined existence" thus "perhaps it does not matter what we call it; we need quality education that prepares people to understand multiple views" (Monroe, 2012, p.43, 46). For others, "environmental education inherently includes education for sustainable development, and thus the use of both terms is tautological" (Le Grange, 2013, p.126). On the level of intentions however, there is significant overlap between environmental education and Education for Sustainable Development, given that both approaches aim to "help people to acquire applicable knowledge and to empower them to act responsibly" (Gadotti, 2010, p.232). Hence, environmental education and Education for Sustainable Development are philosophically distinct approaches which however concur at the level of methods and converge at the level of their declared end goals. At the end of the day, both environmental education and Education for Sustainable Development work towards the same end-goal: the development of environmentally literate citizens.While scholars have yet to come to a consensus on the nature of environmental education and Education for Sustainable Development, let alone sustainability itself, teachers and environmental educators are concerned about the pedagogical challenges that they encounter when they include

environmental and sustainability issues in their teaching. Robert Stevenson (2013, 2008) deplores a policy discourse on environmental education/ Education for Sustainable Development that is becoming increasingly abstract and decontextualized from pedagogy and practice and argues that educators need more guidance in their teaching and curriculum planning (Stevenson, 2008, p.287). In response, scholars called for a renewed emphasis on pedagogical practices and solutions that can help practitioners teach about environmental and sustainability issues (Blum, Nazir, Breiting, Goh, & Pedretti, 2013). However, a discussion on effective pedagogical practices that work well at the practical level necessitates a minimum consensus on the desired outcomes of environmental and sustainability education. In other words, before we can agree on what works in environmental education and sustainability, we need to agree on what environmental and sustainability education is expected to deliver.

At the highest level, environmental education and Education for Sustainable Development constitute distinct approaches, drawing on different philosophical and institutional origins. On the level of pragmatic intentions, however, there is significant overlap between the two, given that both approaches aim to "help people to acquire applicable knowledge and to empower them to act responsibly" (Gadotti, 2010, p.232). Both environmental education and Education for Sustainable Development can be seen as working towards the same end-goal: the development of an environmentally literate citizenry. Teachers and environmental educators continue to seek practical ways to include environmental and sustainability issues in their teaching to fulfil the curricular goals (Stevenson, 2013). The approach of this dissertation aligns with this pragmatic approach by supporting the need for empirical research on the outcomes of environment-related education and does not view environmental education and Education for Sustainable Development as competing or mutually exclusive approaches.

However these issues are approached, we need a comprehensive framework to understand the impact and outcomes of environmental and sustainability education. The construct of environmental literacy has the potential to act as a framework for the assessment of educational efforts related to environmental protection, conservation, and sustainability of natural resources. Below, I discuss the contemporary conceptualizations of environmental literacy as an evaluative framework.

The Concept of Environmental Literacy

Contemporary literature assigns interrelated but discrete roles to environmental education and environmental literacy: while environmental education is a process, environmental literacy is a set of learning outcomes. According to the National Environmental Education Advisory Council and the Organization for Economic Co-operation and Development, environmental literacy is the intended product of environmental education (NEEAC, 2015, p.8; OECD, 2009, p.19). Environmental literacy is not an either/or proposition: A person's environmentally related knowledge, attitudes, skills, and behaviors can develop over time, changing her or his level of environmental literacy. The job of environmental educators is moving people along a continuum toward higher levels of environmental literacy (Ardoin & Merrick, 2013, p.3).

Additionally, environmental literacy provides a useful framework for curriculum planning in Education for Sustainable Development (Stables & Scott, 2002). For example, the Talloires Declaration, signed by 280 universities in 40 countries, urges universities worldwide to disseminate "sustainable development principles, to increase environmental literacy, and to enhance the understanding of environmental ethics" (UNESCO, 1990a, thrust 4). Thus, the concept of environmental literacy can take on a central role in evaluation efforts

(Ernst & Monroe, 2004). The theoretical development of the construct of environmental literacy is essential context for the present research.

The term *environmental literacy* was first introduced 50 years ago by Charles Roth (1968) who posed the question "How shall we know the environmentally literate citizen?" Since then, the meaning of the term has been extensively discussed and reviewed (e.g., Roth 1992; O'Brien, 2007). The notion of environmental literacy has been, and continues to be, promoted through a diversity of perspectives. Currently, a widely accepted meaning of environmental literacy is that it "comprises an awareness of and concern about the environment and its associated problems, as well as the knowledge, skills, and motivations to work toward solutions of current problems and the prevention of new ones" (McBride et al., 2013, p.3).

During the development of the notion, numerous scholars have argued that the term environmental literacy has been used in so many different ways and/or is so all-encompassing that it has been left with very little useful meaning. According to Disinger and Roth (1992), the almost arbitrary application of the term has resulted in nearly as many different perceptions of the term as there are people who use it. Similarly, Stables and Bishop (2001) argued that the overuse and indiscriminate application of environmental literacy has led to the term's degradation. Payne (2005, 2006) dismissed the notions of environmental literacy as vague and messy, calling instead for a "critical ecological ontology," a curriculum theory focusing on the learner's experience of being in the world. As a result, environmental literacy risks being reduced to a hollow term, a "dream that has little bearing on society" (Shamos, 1995, p.215). During the 1990s, the introduction of a plethora of novel literacy types, including ecological literacy, scientific literacy, technological literacy, and so on, has further complicated the conversation (Gough, 1995; The New London Group, 1996).

Environmental literacy provides learners with the understanding that human health and environmental health are joined in complex and interdependent relationships (NAAEC, 2015), and is promoted through high-quality, long-term environmental education interventions (McBeth et al., 2011). Environmental education enhances environmental literacy by cultivating an understanding of humans' complex relationship with the natural world through active and experiential engagement in real-world environmental problems. This leads to environmentally responsible behavior and collective action for a healthier, safer world. Hence, environmental literacy has been purported as one of the essential literacy practices necessary to function within a society (St.Clair, 2003).

As discussed above, Roth introduced the term environmental literacy in 1968 and worked to define the theoretical boundaries of the construct. Roth defined environmental literacy as a concrete and practical notion:

> Environmental literacy should be defined … in terms of observable behaviours. That is, people should be able to demonstrate in some observable form what they have learned- their knowledge of key concepts, skills acquired, disposition toward issues, and the like (cited in Disinger and Roth, 1992, p.2).

In effect, this description suggests the determination of environmental literacy through a set of observable characteristics. According to a more recent, periphrastic approach, "an environmentally literate person is someone who, both individually and together with others, makes informed decisions concerning the environment, is willing to act on these decisions to improve the well-being of other individuals, societies, and the global environment and participates in civic life" (Hollweg *et al*., 2011, p.2-3). Environmental literacy is a multifaceted concept that consists of environmental knowledge, competencies, skills, dispositions and preparedness to act (McBride, 2011; Hollweg *et al*. 2011; Green, Camilli, &

Elmore, 2012). It is through these most recent understandings that the present research attempts to approach, and make sense of, environmental literacy as a resource for linking experience to action (St.Clair, 2003).

International Experiences of Education for the Environment

During the last three decades, a number of countries have introduced environment-related education in their curricular frameworks (Palmer 1998). As international guidelines were absorbed by diverse educational systems, a multitude of pedagogical approaches appeared (Sauvé, Brunelle, and Berryman, 2005). This produced diversity and abundance of learning techniques, but also hindered the coordination and dissemination of educational gains. There seems to be a great potential for contribution to the advancement of pedagogical knowledge by comparing good practices and transferring innovative didactic techniques between countries. Any effort towards the mobilization of pedagogical knowledge in environmental education requires a discussion on how environmental and sustainability education have influenced curricula, policy, and educational practice, in different parts of the world.

Scotland was one of the first places in the world where outdoor environmental education was formalized as early the 1960s and 1970s (Leal Filho, 1996; Borradaile, 2006; Higgins & Kirk 2006). Today, even after fiscal cuts which have led to a decrease in the number of specifically trained and qualified staff, many outdoor and environmental education centres continue to thrive in Scotland (Davies, 2018). Adjusting to the loss of central funding, these educational entities have turned to a more commercial approach to their work and have conceded an enhanced role to NGOs (McNaughton, 2012; Littledyke, 2007). Privatization of Environmental Education Centres in the UK has also led to a decline in the number of specifically trained and qualified staff, especially since many students and their families started

to have difficulties in covering the full cost of environmental education (Higgins and Kirk 2006).

The Scandinavian countries and Finland have long established primary and secondary education systems where outdoor education has found its place (Szczepanski, Mamler, Nelson, & Dahlgren, 2006). The 'Forest School' originated in Sweden during the 1950s as an approach to learning that encouraged children to interact with, and learn about, the natural world. A similar approach to teaching was well established in Denmark as a pedagogical strategy for pre-school education by the 1980s. Littledyke (2007) noted that the children attending Forest School were socially skilled and able to work collaboratively with their peers. They were also confident in their own capabilities and had high self-esteem. Finland was also one of the first European nations with a policy on environmental education, having had a strategy in place since the early 1980s (Leal Filho, 1996; Kapyia & Wahistrom, 2000). Environment-related education made its way into other European, North American, South American, and East Asian countries in the early 1990s and continues to flourish in various contexts (Stokes, Edge, and West, 2001; Russell & Burton, 2000; Palmer, 1998).

In parallel, local communities around the world started working together with environmental educators to come up with environmentally friendly solutions that made sense in their own socio-cultural contexts. Community-based environmental education deserves a special note, even if these initiatives did not always lead to the creation of nation-wide institutional frameworks in support of environmental education. Environmental education approaches, based on the active participation of the local communities, appeared in the US in the early 1980s (Martin, Falk, & Balling, 1981). In Canada, efforts in community-based environmental education began in the early 1990s, in collaboration with grassroots organizations, and with an emphasis on the inclusion of indigenous histories and local cultures (Russell, Bell, & Fawcett, 2000; Hart, 1996). However, the fact that education falls under

provincial jurisdiction makes it difficult to consolidate any gains (Russell, Bell, & Fawcett, 2000).

Lastly, I would like to acknowledge a community-based environmental education model developed by Talero and Humaña (1993) in Colombia. In this model, the school becomes the centre of the community's social and environmental development. Education works through participatory approach: it calls on parents and other members of the community to identify the problems of their locality and its development needs. A conceptualization and implementation phase follows, which sets in motion projects to resolve these problems from an ecological and active community development perspective, including economic aspects, for example by producing and processing pesticide-free fruits by using domestic compost as fertilizer (Talero & Humaña, 1993).

The Colombian example capitalizes on the cultural identity of its local community in incorporating indigenous and local knowledge in its content. Unfortunately, many of these examples did not meet the same level of international institutional support as the one that some European countries enjoyed (Yanniris, 2016). Until recently, it was almost impossible for local initiatives like the one in Colombia to reach high level decision making in national and international fora. This is a governance deficiency which represents a missed opportunity for all of us – we now know that many local and indigenous communities have preserved the empirical knowledge to practice and promote sustainable management of their natural resources (Hughes, 1975). However, these days, something seems to be changing. Over the last decade, there is a growing interest on the role of local communities in environmental education literature. In the leading international journal in the field, *Environmental Education Research*, 64% of the articles that refer to "local communities" in their title or keywords (150 articles in total) have been released in the last decade – the journal has been publishing with a constant rate since 1995. Publications on community-based environmental education rise sharply after

2015. At about the same time, in its most recent publication *Education for Environmental Sustainability and Green Growth*, UNESCO (2016, p.11) brings our attention to the indigenous concept of *buen vivir,* which has been previously highlighted by the government of Bolivia. Buen vivir bears a sense of quality of life, based on a healthy interdependence of humans with their social and natural environments, rather than the accumulation of material wealth.

Until recently, the historical narrative on the origins of education for the environment read as unmistakeably Euro-centric. However, Europe's political interest in environmental education appeared only after its populations started to suffer from the consequences of industrial pollution. Indicatively, the European Conservation Conference of 1970, proposed the preparation of a protocol to the European Convention on Human Rights "guaranteeing the right of every individual to enjoy a healthy and unspoiled environment." It recommended that this protocol should cover "the rights to breathe air and drink water reasonably free from pollution, and the right to freedom from undue noise and other nuisances, and to reasonable access to coast and countryside." (Sohn, 1973, p. 452). In these early texts, we can trace the origins of European environmentalism, that triggered political responses such as the UN International Conference on the Human Environment in Stockholm (1972), followed by the First Intergovernmental Conference on Environmental Education (Tbilisi, 1977), and the other milestones in environmental and sustainability education discussed above.

In my view, it is very promising that institutional actors have understood the educational importance of making traditional ecological knowledge accessible to the broader public (Kim, Asghar, & Jordan, 2017). Besides, it is only reasonable to assume that environmental deterioration cannot be resolved through the very same institutional, educational, and epistemological structures that brought us to this point (Huesemann & Huesemann, 2011). With that respect, the only sensible thing to do is to be inclusive of international educational initiatives that might offer different perspectives on how to educate

for a sustainable future. There is a growing understanding in that preserved pockets of environmental knowledge that survived within isolated communities can offer the key for our collective survival. From an environmental education perspective, the interest towards indigenous and local communities represents more than an act of reparation. It is essentially a reflex of self-preservation.

I started this research project with the conviction that we all stand to gain from exchanging knowledge and experience from the different approaches to environmental and sustainability education around the world. Environmental and sustainability education has become a global affair, and we all stand to gain by sharing and comparing international experience. With that in mind, the following section discusses how the international leverage in support of environmental and sustainability education was specified in the case of Greece. With all its dependencies, inconsistencies, success and failures, environmental and sustainability education in Greece has accumulated thirty years of institutional experience and is worth exploring (Yanniris & Garis, 2018).

Historical Development of Environmental and Sustainability Education in Greece

In Greece, environmental education took its first steps in 1977 when the National Council for Planning and Environment formed an interdisciplinary team that, in cooperation with the Council of Europe, UNESCO and the European Commission, started to work on the introduction and development of EE within the Greek educational system. In 1980, the first environmental education seminar to be held in Athens was organised under the auspices of the Council of Europe. Following that event, 24 Greek teachers went to France between 1980 and 1983 so as to participate to environmental education training courses held by Environment Initiative Centres (CPIE) (Flogaitis & Alexopoulou, 1991). At the same time, four Greek schools implemented the first environmental education projects in the country

inspired by a Council of Europe campaign for seashore protection (Gardeli, 1983). During the mid-1980s, eager teachers started to disseminate environmental education projects within the Greek public school system (Gardeli, 1986).

Since the early 1990s, the Greek Ministry of Education has enacted legislation which provided administrative and infrastructural means in support of environmental education within the schooling system. Initially, each of the country's 52 administrative districts acquired two environmental education counselors selected from the pool of in-service schoolteachers who have had previous experience with environmental education. As a result, 104 environmental education counselors were appointed with an assignment to initiate, support, and evaluate environmental education school projects in primary and secondary schools (Greek Ministry of Education, 1990). The same legislative act enabled the Greek Ministry of Education (1990) to establish Environmental Education Centres with a mission that included the reception and introduction of students and teachers to outdoor learning activities (Greek Ministry of Education & European Union, 2010). Local municipalities were encouraged to convert out-of-use peripheral school buildings into Environmental Education Centres. In parallel, the Ministry committed to covering the running costs and provide educational personnel to the newly established centres.

The country's first Environmental Education Centre was launched in 1993, at the mountain village of Klitoria in Achaia (Katsakiori et al., 2008), and it developed its educational programs based on local ecological resources, such as the surrounding mountain forest and the adjacent Vouraikos Gorge National Park (Kontaras, 2004). Despite its remote location, this centre was soon overwhelmed by an increasing demand from student environmental groups which lined up to visit its facilities (Faragitakis, 2000, as cited in Kontaras, 2004).

In the following years, Environmental Education Centres proliferated all over Greece to accommodate a rising number of student environmental groups (Figure 1). A multilateral agreement between local governments, the national government and the European Union secured the accommodation, staff and funding of Environmental Education Centres (Ministry of Education & European Union, 2010). Indicatively, between 2009 and 2013, Greek Environmental Education Centres were credited 15,362,258 € from the European Social Fund (Greek Ministry of Education and European Union, 2013), which was used to expand their activities and meet their needs of continuing education of the local communities.

Figure 1

Spatial distribution of the 53 Environmental Education Centres operating in Greece (2020).

Using the ecosystem as an open laboratory, Environmental Education Centres developed interdisciplinary programs for primary and secondary school students, teachers and adult learners. During the 2014–2015 school year, 471 one to three-day long educational programs were offered by the 51 Environmental Education Centres operating in the country (Greek Ministry of Education, 2014). Additionally, Environmental Education Centres have the responsibility for the in-service training of teachers in environmental education pedagogies (Chatzifotiou, 2005).

As an example, we present the outline of an educational program offered by the Environmental Education Centre of Krestena to grades 7 and 8 of local middle schools. The program is about the effects of river damming and was developed over the 2011–2013 school years, when the author was a member of the centre's pedagogical team. A single-day educational program offered by the Environmental Education Centre of Krestena to secondary school students includes a visit to a local hydroelectricity dam and its environs, where students are invited to observe the apparent and implicit effects of damming on the natural environment. Through this process the students realize that a hydro-dam is an intervention with cross-scale, interconnected, and ambivalent consequences. A hydro-dam disrupts the local ecosystem, but it also generates electricity and thus saves fossil fuels and restrains global carbon emissions. Dams can cause the displacement of local populations, loss of cultural heritage and soil erosion; yet, they serve as reservoirs of freshwater necessary for irrigation and urban use. At the closing of the educational program, students are asked to debate and reach an informed decision on a hypothetical proposal for the construction of a similar dam in their area of origin. The hydro-dam program draws on diverse disciplines (i.e. geography, geology, engineering, ecology) to expose the complexity of environmental issues and the role of conflicting interests in any major or minor environmental intervention (Yanniris & Garis, 2018).

As the network of Environmental Education Centres is an organic and inextricable part of the modus operandi of environmental education in Greece, their phases of expansion, crisis and recovery reflect the recent political history of the country (Fig. 2). Between 1993 and 2004, Environmental Education Centres functioned within selected administrative districts, and their dissemination was not enough to cover the environmental education needs of the educational community. However, this period was critical for the development of their institutional, operational and educational characteristics. Then, a phase of growth fuelled by a favourable politico-economic environment saw the number of Environmental Education Centres increase fourfold within 5 years (2004–2009). During this period, Environmental Education Centres disseminated their work through peripheral, national and international thematic networks (Greek Ministry of Education, 2005). A thematic network connects schools and institutions to address a related issue, such as pollution in the Corinthian gulf. In addition, an international thematic network works on an international environmental issue, such as overfishing in the Mediterranean.

Teachers who lead environmental education groups enjoy substantial academic freedom in developing their curricula, always within the generic guidelines of UNESCO and the Greek Ministry of Education. There is a network of environmental education counsellors whose job is to advise the teachers in developing their curricula, but these professionals are often left without resources and institutional support. Teachers can use educational resources provided by the Environmental Education Centres as reference material, but they usually lack specialized, on the ground support (Mavrikaki et al., 2004). As a result of these pragmatic conditions, involved teachers do have the academic freedom to develop their own curricula, with the downside that they are often left without institutional support. Greek teachers consistently ask for more in-service training in environmental education methods (Yanniris, 2015).

Despite all the institutional and financial support that environmental education has received, it has only involved a minority of students. In Greece, relevant research indicates that only one-third of in-service teachers included have led environmental education programs (Mavrikaki, Kyridis, Tsakiridou, & Golia, 2004; Yanniris, 2015). It is important to note that environmental education in Greece is an elective, voluntary, activity which receives no grade or individual evaluation for participating students. Hence, environmental education in Greece is realized during the teachers' and students' free time, after the school's schedule, and runs in parallel to the standard curriculum. According to the Greek Ministerial directives, the standard curriculum for Grade 9 includes 8 hours of Language and Literature (modern and ancient Greek), 4 hours of Mathematics, 4 hours of Science, 2 hours of History, 2 hours of Citizenship Education, 2 hours of Religious Education, 2 hours of English, 2 hours of German or French or Italian, 2 hours of Physical Education, 2 hours of Technological Education, and 2 hours of Culture Education (a total of 32 hours) per week. In Grade 10, the standard curriculum consists of 9 hours of Language and Literature (modern and ancient Greek), 5 hours of Mathematics, 6 hours of Science, 2 hours of History, 3 hours of Citizenship Education, 2 hours of Religious Education, 2 hours for a Research Project, 2 hours of foreign language (English or French or German), 2 hours of Physical Education, and 2 hours of Informatics or Geology and Management of Natural Resources or Greek and European Culture or Arts Education (a total of 35 hours) per week (Greek Ministry of Education, 2013; 2016a).

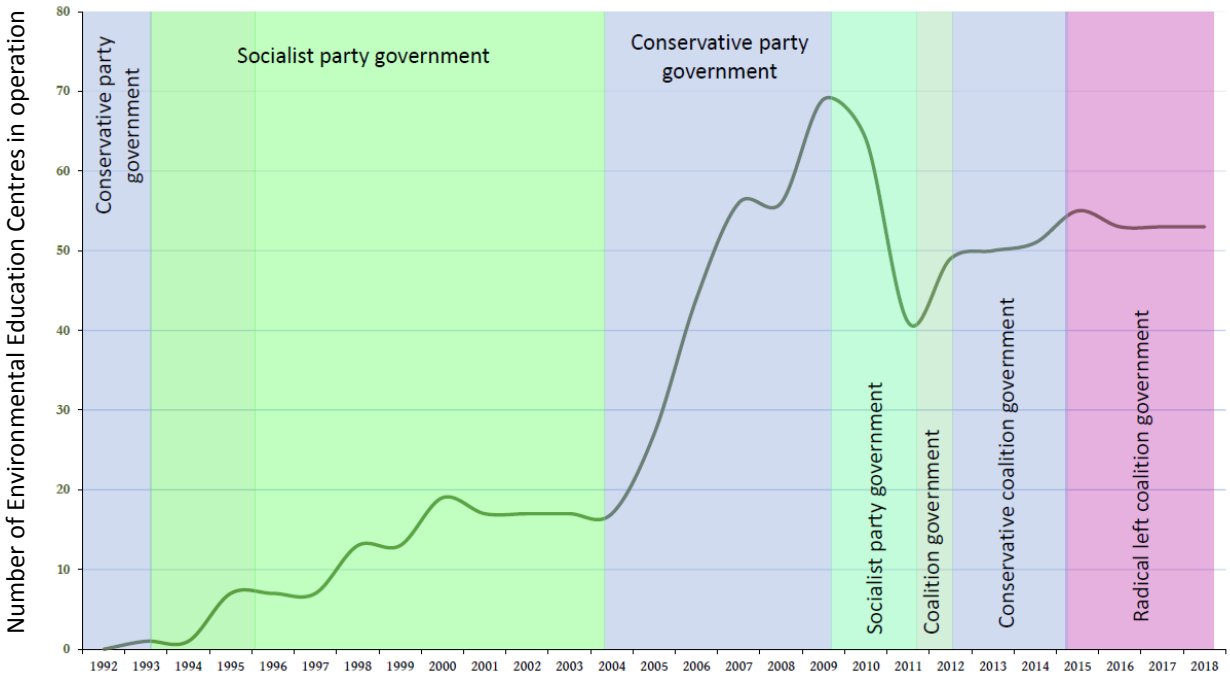
Shortly after the global financial crisis of 2007–2008 and its effect on the Greek economy, environmental education was targeted by policymakers as an ideal field for cutbacks. Promptly, the Greek government abolished the positions of environmental education counsellors, closed 40% of the Environmental Education Centres and curtailed the staff of the remainder (Greek Ministry of Education, 2011). As a result, only half of the

environmental education positions were retained after the cutbacks (Yanniris, 2012). The political decision to shrink environmental education attracted criticism throughout the media, local governments and the national parliament (Notharos, 2010). Overall, it was unclear whether the cutbacks had a positive net effect on the public budget because the closure of Environmental Education Centres entailed an immediate loss of the respective European Union funding. Following 2011, this trend began to reverse; the environmental education infrastructure started to show signs of recovery despite the continuing decline of the national economy (Figure 2). Advocacy and political pressure resulted in the reopening of one-third of the Environmental Education Centres abolished in the wake of the crisis (Kouvelis et al., 2010); moreover, new Environmental Education Centres started to appear (Greek Ministry of Education, 2015). This positive outcome resulted from a broader mobilization in support of environmental education that involved teachers' associations, education officers, local communities, and political parties. Local governments also lobbied against the closure of Environmental Education Centres, which they viewed as hubs of educational and economic activity for their localities (A. Xylokota, Greek Ministry of Education environmental education office director 2010–2015, personal communication, January 29, 2015).

Following 2012, Greek environmental education went through a period of stabilization (Yanniris & Garis, 2018). In 2018, the Greek Ministry of Education enacted Law 4547/2018, where article 12 mandated that the country's *Environmental Education Centres* would be renamed to *Centres of Education for Sustainability* (effective as of June 2019). In article 52, the new law mandates the term *Environmental Education* to change into *Education for Sustainability* in the entire legal and administrative corpus that is based on the law 1892/1990 (A΄ 101), article 111, paragraph 13. This act has been criticized as being hasty and inconsiderate of the significant contribution of environmental education in the country's education system (Pontikakis, 2018).

Figure 2

Juxtaposition of Greek political administration with the number of Environmental Education Centres (EECs) in operation.



Greek education for the environment was never disconnected from the global theoretical and political discussion in the field. The decision to transition into education for sustainability represents a (rather belated) political alignment with UNESCO's Sustainable Development Goals (Hajer et. al., 2015). It is too early to assess the impact of the change in terminologies recommended by UNESCO, and to expand the discussion in this direction lies beyond the scope of this thesis. At this point, a more productive take away message from the comparison between the Greek and the international educational reality is that, in an interconnected world, the dilemmas and challenges emerging in the field of environmental and sustainability education are universal.

Conclusion

In this chapter, I reviewed the international literature to present the definitions and theoretical underpinnings of diverse pedagogical approaches that intend to educate learners

on environmental issues. Then, I went over selected international examples to discuss how these theoretical understandings are specified in particular social and political contexts. Special emphasis was given to the policies and curricula of environmental and sustainability education in Greece, which provided the physical and educational setting for this research. I presented the distinct historical, institutional and epistemological origins of environmental education vis-à-vis education for sustainable development. I explained that the two approaches, although they draw from different origins, concur in their pedagogical methods and converge in their purpose. The declared end-goal of both environmental education and education for sustainable development is to enhance the environmental literacy of its recipients (NEEAC, 2015; Ardoin & Merrick, 2013). On these grounds, environmental literacy could be seen as a point of convergence for all environment-related institutional educational initiatives, to the direction of improving learner's environmental literacy components: environmental knowledge, competencies, skills, dispositions, and actions (Hollweg et al., 2011). The effectiveness of environment-related education in achieving these goals can thus potentially serve as a measure for the evaluation of these efforts. In the following chapter, I will discuss previous attempts to employ an environmental literacy framework as an empirical assessment of environmental education outcomes.

Chapter Three: Theoretical Framework

The previous chapter reviewed the cluster of theoretical approaches that have informed curricular planning and policy in the field of environmental education. In the present chapter, I attempt to move a step further and discuss how curricular policies translate into educational praxis and evaluation. Hence, in this chapter I seek to examine environmental education by specifying its methods and fields of practice. I start by discussing the intended outcomes of environmental education. Then, I touch on outdoor and experiential learning as mainstream pedagogical methods in environmental education. In order to assess the effectiveness of these pedagogical methods in achieving the goals of environmental education, I return to the problem of environmental education program evaluation. A review of the relevant literature reveals that assessments of environmental literacy components have been used as a means for the evaluation of environmental education programs in K-12 settings (Bogner, 1998; Bogner, 1999; Leeming, Porter, Dwyer, Cobern, & Oliver, 1997; Emmons, 1997; Rickinson, 2001; McBeth et al., 2011). Thus, environmental literacy assessments can be considered a valid way to evaluate environmental education programs. Of course, environmental literacy is an evolving concept, and there are a few conceptual and philosophical subtleties concerning its use in evaluation efforts which are being discussed in the current literature. These subtleties will be discussed later in this thesis. In the present chapter, I draw on the relevant literature to look at the ways in which the environmental literacy framework has informed empirical assessments intended to examine the outcomes of environmental education.

The Intended Outcomes of Environmental Education

Hines, Hungerford and Tomera (1987) presented a now well-established conception of environmental education. They stated that environmental education is more than a mere transfer of information. Rather, it involves four aspects: a working knowledge of

environmental issues, a specific knowledge of approaches to address those issues, the competency to make appropriate decisions, and the possession of certain affective qualities and attitudes that make people care about (and pay more attention to) environmental conditions. In 1994, NAAEE provided a characterization of environmental education that expanded these four aspects and included environmental and socio-political knowledge, knowledge of environmental issues, cognitive skills and affective qualities, and environmentally responsible behaviour (McBeth et al., 2008, p.14).

Analysis of environmental education frameworks used in national and state programs (in the US) provided the basis for another framework, developed in 1995, which served as the basis for the NAAEE's National Project for Excellence in Environmental Education (Simmons, 1995, pp. 54-58; NAAEE, 2004). From this analysis, Bora Simmons identified seven elements of environmental literacy:

1. Affect (e.g., environmental sensitivity, attitudes, and moral reasoning).
2. Ecological knowledge.
3. Socio-political knowledge (e.g., the relationship of cultural, political, economic, and other social factors to ecology and environment).
4. Knowledge of environmental issues.
5. Skills pertaining to environmental problems/issues and action strategies, systemic thinking, and forecasting.
6. Determinants of environmentally responsible behavior (i.e., locus of control and assumption of personal responsibility).
7. Behavior (i.e., various forms of active participation aimed at solving problems and resolving issues).

(Simmons, 1995, as cited in Hollweg et al., 2011, p. 2-3.)

As mentioned above, the international literature suggests that environmental education programs can be evaluated based on their demonstrated capacity to improve students' environmental literacy (Ardoin & Merrick, 2013, p.3). In its general sense, environmental literacy refers to "the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems" (Disinger & Roth, 1992, p. 2). The promotion of environmental literacy is essential for the well-being of human communities (Orr, 1992; UNESCO, 1990b). Given that environmental literacy is one of the intended outcomes of environmental education, the former can be used as an indicator of the quality of the latter (National Environmental Education Advisory Council [NEEAC], 2015, p. 8). According to the current theoretical understandings, environmental education thus works to improve the behaviours of its recipients towards the natural environment. This thesis aligns with the aforementioned conceptualizations and regards environmental literacy as the intended outcome of environmental education.

The broader aim of environmental education is to resolve one or more environmental problems though influencing people's behaviours. However, it is not clear what the most effective pedagogies in promoting the intended goals of environmental education are. Recent meta-analyses on environmental education program evaluation suggest that active and experiential engagement in real-world environments are the most effective methods in promoting the environmental literacy of participating students (Stern, Powell, & Hill, 2014, p.20). The following sections review the literature on two pedagogical methods that are advocated in the literature on environmental education policy and pedagogical practice: outdoor and experiential learning. Environmental education researchers and practitioners argue that both outdoor and experiential learning are associated with improvement in the environmental literacy of participating students (Stern, Powell, & Hill, 2014, p.15,18).

Outdoor Learning

A literature search reveals that there is no theoretical or regulatory framework explicitly mandating the place where environmental education should be taking place. According to the current theoretical understandings, various types of indoor and outdoor education fulfil the criteria to be considered as environmental education, based on their programmatic goals and curricular methods. Outdoor learning is only one of the multiple approaches to environmental education, and it is not mandated that environmental education should be taking place outdoors. Educators have been employing both indoor and outdoor approaches to serve the purpose of environmental education. However, are both approaches equally effective in promoting the declared objectives of environmental education? Or, to elaborate on the question, what is the optimal physical place for the realization of environmental education programmatic goals?

In this thesis, I have declared my intention to investigate a form of environmental education that includes a strong outdoor component. My preference for outdoor environmental education pedagogies is not arbitrary. My interest in outdoor environmental education draws on my personal experience as an environmental education practitioner, and also from the empirical findings that have emerged in the relevant literature. As I discuss below, there are strong indications in the literature suggesting that experiential contact with nature during childhood generates: (a) multiple benefits for individual's physical and mental development, and (b) improved environmental behaviours in adulthood.

A systematic literature review of empirical research with samples spanning across children aged 3 to 18 years old, suggests that young people who have regular experiences with nature, develop critical and creative thinking skills that will help them succeed in adult life (Adams & Savahl, 2017). Evidence is accumulating that immersing children in nature to play and learn can result in reduced stress, improved brain development and restoration,

increased social and emotional skills development, and civic engagement (Hartig, Mitchell, de Vries, & Frumkin, 2014). The benefits of childhood outdoor experience for individuals' mental and physical health are well documented and have been confirmed by recent research (Louv, 2008; Braus, & Milligan-Toffler, 2018). Conversely, children surrounded by low amounts of green space have up to a 55% higher risk of developing a mental disorder in their later lives – even after adjusting for other known risk factors such as socio-economic status, urbanization, and the family history of mental disorders (Engemann, 2019).

Moreover, the literature suggests that outdoor experience during childhood affects environment-related behaviours observed in adulthood. In 1999, Chawla interviewed environmental activists from Kentucky and Norway and inquired about their source of commitment for environmental action: 77 % cited experience of natural areas, 64 % cited family influence, 55 % cited participation in environmental organizations, and only 38 % cited education as their source of commitment (Chawla, 1999). Somewhat earlier, Palmer (1993) showed that when 200 environmental educators from around the world were surveyed, the strongest predictor of their current environmental concern was the amount of outdoor experience they had as children.

The research referenced here suggests that outdoor experience during childhood connects with a) improved physical and mental health, and b) improved environmental concern and commitment to action in adulthood. Hence, it is reasonable to assume that educational activities based on students' direct experience of the natural environment are aligned to the programmatic goal of environmental education to improve participants' pro-environmental behaviour. The significance of childhood outdoor experience in shaping environmental concerns and behaviours justifies further discussion of outdoor and experiential learning.

Experiential Learning

Experiential learning is an important theoretical framework in educational studies, with influences drawn from John Dewey and earlier (Beard & Wilson, 2006). According to David Orr, "experience of the natural world" is an essential component of environmental literacy (Orr, 1992, as cited in St.Clair, 2003, p.71). Hence, some type of experiential contact of students with the natural world is essential in building environmental literacy. Experiential education uses the local community and environment as a starting point for interdisciplinary learning. Experiential education is place-based education, and as such it emphasizes on hands-on, real-world learning experiences, enhances students' appreciation for the natural world, and helps students develop stronger ties to their communities (Sobel, 2004).

Experiential learning theory draws from the philosophies of Kurt Lewin, Jean Piaget, and John Dewey (Kolb, 1984). It is a "reactive process in which learning occurs by reflecting on previous experiences" (Wurdinger, 2005, p. 8), which "involv[es] theory and practice, action and reflection" (Gregory, 2006, p. 118). Experiential learning theory is "the sense-making process of active engagement between the inner world of the person and the outer world of the environment" (Beard & Wilson, 2006, p. 19). It is a form of learning that plays a role in the shaping of experience and is a result of experience along with the help of application and reflection (Kolb, 1984). Experiential education is "an intentional, purposeful approach to teaching and learning" (Breunig, 2008, p. 79) that "has students actively engaged in exploring questions they find relevant and meaningful, and has them trusting that [both] feeling [and] thinking, can lead to knowledge" (Chapman, McPhee, & Proudman, 2008, p. 7).

The philosophy and methodology of experiential learning value the experience of the learner as both the context for learning and the process by which learning occurs. Experiential education encourages an organic relationship between learning and experience, realized through a process of inquiry, planning, testing and reflecting. It is "holistic in the

sense that it addresses students in their entirety—as thinking, feeling, physical, emotional, spiritual, and social beings" (Carver, 1996, p. 8). These holistic experiences are organized by experiential educators to build on previous experience as well as relate to quotidian experiences from everyday life (Dewey, 1938, 1958).

A number of researchers believe that the thread of experiential learning can be traced back to the writings and teaching of Henry David Thoreau (Roberts, 2012). Thoreau's relevance to contemporary experiential learning draws from his sense of place as a focal point that demonstrates the unity between humans and nature (Schneider, 2000). Thoreau observed and studied nature experientially by walking many miles per day in the countryside of his native Concord, Massachusetts: "I come to my solitary woodland walk as the homesick go home," he wrote in his journal in 1857 (Thoreau, 1995, p.34). For Thoreau, the natural landscape was a constant source of inspiration for his ideas on life, philosophy, and education. In 1860, he wrote:

> I think it would be worth the while to introduce a school of children to [this] grove, that they may get an idea of the primitive oaks before they are all gone, instead of hiring botanists to lecture to them when it is too late. (Thoreau, 2013, p. 3657.)

These three lines contain a full preview of the subsequent purposefulness and agony of environmental education. Consider this slightly later text, again from his journal writings in 1861:

> A river, with its waterfalls and meadows, a lake, a hill, a cliff or individual rocks, a forest and ancient trees standing singly. Such things are beautiful; they have a high use which dollars and cents never represent. If the inhabitants of a town were wise, they would seek to preserve these things, though at a considerable expense; for such

> things educate far more than any hired teachers or preachers, or any at present recognized system of school education. (Thoreau, 1995, p. 57.)

This passage can be considered as an antecedent of the contemporary purpose-based definition of environmental education. The advocacy for outdoor learning is also clear, as well as the use of experience as a medium to achieve the educative purpose (to preserve these things). Thoreau believed that experiences needed to achieve a certain degree of intensity to be truly educative (Ingman, 2011). These experiences are often triggered by solitude, community, or immersion in nature (Fox, 1999), and holistic engagement in an experience with "the conscious recognition of a connection that goes beyond our own minds or limits" (Lantieri, 2001, p. 8). It is often characterized by a "momentary loss of self " (Frederickson & Anderson, 1999, p. 22) due to the extreme levels of engagement in the experience, and is thus likened to a *flow* or optimal experience (Csikszentmihalyi, 1990, 1997). More recent research also supports this notion of flow-like optimal experience as educative (Heintzman, 2008). Thoreau, a former teacher himself, had been thinking ahead of his time in proposing the *uncommon school*, where education is based on direct experience of the natural environment, and learning depends on the intensity of the experience (Thoreau, 1878).

Conceptual antecedents of place-based experiential learning can be also found in Mumford's (1946) vision of a "regional survey," a "method of study in which every aspect of the sciences and the arts is ecologically related from the bottom up, in which they connect directly and constantly in the student's experience of his region and his community" (pp. 151–152). More recently, Paul Maiteny (2002) argued that behavioural change to support sustainability can only take place when the individual has gone through a deep-rooted personal transformation, as in experiential learning processes. St. Clair (2003) also regards

experience of the natural world as an essential component in the development of environmental literacy (p. 71).

Experiential and Outdoor Learning in the Greek Curriculum

Greece has provided the physical and educational setting for this study, and hence this section explores how experiential and outdoor learning are discussed in the Greek curricular context. This part reviews the Greek curricular production in the field, focusing on the references to environmental, experiential, and outdoor education. The content of the subjects taught in the country's primary and secondary education is regulated by the Greek Pedagogical Institute (2003, 2010). In Greece, the Pedagogical Institute is considered as the main body of curricular policy formation in the country and works in tandem with the Ministry of Education.

In 2003, the Pedagogical Institute released the Environmental Education Curriculum, which employed a broad definition of the environment encompassing natural, artificial (urban/ rural), socio-economic and historical landscapes (Pedagogical Institute, 2003). These landscapes are used as working fields for the implementation of environmental education projects. The 2003 Environmental Education Curriculum mandated that environmental education is delivered through environmental education groups of one or two teachers and twenty to twenty-five students that are formed in primary and secondary school units at the start of each school year. These teachers volunteer to lead environmental education groups in their own school. There have been changes in terminology and guidelines/ the curricula and educational conditions, but pretty much consistent from the start of environmental education in Greece who work in their free time. Despite the lack of economic or other incentive, environmental education has taken routs in the Greek educational routine. Perhaps the tenacity of (a minority of) Greek teachers to keep on undertaking environmental education

programs can be explained by that (as they consistently report) this process significantly benefits participating students and the overall educational process (Yanniris, 2015).

In 2010, Greek lawmakers introduced the Environmental and Sustainability Education Curriculum in continuation of the 2003 Environmental Education Curriculum (Pedagogical Institute, 2010). The Environmental and Sustainability Education Curriculum reflects the international discourse on sustainability education and expands the scope of environmental education to include the social, political, and cultural dimensions of sustainability. Moreover, the new curriculum sets specific cognitive and behavioural goals for each grade of primary and secondary education and cites pedagogical methods and available resources in support of these goals (Malandrakis, 2017). In terms of pedagogical philosophy, the new Environmental and Sustainability Education curriculum preserves the core principles of environmental education while it expands its scope to encompass elements from other innovative educational movements, such as health education and education for peace, human rights, and diversity (Pedagogical Institute, 2010).

The pedagogical priorities of the new curriculum are informed by five thematic areas: a) the continuity of knowledge from early childhood to secondary education, b) the promotion of the type of critical thought, inquisitive and creative thinking that leads to individual and collective solutions, c) the negotiation of environmental education topics related to students' *direct experience* of their immediate environment, d) the emergence of a pedagogical framework that will sensitise and activate students and will thus urge them to participate to decision making with respect to environmental issues and e) the trans-disciplinary diffusion of the pro-environmental values and attitudes, given that the environmental problem affects all fields of human activity and knowledge (Pedagogical Institute, 2010, p.3-4). According to the Environmental and Sustainability Education

curriculum, students are guided through inquiry, place-based learning, and experiential and cooperative pedagogies in order to acknowledge their own interdependence with the environment and to develop evaluative, action planning, and research skills.

Experiential and outdoor learning appear in the Greek administrative and literary corpus as recommended methods for the implementation of environmental education programs. In 2002, Deloudi discusses experiential learning as part of a meaning making process. She argues that the Greek legislative framework in support of a flexible structure featuring complementary school activities favors the introduction of experiential learning. Indeed, the official curricular guidelines published in 2009 by the Greek Ministry of Education (specializing on environmental education) contain explicit references to outdoor and experiential learning (Fermeli et al., 2009). In the same curricular guidelines, field study is proposed as a method for the actualization of environmental education. Field study is described as a "group learning activity, taking place outside the classroom and aims to the acquisition of lived experiences (in Greek: βιωματικών εμπειριών) by participating students" (Fermeli et al., 2009, p.18). Georgopoulos, Birbili, and Dimitriou (2011) claimed that the experiential element is "preferable over other ways of teaching environmental education" (p.11). Hence, a plethora of programs, employing outdoor and experiential learning is encouraged under the Greek curricular framework. More recently, the Institute of Educational policy (2015), a consulting body supervised by the Greek Ministry of Education, reiterated its commitment in its curricular guidelines for experiential learning (in Greek: βιωματική μάθηση) in the context of Environmental and Sustainability Education and beyond.

The current study has a strong consistency with the learning outcomes of the Environmental and Sustainability Education Curriculum (2010). The proclaimed end goal of the Greek Environmental and Sustainability Education curriculum (2010) is to develop

environmentally literate citizens who will be “informed, sensitized and eager to work, both independently and collectively, towards achieving a balance between development, quality of life and environmental health” (Spyropoulou, Mardiris, & Stefanopoulos, 2012, p.3). An environmentally literate citizenry is described as aware of environmental issues and willing to undertake personal effort in order to resolve these issues through sustained changes in their attitudes and behaviours. In order to explore whether Environmental and Sustainability Education in Greece is delivering its mandate, this study will probe for significant changes in the environmental literacy levels of students who participated in the Greek Environmental and Sustainability Education program.

In 2016, educational policy councillor Dimitra Spyropoulou and colleagues placed interdisciplinary and experiential learning at the centre of the of the new environmental and sustainability education curriculum (Spyropoulou, Koskolou, Mitsis, Paulikakis, & Fermeli, 2016, p. 1). The evidence in the literature suggests that experiential and outdoor pedagogies are clearly described, prescribed and promoted in the Greek environmental education curriculum. The importance of experiential education for the Greek system is also evident from the university-based relevant literary production. Environmental education professor Georgopoulos devotes two chapters of his most recent book to experiential education methods, focusing on thematic ideas and practical advice towards teachers on how to introduce experiential learning methods in their teaching (2014, p. 66–112).

To conclude, the Greek curriculum encourages, but does not mandate experiential and outdoor learning practices in environmental education. When the elective environmental education lesson is being offered by a primary or secondary education unit, outdoor and experiential pedagogical practices are recommended by the relevant curriculum. Under the curricular framework that regulates elective educational activities, the environmental

education curriculum offers examples and guidelines for the implementation of outdoor and experiential pedagogies. The Greek regulatory framework produces an on-the-ground reality where a plethora of diverse pedagogical approaches take place simultaneously in the field of environmental education. However, how do these approaches differ in terms of educational practice? Where are they different, and where do they overlap? The following section touches on the conceptual differences between these learning approaches and then draws on the international literature to discuss how these approaches are defined in the physical landscapes of environmental learning.

Mapping Environmental, Experiential, and Outdoor Learning

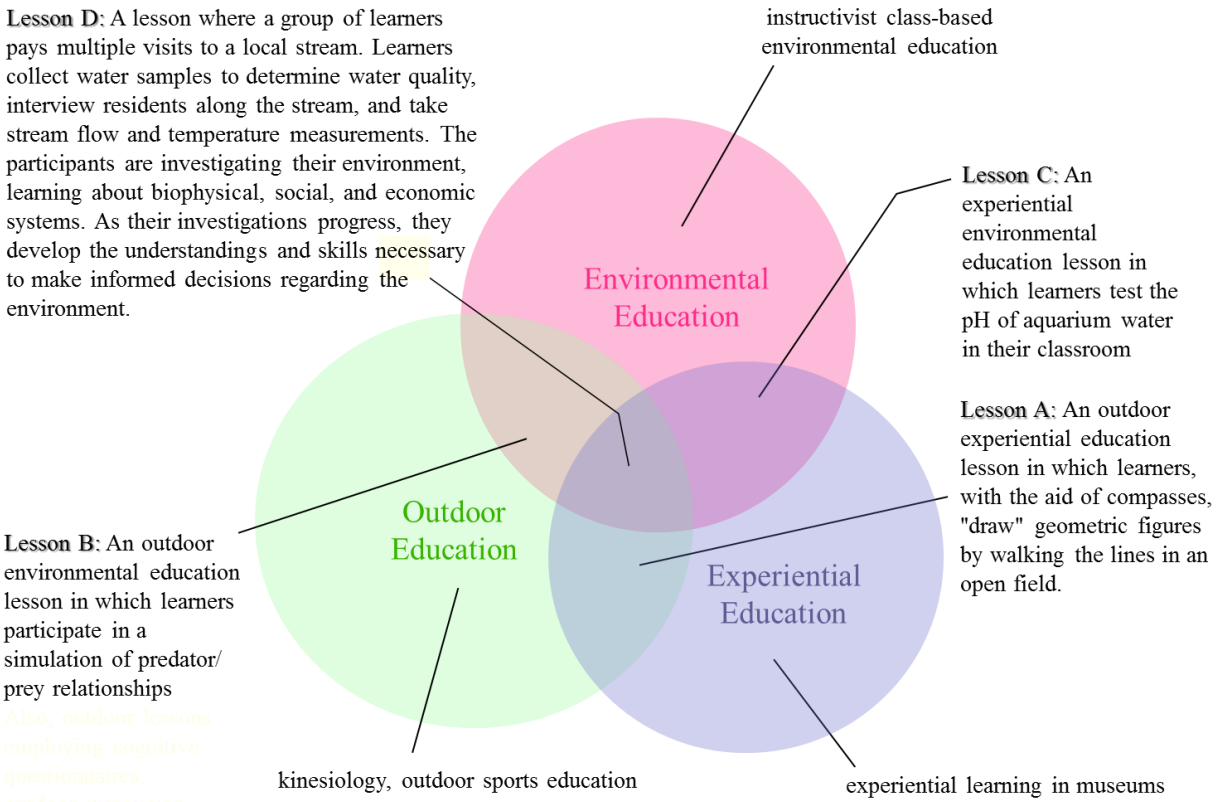
A number of countries have seen educational initiatives drawing on environmental, experiential, and outdoor learning (Beard & Wilson, 2006; Breunig, 2008; Wurdinger, 2005;). As the three different approaches were introduced into pedagogical practice, theorists and administrative officers sought to develop a systematic method for systematizing and classifying these learning approaches (Gavrilakis, 2006, p.119). This section presents an overview of ways to classify of these approaches, which so often overlap and run together.

A first-level examination of the three approaches reveals that environmental education is defined based on its objective (purpose), outdoor education is defined based on its physical field of application (place), while experiential education is defined based on its pedagogical approach (method). This distinction based on purpose, place, method might offer a good opportunity from which to proceed toward a practical disambiguation of the three approaches. However, in 1986, Priest argued that [environmental] outdoor education is always experiential (Priest, 1986). He claims that "Outdoor education: (1) is a method for learning; (2) is experiential" (p.13). Based on years of practical experience, Adkins and Simmons (2002) answered the same question by developing a more nuanced understanding.

They used inductive logic to proceed into a disambiguation of environmental, outdoor, and experiential education. As such, they presented a thought experiment. They considered four examples of pragmatic educational activities, and proceeded to allocate these examples in a classification system that they have created (Figure 3).

Figure 3

A visualization of how Adkins and Simmons (2002) typified four hypothetical lessons in the theoretical space between environmental, experiential, and outdoor education.



adapted from Adkins and Simmons, 2002

In a practice-based disambiguation, Adkins and Simmons (2002) proposed the following four hypothetical educational activities: (A) A lesson in which learners, with the aid of compasses, draw geometric figures by walking the lines in an open field, (B) A lesson in which learners participate in a simulation of predator/prey relationships, (C) A lesson in

which learners test the pH of aquarium water in their classroom, and (D) A lesson where a group of learners pays multiple visits to a local stream. Learners collect water samples to determine water quality, interview residents along the stream, and take stream flow and temperature measurements. The participants learn by doing: collecting, interviewing, and measuring. Finally, they are investigating their environment, learning about biophysical, social, and economic systems. As their investigations progress, they develop the understandings and skills necessary to make informed decisions regarding the environment.

According to Adkins and Simmons (2002), there are eight possible classifications for any type of educational activity (see Fig. 3). Based on their classification, all traditional, teacher-centred lecture-based instruction can be classified into the category of non-environmental, non-experiential, non-outdoor education. In their thought experiment, each of the lessons A, B, and C combine two of the educational approaches under discussion. Lesson D, which "builds from the strengths of all three approaches" is presented by the authors as an exemplary case (Adkins & Simmons, 2002, p.7). Hence, in their work, Adkins and Simmons (2002) are clear on their preference for lesson D, which combines environmental, experiential, and outdoor education. However, this does raise the question of whether there is any evidence in support of their preference. The following section addresses this question, exploring the role of environmental literacy as a means to understand the effects of pro-environmental education.

Environmental Literacy as a Means to Understand the Effects of Pro-environmental Education

Despite a recent growth in environmental education programs, the global educational community has yet to agree on a systematic evaluation framework that would demonstrate the effectiveness of these programs in meeting their educational goals. As a result,

environmental education program evaluation has been an ongoing challenge. Researchers have pointed out that evaluation in environmental education has been largely neglected, most environmental education programs worldwide have failed to incorporate high quality, systematic evaluation into their programming (Carleton-Hug & Hug, 2010; Fien, Scott, & Tilbury, 2001)

Program evaluation uses data that are collected in relation to educational activities, aiming reach informed ideas about their effectiveness and efficiency (St.Clair, 2002). Environmental education program evaluation asks whether and to what extent a particular project or program achieves its mission, objectives, goals, outcomes or impacts, and/or whether the resources invested into these projects or programs are worthwhile (Brody & Storksdieck, 2013). According to educational policy makers, environmental education aims to develop the environmental literacy levels of its recipients (Ardoin & Merrick, 2013; NEEAC, 2015;). This suggests that environmental education programs could be evaluated on their demonstrated capacity to improve students' environmental literacy in five factors: *environmental knowledge, competencies, skills, dispositions,* and *actions* (Hollweg et al., 2011). Indeed, McBeth, Hungerford, Marcinkowski, Volk, and Cifranick (2011) have ventured to assess the effectiveness of environmental education programs across North America based on the environmental literacy outcomes of participating students. According to their rationale, an instrument designed to measure the relative levels of environmental literacy might also serve as an evaluation tool for environmental education programs. Their work opens the way for a more systematic evaluation of environmental education programs, as appropriate to the objectives, goals, and priorities of each national context.

McBeth et al. (2011) compared the general environmental literacy levels of two groups of secondary education students across the US. The first one was a group of students who participated in exemplary environmental education programs at their schools, and the

second group (control group) was a baseline sample of students taken from an earlier study (McBeth, Hungerford, Marcinkowski, Volk, & Meyers, 2008). For the needs of their survey, McBeth et al. (2008) developed the Middle School Environmental Literacy Survey (MSELS). MSELS is based on the Middle School Environmental Literacy Instrument (MSELI), developed by Bluhm, Hungerford, McBeth, and Volk (1995) for students in grades six to eight and including knowledge, affect, skills, and behavior subtests. MSELS also includes material from Leeming, Dwyer, and Bracken (1995), Meyers (2002), Peterson (1982, 2005), Quale (1993), and Tanner (1980). The eight subtests of the MSELS fall into four major components of environmental literacy: *knowledge*, *affect*, *cognitive skills*, and *behaviour*. Environmental literacy subcomponents measured by the MSELS include ecological knowledge, verbal commitment to action, environmental sensitivity, general environmental feelings, issue identification, issue analysis skills, action planning skills, and actual commitment or environmental behaviour. In the MSELS, the items related to knowledge and cognitive skills utilize multiple-choice responses, and the items related to affect and behaviour utilize a Likert-type response format.

Even though McBeth et al. (2011) frame their research as an assessment/ evaluation (p.8), their findings are not conclusive. The researchers report that "it appears that students participating in school-based environmental education programming have higher levels of environmental knowledge, and indicated higher levels of environmental affect and behavior than their counterparts in the baseline study" (McBeth et al., 2011, p.106). However, they acknowledge that they "do not know whether this [difference] is a result of the environmental education programming itself, or of the extent to which other influences might impact environmental literacy (e.g., social, familial, teacher-related, etc.)."

In 2016, Blessing Adaku Igbokwe followed a similar rationale in her doctoral research. In her work, the MSELS was employed, together with supplementary instruments,

to assess the "strength of an Environmental Education Program (EcoSchools) in Ontario Secondary Schools" (Igbokwe, 2016, p.i). Environmental literacy levels were compared among students in Eco and non-EcoSchools. Results from her doctoral research showed that "students in EcoSchools demonstrated a higher levels of environmental literacy compared to students in the non-EcoSchools" (Igbokwe, 2016, p.163).Furthermore, a few other countries (beyond the US) have used environmental literacy/ learning outcomes as a framework to evaluate the general levels of environmental literacy. However, these studies did not claim to be directly evaluating an environmental education program or curriculum. Rather, the purpose of these national or sub-national assessments was to report on the general levels of environmental literacy in these geographical contexts. This was achieved using MSELI-based instruments, usually MSELS which is a subsequent version of MSELI. To that end, environmental literacy assessments have been undertaken in the United States, South Korea, Israel, Turkey, Indonesia, Greece, and Taiwan (Liang et al., 2018; Maulidya, Mudzakir, & Sanjaya, 2014; Kyriazi & Mavrikaki, 2013; Marcinkowski et al., 2014; Erdogan, 2009; Negev et al., 2008; Shin et al., 2005).

Lastly, there is a category of evaluative studies which are of particular interest for this research. Leeming, Porter, Dwyer, Cobern, and Oliver (1997) used the Children's Environmental Attitude and Knowledge Scale (CHEAKS) to evaluate the Caretaker environmental education program in the US. CHEAKS was developed earlier by Leeming, Dwyer, and Bracken (1995) and was used to obtain pre-test and post-test measures of the students' environmental attitudes and knowledge. Following a quasi-experimental research design, Leeming et al. (1997) reported significant positive influence on environmental behaviour, but no significant impact on environmental knowledge (Leeming et al.,1997, p. 33).

Around the same time, quasi-experimental, evaluative research was released from Germany. Bogner and Wilhelm (1996) developed an environmental attitude and behaviour scale, intending to measure educational outcomes. Following this, Bogner proceeded to test the newly developed instrument which measured environmental knowledge, attitudes, and behaviour (Bogner 1998, 1999). Through quasi-experimental designs, Bogner evaluated outdoor environmental education programs. He concluded that "direct experience of sufficient duration can, then, elicit a positive shift in attitudes and behavior" (Bogner 1998, p.27).

Ten years after Bogner's research, a validated instrument based on Bogner's Environmental Perception (ENV) scale was used to examine the effects of the Sunship Earth program in the US (Johnson & Manoli, 2008). Paired sample t-tests were used to assess the environmental perceptions of fifth and sixth grade students who participated in the Sunship Earth environmental education program. Sunship Earth was conducted at a residential outdoor school outside of an eastern US state city. Research findings showed a statistically significant change toward more pro-environmental perceptions (for all factors described in the Bogner scale) for children who participated in Sunship Earth. No improvement was reported for a control group.

Earlier in this section, I discussed the rationale for employing an literacy approach for evaluating environmental education. To that end, I presented studies that have performed environmental literacy assessments using appropriate instruments. In summary, two parallel research approaches have been identified with respect to environmental education program evaluation. These approaches appeared, independently, in the US and Germany in the mid 1990s. The US approach is based on environmental literacy instruments that have derived from MSELI, while the German approach draws on Bogner's Environmental Perception (ENV) scale. MSELI was developed in the US by Bluhm, Hungerford, McBeth, and Volk

(1995), while the ENV scale was created in Germany, based on the work of Bogner and Wilhelm (1996) and Bogner and Wiseman (1999).

Since then, the US instrument (MSELI) has been used in a nation-wide survey, and furthermore it has been exported and adapted to serve numerous environmental literacy assessments around the globe. In my research, I am following the research tradition that initiated in the US, because that tradition has diversified enough to have produced an instrument adapted to the specific geographical context that the measurement will take place, and because it aligns with my interest in environmental literacy as an approach to evaluating environmental education. In the following chapter, I provide more detail on the variety of environmental literacy instruments that are based on from MSELI.

Conclusion

This chapter reviewed the literature that discusses the evidence-based learning outcomes of environmental education (Rickinson, 2001). The international literature suggests that environmental education programs can be evaluated based on their demonstrated capacity to improve students' environmental literacy (Ardoin & Merrick, 2013, p.3). The works of Bogner (1998, 1999), McBeth et al. (2011), and others, have opened the way for a more systematic evaluation of environmental education programs, as appropriate to the objectives, goals, and priorities of each national context. The present research attempts to transfer their rationale to the Greek context, and explore the potential of environmental literacy as a practical indicator of quality in environmental education practice.

Chapter Four: Methods

As discussed in the previous chapter, environmental literacy measurements were attempted in different national contexts as a means to assess the effectiveness of environmental education programs. This research applies a locally validated instrument (GELI) in order to extend this assessment practice to the Greek context. By applying the instrument before and after outdoor environmental education interventions, students' environmental literacy levels are assessed and compared. The data obtained by this process will be used to assess the validity, reliability and usability of this method for measuring and assessing the effects of environmental education. Hence, the data created by this research design are used to reach an inform judgement of the potential of this process as an evaluative approach. The broader aim of this study is to contribute to the literature that explores the extent to which environmental literacy can work as a way to build evaluation of outdoor education programs.

Research Question

The design of this research is based on the research question: "What is the potential of an environmental literacy approach to capture the effects of outdoor environmental education?"

Research Hypothesis

The empirical aspects of this dissertation are anchored on the hypothesis that the associated environmental literacy instrument (GELI) will be able to capture a significant improvement in the environmental knowledge, attitudes, and behaviour of students who have participated in outdoor environmental education as compared to students who follow the standard curriculum.

Research Design

This study seeks to explore the potential of an environmental literacy centred assessment to capture the effects of students' participation in outdoor environmental education delivered in the context of the Greek environmental and sustainability education curriculum ([Greek] Ministry of Education, 2019). Two rounds of data were collected: The first round (pre-test) was obtained before students' participation to outdoor environmental education, and the second round of data (post test) was collected after the completion of the environmental education program. The comparisons between the pre and post test outcome variables were used to inform the research question.

The data used in this quantitative quasi-experimental research design were collected from Grade 9 and 10 students who attended the High School and Lyceum of Kalymnos, Greece. This is a pseudonym that does not compromise the confidentiality of the school units because Kalymnos has more than one school in each category. These schools were selected because one teacher from each school, and the schools' principles agreed to participate in the research. The researcher was initially referred to these schools by the school counselor for environmental education in the prefecture of Dodecanese (based on Rhodes) which consists of 26 inhabited islands. The sampled schools correspond to the educational levels ISCED 2 and ISCED 3, respectively. The ISCED categorization was introduced by UNESCO in 2011 and is being implemented in all EU data collection as of 2014 (UNESCO, 2012).

Data were collected during two successive short visits to the participating schools in October 2017 and May 2018. Over the course of the 2017–2018 school year, a selected group of students in these schools followed the Greek Environmental and Sustainability Education curriculum (2010) while another group of students followed the standard curriculum. Participation of students in the environmental education program is considered in this study as an independent between-subjects variable. The dependent variables of this

research study are the components of students' environmental literacy as measured by an appropriate environmental literacy assessment instrument. These dependent variables will be analysed in order to inform the research question.

From a research design perspective, two groups of students can be identified as participating in the study: one group that received an environmental education intervention (treatment group) and another group that did not (control group). Students in the control group followed the standard curriculum over the course of the 2017–2018 school year (as outlined by the Greek Ministry of Education, 2013; 2016b). Students in the treatment group followed the standard curriculum, enhanced by two hours of environmental education per week at their school, during the weekend. In addition, students in the treatment group took part in three different three-day long educational field trips to Environmental Education Centres in mainland Greece where they received additional environmental education interventions (Table 2; Figure 4). Educational visits to Environmental Education Centres are a complementary option for students who participate in environmental education groups (Greek Ministry of Education, 2017).

In this quasi-experimental research design, the researcher did not intervene in the process of assigning students to treatment and control groups. Instead, the assignment into treatment and control groups was made by the teachers who undertook the environmental education complementary educational activity during the 2017 – 2018 school year school year. As a result of this selection process, two different educational streams were established *in situ* (and *in natura*): Students who participated in the environmental education groups (treatment group), and students who followed the standard curriculum (control group). This division ran within participating classes and was maintained over the course of the 2017 – 2018 school year. A more thorough discussion on the selection criteria that teachers used to select students for the environmental education stream, as well as validity concerns stemming

from this selection procedure are discussed in the Validity and Reliability Concerns section, later in this chapter. In terms of typology, this study can be classified as a natural experiment that uses a testing instrument as a data collection method.

Students' pre and post environmental literacy performances were compared, in order to assess the potential of environmental literacy as an evaluative approach. Data were collected over two successive visits of the researcher to the Kalymnos schools, at the start and at the end of the 2017–2018 school year. During these visits, the researcher asked participating students to take the Greek Environmental Literacy Instrument (GELI) test. Based on the tests, students' levels of environmental literacy were assessed. Data analysis involved a comparison of student environmental literacy levels between treatment and control groups as part of a repeated measures (pre versus post) quasi-experimental design. Further details on instrumentation will be presented later in this chapter.

Kalymnos is a rugged Greek island adjacent to Asia Minor, Turkey. The island of Kalymnos has a land area of 134.5 km^2 – for comparison, Kalymnos is four times smaller than the island of Montréal. There are two mountain ranges that transect the island of Kalymnos, reaching 740 meters and 608 meters each – for comparison, the highest point of the island of Montréal (Mt.Royal) stands at an altitude of 233 meters. Two narrow valleys are created by the mountains of Kalymnos, and ninety per cent (90%) of the island's population is concentrated in the southern valley, which opens out to the commercial port (ELSTAT, 2011; Figure 4). According to the 2011 census, Kalymnos' has a permanent population of 16 001 residents. Hence, the island's population density is 119 residents per square km., which makes it one of the most densely populated Greek islands (Journal of the Greek Government, 2014).

Figure 4

View of the commercial port and main settlement in the island of Kalymnos, Greece.

Population: Geography and socio-economic background of Kalymnos

Over the past 200 years, Kalymnos has seen sharp fluctuations in its population, which can be directly attributed to the rise and fall of the global sponge industry. Between 1850 and 1900, the population of Kalymnos more than doubled (Bernard, 1976). Three factors accounted for this: (1) The threat of piracy was quelled, after intervention by the US navy, (2) Fleets from Kalymnos and Symi (a nearby Greek island) discovered the world's largest sponge beds off the coast of Libya, and (3) Deep sea diving gear was introduced into the Aegean Sea, increasing the production potential (Bernard, 1976). Natural sponges were in high demand by international markets by that time, and the economic activity of fishing, processing, and exporting of sponges produced significant wealth for these islands. The

islands' population continued to grow into the early 20th century, with Kalymnos reaching its historical height of 23 200 inhabitants in 1912 (Bernard, 1976). Then, in 1912, Italy took over the Libyan sponge grounds which were previously exploited by Kalymnian and Symian fleets. In the five years following the Italian blockade of their fleets from the Libyan sponge grounds, the island of Kalymnos lost 35% of its population to migration; at the same time, the island of Symi lost a 67% of its population to migration (Bernard, 1976). The remaining residents turned to local sponge grounds to make a living, and hence the islands' economies and populations stabilized in the following decades.

Sponge-diving ceased to be economically important for Kalymnos after 1986, when an epidemic of unknown origin devastated the commercial sponge populations of the eastern Mediterranean (Webster, 2007). Fishermen in Kalymnos attribute the disaster to the major nuclear accident that occurred in April 1986, in Chernobyl, Ukraine (Alahouzos et al., 2015). The aetiological agent of the sponge disease that devastated the sponge populations in the Eastern Mediterranean between 1986 and 2000 has yet to be identified (Lewbart, 2012), and marine biologists have attributed the recurring global events of mass mortality of sponges and other marine organisms to global warming (Cebrian, Uriz, Garrabou, & Ballesteros, 2011). In order to find an alternative source of income following the collapse of the sponge populations, Kalymnos' society has opened to tourism and caters today to specialized tourist markets such as diving tourism and climbing tourism. Since the late 1990s, the island has become a popular worldwide destination for rock climbing, with more than 1200 routes in 77 climbing fields (Mavrothalassiti & Farsari, 2011). These days, even as the nautical traditions of fishing and sponge diving have lost their economic significance, they remain important for the island's culture and character.

The High School and Lyceum of Kalymnos are public schools with a capacity of 219 and 232 students respectively, situated in the main settlement of the island, near the

commercial port (Figure 4). Public schools cater to ninety-four per cent (94%) of the Greek student population (IOBE, 2013). These schools were purposefully selected for this study because two of its teachers, with significant teaching experience in environmental education, agreed to help with the experimental phase of this research. Moreover, the selected schools fulfil the following two conditions. Firstly, these are public schools that do not diverge significantly from the mean of Greek schools in terms of academic performances and socioeconomic background of its student population (Lignou, 2016). A selection of a purposeful sample close to the parametric average protects the external validity of the study. Selection of a school that represents a statistical extreme could have threatened the external validity of results (Teddlie & Yu, 2007). Secondly, the selected schools demonstrated, at the beginning of the school year, sufficient size to contain two groups of students in each of grades 9 and 10, one on track to follow an environmental education program and one not. Thus, both treatment and control groups had sufficient and comparable sizes for the needs of the statistical analysis, and the participating teachers and the school principals were willing to give official consent for the study.

The first school-based environmental education program in Kalymnos took place in 1992, following the enactment of the first law in support of environmental education in 1990 (Journal of the Greek Government, 1990). The environmental education program was offered for eight consecutive school years, and concluded in the year 2000 with a publication featuring the island's endemic flora and fauna (Vassiliou, 2000). This first tranche of school-based annual environmental education programs is also credited with the creation of the grassroots environmental group *Ydna*, which continues to undertake educational and environmental initiatives on the local level.

In the following years, Kalymnos' educational community embraced environmental education, which is documented by a plethora of publications featuring Kalymnos-based

environmental education programs (see for example Billiri & Marinoy, 2016; Kalogerakis, 2016; Kefala et al., 2016; Koutsoumbou, 2014; Mitroyanni et al., 2016; Panou, 2016; Platsi, 2016; Trikoilis et al., 2014). Today, the schools of Kalymnos are already in their third decade of environmental education, and always actively interested in publishing their results (Kalogerakis, 2018; Pougounia, 2018; Platsi, 2018).

Figure 5

Memories of the Earth environmental education group in outdoor learning activity

Photo courtesy of science teacher Vassilis Kalogerakis (Kalogerakis, 2018, p.199).

Settings: The Nature of the Educational Intervention

In 2017–2018, teachers who agreed to participate in this research were instructing Grades 9 and 10 in the public schools of Kalymnos, Greece. That year, about half of the students attending Grades 9 and 10 took part in seven different complementary school activities. Table 2 summarizes the educational activities sampled in this study. Below, I am

including a short description of the sampled educational activities. The information on these programs or activities is based on a) the lesson plans which were officially submitted and approved before the programs' implementation, b) my notes from conversation with the teachers during the programs' implementation, and c) academic publications on the programs' content, released after the programs' completion. The utilization as data of my fieldnotes as well as the information from the post discussions I had with the teachers about these activities was made possible after receiving the McGill Research Ethics Board III #: 67-0717 Certificate of Ethical Acceptability Involving Humans of 2017-08-03 and approved amendments of 2017-10-13 and 2019-2-28.

In the environmental education program *Memories of the Earth: Geological Monuments of Kalymnos,* Grade 9 students explored the geophysical environment of their island through experiential and outdoor learning (Figure 5). In the program *Freshwater sources of Kalymnos,* Grade 10 students visited the island's (scarce) freshwater sources, and worked on proposals concerning the management, marking, and protection of surface and underground freshwater sources in the island. In *Sustainable trails,* extensive trekking is included, which takes place on ancestral trails connecting the island's villages (Grade 10). In the described implementation methods of *Recycling,* educational visits to the island's waste management facilities were provided for Grade 10 students. In *Byzantine mosaic patterns in the East and West,* Grade 10 students, together with students from higher grades, studied the mosaic patterns that are used to decorate public spaces on their island. The program culminates with an educational visit to Thessaloniki, where the students compared these patterns with the ones found in their island. Initially, the plan was to travel to Ravenna, Italy for this purpose but the environmental education group was able to realize only the domestic part of the educational visit due to economic difficulties (Moula & Papadomarkakis, 2018, p. 183-190). In *Highly energetic scientists*, Grade 10 students, together with students from

higher grades, take stock of the experience of participating in the design of a high energy Physics experiment. This program is described an international educational collaboration with CERN [Conseil Européen pour la Recherche Nucléaire], Switzerland. According to the program's declared goals, students are expected to acquire knowledge on solar radiation, realize the significance of the magnetosphere for the ability of Earth to sustain life, and other related topics. Lastly, in *Virtual Enterprise*, Grade 10 students, together with students from higher grades learn how to set up a start-up company, in the context of the school's professional orientation.

Table 2

A typology of educational programs sampled in the island of Kalymnos, Greece, over the 2017 – 2018 school year.

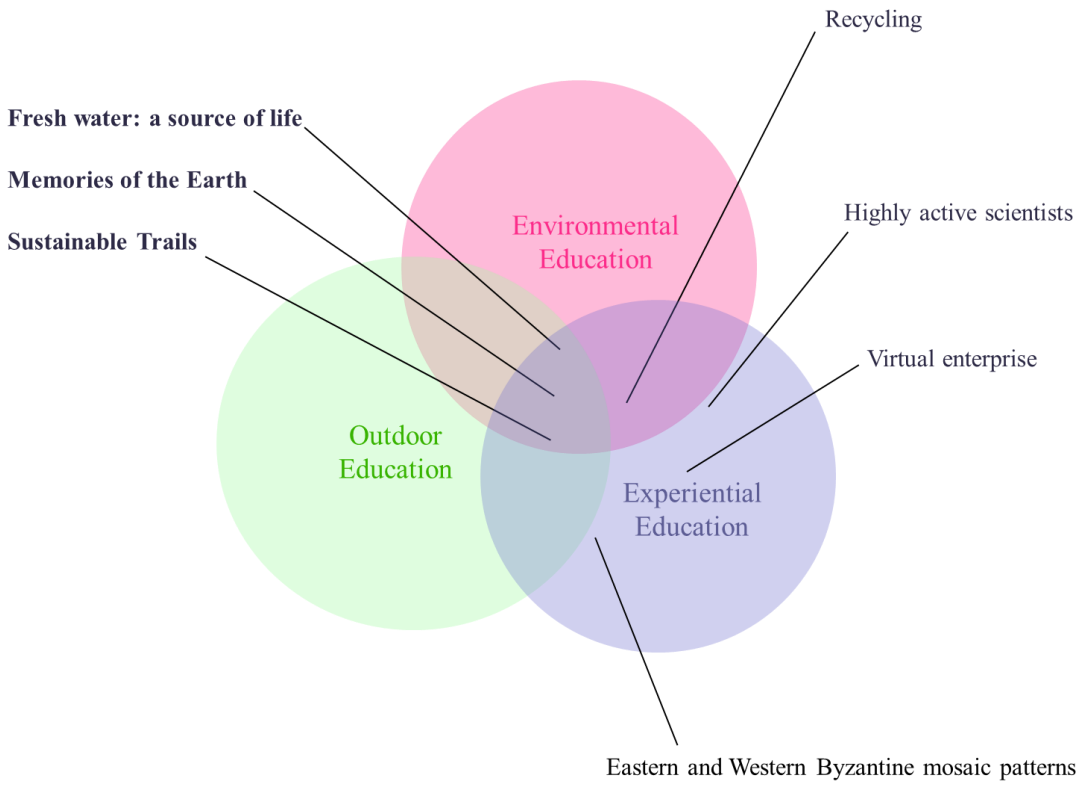
N of students sampled	Title of school activity	Ministerial categorization of school activity	Specialty of teacher in charge	Number of independent outdoor fields described in official programmatic planning	Reported total / **outdoor hours of environmental education** received by participating students	Hours of outdoor education include extra 9 hours of outdoor education delivered in an Environmental Education Centre?	Program content publicised in academic literature (Moula and Papado-markakis, 2018)
27	Memories of the Earth: Geological Monuments of Kalymnos	Environmental Education	Physics	8	46/ **15**	YES (EEC of Anogia)	YES
12	Freshwater sources of Kalymnos	Environmental Education	Greek Language	6	37/ **11**	YES (EEC of Klitoria)	YES
10	Sustainable trails	Environmental Education	Physics	6	19/ **13**	YES (EEC of Konitsa)	NO
13	Recycling at home and at school	Environmental Education	Chemistry	3	12 / **2**	NO	NO
5	Byzantine mosaic patterns in the East and West	Cultural Education	Greek Language	1	32 / **2**	NO	YES
4	Highly energetic scientists	Environmental Education	Physics	0	20 / **0**	NO	NO
1	Virtual enterprise	Professional Orientation	Sociology	0	20 / **0**	NO	NO

Note. Both total and outdoor hours of environmental education include 9 hours of outdoor education received by those students who visited an Environmental Education Centre.

In classifying the observed environmental education programs based on their pedagogical methods and fields of implementation, I proceed to situate programs on Adkins and Simmons' (2002) Venn diagram (Figure 6). I will unreservedly adopt Adkins and Simmons preference towards environmental, experiential, and outdoor education, especially since their stance is supported by the discussion of learning outcomes that I presented in Chapter 3. Hence, in this research, I will be interested in studying the effects of programs that combine the strengths of environmental, experiential, and outdoor education alike.

Figure 6

An empirical topography of the seven educational activities sampled in Kalymnos, based on the Adkins and Simmons (2002) classification.



Note. Programs that were forwarded to data analysis appear in bold letters.

Out of the seven programs that were represented in the sample, only the three programs that are found at the centre of the Venn diagram meet the requirements mandated by the research question (outdoor experiential environmental education) (Figure 6). These three programs fit the theoretically derived parameters for environmental, experiential, and outdoor learning, which have been established in the previous chapter. These three programs are titled *Memories of the Earth: Geological Monuments of Kalymnos*, *Fresh Water* and *Sustainable trails* (shaded in Table 2). Moreover, students from all three environmental education programs received an additional nine hours of complementary outdoor education when they were hosted for three-day-long, complementary educational interventions by the Environmental Education Centres of Anogia (Crete), Klitoria (Peloponnese), and Konitsa (Epirus), respectively (Table 2; Figure 7).

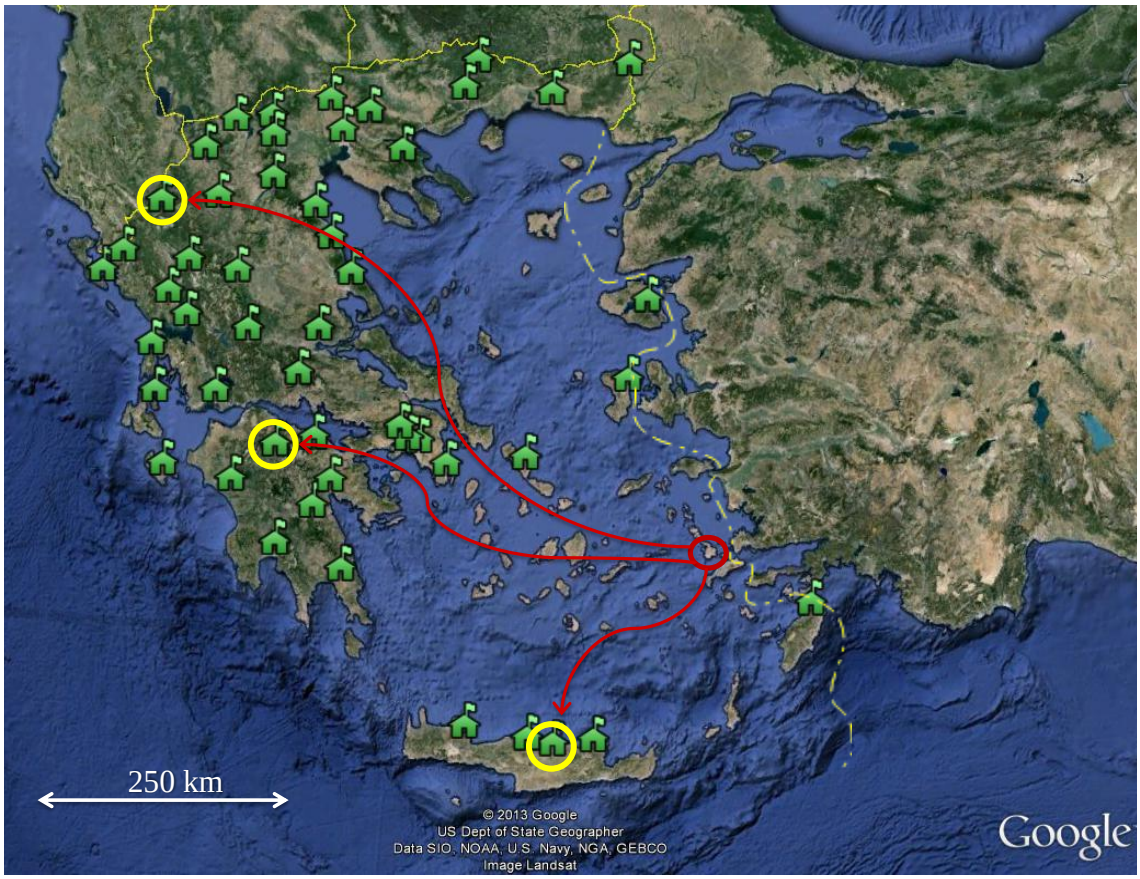
According to the submitted lesson plans and published programmatic content, students learned about the geological history, freshwater sources, and environmental history of their island in the three different environmental education groups which were observed by this study. These three programs meet the theoretical requirements of environmental education, since they orient towards the solution of an environmental problem. Indicatively, in *Memories of the Earth* the program's goals included learners' familiarization with the geological monuments of their island, but also for them to propose solutions for the protection of the island's soil and geological heritage in the context of sustainable tourism. In *Fresh water sources of Kalymnos,* learners were expected to promote public awareness, but also to propose ideas concerning sustainable management and protection of the island's water sources (Moula & Papadomarkakis, 2018). Lastly, in *Sustainable trails*, the program's goals include the development of students' civic intervention and decision making skills so as for them to act for the preservation of their island's walking trails. The end goal of maintaining the island's walking trails, according to the program's submitted lesson plan, is to preserve

the memory of the island's geological and human history. This is reminiscent of David Orr's teachings, in that 'a place has a human history and a geologic past' (Orr, 1992, p. 129).

These three programs also meet the requirements of experiential education, since an important part of their methods is based on students' lived experiences. Finally, they meet the requirements of outdoor education, since they include a strong outdoor component at their implementation phase. Students of the treatment group received the greatest part of their outdoor education instruction through educational visits to Environmental Education Centres, (Figure 7; Table 2).

Figure 7

Educational visits to Environmental Education Centres by the three groups of students that participated in outdoor, experiential environmental education.



Research Instrument

The Greek research community has started to negotiate direct measurement of environmental literacy in order to assess students' environmental literacy levels. In 2013, Kyriazi and Mavrikaki developed and piloted the Greek Environmental Literacy Assessment Instrument (GELI) with first year university students. As is evident from the literature reporting on the innstrument's development, the GELI was influenced by the pre-existing environmental literacy assessment instruments MSELS (USA), ESELI (Turkey), and others (Kyriazi & Mavrikaki, 2013, p.166). In turn, both the MSELS and ESELI were influenced by the MSELI which was developed in the USA by Bluhm, Hungerford, McBeth, and Volk (1995) for students in grades six to eight, with knowledge, affect, cognitive skills, and behavior subtests. McBeth et al. (2008) discuss how they developed the Middle School Environmental Literacy Survey (MSELS) using MSELI as the basic instrument, and by incorporating portions of the Children's Environmental Attitude and Knowledge Scale (CHEAKS) and/or other scales as appropriate. The CHEAKS was developed by Leeming, Dwyer, and Bracken (1995) for students in grades one to seven, with knowledge, attitude, and behavior scales.

GELI developers Kyriazi and Mavrikaki (2013) explain how they constructed the instrument using a pool of items which were drawn from instruments which have been developed and validated by previous studies (245 items) combined with items developed by the researchers themselves (50 items). The researchers treated the item pool with face validity checks (to ensure that the instrument reflects a reasonable definition of environmental literacy) and exploratory factor analysis using the Principal Components Analysis method (Kyriazi and Mavrikaki, 2013). As a result, most items were excluded and the final draft of the instrument was composed of 4 parts including 100 items. In final form, the GELI consists of 79 items which are assigned to one section of demographic information and three environmental literacy components: knowledge, attitude and environmentally responsible behavior. The knowledge

section consists of multiple choice items, while attitude and behavior are assessed using five-point Likert-type scales.

Kyriazi and Mavrikaki (2013) piloted GELI with a sample of 59 students at the onset of their studies in two Greek Universities. GELI was shown to have sufficient internal consistency with a Cronbach's Alpha of α=.84, α=.87, α=.83, regarding the components of knowledge, attitude and environmentally responsible behavior, respectively. This suggests that the data generated is internally consistent and provides evidence that there is adequate conceptual coherence to the instrument and the constructs behind it. In the context of her doctoral research, Kyriazi (2018, p. 168) administered GELI to a sample of 1010 students from Greek Universities, getting similar values of Cronbach's Alpha for the three environmental literacy components. However, the GELI has only been used at the higher education level. To date, no available research has directly assessed the level of environmental literacy of secondary students who participate in the Greek environmental education programs. The association of outdoor environmental education with specific and measurable environmental literacy outcomes can provide a framework for the evaluation and improvement of environmental education practice in Greece.

GELI allows for the measurement of three environmental literacy components: environmental knowledge, environmental attitude and environmentally responsible behavior. These components represent the dependent variables of the present research design. Exposure to treatment (outdoor environmental education) is considered in this study as a between-subjects independent variable and the temporal difference between the pre and post testing as a within subjects independent variable. The relationships between dependent and independent variables will be quantified by observing the experimental groups as they will be exposed to different treatments (Carpi & Egger, 2008). Additionally, GELI collects demographic data that will be used ex post facto to control for possible blocking variables that may confound

the relationship between independent and outcome variables. In sum, GELI produces five numerical variables (environmental knowledge, environmental attitude, environmentally responsible behavior, age and GPA), four categories of binary data (including gender and exposure to environmental education), nineteen categories of ordinal data (derived from Likert-type scales of parental educational level and others), and fourteen nominal categories of data.

The selected instrument was shown to have a high degree of coherence, but the face validity of the three different environmental literacy components that GELI measures is still to be established. Out of the three components that GELI assessed, environmental knowledge appears to be the most intensive (and time-demanding) for students taking the test (Appendix C). Analysis of the test reveals that out of 42 equal weighted questions in the knowledge component of the test, 34 questions (81%) refer to global environmental problems and are thus transferable *per se*, 5 questions (12%) are country-specific but easily transferable to other national contexts through moderate modifications, and 3 questions (7%) address regional, localized issues and are not transferable. Since the majority of the environmental knowledge questions refer to global environmental issues, the instrument has the potential for a high level of external validity.

In terms of GELI's internal validity in the environmental knowledge component, this was approached by the instrument's principal developer, Dr. Kyriazi, through the following process. In order to establish face validity with respect to environmental knowledge, the instrument's developer worked with four non-experts, whom she considered as a sample of the instrument's target group (Kyriazi, 2018, p.67). Following this, the content validity of the environmental literacy constructs was examined by two researchers and two professors with expertise in environmental and sustainability education. Following their observations, 152 questions were removed from the initial questionnaire in order to improve the instrument's

validity. Then, the remaining items (140) were subjected to exploratory factor analysis using the Principal Components Analysis method. Following this analysis, 29 items from the attitudinal component and 14 items from the behavioural component were also excluded due to their low loading score (< 0.40) in the factor analysis or due to yielding high loadings to more than one factors (to ensure that each scale is unidimensional).

In the component of environmental attitudes, GELI's developer reports that the Kaiser–Meyer–Olkin measures of sampling adequacy were used as a construct validity check (Kyriazi, 2018, p.74). The measure was considered adequate, with a value of KMO = 0.777 as regards to the 11 questions (items) that constitute the environmental attitudes component. In terms of the external validity of the environmental attitude component, the content of all items can be seen as highly transferrable. Attitudes toward nature are universal, and there is no specificity in the instrument on place specific natural characteristics or landscape. However, there might be differences between cultures in the intensity by which environmental attitudes or feelings are being reported. Indeed, there are observed differences in how feelings and attitudes are expressed across cultures, and this might affect the transferability of the research design.

Moving to the last of the assessed environmental literacy component, pro-environmental behaviours, construct validity is established by applying the Kaiser–Meyer–Olkin measures of sampling adequacy which gives a value of KMO = 0.888 as regards to the 11 questions (items) that constitute respective environmental literacy component. The result is very strong (Kyriazi, 2018, p.76). The pro-environmental behaviour items also appear to be highly transferable, though there is always the risk of social desirability affecting answers. Empirical data suggest that social desirability does not represent a significant validity threat in self-reported measures of environmental attitudes and ecological behaviour (Milfont, 2009), though it cannot be ruled out as a threat to validity.

Lastly, construct validity might be affected by changes in the definition of specific environmental literacy components. Notably, environmental behaviours in GELI seems to be influenced by the evolving definitions of environmental literacy. As discussed earlier, in 2011 NAAEE proposed a definition of an environmentally which placed increased emphasis on participatory and civic action (Hollweg et al., 2011). Accordingly, the behavioural component of GELI consists mostly of participatory and civic action items, unlike previous environmental literacy assessment instruments which featured mostly items referring to individual action (for example, consider MSELS in McBeth et al., 2011, p.153-164, in juxtaposition to GELI, Appendix C).

Choice of Instrument

The present study aims to apply GELI in order to probe the development of middle school students' environmental literacy during their participation in environmental education programs. GELI was selected because:

a) GELI has been validated in the Greek context, which saves the research design from the threats to validity that derive from cross-cultural normative interpretations (Geisinger, 1994).
b) GELI adopts a broad conception of environmental literacy (Stables and Bishop, 2001) that it is consistent with the multi-disciplinary practice of environmental education in Greece.
c) GELI includes three of the universally accepted environmental literacy components, i.e. knowledge, attitude, and behaviour and thus its application can produce data sets useful for international comparative research.

Data Collection

During two successive data collection trips to Kalymnos, Greece, in October 2017 and May 2018, I administered GELI to three classes of Grade 9 and three classes of Grade 10 students. The sampling was exhaustive, meaning that all the students of the three Grade 9 classes and three Grade 10 classes who were present at the time of the researcher's visit agreed to participate in the research when the purpose of the research was explained. Each of the six participating classes consisted of a number of students who were exposed to environmental education interventions during that particular school year (treatment group), while a comparable number of students in the same classes followed the standard curriculum and were not exposed to environmental education (control group). Thus, in each of the six participating classes, both treatment and control groups were represented. The treatment and control groups did not consist of intact classes; instead, the separation of treatment vs control groups ran within each of the six participating classes.

Every possible measure was taken so as to minimize the interference with the quotidian school activity. During the test, students were seated in their regular seats in their classes and were supervised by the teacher who was scheduled to teach at that hour. GELI was administered to collect baseline data from the two experimental groups in the Kalymnos High Schools both before and after the educational intervention. Each of the six participating classes devoted 40 minutes for the completion of the GELI questionnaire in October 2017 and again in May 2018.

As a result of these repeated visits, I obtained pre and post quantitative data from each of the three environmental literacy components measured by GELI: environmental knowledge, environmental attitude and environmentally responsible behavior. Moreover, GELI provided demographic information on gender, previous education, parental education, and leisure activities. During my second visit to Kalymnos, I had detailed conversations with

the teachers about the content and the pedagogical approaches employed in the environmental education intervention. I kept a log of these discussions, including information on the fieldwork conducted by the student groups, visits to Environmental Education Centres and notable events that occurred during the implementation of the program. I also maintained communication with participating teachers using social media during and after the completion of the environmental education intervention to complement my information and request clarification. An additional source of information on the environmental education interventions were the environmental groups' submitted project plans, which were sent to me by Dr. Evangelia Moula. Dr. Moula, who at that time held the position of the environmental education counsellor of the Dodecanese peripheral district (consisting of twenty-six inhabited islands), was institutionally responsible for supervision of the programs.

During my first visit in October 2017 I collected 75 questionnaires from Grade 9 and 68 questionnaires from Grade 10, for a total of 143. In my second visit, I collected 66 questionnaires from Grade 9 and 63 questionnaires from grade 10, a total of 129 (on this second visit, a number of students were absent from the school for educational activities unrelated to environmental education). I collected identification data on the questionnaires so as to be able to pair –and compare– pre- and post-test performances of individual students and thus maximize the power of the statistical analysis. Using students' identification codes, I managed to pair 62 questionnaires from Grade 9 and 60 questionnaires from Grade 10: in total, 122 questionnaires were matched.

No data were discarded on grounds of consistency or statistical results. Outliers are consistently included and presented in the statistical analyses. However, there were cases where students left either single questions or entire sections of the questionnaires unfilled. In the attitudes and behaviour sections, consisting of 12 and 11 questions respectively, I decided to discard the whole section when even one uncompleted question was found. I could not come

up with a convincing statistical correction to neutralize the effect these uncompleted questions. In the knowledge section, consisting of 42 questions, I decided to allow one or two uncompleted questions and treat these as having selected the "I do not know" answer. However, I discarded the whole cognitive section in cases where entire pages of the questionnaire (three questions or more) were found uncompleted, assuming that students failed to pay the necessary attention to these pages.

As a result of this filtering process, out of the 97 paired questionnaires that fulfilled the research question criterion, 95 were forwarded to data analysis regarding the knowledge component, 76 regarding the attitudes component, and 86 regarding the behaviour component (Table 3). Eventually, notwithstanding that all students from the six participating classes agreed to participate in the research (census), not every test section was completed. The possible methodological implications of this selective experimental attrition are discussed in the Limitations of Study section of Chapter 7.

Table 3

Number of students from the treatment group who completed both pre and post test, by test sections.

Number of students who completed the test sections below	Control group (N=48)	Treatment group (N=49)	Total (N=97)
Environmental knowledge	47	48	95
Environmental affect	34	41	76
Environmentally responsible behavior	41	44	86
At least one of the sections environmental knowledge, environmental affect, environmentally responsible behavior	**48**	**49**	**97**

According to the research question, this study aims to explore whether (and how) an environmental literacy approach can capture the effects of outdoor environmental education. Hence, the treatment group students were exposed to outdoor environmental education by participating in either of three different outdoor environmental education programs that fulfilled the criteria derived from the research question (Table 2; Figure 6). Treatment group students from Grade 9 participated in the environmental education program titled *Memories of the Earth: Geological Monuments of Kalymnos*. Treatment group students from Grade 10 participated in either of two environmental education programs *Freshwater Sources of Kalymnos* and *Sustainable Trails*. Only students who participated in programs that included educational visits to Environmental Education Centres are counted in the treatment group.

A number of students in the sample (25 students from Grade 10) reported participation in five environmental and cultural education programs that did not include an outdoor component. These students could not be included in the treatment group, because they were not exposed to outdoor environmental education. On the other hand, these students could not be included in the control group either, because they have been participating in parallel educational activities in addition to the standard curriculum; some of the themes in these parallel educational activities touched on environmental issues or included traces of outdoor learning (Table 2). Therefore, the control group consisted of students who followed the standard curriculum, and did not participate in complementary educational activities during the 2017–2018 school year.

Preliminary Analysis

An intercorrelation matrix was constructed so as to reveal interaction patterns between dependent, independent, and demographic variables. Results from the intercorrelation matrix informed the methodological design, and specifically indicating

whether it is meaningful to control for the effect of blocking variables that may act as confounders of the explored relationships. Blocking variables represent undesired sources of variation and hence are threats to drawing valid inferences from research, and the methodological purpose for collecting data beyond the dependent and independent variables (such as demographic variables) is to permit analysis of any such effects (Basu, 1977). It is also theoretically possible that variables originally considered as blocking variables may prove to have predictive value regarding the dependent variables, thus allowing for openings for future research. Firstly, I considered the significance of the correlation between the dependent variables and possible blocking variables such as GPA, parental education levels, and other. The significance of these correlations (using a =.05) allowed me to decide whether it is meaningful and necessary to control for the effect of blocking variables during data analysis. Additional preliminary statistical checks included the skewness of variables, i.e. asymmetries in the frequency distributions of variables that might introduce a directional bias to the results. In the following chapter, I elaborate on how these preliminary statistical tests relate to the basic research analysis plan, and how the preliminary analysis informs ex post facto the selected data analysis methods.

Data Analysis

Data analysis draws on descriptive and inferential statistics employing frequency distributions, statistical correlations, t-tests and multivariate analyses to compare the levels and development of environmental literacy between the treatment and control groups. An initial step of data analysis involves the tabulation of frequency counts for responses to closed-ended questions included in the environmental literacy assessment instrument. Once the data files for each group of students were prepared, raw scores for each student on each part of the instrument were used to generate descriptive statistics, including the mode, median, mean, and standard deviation of the environmental knowledge, environmental

attitude and environmentally responsible behavior scores for the four participating classes. The mode, median, mean, and standard deviation were also generated for each of the three environmental literacy components addressed by GELI (environmental knowledge, environmental attitude and environmentally responsible behavior). Lastly, the adjusted Fisher-Pearson coefficient was determined for the three measured environmental literacy components in all participating subgroups in order to assess threats to the reliability of results related to data skewness.

Inferential statistical analysis was used to compare the development of environmental literacy between the two groups of students (treatment and control) and eventually to inform the research question concerning whether significant cognitive and/ or behavioural changes could be captured after the participation of 14 and 15-year-old students in outdoor environmental education. The first phase of inferential analysis involved the use of t-tests to compare the results of the two experimental groups (treatment and control groups) with respect to their composite environmental literacy scores. The t-tests help us gauge whether there is a statistically significant difference between the control and the treatment groups for each of the three environmental literacy components.

The second phase of inferential analysis, which is the definitive test of the statistical significance of findings, applied a series of Repeated Measures Analyses of Variance (RM-ANOVA), with pre- and post-test as the repeated measure. Each environmental literacy component (environmental knowledge, environmental attitude and environmentally responsible behavior) was analysed as the dependent variable of a separate significance test. In each of these significance tests, the between-subjects independent variables gender, treatment, and grade were treated as binary with two permitted states for each variable. Gender, treatment, and grade are between-subject variables, which were crossed by time.

RM-ANOVA served as a separate significance test for each of the pre- versus post-test change of each of the three environmental literacy components which are measured by the associated instrument. The RM-ANOVA compared the change in each environmental literacy component between students of the treatment group (who received experiential environmental education) and students of the control group (who followed the standard curriculum) In order to avoid experimental error of type I (false positive) additional, post hoc analysis was performed after the analysis of variance tests. Hence, in cases where the initial RM-ANOVA results were significant, follow-up tests were performed to determine whether the results were real or whether they were statistical artefacts produced by the interference of *blocking variables*.

Demographic variables that found to correlate significantly with the outcome variables could be confounded with the independent variables of interest, thus leading to false inferences. In such cases, the effect of these additional independent variables could be mistakenly understood as the effect of the treatment. Therefore, any effect of these variables was controlled for statistically by treating them as blocking variables (including them as additional independent variables in the RM-ANVOA, so that their effect on the outcome variable(s) can be differentiated/ distinguished from the variables of interest). Thus, the effects of these potentially blocking variables, such as student GPA, parental education levels, and others, were accounted/controlled for statistically by including them as additional independent variables in the RM-ANOVA, so that their effects are separated from the effects of the variable of interest.

Validity and Reliability

A method has high validity if it truly assesses what it claims to be assessing. On the other hand, a method has high reliability if its findings can be sufficiently reproduced

(Oluwatayo, 2012). Consider for example that an inventor develops an instrument intended for measuring citrus fruits in the fields. However, because of a methodological error, the inventor is unaware that the instrument is able to measure only lemons but misses out on the other types of citrus fruits. The instrument can still achieve high reliability, given that it is consistently effective in what it measures. In a field of orange trees for example, it would consistently (even though erroneously) report zero citrus fruits. The root of the validity issue lies in claiming that that the instrument can assess citrus fruits in general, while in effect it can only assess one class of citrus fruits (lemons). It would require a more detailed factor analysis to reveal its validity issue. Eventually, by applying the citrus instrument to many different fields, its validity issue would eventually become apparent. Renaming the hypothetical instrument into a lemon assessment instrument would restore its validity. Hence, while reliability depends on the ability of the method to produce the same results when the same subjects are measured, validity concerns the meaning-making process by which specific measures are attributed to certain concepts and ideas.

The present study uses an environmental literacy instrument aiming to capture the effects of outdoor experiential environmental education. The broader aim is to assess the extent to which environmental literacy can work as a way to build evaluation of outdoor education programs. I conducted the evaluation of the students in order to create data to be used for an informed judgement of the potential of the process. This section discusses the validity and reliability of (a) assessment of environmental literacy levels using GELI, and (b) the validity and reliability of environmental literacy assessments as a means for program evaluation.

Environmental literacy is a multifaceted concept, so no instrument can claim to be capturing the entirety of its components. Hence, the content validity of environmental literacy depends on how many of the theoretically derived environmental literacy components it can

effectively capture. On the other hand, not every environmental literacy component can be measured in valid and reliable ways, and this limits the number of components and subcomponents that are included in each evaluation. For example, as will be discussed later in this section, the alpha coefficient for the issue analysis and identification subcomponent in MSELS was a mere .389. Hence, there is a need to examine how many variables can be examined that represent a valid and reliable overview of environmental literacy with realistic formatting, administration, and scoring parameters. In other words, a valid instrument needs to be both broadly representative of environmental literacy and, at the same time, relatively easy to administer, complete, score, and compare its results with other tests.

Since environmental literacy assessment instruments are relatively new, establishment of their construct validity is an ongoing process. In a review of the status of environmental literacy in the United States, Volk and McBeth (1997) found that the large majority of research instruments addressed only knowledge and affective components and few had established validity or reliability. They identified two literacy instruments that addressed three or more components of environmental literacy, that have reported established validity and reliability, and that were appropriate for a middle level audience. One of those instruments was the Middle School Environmental Literacy Instrument (MSELI). MSELI was developed by Bluhm, Hungerford, McBeth, and Volk (1995) for students in grades six to eight, with knowledge, affect, cognitive skills, and behavior subtests. The other was the Children's Environmental Attitude and Knowledge Scale (CHEAKS), developed by Leeming, Dwyer, and Bracken (1995) for students in grades one to seven, with knowledge, attitude, and behavior scales.

Using MSELI as the basic instrument, and by incorporating portions of the CHEAKS (and/or other scales) as appropriate, researchers developed the Middle School Environmental Literacy Survey (MSELS) (McBeth et al., 2008). The initial validity assessment of the

MSELS was based on a comparison of elements of the instrument and the body of environmental education research literature, and construct validity was established using an expert panel. The panel confirmed that the instrument reflected a reasonable definition of environmental literacy, was appropriate for a middle school audience and non-biased. Construct validity was established for the non-cognitive scales (affective and self-reported measures) through factor analysis of data from the sixth- and eighth-grade samples. The results of the factor analysis for these scales of the MSLES revealed that the one-factorial model for each scale was the best fit, confirming that each scale was unidimensional. The field testing scores (using a pilot sample of 65 students from grades six to eight) yielded an overall Cronbach's alpha coefficient of .817 for internal consistency. Alpha ranges for subscales were between .701 and .869, with the exception of issue identification which had an alpha coefficient of .389. (McBeth et al., 2008).

The instrument employed in this study (GELI) utilized items from MSELS and other environmental literacy instruments (Kyriazi & Mavrikaki, 2013, p.166). Environmental literacy is also thought to consist of the broad categories of environmental knowledge, skills, attitudes, and behaviours (Marcinkowski et al., 2014). Most of the existing environmental literacy instruments include two to four environmental literacy components. From a comparison of eight environmental literacy instruments from different parts of the world, it follows that all of them included environmental attitudes and environmental knowledge – that is, knowledge of environmental issues and principles of ecological science. Environmental behaviour was assessed in most cases, while environmental skills were assessed only in some cases (Kyriazi, 2018, p.65)

For the needs of GELI, an item pool was created by mixing 245 items drawn from existing instruments with 50 items developed by the researchers. The instrument's validity was constructed by narrowing down to a final version consisting of 79 items. In order to

establish face validity with respect to environmental knowledge, the instrument's principal developer worked with four non-experts, whom she considered as a sample of the instrument's target group (Kyriazi, 2018, p.67). Following this, the content validity of the environmental literacy constructs was examined by two researchers and two professors with expertise in environmental and sustainability education. The researchers treated the item pool with face validity checks and exploratory factor analysis using the Principal Components Analysis method. GELI's reliability was assessed with a sample of 59 students at the onset of their studies in two Greek Universities, yielding a Cronbach's Alpha of α=.84, α=.87, α=.83 for the components of knowledge, attitude and environmentally responsible behavior, respectively (Kyriazi & Mavrikaki, 2013).

Up to this point, I have discussed the validity and reliability of the application of GELI (and preceding instruments) for the assessment of environmental literacy. However, assessing baseline levels environmental literacy levels is not the same with assessing the change in environmental literacy in response to educational treatment. Henceforth, I will discuss the validity and reliability of applying GELI as a means to capture the effects of outdoor environmental education. According to Igbowke (2016, p.65), studies assessing environmental literacy in the literature generally fall under one or more of the following headings:

1. studies that assessed the effectiveness of environmental education programs for enhancing environmental literacy
2. studies on environmental literacy to establish environmental literacy baseline for students or teachers
3. studies on environmental literacy assessment to determine the relationship between environmental literacy components as predictors of responsible environmental behaviour

4. Studies conducted to assess environmental literacy in order to develop or test the validity, reliability and usability of an instrument for measuring and assessing the effects of environmental education.

The broader aim of this research is akin to the fourth category and in this sense, this is an exploratory study. This is not an evaluation study per se. Instead, I intend to examine what the associated instrument can tell us about environmental literacy as a way to capture the effects of outdoor environmental education. If some of the effects are captured, then I will return to the program content for triangulation.

A challenge here is that while validity and reliability is sufficiently established for research falling into categories 2 and 3, in Igbowke's classification, validity and reliability for categories 1 and 4 were undertheorized. In effect, in the report of the [US] National Environmental Literacy Assessment (NELA) findings, any discussion on validity and reliability is limited to the applied instrument (McBeth et al., 2011). Even thought the purpose of their assessment was to measured the effectiveness of north American environmental education programs with respect to students' parameters of environmental literacy, there is no discussion on the validity and reliability of the evaluative approach. While the validity and reliability of the instrument (MSELS) was extensively discussed, the validity and reliability of their evaluative approach was not examined.

The same stands for a recent Israeli study that used a mixed methods environmental literacy approach to assess the influence of a non-formal environmental education program on junior high school students (Goldman, Assaraf, & Shaharabani, 2013). While the validity and reliability of their pre and post evaluative approach is not explicitly established in the study, a discussion of the validity and reliability of one of the employed instruments is included (the Word Association procedure, Hovardas & Korfiatis, 2006). Hence, in both

cases the validity and reliability of the environmental literacy instruments is quietly assumed to extend to the evaluative approach.

However, even if the use a valid instrument can entail (under certain sampling and procedural conditions) a valid assessment based on pre and post measures, the same argument cannot be claimed for reliability. Instead, a drop in measures of reliability is to be expected in any repeated measures designs, which relies on a change in scores rather than on the scores themselves. It has been observed that a calculated reliability of difference scores must be less, often much less, than the reliability of the two base measures themselves (Thomas & Zumbo, 2012).

In terms of validity and reliability, there is a difference between assessing students' baseline levels of environmental literacy, and using environmental literacy as a means for the assessment of environmental education programs. In the former case, validity and reliability of the baseline assessment draws directly from the validity and reliability of the associated instrument. In the latter case, the validity and reliability of the evaluative approach has to be established through new research. Indeed, this is one of the main purposes of the present study: to provide substantiative knowledge in order to inform the potential of environmental literacy assessments as an evaluative approach. This and other future research will generate data that will help us decide whether the validity and reliability of the established instruments can be effectively extended into an evaluative approach.

Furthermore, if this were a program evaluation study per se, then for a method to produce valid and reliable data there should be a perfect alignment between the instrument's components and programmatic content. However, this is not a program evaluation study. In effect, this is an exploratory study on the extent to which environmental literacy assessments can work as a way to build evaluation of outdoor education programs. Hence, it belongs to

the class of studies conducted to assess environmental literacy in order to develop or test the validity, reliability or usability of a method for evaluating environmental education programs. In particular, this research aims to assess whether environmental literacy provides a viable framework for assessing the impacts and outcomes of outdoor experiential environmental education. Even though this is not an evaluation study (where any misalignment between the instrument components and the program content would constitute an immediate threat to validity), a certain degree of alignment between the instrument and the program content is expected. I will revisit this issue of alignment in Research Limitations, in Chapter 7.

Validity and Reliability Concerns

Every experimental or quasi-experimental study aims to achieve a balance between internal and external validity, and methodological choices have an impact on this balance. According to McDermott (2011), there is a hierarchical relationship between the two concepts: internal validity concerns come first, both sequentially and practically. Without first establishing internal validity, the processes to be explored in the real world remain unclear. External validity follows, as replications across time and populations seek to explore whether the research conclusions can be generalized to a larger population.

In the present research, and at the stages of conceptualization, instrument selection, data collection and analysis, I was constantly concerned about the internal validity of the experimental design. As discussed earlier, environmental knowledge is the most time-demanding part for students taking the test, and contains items both of national and global interest. There is a possibility of internal validity challenges, as the knowledge tested may not match the curricular content and aims. However, it is understood that any effort to increase internal validity (by including more items on local and place specific environmental

knowledge) would inevitably come at the expense of external validity. This issue is discussed further in chapter 7, Research Limitations.

A second concern, beyond the instrument, is the validity and reliability of a natural experiment. Natural experiments use pragmatic research designs and readily available data sources to evaluate and compare a new or existing policy to other policy alternatives or generate predictions of what may have happened in the absence of any intervention (Ackermann et al., p. 748). When conducting a natural experiment, the researcher is conducting the study in the setting of direct interest and should be able to conduct the study with minimal disturbance to the contextual ecology of that setting. Ecological validity is related to external validity, even though it is distinct as a concept. Studies with high ecological validity have a lower burden of proof for establishing external validity than studies with low ecological validity (Roe & Just, 2009). Even though the natural experiment may be able to claim a greater likelihood of relevance to other, similar settings, this does not remove the requirement to ensure that internal validity (ensuring that the instrument measures what it claims to measure) is satisfactory.

In order to protect the ecological validity of this study as a natural experiment, I made every effort not to disturb or alter the ecological context of the study as I was conducting the experiment. I paid two short visits to the participating classes of students, who saw me for 40 minutes in October 2017, when I had them complete the pre-test, and another 40 minutes in May 2018, when I had them complete the post-test. Moreover, I did not intervene in the content of the lesson plans or the assignment of students into (treatment and control) educational streams, which happened after my first visit to the island. The lesson plans were developed after my first visit to the island, with co-consultation between the students and teacher who decided on the themes.

The schools' educational routine, including the environmental education intervention, would develop with few or no changes in the absence of the researcher. In other words, the students would have experienced identical or very similar grouping into treatment and control groups and the subsequent educational treatments even if their schools did not participate in this research. One factor adding to internal validity is that the two experimental groups received exactly the same hours and content of science education during the standard curriculum, and by the same science teachers. This condition was enabled by the division of each of the six participating classes into treatment and control groups. Hence, this study followed a naturally occurring selection pattern that exposed two groups of students to differential pedagogical treatments: the control group receives the standard curriculum, while the treatment group received the standard curriculum enhanced by the environmental education component. Hence, the assignment into groups was a natural, non-randomized outcome of the school's educational routine.

Though this research design has many merits as a natural experiment there are threats to validity that must be taken into account. A characteristic threat for this type of research is the potential presence of differences between the treatment groups due to non-randomized assignment to groups (selection bias). As discussed, students who participated in this study were assigned to treatment and control groups by teachers who implemented environmental education programs in the given school year. Hence, the decision of who was assigned into treatment and control groups was taken by their teachers. Teachers who lead the environmental education interventions selected the participants to the environmental education stream out of an oversupply of interested students. In order to assess the presence of selection bias, I included in the preliminary analysis a comparison of the pre-test pedagogical and demographic characteristics between treatment and control groups.

Firstly, preliminary statistical tests were performed to examine whether the treatment and control groups were at the same environmental literacy levels at the start of the study, before their exposure to different pedagogical treatments. As is discussed in more detail in the findings chapter, no significant difference was found between treatment and control groups in their pre-test environmental knowledge and behaviour levels. This seems to confirm that the teachers did not select students for the environmental education stream based on the latter's existing environmental knowledge or behaviour. However, a statistically significant difference did appear in students' GPA and environmental attitudes (in favor of the treatment group). As is discussed in the following chapter, this observed difference between the experimental groups is nested within demographic characteristics. After assessing the extent of the differences between the experimental groups in this natural experiment, every possible statistical measure was taken to control for these differences and to address the resulting threats to validity and reliability.

Ethical Concerns

The researcher did not foresee any potential harm for the participants during or after their participation to the research. Environmental education is well established in Greece and its implementation is routine practice in the country. The subject of the research combined with the nature of the data collection methods averts the risk of any psychological, physical, emotional, social, legal, economic, or political harms for the participants. Moreover, the confidentiality of participants was protected throughout this research. The research was conducted with the permission of participating teachers and school administrations and the consent of participating students. Data collection and analysis were authorized and supervised by the McGill Research Ethics Board III #: 67-0717 Certificate of Ethical Acceptability Involving Humans of 2017-08-03 and approved amendments of 2017-10-13 and 2019-2-28.

An ethical concern of different type has to do with the professional involvement of the researcher (myself) in environmental education. My motivation in starting this research, as was explained in the opening of this thesis (Situating the Researcher), was to find out whether environmental education produced any observable results. Since I was actively involved as a teacher working for environmental education, there is an explicit personal and professional bias penetrating this research. Any type of research is prone to bias – there is always the danger to find what one wants to see in a pool of data. As human being, it is even questionable whether we are ever able to see anything else that our preconceived ideas and mental constructs in our surrounding cosmos, either in our academic practice or in our everyday lives.

As I was aware of the personal and professional biases mentioned above, I consciously tried to control it. What I tried to at the phases of research planning, data collection, and analysis, was to firstly become aware of the potential sources of bias, and secondly to try and control these when possible. Some of these concerns were discussed above, in the Validity and Reliability Concerns section.

In the data analysis, I consistently tried to avoid performing multiple significance tests on the same data set, as I was aware that this would artificially inflate the probability of a type I error (false positive) accumulating across multiple tests (Keselman, Cribbie, & Holland, 1999). This is a special type of publication bias – selecting to present only what shows up as significant (Begg, 1994). Instead of performing multiple significance tests, I firstly performed the RM-ANOVA horizontally across the entire data set, and then proceeded to a deeper, fine grain analysis aiming to examine the presence of statistical artefacts. Following this screening process, as is detailed in the following chapter, a finding which appeared significant in the RM-ANOVA test for one of the three observed environmental education programs, was eventually rejected as a statistical artifact following post-hoc

analysis. Thus, at least on a conscious level, I tried to reject rather than to prove my initial hypothesis – that the effects of outdoor environmental education could be captured using an environmental literacy instrument.

Despite these consistent efforts, I am aware that no research can be entirely free of bias. My internal motivation in trying to address this bias was that I initially and first of all had to be able to convince myself about the trustworthiness of any findings, and secondly try to convince others. It would be very hard to continue to invest the resources in time and matter that any project requires at this level, if I hadn't convinced myself that the results are real. Note that I am using the word real not in the sense of an objective reality with the implication of a deterministic cosmos, but rather in the critical realist tone (Khazem, 2018). But obviously, convincing one's self is not enough. What eventually gives credibility to research findings is their reproduction through converging rationales that follow different methodological traditions.

Conclusion

The methodology of this study is based on the extent to which environmental literacy measurements can be a valid way to evaluate environmental education programs. The previous chapter presented a review of the international literature that has followed this basic assumption. This chapter included excerpts from the Greek curricular framework, to support the case that the selected instrument (GELI) is actually measuring what environmental education is expected to be delivering. The presented methodology was used to monitor three environmental education programs in Kalymnos, Greece. The educational outcomes of students who participated in these three environmental education programs (treatment group) were compared to the educational outcomes of students from the same grades and classes, who followed the standard curriculum (control group). The comparisons concern three

environmental literacy components: improvement in environmental knowledge, environmental attitudes, and environmentally responsible behaviour. The findings of these comparisons are presented in the following chapter.

Chapter Five: Findings

This chapter describes the statistical aspects of the findings, which will be discussed in more detail in the following chapters.

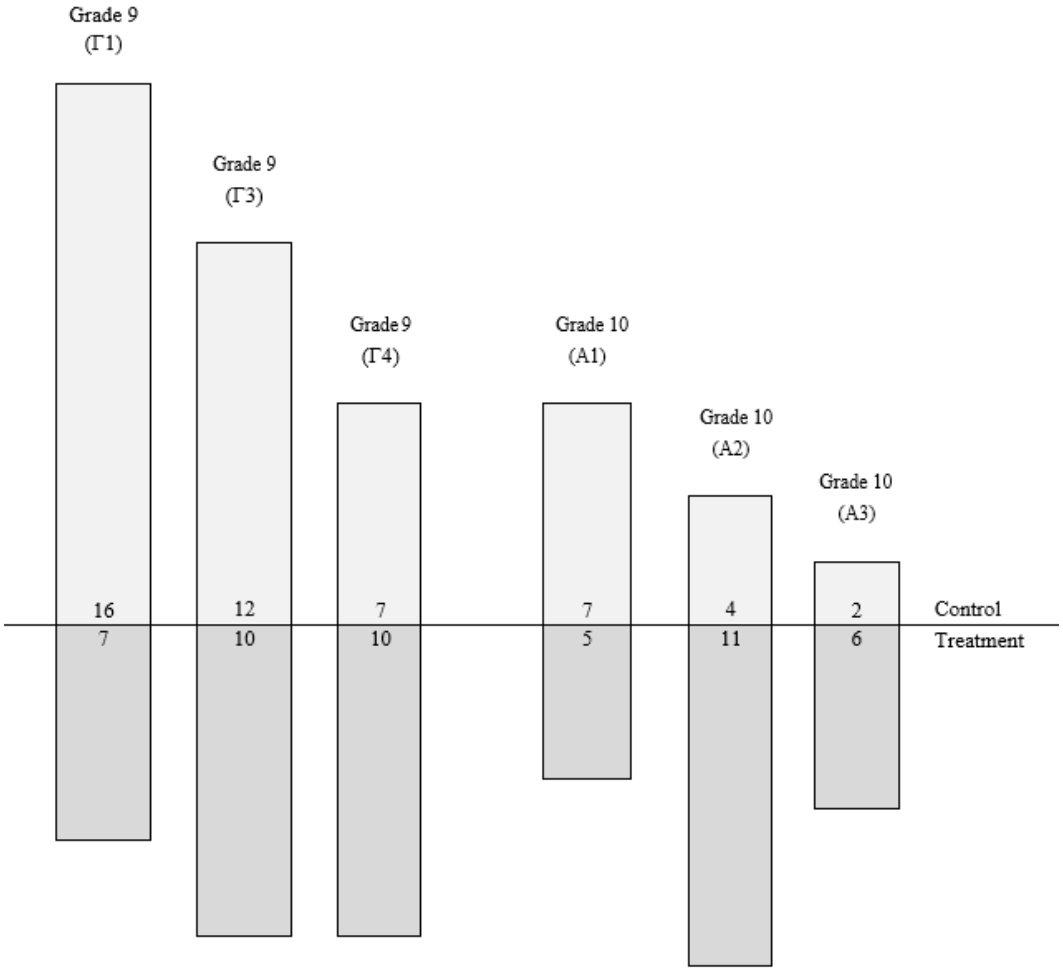
Descriptive Statistics

Descriptive statistics summarize the information collected in a research project. In the context of the present research, descriptive statistics are used to explore the features of the collected sample, setting the scene for inferential data analysis. This section on descriptive statistics starts with visual and numerical representations of the group means, variance of the outcome variables, and their rates of change. This section provides an overview on the characteristics of the data set – these characteristics are used to discuss the relevance of methods selected to provide an informed answer to the research question.

As noted above, students from different grades and classes participated in this study. Hence, it is important to consider the legitimacy of pooling data from different grades and classes into one larger group in order to augment the statistical power of the analysis. If data from different grades and classes can be pooled, then the experimental groups would be crossed only by the binary variable of the treatment (with two allowable states: 1 for treatment, 0 for non-treatment). I concluded that there is no methodological or philosophical reason compelling us to present the findings separately for each class or grade. According to the analysis presented in chapter 4, the treatment provided by the three different programs is adequately similar in terms of the applied learning methods: outdoor, experiential environmental education (Table 4; Figure 6). Hence, data from different school grades and classes were pooled together, in order to create one comprehensive control group (n=48) and another comprehensive treatment group (n=49). Both of the pooled treatment and control groups contain individuals from each of six classes in two grades (Figure 8).

Figure 8

Number of students from each grade and class, represented in the control (n=48) and treatment (n=49) groups.



Findings are presented in this section as boxplots (Figure 9) and also as numerical values (Table 4). Figure 9 presents an overview of pre versus post comparisons by experimental group and environmental literacy component. Results for the control group are presented in the left half of the graph, and results for the treatment group in the right half of the graph. The boxplots of Figure 9 offer a visual representation of the mean values (the X mark), the value spread, and the outliers per experimental group and environmental literacy

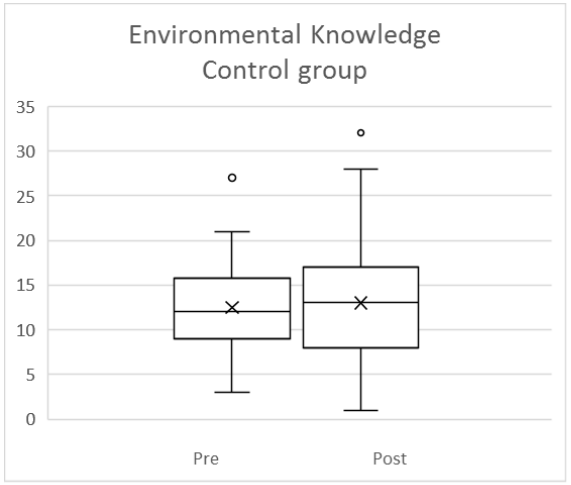
component. In both treatment and control groups the numerical means of all environmental literacy measures improved between October 2017 and May 2018.

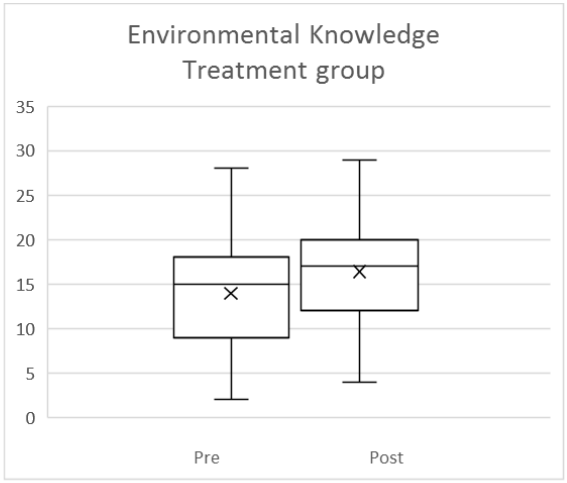
At this point, it is useful to remind the reader that GELI's cognitive component consists of 42 multiple choice environmental knowledge questions. One point was given for each correct answer, and zero points for each false or "I do not know" answer; the maximum score for this component is 42, and minimum score is 0. The attitudinal component of the test consists of 12 Likert-scale questions with 5 possible answers. Accordingly, the maximum score for the environmental attitudes component is 60 and the minimum score is 12. The behavioural component of the test consists of 11 Likert-scale questions with 5 possible answers. Hence, the maximum score for the environmental behaviours component is 55 and the minimum score is 11.

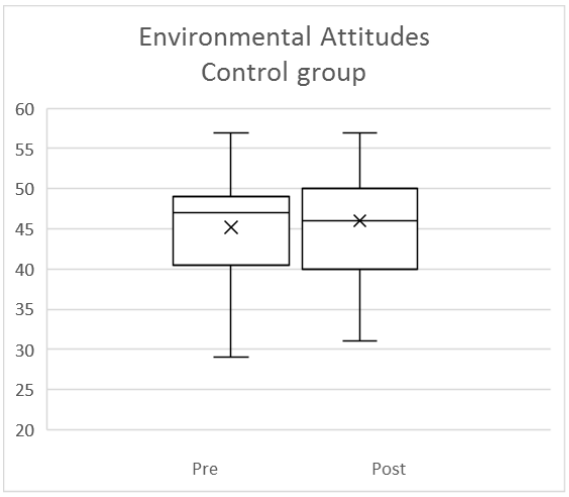
Figure 9 is a visual representation of the differential improvement between treatment and control groups in their environmental literacy components. Assessing Figure 9 visually, there appears to be an advantage of the treatment group over the control group in the improvement of environmental knowledge. On the other hand, there seems to be no observable difference between treatment and control group in environmental attitudes. Lastly, in environmentally responsible behaviour, there appears to be a noticeable improvement in the treatment group, as compared to the control group. These observations necessitate further analysis.

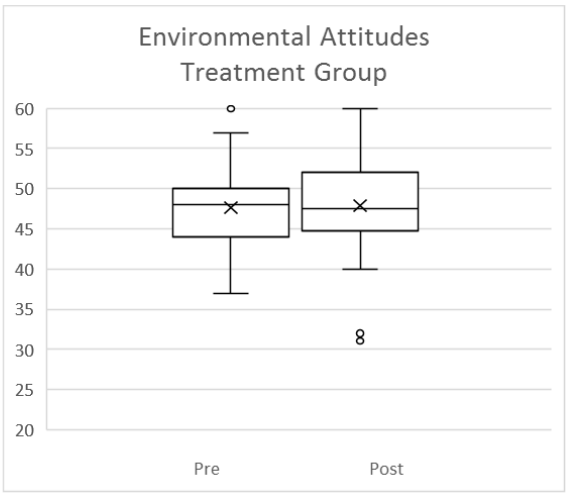
Figure 9

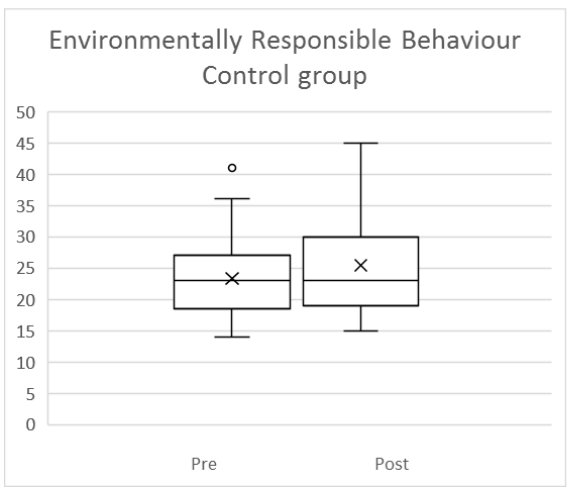
Box plot comparison of pre versus post environmental literacy levels in treatment and control groups (Merged Grades 9 and 10). The box represents the interquartile range, the horizontal line within the box represents the median, and the X mark represents mean values.











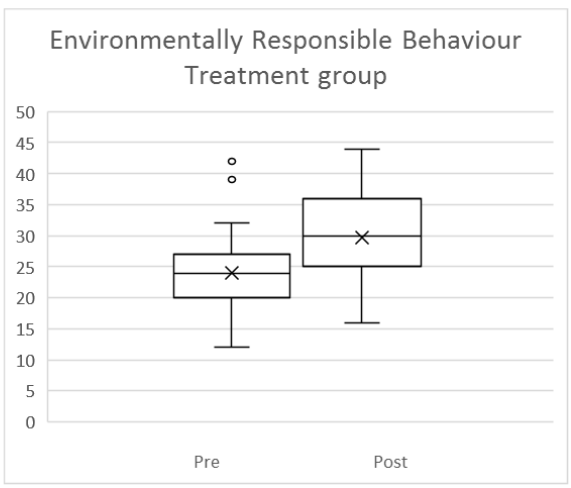


Table 4

Mean values and standard deviations of the pre and post outcome variables in each experimental group.

	Environmental Knowledge		Environmental Attitude		Environmental Behaviour	
	Treatment	Control	Treatment	Control	Treatment	Control
Pretest SD	6.69	4.93	4.94	5.90	6.01	6.24
Posttest SD	6.44	6.87	6.14	5.95	7.06	7.02
Pooled SD	6.57	5.97	5.54	5.92	6.56	6.64
Pretest Mean	13.98	12.50	47.67	45.22	23.98	23.33
Posttest Mean	16.43	13.02	47.90	46.00	29.74	25.43
Change	2.45	0.52	0.23	0.78	5.76	2.11
Cohen d	0.37	0.09	0.04	0.13	0.88	0.32
d value	Medium	Small	Small	Small	Large	Small

Note. Differences between the groups were quantified using a measure of effect size (Cohen's d) in order to provide a measure of the magnitude of the change observed (Ellis, 2009).

Table 4 compares pre and post measures of test performance for each experimental group in environmental knowledge, environmental attitude and environmentally responsible behaviour. These comparisons constitute a first measure of the development of environmental literacy per experimental group. The group means of all post measures are improved, as compared to the pre-test measures. In order to quantify the extent / magnitude of this improvement, Table 4 includes measures of the observed improvement, firstly in absolute values for the change in the means of the outcome variables and secondly as in measures of effect size. Estimates of effect size are useful in expressing the magnitude of quantitative comparisons. When the methodological approach to the observed phenomenon involves comparisons between group means, then its effect size can be expressed as Cohen's d (Cohen,

1988). In its generic form, Cohen's d is in effect a measure of how many (pooled) standard deviations separate the mean values of two given distributions. In the context of this research, which involves change over time, Cohen's d is expressed as the number of (pooled) standard deviations by which the mean values change.

Considering Table 4, the treatment group demonstrates a moderate improvement in environmental knowledge (Cohen's d = .37), while the control group's improvement in environmental knowledge is small (Cohen's d = .09). This means that there is evidence of a positive effect on environmental knowledge arising from the outdoor education program. There is only a small effect on environmental attitudes in either the treatment or control groups. Lastly, the treatment group demonstrates a large improvement in environmentally responsible behaviour (Cohen's d = .88), while the control group demonstrates a small improvement in environmentally responsible behaviour (Cohen's d = .32), suggesting that outdoor education programs have a real effect.

In contemporary research, p-values are the most common measure of statistical significance. However, p-values represent nothing more than the probability that differences between group comparisons are generated by chance, so they must be considered in parallel with effect size (Sullivan & Feinn, 2012). On the other hand, for comparisons that fail to demonstrate statistical significance, any further discussion on effect size is devoid of meaning.

Inferential Statistics

This section uses inferential statistics in order to identify patterns in the data, improve our understanding of the characteristics of the sample, and prepare the grounds for direct hypothesis testing. This section presents comparison of group means by levels of statistical confidence and effect size. This series of analyses calculates both p values and effect sizes for

the differences between the groups of this research design, setting the scene for direct hypothesis testing.

In Figures 10 to 12, groups are compared on the basis of two independent variables: pre versus post (time difference) and treatment versus control group (difference in treatments). For any given comparison between two groups means, the simplest method to obtain significance levels is a t-test. As is the case with every statistical test, t-tests work under certain assumptions. One assumption that would increase the tests' statistical power is the expectation that the observed phenomenon will develop towards a certain direction (one-tailed test). In the context of this research, this implies that students' environmental literacy will either improve or remain at the same levels after the treatment. However, since we cannot theoretically exclude the possibility of environmental literacy measures deteriorating after the treatment, I decided to proceed with two-tailed tests, which allow that the phenomenon might develop in any direction. All statistical tests in this study were run as two-tailed tests, even though this raises the bar for significance.

For the within-subjects comparisons, which compare pre to post performances in the same group of students, there is the alternative option of running a paired t test, which pairs the pre and post individual performances of students, in order to increase the test's statistical power. The increase in the paired t tests' statistical power arises from the control of individual differences by pairing each individual's pre and post test scores (Asghar, 2004). All the t tests appearing in Figures 10 to 12 were unpaired unless otherwise noted. Hence, the p values presented in Figures 10 to 12 were generated by unpaired equal variance homoscedastic 2-tailed t-tests – the homoscedasticity requirement was met by measurements of variable skew presented in Appendix B.

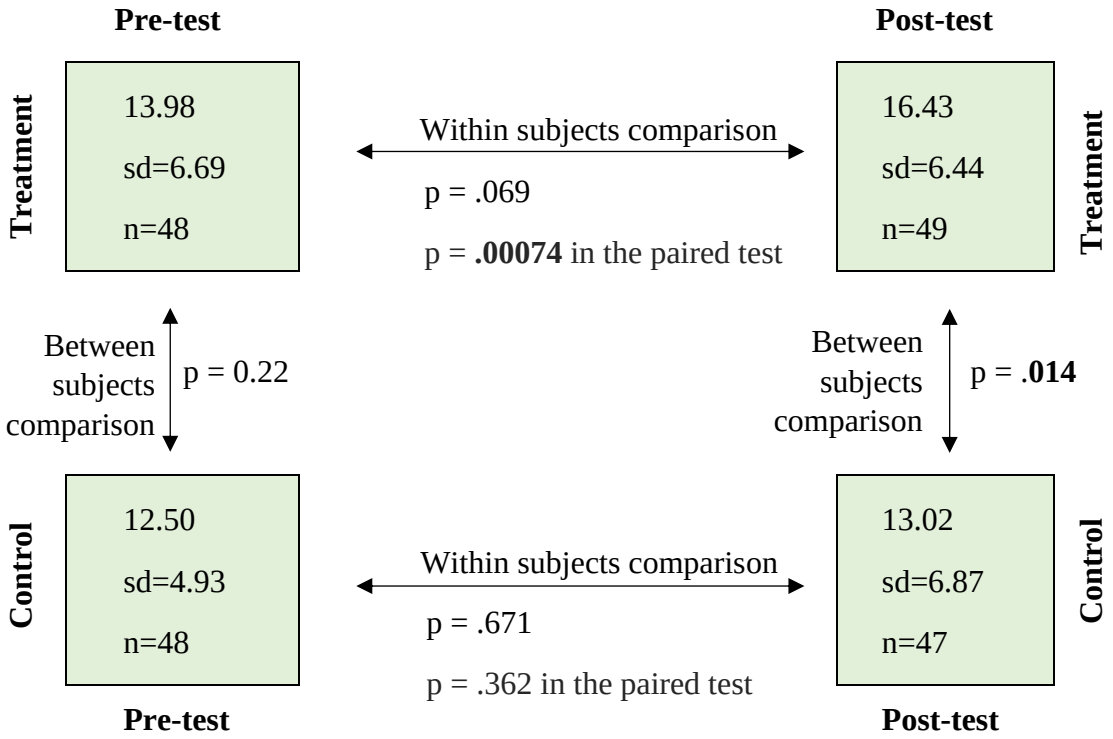
An Improvement of Environmental Knowledge in Response to Treatment?

Based on Table 4, there is a moderate improvement in the environmental knowledge of the treatment group. Furthermore, assessing Figure 10, the insignificant difference between the experimental groups in the pre test is followed by a statistically significant difference between the experimental groups in the post test (p= .016).

The improvement in the environmental knowledge of the treatment group easily reached significance (p= .00074 in the paired 2-tailed t-test), as opposed to the insignificant improvement in the control group (p= .362 in the paired 2-tailed t-test). At this point, rejection of the null hypothesis for environmental knowledge seems reasonable.

Figure 10

Within subjects (over time) and between subjects (over experimental group) comparisons of ***environmental knowledge****, as measured by GELI.*



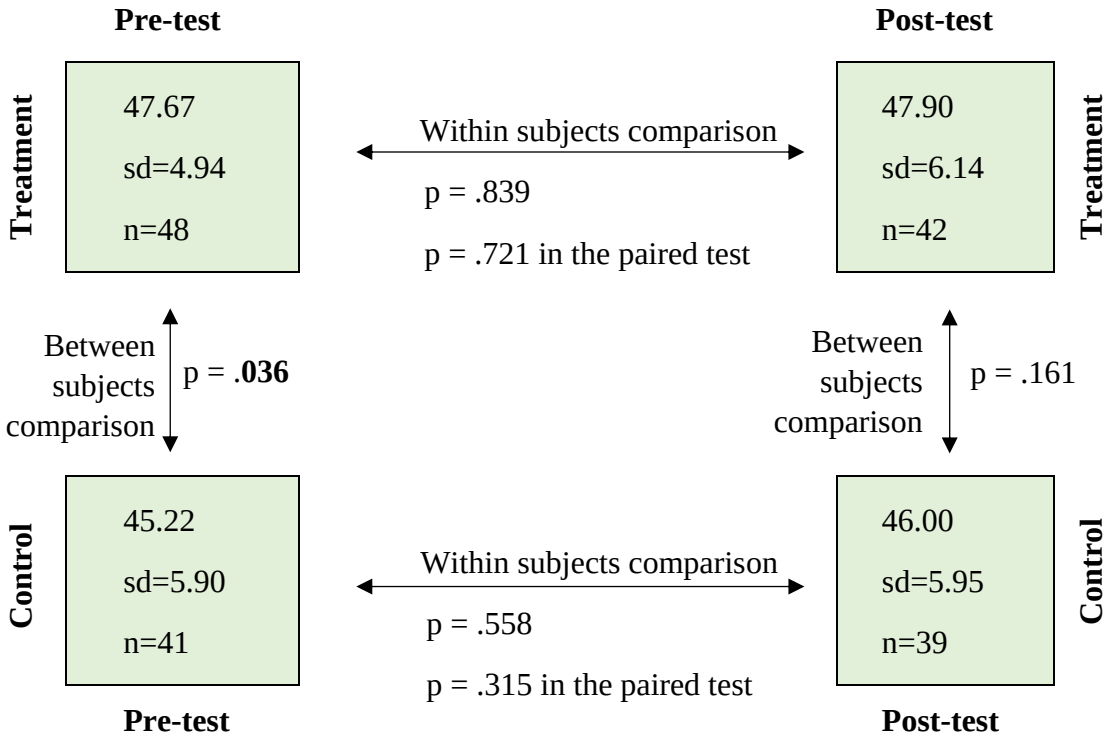
Note. Significance levels were generated by unpaired equal variance homoscedastic 2-tailed t-tests, except where noted otherwise. p values for significant comparisons appear in bold letters.

No Improvement for Environmental Attitudes

A significant pre-test difference between experimental groups (treatment and control) in the pre test is followed by a non-significant difference in the post test (Figure 11). The absolute difference in favour of the treatment group decreases from pre to post test, and the difference between experimental groups drops below the conventional threshold of significance. What is important to understand from this analysis is that, in both treatment and control groups, any changes in environmental attitudes are not significant.

Figure 11

Within subjects (over time) and between subjects (over experimental group) comparisons of ***environmental attitudes****, as measured by GELI.*



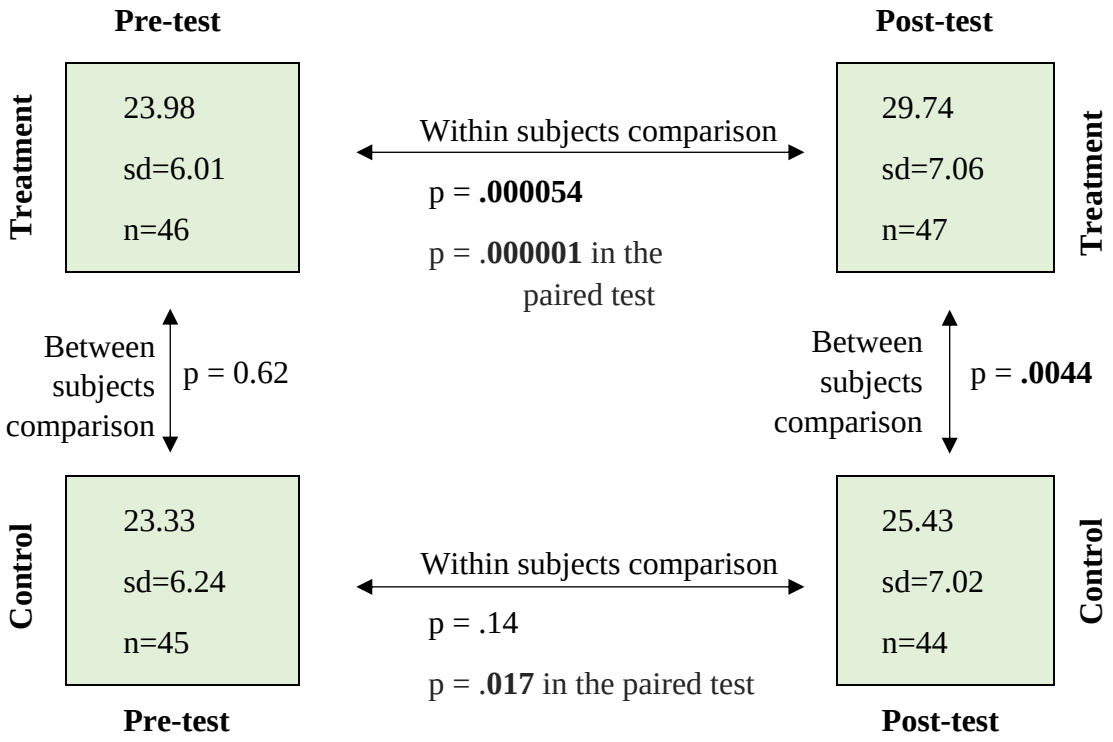
Note. Significance levels were generated by unpaired equal variance homoscedastic 2-tailed t-tests, except where noted otherwise. P values for significant comparisons appear in bold letters.

Self-reported Environmental Behaviours

The effect of treatment on self-reported environmental behaviours is much clearer than on environmental knowledge or attitudes. In Figure 12, an insignificant pre-test difference between experimental groups is followed by a significant post-test difference between the same groups.

Figure 12

Within subjects (over time) and between subjects (over experimental group) comparisons of ***environmentally responsible behaviours****, as these are reported by the students on GELI.*



Note. Significance levels were generated by unpaired equal variance homoscedastic 2-tailed t-tests, except where noted otherwise. P values for significant comparisons appear in bold letters.

However, something is different in the case of self-reported behaviours. In both the treatment and control groups, the paired t tests demonstrate significant improvement. The

effect size is small for the improvement in the control group, and large for the improvement in the treatment group (Table 4). This parallel improvement in both treatment and control groups, confirmed by the paired t tests in the case of environmental behaviour, necessitates further discussion. A fine grain analysis presented in chapter 7 reveals that certain environmental initiatives diffused to embrace the whole school community, thus affecting both treatment and control groups (Table 8). Furthermore, the improvement in both treatment and control groups can be partially attributed to a maturation effect (Lee, 2012). In the context of this study, a maturation effect would confound any effect of the treatment with the potential improvement in the outcome variable owing to a developmental improvement in students' cognitive and emotional abilities over the time (6 ½ months) that has lapsed from the pre-test to the post-test. In the presence of a hypothetical maturation effect, the effect of treatment would be acting on top of a baseline improvement in the outcome variable (Figure 12). The effect of treatment can be statistically isolated from this baseline improvement only by the use of omnibus methods such as Analysis of Variance, only under the condition that the research design has included a control group, as is the case here.

Justification for the Choice of Method (Omnibus Test)

In time series designs like the present one where pre and post measures were taken from both treatment and control groups, more than one statistical comparison needs to be combined in order for the research hypothesis to be tested. Hypothesis testing will proceed with a two-dimensional analysis that combines information from both within subjects and between-subjects comparisons. Omnibus methods combine within-subjects with between-subjects comparisons to generate results (Bland & Altman, 1995). As was introduced in the Methods chapter, Analysis of Variance (ANOVA) was used to compare treatment group with control group performances, aiming to the rejection (or failure to reject) the null hypotheses.

The p values generated by the omnibus method will represent the probability that the differential improvement observed in these outcome variables is generated by chance.

Repeated Measures Analyses of Variance

The core assumptions of ANOVA methods are the independence of the cases compared, and the normality and homoscedasticity of the frequency distributions involved (Gamst et al., 2008). Prior to the ANOVAs, preliminary statistical analyses were performed in order to verify that these assumptions are met by the specific data sets.

The results from the preliminary analyses were considered sufficient for the study to proceed into the hypothesis testing phase, and have informed the operationalization of the hypothesis testing methods, as explained below. Two categories of preliminary statistical tests were performed. Firstly, the skewness of outcome variables was assessed as a measure of homoscedasticity. As a general principle, skewed sets of data represent a significant threat to validity for every statistical test that assumes a normal distribution of a given variable with a population. Skewness of data is an important concern, and there was some evidence of skew. However, comparison of original and skew-corrected data showed skew did not significantly affect the findings, and so analysis continued with the original data. See Appendix B for more details.

Secondly, an estimate of the pre-test differences between treatment and control groups was performed. This quasi-experimental study did not follow a randomised assignment of students into treatment and control groups. Instead, the assignment of students into experimental groups was conducted by their teachers, as part of the educational routine of their school. Since the researcher cannot be certain about the criteria that the teachers applied to assign students into experimental groups, it is meaningful to compare the pre-test dependent variables between experimental groups, identify any differences, and take all the

appropriate statistical measures to control for these pre-test differences in the data analysis phase. No significant difference was found between experimental groups in student pre-test environmental knowledge and environmentally responsible behaviour levels (Appendix A). However, significant pre-test differences between experimental groups (treatment and control) did appear in student environmental attitudes (correlation between preA and current exposure to environmental education, Appendix A). RM-ANOVAs do not require the assumption that the experimental groups are equivalent at pre-test, since they directly test the significance of the improvement from pre to post-test between groups, rather than the differences between groups at post-test (Potvin & Schutz, 2000). One test was run for each null hypothesis, dealing respectively with knowledge, attitudes, and behaviours.

Results of these statistical tests are presented in Table 5. The treatment (outdoor, experiential education provided by Environmental Education Centres) seems to be making a difference in the students' self-reported environmentally responsible behaviour. On the other hand, no significant improvement was observed in students' environmental attitude. In environmental knowledge, any effect lies below the threshold of statistical significance. Indeed, the omnibus test returns a non-significant result for the improvement in environmental knowledge ($p = .055$).

Why does the change in environmental knowledge show up as insignificant in the omnibus test, when Fig. 10 suggested that the rejection of the null hypothesis was likely? Different statistical tests work under different assumptions. Indeed, paired tests contain increased statistical power (arising from the control of individual differences by pairing individual pre and post test scores) compared to unpaired tests, and omnibus tests lie somewhere in between. Hence, omnibus tests use a subset of the statistical power arising from the control of individual differences by pairing individual pre and post test scores. This is the methodological explanation on why the omnibus test provides a p value which is closer

to the unpaired t test (rather than the paired test) for the change in the treatment group (Fig. 10). Concluding this section, it is useful to note that hypothesis testing cannot rely on a *comparison* between p values; instead, each of the three research hypotheses has to be associated to a single p value. Descriptive statistics and t-tests were chosen as a way to gauge the significance of the observed changes, and provide insight on the processes that are reflected on the data set. Following this phase of analysis, RM-ANOVAs were performed as the definitive test. As an omnibus test, RM-ANOVA compares the change of each dependent variable in the treatment group to its change in the control group. It thus performs a dual comparison: pre to post change (within students) and treatment to control group (between students), and assigns to this dual comparison a single p value.

Table 5

RM-ANOVA pre/post significance levels per environmental literacy component

RM-ANOVA results with time as a variable within students and exposure to environmental education as a variable between students	Knowledge	Attitude	Behaviour
Merged Grades 9 & 10 Pooled treatment (n=49) controlled with Pooled control (n=48) group (Total N=97)	.055 (N=95)	.316 (N=75)	.0051 [η^2= 0.09] (N=85)

Note. Exposure to environmental education as between subject variable and time as within subject variable. Estimates of effect size are provided as eta squared for results that are statistically significant.

In order to test the three hypotheses of this research, I have selected and described a method which assigns a single p-value to each research hypothesis. The method that was used for that purpose (the RM-ANOVA) has been described in advance and cannot be modified

post hoc, depending on the outcome. That would be a clear violation of the principles of academic research and constitute an open threat to the validity of the findings. Hence, it is mandatory to accept that there has been no improvement in environmental knowledge, even though at this point, the result for environmental knowledge appears to be close to significance. However, as described in chapter 4 (Methods), the definitive decision will be taken after gauging the influence of background factors.

The omnibus test (RM-ANOVA) which was selected as the definitive statistical test for this research design, returns a single p value and an estimate of effect size for each of the three research hypotheses (Table 5). Estimates of effect size are provided as eta squared for every statistically significant RM-ANOVA result. On the other hand, it is meaningless to provide measures of effect size for results that are *not* statistically significant – in those cases, the effect sizes are assumed to be zero and are not reported in the ANOVA results (Pierce, Block, & Aguinis, 2004).

The data analysis singles out one statistically significant result, suggesting that students' self-reported environmental behaviours improved after their exposure to experiential environmental education (Table 5). The magnitude of the observed phenomenon (the effect size) is expressed using eta squared (as computed by SPSS) for all significant ANOVAs. The advantage of using eta squared as a measure of effect size is that it can be compared across different statistical tests (and data sets) as it is an estimate of r-squared, the percent of variance of the measure that is explained by group membership.

In this particular data set, eta squared for the change in environmental behaviours was computed to be 0.090, which is a medium effect size (Borenstein, 2009). It suggests that 9.0% of the variance in the outcome variable is explained by the treatment. As is explained in the following part, the levels of statistical significance and estimates of effect size hereby reported for environmental behaviours, survive the controls for the influence of background

factors (or blocking variables). Controlling for blocking variables means that they are brought into a multi-factorial analysis so that their contribution to variance can be specifically attributed. This allows for more accurate assessment of the contribution to variance of the primary independent variables.

Background Factors

The purpose of collecting demographic information with GELI was the prevention (and ad-hoc correction) of methodological errors stemming from experiential or other differences between the study's experimental groups. These differences are potentially related to demographic or other variables that could be producing differential effects on the outcome variables per experimental group. GELI collects information on student names, age, gender, place of residence, place of birth, nationality, academic performance (GPA), and schools attended by the students in their previous schooling history.

At this point, I would like to acknowledge that, according to the guidelines of the American Psychological Association, "gender is a nonbinary construct that allows for a range of gender identities and that a person's gender identity may not align with sex assigned at birth" (American Psychological Association, 2015, p.834). However, the public discourse in Greece has only recently started to include complex definitions of gender. Binary definitions of gender were in use when the data collection instrument was developed by Kyriazi and Mavrikaki (2013). In the data collection field for gender, GELI allows for two possible entries and this research adheres to the instrument's binary treatment of gender in order to (a) comply with the local legal framework, and (b) protect the reliability of the method and the external validity of the results when these are compared to previous research that uses similar definitions.

Background information collected by GELI also includes parental educational level, parental level of environmental sensitivity (as this is perceived by the students), and lifestyle questions such as the frequency of student participation in a number of outdoor sports and activities. In GELI, students also were asked to report on possible significant life experiences and figures that have influenced them in their environmental sensitivity and awareness, their potential membership in environmental and scouting organizations, and their sources of information for their present-day environmental knowledge. As explained in chapter 4, GELI was modified to collect information on students' participation in school-based environmental education during the current school year (this information was later confirmed with two of their teachers who participated in this research). Also, GELI was modified to collect information on students' participation in school-based environmental education during their previous schooling history. Previous exposure to environmental education is expressed in interval scale with four values, with higher values assigned to the most recent exposures: No past exposure to environmental education = 0, Exposure only in primary school = 1, Exposure only in high school = 2, Exposure in both high school and primary school = 3. No other alterations from the data collection instrument's original version were made.

Blocking Variables

An intercorrelation matrix was constructed in order to reveal interaction patterns (two-way correlations) between dependent, independent, and demographic variables (Appendix A). The methodological purpose for collecting data beyond the dependent and independent variables (such as demographic variables) is to protect the validity and reliability of the research design by identifying possible blocking variables. Blocking variables represent uncontrolled sources of variation and hence threaten the validity of inferences drawn from this research. Results from the intercorrelation matrix were looped back to the hypothesis testing methods, by indicating whether it is meaningful to adjust the effect of

extraneous variables that may be having an effect on the relationships explored. In order to mitigate potential threats to validity and reliability, results from the intercorrelation matrix have informed a number of ad-hoc adjustments on the methodological design.

In the correlation matrix, I considered the significance of the correlation between the improvement in environmental knowledge, attitude, and behaviour, and potentially blocking variables such as student GPA, parental education levels, and other (Appendix A). The significance of these correlations helped me to decide whether to adjust the effect of specific variables during hypothesis testing. The correlation matrix reveals the following correlations between dependent variables and potentially blocking variables. Improvement in environmental knowledge (ΔK) correlates with the variables of gender and previous exposure to environmental education. Significance levels are p =.000063 for the ΔK/ gender correlation and p =.011 for the ΔK/ previous exposure to environmental education correlation. These correlations are significant enough to justify the consideration of gender and previous exposure to environmental education as potentially blocking variables in the Analyses of Variance through multiple regressions.

The effects of these potentially confounding variables were accounted/controlled for statistically by including them as *blocking variables*, additional independent variables in the RM-ANOVA, so that their effects are separated from the effects of the variable of interest. The influence of these blocking variables was fully explored by the use of RM ANOVAs, with blocking variables introduced as covariates in the repeated measures (time series) test. A separate RM-ANOVA test was conducted for each blocking variable, which entails that the order by which the covariates are reported in Table 6 does not change the level of significance reported along each covariate. The combined effect of both blocking variables need not be explored: each of the covariates threw the confidence level below the threshold of significance for the improvement in environmental knowledge (Table 6).

Table 6

RM-ANOVA pre/post significance levels per grade and program after adjusting for blocking variables. Estimates of effect size are provided as eta squared for every statistically significant result.

RM-ANOVA results with time as a variable within students and exposure to environmental education as a variable between students		Knowledge	Affect	Behaviour
Merged Grades 9 & 10 Pooled treatment (n=49) controlled with pooled control (n=48) group (Total N=97)	No covariate	.055 (N=95)	.316 (N=75)	.0051 [η^2= 0.09] (N=85)
	Adjusted for Gender	.555 (N=95)	Does not correlate significantly with outcome variable	Does not correlate significantly with outcome variable
	Adjusted for previous exposure to environmental education	.190 (N=93)	Does not correlate significantly with outcome variable	Does not correlate significantly with outcome variable

Table 6 presents the research findings adjusted for the variables that were found to correlate significantly with the dependent variables. After accounting for these blocking variables, the significance for the effect of treatment on the improvement in knowledge dropped by a considerable extent. The considerable drop in significance indicates the presence of an artificial inflation in the original assessment of significance with respect to environmental knowledge. The artificial inflation stemmed from the correlation of

uncontrolled variables with the dependent variables, where the effect of gender or previous exposure to environmental education was confounded with the effect of treatment.

I do not have enough evidence to discuss the meaning of the observed differential improvement of environmental knowledge relating to gender and previous exposure to environmental education (the two blocking variables). However, these blocking variables are important to recognise, especially when the variables are distributed demonstrably differently between experimental groups. For example, there were many more female students in the treatment group. This is a complex issue, since there were not any significant pre-test differences between the groups in their levels of environmental knowledge and the blocking variables only show their effect in the post measures. In essence a female student with environmental education experience will not appear to be very far ahead of a male peer without such experience before exposure to outdoor environmental education, but will change more (in terms of environmental knowledge) due to the experience.

In order to separate the effect of treatment from the effect of the blocking variable, I introduced gender as an independent variable in the RM-ANOVA (Table 6). This is the statistically appropriate method to separate the effect of gender from the effect of treatment. By accounting for the effect of gender, we are in essence projecting how the result would look like in an experiment where the composition of both experimental groups would adhere to the gender proportions of the sampled population. The adjusted result ($p = .555$) falls far from the level of significance, suggesting that any improvement in environmental knowledge is the effect of skewed gender proportions rather than being the effect of treatment.

The second blocking variable, previous exposure to environmental education, works in a similar way to gender, with a smaller effect size. Students who were exposed to environmental education at some point in their previous schooling, demonstrate a clear advantage in improving their level of environmental knowledge between October 2017 and

May 2018 (Appendix A). Moreover, students with previous exposure to environmental education are overrepresented in the treatment group, thus producing an analogous confound of the effect of treatment with the effect of the blocking variable. Indeed, the result concerning environmental knowledge drops considerably in significance after subtracting the effect of past exposure to environmental education (Table 6).

In this section, the blocking effect of gender and previous exposure to environmental education was accounted for by introducing these two variables as additional independent variables and thus separating the effects of gender and previous exposure to environmental education from the effects of the variable of interest. Hence, Table 6 summarizes the findings of this study, after the effect of the blocking variables has been subtracted. This procedure was described in detail as the final step of the definitive hypothesis test already from Chapter 4 (Methods). The result for environmental knowledge, which occurred after subtracting the effect of the blocking variables, is thought to be closer to the result that a random assignment into experimental groups would have returned. Eventually, after removing the effect of the blocking variables, it can be supported that the treatment does not associate with any improvement in environmental knowledge – the result falls considerably below the benchmark of significance. Any effect on students' environmental knowledge associates with the effect of the background factors rather than being the effect of treatment.

Lastly, it is important to note that the effect of blocking variables is restricted to the environmental knowledge component. For unknown reasons, gender and previous exposure to environmental education do not corelate with the rate of change in student's environmental attitudes or behaviour. Hence, the change observed in environmental attitudes and environmentally responsible behaviour was unaffected by the blocking variables, and any effect of the treatment in attitudes and behaviour initially reported in Table 5 retains its credibility as is (Table 6). Hence, the blocking variables had a significant impact only in the

rate by which the students improved their environmental knowledge; the blocking variables did not affect the results concerning environmental attitudes or self-reported behaviour.

Instrument Reliability Measurements

This study applied GELI to a sample of Greek students of grades 9 and 10, in two phases: In October 2017 (pre test) and in May 2018 (post test). This application allowed the researcher to measure the reliability of the instrument, and compare it to the reliability measures reported by the instrument's developers (Table 7). Since reliability is a product of the instrument and not of respondents' experience, reliability was calculated in mixed treatment and control group sample, both in the pre and the post test phases. The findings suggest that the estimated reliability of the instrument, as calculated based on the Kalymnos data, is close to the reliability levels estimated by the principal developer of the instrument based on a sample of N=1010 first year students in Greek Universities (Kyriazi, 2018).

Interestingly, estimates for the reliability of environmental attitudes are lower than the other environmental literacy components both in the Kalymnos sample, as well as in Kyriazi's doctoral research. According to Kyriazi (2018), the lower measures of reliability in the case of environmental attitudes may be owing to the sub-components that constitute tis component: environmental affect, environmental intension, and environmental awareness. These subcomponents are internally consistent as stand alone items (a=.85, a=.69, a=.73) but they drop in internal consistency where they are brought together in a single category (Kyriazi, 2018, p. 78).

Table 7

Validity and reliability of Kalymnos pre test and post test data, compared to the validity and reliability reported by the instrument developers.

GELI's Cronbach's a	Kalymnos Oct. 2017 pre test (N=143)	Kalymnos May 2018 post test (N=129)	Kyriazi,(2018) baseline study (N=1010)	Kyriazi & Mavrikaki (2013) pilot test (N=59)
environmental Knowledge	.80	.83	.82	.84
environmental Attitude	.69	.79	.65	.87
environmentally responsible Behaviour	.73	.81	.82	.83

Summary of Findings

An overview of the results from the RM-ANOVAs reveals a significant improvement for the environmental behaviours of students who were exposed to environmental education, with the influence of environmental education corresponding to a medium effect size (Whitehead, Julious, Cooper, & Campbell, 2015). No significant influence of the treatment on environmental knowledge or attitudes was observed. In conclusion, self-reported environmentally responsible behaviours improved significantly after exposure to outdoor environmental education, but there is no statistically significant effect on environmental knowledge or environmental attitudes. The reliability of the instrument, as measured based on the Kalymnos data, is somewhat weaker than what was reported in its pilot testing.

Conclusion

At the beginning of this chapter, I presented descriptive and inferential statistics concerning the levels of environmental literacy among students who participated in this

study's experimental groups. Then, the change in environmental literacy components between experimental groups was examined through Analysis of Variance methods. Three p values were assigned by the omnibus method, as indicators of the statistical significance on whether the treatment group performed better than the control group on either of the three measured environmental literacy components: environmental knowledge, attitude, and behaviour. Initially, environmental knowledge appeared to be close to significance (with a 94.5% level of statistical confidence), but the effect on environmental knowledge disappears when the outcome was controlled for blocking variables.

Another finding delivered by omnibus test was a moderate in effect size and statistically significant (over 99% in statistical confidence) improvement in students' environmental behaviours. Moreover, the effect size and significance levels for the observed improvement in environmental behaviors did not change when the outcome was controlled for blocking variables. This post hoc control allows me to pass on this finding to the next part with a high level of confidence in that treatment associates with a moderate improvement in students' self-reported behaviours. In conclusion, the effect on self-reported behaviours is unaffected by background factors. The findings from hypothesis testing, as well as the findings from the preliminary and ad-hoc analyses, inform the discussion and interpretations of the following chapter in light of the research question.

Chapter Six: Discussion

This study set out to assess the potential of an environmental literacy approach to capture the effects of outdoor environmental education. To that end, the ensuing research explored how exposure to outdoor environmental education influenced the environmental literacy of high school students in an educational setting. I begin this chapter with an assessment of the findings' face validity. Face validity refers to the degree to which a procedure, especially a psychological test or assessment, appears effective in terms of its stated aims. In this context, face validity is approached by comparing the students' answers with the content and the activities with which they were engaged in their programs. Then, I discuss the study findings with respect to the literature leading to the existing theories on the relationship between environmental knowledge, environmental attitudes, and environmentally responsible behaviours. Subsequently, I consider the study findings vis-à-vis the literature that has studied the learning outcomes of environmental education interventions. The intention of this sequential discourse is to create an appropriate conceptual and empirical basis in order to assess the viability of environmental literacy as a way to conceive the outcomes of outdoor environmental education.

This study's experimental design incorporated an environmental literacy assessment instrument (GELI) aiming to capture the effects of outdoor environmental education programs implemented in the public high schools of Kalymnos, Greece. Students' self-reported behaviors improved after the educational intervention, as was demonstrated by comparisons between treatment and control groups. However, no significant improvement was observed in students' environmental attitudes or environmental knowledge.

Student Outdoor Experience and Outcomes

This section approaches the face validity of the reported changes in students' behaviours via the experiential aspects of environmental learning. According to Hines, Hungerford, and Tomera (1987), changes in environmental behaviour occur when learners gain knowledge and experience of viable action strategies. In more recent works, action strategies appear as a binding concept that links environmental education (as a process) to environmental literacy (as a learning outcome). Hence, environmental literacy is understood as a link that connects experience to action (St.Clair, 2003).

The development of action strategies (as ability to intervene and participate in decision making) lies within the declared goals of the submitted program plans that this study observed in Kalymnos (see also Moula & Papadomarkakis, 2018, p.191-214). This section explores how the effect of the observed programs in engendering action strategies can be tracked by student responses to specific behavioural questions derived from the concept of environmental literacy. The associated instrument included eleven questions on environmental behaviour (Appendix C). The three programs this study observed have focused on slightly different action strategies as explained below. Table 8 presents the effect of the observed programs on the improvement of student responses per environmental behaviour question. The comparisons were performed using 2-tailed, paired t tests to compare pre to post.

This section proceeds to explore how student responses captured by GELI correspond to the content of the environmental education programs that they followed. The *Memories of the Earth* environmental education program aims to educate students on the geological history of their island, and it involves visits to a number of the island's geological monuments, hosting an educational visit by a staff member from the Cretan Museum of Natural History, and finally paying an educational visit to the Environmental Education

Centre of Anogia (Crete). One of the goals described in its submitted program plan is for students to "Feel joy and excitement from visiting the island's geotopes and create awareness towards to the need to protect the natural heritage of their place" (Moula & Papadomarkakis, 2018, p.198) and to "suggest ideas for the promotion, management and protection of local geological monuments" (p.199).

Table 8

Responses by program

	Memories of the Earth (n=27)	Sustainable Trails (n=10)	Fresh Water (n=12)	Control group (N=48)
1. Check for recycling symbol	**.0010**	.2987	.2750	.0832
2. Collect litter from public spaces	.0615	.2443	.8380	.0569
3. Campaigns for clean-up	**.0460**	.7320	.0560	.2910
4. Intervene when see environmental harm	**.0309**	.7287	.0558	.3884
5. Report violations of environmental code	**.0026**	.5911	.6380	.9043
6. Petitions on environmental issues	.1532	.0697	.0674	.5847
7. Complain to mayor	**.0395**	.2695	.4293	.4896
8. Campaigns to avert degradation	.2405	**.0368**	.7318	.0994
9. Events to discuss topics	**.0162**	.1690	.8514	.9150
10. Give money to env/mental organisations	**.0013**	**.0095**	.7545	.3100
11. Create recycling bins	**.0001**	**.0011**	.6427	**.0001**

Note. p values were calculated by 2-tailed, paired t-tests which compared the pre versus post change in each question. Bold figures indicate significant change, with the alpha level set at .05

The significant change in questions 4, 5, and 7 in *Memories of the Earth* can be related to learning experiences the participants of this program had during the school year. In their weekly meetings, the group of students who followed the program got into a detailed

discussion of local environmental issues. Indicatively, according to post hoc discussions with the teacher who led the program, open waste dumps is one of the most common local environmental issues and turns up every year. Given the group's emphasis on action planning, it is reasonable to assume that viable action strategies emerged from the discussion of specific environmental issues of local interest. Other significant changes in students' self-reported behaviours, such as their improvement in questions 1 and 10, are more difficult to link to specific program content or methods.

An interesting case concerns the improvement of learners in question 11, which asks about student participation in the creation of recycling bins at their school. In that particular school year (2017–2018) there was an initiative to create recycling bins in their school, which was also documented in the schools' newspaper. Students and teachers created makeshift bins for collecting aluminium, plastic and paper. This effort to create recycling bins diffused beyond the environmental education group, and involved the whole school community. Hence, it is reasonable that this was the only question (question 11) where a significant behavioural improvement was observed in the control group as well.

Even if science teacher Mr. Eustathius Klimis did not proceed to publish the program content of *Sustainable Trails* in the academic literature, the submitted program plan does a good job in explaining students' answers. The program's goals include the opening-up of the school to the local society, cooperation with local stakeholders and NGOs. In regard to its implementation phase, the program mentions the involvement of a local environmental NGO and a local rescue team, and the program centres around trekking and mapping the island's walking trails. The program's intention is to develop students' environmental intervention and decision-making capacity by proposing the creation of a map of forgotten names of remote geographical locations to be shared with the community. These pedagogical goals and activities correspond well with the significant improvement that was observed in questions 8,

10. As discussed above, improvement in question 11 can be justified since the recycling bins creation activity diffused throughout the school community.

Unlike the other two programs, students who participated in the *Fresh Water* program do not demonstrate any significant improvement in their self-reporting of any of the environmental behaviour questions – even if their improvement is close to significance in at least two items (campaigns for clean-up & intervene when see environmental harm). The submitted program plan for *Fresh Water* does *not* include discussion of action strategies in its programmatic goals (Platsi, 2018). In this program, students are expected to learn about the island's current water resources, to identify activities that potentially pollute or deplete the island's aquifer, to ascertain how water has served as a link between religions, traditions, and customs of Mediterranean peoples, and also to suggest ideas concerning sustainable management and protection of the island's water sources and to publish their results. These are legitimate goals for environmental education, however the description of the program's implementation does not centre around or even include action strategies. Perhaps this lack of emphasis in action planning, along with the small number of students sampled, explains the failure of this instrument (and method) to capture an improvement in the environmental behaviour of students who participated in this program. Besides, most of the instrument's behavioural questions focus on civic action, which is clearly not within the scope of this environmental education program.

The observed programs had differential measured impacts on students' environmental behaviours. Two of the observed programs seem to have focused on action strategies, while a third program does not include environmental action in its educational goals. A detailed analysis that explored the content of the programs vis-à-vis students' responses to the behavioural questions of the instrument suggests that young learners improved their civic environmental behaviours after gaining knowledge of viable action strategies through outdoor

experiences. The literature has noted before the importance of action planning for environment-related education, by suggesting that “environmental education must lead to action to be considered effective” (St.Clair, 2003, p.71). To that end, “educators should explicitly recognize and build upon the experiences of learners when developing programs and materials”. Hence, “environmental literacy is a resource for linking experience to action and can never be a substitute for either” (St.Clair, 2003, p.72).

However, there is an important distinction to be noted. Knowledge of action strategies should *not* be confused with knowledge of environmental issues. Knowledge of the problem appears to be a prerequisite to effective action (Jensen, 2002). Individuals and societies need to know what are the parameters of an environmental issue before they can work toward its solution. However, “an individual must also possess knowledge of those courses of action which are available and which will be most effective in a given situation” (Hines et al., 1987, p.6). The distinction between these two categories of knowledge is essential. Separate components for knowledge of environmental issues and knowledge of how to act on these issues were included in the early models of environmental learning. To this date, the literature has substantially explored the contribution of environmental knowledge to individual environmental behaviours, but it seems that the contribution of knowledge of action strategies requires a more detailed analysis that would include both qualitative and quantitative measures. The existing environmental literacy scales and environmental education instruments do a fairly good job in assessing students’ knowledge of environmental issues, borrowing assessment methods from environmental science and geoscience. However, assessment of knowledge of action strategies is not standardized to the same extent and hence a more nuanced approach is warranted.

Over-reliance on a Formal Knowledge–Attitude–Behavior Model might be Causing Shortcomings in Environmental Education Assessment

The assumption that gains in knowledge of environmental issues can lead to improved environmental attitudes, and eventually to the adoption of environmentally responsible behaviours has been the basis of the Knowledge–Attitude–Behavior or KAB model. The model was informed by empirical data from the work of Hines, Hungerford, and Tomera (1987) who analyzed 128 studies, reporting on measurements of learners' environmental knowledge, environmental attitudes, and environmentally responsible behaviour. Hines et al. (1987) calculated the mean correlation strengths for the environmental knowledge – attitude – behaviour relationships, as derived from the respective measurements reported in the literature. Their work provided the first systematic evidence on the relationship between the variables of environmental knowledge, environmental attitudes, and environmentally responsible behavior regarded today as essential components of environmental literacy. Their findings have been confirmed by a subsequent meta-analysis by Bamberg and Möser (2007). However, as this section intends to explain, the KAB model has always had only moderate criterion and predictive validity in connecting the three constructs of environmental knowledge, attitudes, and environmentally responsible behaviour.

In a recent editorial in *Environmental Education Research*, Marcinkowski and Reid (2019) observed that "evidence overwhelmingly indicates that practices based on a K–A–B model are not as well founded on research evidence as some of the quotations above might imply" (p.463). Indeed, in the general population, only a moderate relationship of attitudes to behaviour is substantiated (r = .347), while the relationship of knowledge to behaviour is consistently lower (r = .299) (Hines et al. 1987, p. 3; Marcinkowski & Reid, 2019, p. 463). However, as the authors note, aspects of the KAB model echo through the field's most recent work, and continue to influence programs in environmental education, as well as surveys

designed to assess knowledge, attitudes, and behaviors (Marcinkowski & Reid, 2019). The instrument employed by the current research is another example of the model's influence in environmental education research.

In many ways, the KAB model reflects the preconception that providing students with knowledge of environmental issues should somehow be enough to engender behavioural change. However, empirical research has demonstrated that gains in environmental knowledge are not directly linked with immediate improvements in environmentally responsible behaviour (Borden & Schettino, 1979; Krnel & Naglic, 2009; Maulidya, Mudzakir, & Sanjaya, 2014). Accordingly, in 2000 Jeffrey Salmon urged us to resist the temptation to believe that 'knowledge is sufficient by itself to convince people that responsible environmental choices are correct and cause them to act in specific ways' (Salmon, 2000, in St.Clair, 2003, p.75). In their recent editorial, Marcinkowski and Reid (2019) suggest that the assumption that underpins the KAB model, of a linear progression leading from knowledge to attitudes to behaviour, is perhaps 'problematical' (p. 462).

A key point to remember is the type of environmental knowledge considered by the KAB model, as well as by all the instruments influenced by this tradition, refers to knowledge of environmental issues and knowledge of environmental science – not knowledge of action strategies. Hines et al. (1987) also described knowledge of action strategies as an essential component of the model, and recommended educational approaches that would "address both affective and cognitive experiences and which provide individuals with opportunities to develop and to practice those skills necessary to lead to environmental action" (p. 8). Furthermore, environmental education theory has described experience in the natural world as an essential component of environmental learning (Orr 1992 in St. Clair, 2003). Subsequent work in environmental literacy theory has framed the concept as a resource that links learners' experience to action (St.Clair, 2003). However, knowledge and

experience of action strategies were not included in any of the successive instruments that were developed for the assessment of environmental learning (GELI has only included a civic action component in is behavioural section) (Marcinkowski et al., 2014).

Hence, knowledge of environmental issues is included in most environmental literacy instruments, as it is considered a valid and reliable environmental literacy component (Kyriazi, 2018, p.65). However, even though environmental knowledge (and especially knowledge of ecological science) can be assessed through valid and reliable measures, empirical research suggests that improvements in environmental knowledge have small -if any- effect on learner's environmental behaviours (Stern et al., 2014; Loughland, Reid, Walker, and Petocz, 2003). Hence, it is important to be cautious about the linear assumptions suggesting that environmental learning should always start from students' ability to describe environmental issues using scientific language. Recent research (including the findings of the present research) challenges the assumption that environmental learning works in a hierarchical, linear fashion that should begin from a detailed knowledge of environmental issues – not least on an in-depth understanding of environmental science. Environmental literacy theory has brought on more comprehensive understandings/ representations of environmental learning, of which the KAB model is simply one of the possible routes leading to environmentally responsible behaviours. There might be ongoing, non-linear dynamic interactions among these components (and also among other, non-measured components) during the environmental education experience. On that basis, an environmental literacy approach entails less reliance on the formal KAB model, and more emphasis on action and experience.

The Form of the Instrument May Have an Effect on Measurement Validity

A valid instrument is expected to be able to effectively measure the dimensions of the constructs that it claims to be measuring (McDermott, 2011). On the other hand, a valid instrument can produce invalid measurements when it is used in an inappropriate field of application. In the case of GELI, the instrument measures three components of environmental literacy (knowledge, attitudes, and behaviour), which means that it misses out on several others. Naturally, this affects the instrument's content validity, since the composite concept of environmental literacy is not restricted to three components – even if these three components have received increased attention from theoretical models such as KAB.

As discussed above, knowledge of environmental issues is considered to be one of the environmental literacy components, and GELI has been validated with respect to this component. However, GELI focuses on knowledge of environmental science, and hence it cannot capture every aspect of environmental knowledge. There are several other forms of environmental knowledge that influence environmental learning, such as experiential knowledge, place-based knowledge and knowledge of local environmental issues. As an example of experiential knowledge, I mention that every student in Kalymnos knows that their tap water is saline, and perhaps they have a clue in how to solve this problem: moderate the demand for freshwater. This type of knowledge on a local environmental issue does not necessarily depend on students' ability to describe the exact physicochemical process through which saltwater diffuses in their island's aquifer. Elements of local and place-based environmental knowledge are not included in the instrument's components. However, this type of experiential knowledge is perhaps important: learners who become aware of the anthropogenic causes of the current environmental issues that they are facing are more likely to advocate for more sustainable environmental practices (Pe'er et al., 2007).

Furthermore, there is a third type of knowledge, which is knowledge of action strategies. Knowledge of action strategies is not the same as knowledge of environmental issues, and it is not being included in GELI's components (or any other assessment instrument that I have reviewed). However, considering that political activity is a necessary component of environmental literacy (Hull, Mikulecky, St.Clair, & Kerka, 2003) , it is reasonable to expect that instruments informed by environmental literacy theory should aim to capture the effects of student learning in civic engagement. Another cognitive environmental literacy component that might reflect student learning in civic engagement is socio-political knowledge, e.g. "the relationship of cultural, political, economic, and other social factors to ecology and environment" (NAAEE, 2004; Simmons, 1995, p. 55-58;).

In the context of the National Project for Excellence in Environmental Education, Simmons (1995) has proposed two other components that relate to civic action and community learning: Firstly, "skills pertaining to environmental problems/issues and action strategies, systemic thinking, and forecasting", and secondly, as a behavioural component, "various forms of active participation aimed at solving problems and resolving issues" (p. 55-58). These are environmental literacy components that might reasonably be expected to capture the effects of student learning in civic engagement. However, all of these potentially interesting components were not included in assessment instruments, possibly because of the difficulties their assessment poses in terms of validity and reliability. Indeed, components aiming to assess complex issues, that have to do with issue identification and analysis, have been shown to achieve very low reliability scores (McBeth et al., 2008, p.17).

However, this study shows that, at least some elements of civic and political action can be measured in reliable and valid ways. The work that the Kalymnos environmental education programs are doing in promoting students' civic and political action was captured by the associated instrument's behavioural component (Table 8), which has incorporated

citizen action in its items. The inclusion of civic and political action in environmental learning is consistent with earlier works in environmental literacy theory (Hull et al, 2003). Moreover, relevant research has shown that, in educational systems that have managed to mainstream environmental and outdoor learning practices into formal education, teachers overwhelmingly support the inclusion of social justice and civic action themes in environmental and outdoor education themes. For example, in sample of 377 in-service teachers from Ontario, Canada who responded to five-point Likert-scale questions, a weighted average of 4.36 responded that environmental education should include an action component, and 4.03 responded that outdoor education should be about helping students to make choices about socio-political action (Pedretti et al, 2012). Instruments such as GELI have incorporated these items on civic and political action and hence can more effectively capture the respective learning outcomes of outdoor experiential environmental education.. Reasonably, there are other theoretical components of environmental literacy where engagement of learners in civic and political action might show up, that still being left out of measurement.

The instrument employed in this research (GELI) assessed learners' environmental knowledge, attitudes, and behaviour. While GELI demonstrates continuity vis-à-vis preceding instruments (and underlying theory) in some of its components, the influence of the environmental literacy concept is evident in some other components. A characteristic example is that under the influence of the most recent definitions of environmental literacy, which place emphasis on civic action, GELI has incorporated a civic action sub-component in its behavioural component (Hollweg et al., 2011). As an example, the items presented in Table 8 draw directly from the 11 items that constitute GELI's behavioural component. Ten out of the eleven behavioural questions in GELI refer to civic and political environmental action. By comparison, the behavioural component of the preceding instrument MSELS contains only

one out of twelve items that refers to civic and political action (McBeth et al., 2011, p.158). Hence, it seems that the increased emphasis that environmental literacy theory has placed on citizenship action has changed our understanding of environmental learning, and the way that we measure its effects.

Instruments for the assessment of environmental learning are incorporating these theoretical developments in their components with different speeds. While GELI's behavioural component has indeed been updated to follow the most recent developments in environmental literacy theory, the cognitive component has been largely preserved in comparison with preceding instruments. As I discussed earlier in this chapter, GELI's cognitive component consists of knowledge of environmental issues and knowledge of environmental science –knowledge of action strategies is not included in its cognitive component. In this section, I have touched on the substance of the inquiry concerning the potential of an environmental literacy approach to capture the effects of outdoor environmental education. In the following chapter, under research limitations, I include a more thorough discussion on the process that I used, focusing on the technicalities of the alignment issues between the associated instrument and the programs' curricular content.

Potential Need for Multi-instrumental Approaches

In discussing the effectiveness of GELI as an environmental literacy instrument, one must consider the complexities of environmental literacy as a composite concept. Environmental literacy is currently understood as a multi-faceted concept that consists of many different components. As noted in the previous section, the ability of an instrument to adequately represent the theoretical dimensions of a given concept is expressed as its content validity. Some of these components, like skills and affective dispositions, are easier to approach in credible ways through qualitative methods, while some other components, such

as environmental knowledge, attitude, and behaviours, have been assessed with sufficient reliability though a number of quantitative measurements.

This experimental design focuses on assessing three environmental literacy components that have already been measured with adequate reliability by previous studies. However, there is no single instrument that can capture every aspect of the composite concept of environmental literacy. Perhaps a combination of instruments merging different methodological traditions could capture a broader array of outcomes. In a recent study from Israel, two different instruments were used to assess the outcomes of an environmental education intervention. Goldman, Assaraf, and Shaharabani (2013) used a pre-test / post-test design to investigate the influence of participation in the environmental education program on components of junior high-school students' environmental literacy over the course of an entire school year. The environmental education program they observed was similar in structure with the programs that we observed in Kalymnos. However, the researchers included no control group in their research design.

More specifically, the program studied in Israel included two weekly hours of after school environmental education throughout the school year to work on local environmental issues, and a field trip or meeting with the local community met each month. The researchers used a mixed methods approach employing a combination of quantitative and qualitative tools such as the Draw-an-Environment Test (DAET) (Shepardson, Wee, Priddy, & Harbor, 2007) and a word association (WA) procedure (Ben-Zvi Assaraf & Orion, 2010; Hovardas & Korfiatis, 2006). Their findings suggested that the environmental education program's "major impact was on the affective domain and not on the cognitive domain of students" (p. 542). The researchers attributed this finding to the limited potential of non-formal programs to provide sufficient contribution in the cognitive domain to develop a sophisticated systemic

understanding of the underlying ecological and environmental concepts related to environmental issues.

In the Israeli study, measures of students' environmental knowledge, attitudes, and behaviour are described as environmental literacy components, and the researchers clearly frame their study as an effort to investigate the influence of the program on components of junior high-school students' environmental literacy. It seems that by using a mixed methods approach that combines the strength of different instruments, the researchers were able to capture diverse aspects of environmental literacy.

In conclusion, the present study has added substantive knowledge to our understandings concerning the processes and mechanisms of environmental learning. Based on the present study's empirical findings, and after comparing these findings to the literature exploring the outcomes of environmental learning, it seems that an environmental literacy approach has the potential to capture the effects of outdoor environmental education. However, there might be aspects of environmental literacy that remain out of scope of current environmental literacy instruments. The conception of environmental literacy is currently under-theorised and under-developed. Hence, almost twenty years after St.Clair's exhortation, there seems to be more work to be done before we can "decide on what environmental literacy means to educators and learners, and what kind of outcome will result from the educational process" (St.Clair, 2003, p.75). The present study aspires to contribute to that direction, by associating specifically defined educational interventions to observable learning outcomes.

The Appropriateness of Content for an Environmental Literacy Approach

Different environmental education programs are reasonably expected to produce different learning outcomes depending on their curricular focus. The relevant literature has

commented before on the differential outcomes of different types of environmental education programs. In an extensive meta-analysis of literature reporting on the measurable outcomes of environmental education programs, Stern, Powell, & Hill (2014) concluded that "programs that focus primarily on providing new knowledge should not be expected to necessarily influence behavioral outcomes, even though they may measure them" (p.23).

In an earlier study, Leeming et al. (1997) commented on the problems of alignment between the methodological instrument and activities performed in the context of the environmental education intervention. The researchers administered the Children's Environmental Attitude and Knowledge Scale (CHEAKS) pre and post an outdoor educational intervention that lasted 4 ½ to 6 ½ months. The instrument used consisted of the constructs that these days we commonly refer to as environmental literacy components (environmental knowledge, attitudes, and behaviour). The Caretaker program included a variety of experiential learning activities, such as planting trees and flowers and maintaining school grounds. In their results, Leeming et al. (1997) reported that the outdoor environmental education program that they observed had a significant positive influence on environmental behaviour, but no significant impact on environmental knowledge (Leeming et al., 1997, p. 33).

Leeming et al. (1997) use the following rationale to describe the challenges that they faced in attempting to capture the cognitive effects of environmental education:

> It is likely that larger effects would have been found if measurement instruments had focused exclusively on topics directly relevant to the specific activities performed in each Caretaker class. This problem could be remedied by designing different instruments to match each set of activities, but this

> approach would require extensive time and effort for the proper development of the numerous instruments. (Leeming et al., 1997, p. 40)

In the present study, I had to consider whether the programs' content corresponded with the associated environmental literacy instrument. The Greek environmental education curriculum includes thematic topics such as water and energy use, biodiversity, and geological history (Pedagogical Institute, 2003). Likewise, the instrument used in this research (GELI) includes in its knowledge component items on water and energy use, biodiversity and ecosystem functions (Kyriazi, 2018). Hence, at the phase of research design, the instrument appeared to have good correspondence with the curricular content. However, the Greek institutional framework gives teachers the liberty to adapt the content of their study to local, place-specific topics and themes (Greek Ministry of Education, 2010). Therefore, the lesson plans were developed and specified during the course of the school year, with co-consultation between the students and teacher who decided on the themes.

Kalymnean students of the treatment group participated in three distinct environmental education programs where they followed different curricular themes. According to the submitted lesson plans and published programmatic content, students learned about the freshwater sources, geological history, and environmental history of their island in the three different environmental education groups observed by this study. In "*Fresh Water*" the teacher's first cognitive goal, according to the submitted lesson plan, is for the students to "acquire knowledge about their region, studying the natural environment and geography of their island" (Moula & Papadomarkakis, 2018, p.208). The type of place-based learning that the students were exposed to emphasizes on hands-on, real-world learning experiences and uses the local community and environment as a starting point to teach concepts across the curriculum (Sobel, 2004).

The majority of the environmental knowledge questions in GELI, as well as in similar environmental literacy instruments, refer to global environmental themes. The advantage of such a global outlook is that these instruments have a high potential of transferability to different geographical and cultural contexts. However, this emphasis on global themes comes at a cost: these instruments apparently miss out on some of the local environmental themes developed by the environmental education groups, and hence this compromises the method's ability to measure what the students are actually learning in the field. Examples of this type of place specific, local environmental knowledge include the local sources of water and other environmental resources, as well as the local environmental history that substantiates people's historical coexistence with the natural landscape. Thus, the effects of programs that concentrate on local and place based environmental knowledge cannot be effectively captured by instruments that focus on global themes. Instead, it seems that a good measure/evaluation of environmental literacy requires both global and local knowledge components.

Current models of environmental learning continue to place disproportionate emphasis on general knowledge of environmental issues or knowledge of environmental science rather than working on local and place-based elements of environmental knowledge. That is, despite St.Clair's (2003) admonition that "environmental literacy does not always depend on in-depth understanding of environmental science" (p.74). However, the relevant body of research shows that it makes more sense to begin with the basic knowledge most relevant to the real-life problem — which means always working toward localization of environmental issues, a strategy borrowed from other forms of political literacy (St.Clair, 2003, p.74). However, we have yet to see a systematic pedagogical approach, mainstreamed at all levels of education, where educators will be encouraged to "localize environmental literacy, rendering it relevant and motivating for participants, and ensure the incorporation of

critical issues from their lives" (St.Clair, 2003, p.75). In changing learners' environmental behaviours, offering environmental knowledge both at the local and global levels is important.

The inclusion of localized variables could be achieved by items focusing on the effects of place-based, experiential environmental education. These items can be perhaps be classified into two major categories: Those that are transferable to different cultural and educational contexts, and those that make particular sense only in a local context. Concerning the first category, Orr (1992) has provided examples of transferable questions that touch on place specific environmental knowledge: From which direction does the prevailing wind blow in your area? When was the last time that a wildfire burnt your local ecosystem? Where does your drinking water come from? Name the physical location where your household waste ends up (p.137). These questions are transferable (or at least adaptable) to different educational and geographical contexts. The answers to these questions might differ depending on the geographical context, but the *success* of learners from different contexts in answering these questions can be used to draw meaningful comparisons. Hence, under certain conditions, these questions (which could be included in a background questionnaire) can be used to generate comparable results.

Other place specific items might not be readily transferable to different to different cultural and geographical contexts. These items refer to aspects of local environmental knowledge that are specific to the human and environmental history of each place. The environmental history of Kalymnos is an appropriate example: It appears that Kalymnos is a historical case of severe environmental degradation. This environmental degradation accelerated during the island's recent history due to booming demographics and the economic activity associated with the exporting of sponges. The overexploitation of the island's limited natural resources followed suit. Hence, contemporary inhabitants of Kalymnos have a

personal experience of the long-term impacts of human activity on the landscape: deforestation, soil erosion, salination of freshwater, depletion of fish and sponge stocks affect the economy and their everyday lives. Even though these patterns of environmental degradation are quite common around the world, it is not easy to design transferable questions aiming to capture place specific environmental knowledge. Due to the complexity of factors involved in local environmental histories, the direct comparison of different communities' level of understanding of their local environmental histories might be problematic. In any case, the inclusion of more local themes into environmental education entails less reliance on a formal KAB model, since there will be less emphasis on environmental science knowledge.

When it comes to the attitudinal sections of GELI, the instrument appears to be well aligned with the curricular content. Indeed, in the curricular content of the observed programs, it is clearly described that students are expected to develop their environmental sensitivity and affect; to 'feel joy and emotional movement' by participating in the program (Moyla & Papadomarkakis, 2018, p. 198, 208). Accordingly, the instrument's attitudinal component places increased emphasis on environmental affect and learner's feelings, since it follows the Erdogan and Ok (2011) typology, which merges environmental affect with the altitudinal component. No changes were observed in the environmental attitudes in either of the student groups that participated in the study. Furthermore in terms of reliability, environmental attitudes are the weakest part of the test. Nevertheless, environmental attitudes show the expected criterion validity in its correlations with demographic variables and other environmental literacy components (Appendix A).

In the previous section, I explained that two out of three observed programs seem to be doing a good job in providing students with knowledge of action strategies. In the context of the environmental education programs observed in Kalymnos, students acquired

knowledge of action strategies by participating in civic events such as campaigns for the clean up of public spaces, but also by participating in small scale actions that included the mobilization of resources at the level of civic society. A good example is the *Sustainable trails* program's effort for the creation of a map of forgotten names of remote geographical locations to be shared with the community. However, knowledge of action strategies is not included in the cognitive component of the associated environmental literacy instrument. These changes were captured by the behavioural component.

Returning to assessment of students' environmental behaviours, there is a subtle yet notable difference on whether the observed programs focus on the development of individual or civic behavioural sub-components. Environmental literacy theory has shifted the focus of program planning from individual behaviours to civic and political action. Early works theorizing on the kind of education that can lead to environmental literacy have suggested "an orientation toward learner empowerment and action as the final measure of program effectiveness" (St.Clair, 2003, p. 71). This point is important especially in light of the consideration of "political activity [as] a necessary component of environmental literacy" (Hull, Mikulecky, St.Clair, & Kerka, 2003, p.15).

Developments in theory do influence the typology of the various instruments being applied to capture the effects of environmental learning, and it has been observed that differences between instruments often reflect different philosophical and methodological predispositions. For example, MSELS focuses on individual environmental behaviours, such as learners' habitual use of water and energy in their households (McBeth et al., 2011). On the other hand, GELI focuses on civic environmental behaviours in its behavioural component. These differences in reflect the evolution of ideas in environmental education research. Since environmental literacy theory clearly places increased emphasis on learners'

civic behaviours, an environmental literacy approach is more appropriate for programs that include participatory learning activities such as community learning experiences.

Experience of the Natural World as an Essential Component of the Kind of Education that can Lead to Environmental Literacy

In the context of the present study, students were exposed to outdoor environmental education which gave them the opportunity for direct experiential contact with the natural environment. According to environmental education theorist David Orr, experience in the natural world is an "essential component of the kind of education that can lead to environmental literacy" (Orr, 1992, as cited by St.Clair, 2003, p.71). Future research is invited to initiate a more detailed discussion on the type of the educational intervention as a factor that influences educational outcomes. Experimental research in the field of environmental education has indicated that "outdoor ecology programs can influence a student's behavior toward a more positive environmental attitude, provided the intervention is of sufficient duration" (Bogner, 1998, p.27). These results were confirmed ten years later by Johnson and Manoli (2008), who applied the same instrument in a North American study. Contiguous results on the outcomes of outdoor environmental education programs were obtained by Leeming et al. (1997), who reported significant positive influence on environmental attitudes, but no significant impact on environmental knowledge (they did not measure behaviours) (Leeming et al.,1997, p. 33).

Furthermore, the meta-analysis presented by Stern, Powell, and Hill (2014) suggests that classroom-based environmental education produce different learning outcomes compared to experiential, outdoor environmental education. While the majority of the traditional *classroom* approaches were associated with improvement in knowledge of environmental science, only a minority of the traditional classroom approaches were associated with improvement in environmental attitudes and behaviours. On the other hand, the majority of

outdoor environmental education programs do associate with improvement in environmental attitudes and behaviours. These indications remain to be confirmed by future research.

The specificities of how different environmental education treatments produce differentiated learning outcomes has not yet been clearly established in the literature. However, there is abundant research, from diverse methodological traditions, supporting the claim that experiential contact with the outdoors is significantly associated with environmental behaviour. Firstly, important theorists in the field of environmental learning consider experience in the natural world as an "essential component of the kind of education that can lead to environmental literacy" (Orr, 1992, as cited by St.Clair, 2003, p.71). Secondly, researchers have presented empirical evidence of cases where experience in nature has been shown to influence environmental action (Tanner, 1980; Hattie et al., 1997; Chawla, 1999; Bögeholz, 2006; Louv, 2008). Research in psychology has also demonstrated that outdoor experience during childhood was found to be the strongest predictor of adult environmental concern (Gifford & Nilsson, 2014, p.142). Moreover, recent educational research based on a large sample (n=1545) of grade five students suggests that experiences of natural regions (frequency of experiences) is the strongest available predictor of their environmentally responsible behaviour (Erdogan, 2009, page.v, 155-156).

Concluding Remarks

This chapter discussed the empirical evidence that were necessary for addressing the research question, which asked about the potential of an environmental literacy approach in capturing the effects of outdoor environmental education. Preparing to address the research question, I remind readers that, in order to conceptually distinguish environmental literacy from environmental education, I have followed the postulate of the National Environmental Education Advisory Council [NEEAC], according to which "environmental literacy is the intended outcome of environmental education" (2015, p.8).

On this note, it is important to stress that the intention of this study was not to prove that experiential learning induces behavioural change. That part has already been empirically demonstrated by previous research, and it is also fully supported by the earlier theoretical works in the field of environmental education. The larger aim of this study is to understand how well the environmental literacy concept and associated instrument function as measures of effect. In reviewing the empirical data vis-à-vis the literature, two basic factors appear to affect the outcomes of environmental education. The first factor is the type of the educational intervention. As was discussed earlier in this chapter, classroom based programmes appear to be more effective in fostering the cognitive component of environmental literacy (Stern et al., 2014), while community based learning that includes elements of the learner's experience is more effective in promoting the localization of environmental literacy, rendering it relevant and motivating for participants (St.Clair, 2003). The second factor affecting the measured outcomes is the method (instrument) through which the learning outcome is being measured. This issue will be revisited below, and referred to the following chapter for further discussion.

After studying the empirical findings of this study, I believe that the introduction of the of environmental literacy concept improves our general understanding of the processes of environmental learning. The conceptualization of environmental literacy as a multi-faceted, composite concept has already shed new light on the complexities of environmental learning. Previous attempts to use environmental literacy as a basis of assessment have highlighted the role of localized action strategies (rather than generic environmental knowledge) in developing learners' pro-environmental concern and behaviour (St.Clair, 2003).

When applying an environmental literacy framework, this study was able to capture self-reported changes in behaviours brought about when young learners gained knowledge of viable action strategies through outdoor experiences. However, the evidence did not support

the full KAB model which is often taken as the underpinning of environmental literacy. Some of the possible changes that would strengthen environmental literacy as a measurement approach may be inclusion of localized variables, less predication on a formal KAB model, and inclusion of a background questionnaire to allow fuller consideration of respondents' experience and life circumstances.

Measurements of learning outcomes can be influenced by the different instruments that are being applied to obtain these measures. The exact definitions of the environmental literacy components environmental knowledge, environmental attitudes, and environmentally responsible behaviour depend on the theoretical and methodological traditions that are followed by each piece of research. It is important to remember that empirical research and assessment efforts follow an evolving body of theoretical research. Hence, we need to be mindful of the subcomponents included in the instruments that measure specific environmental literacy components. Phase differences between theory and the instruments used in empirical research cause issues of misalignment between theory and practice, which are remedied as research proceeds. This problem will be revisited in the following chapter, under the study conclusions as well as the limitations of study. Lastly, future research is invited to probe for the signal that produces the observed effects, as well as to conclude on whether certain types of educational programs affect specific environmental literacy components.

Chapter Seven: Conclusion and Reflections

The purpose of this chapter to provide an informed answer to the research question concerning the potential of an environmental literacy approach to capture the effects of outdoor environmental education. Starting this thesis, I firstly reviewed the body of literature that examines the observable outcomes of environmental education. Then, aiming to examine the way in which the effects of outdoor experiential education were typically considered with an environmental literacy framework, I employed a recently developed (and culturally appropriate) environmental literacy instrument in a repeated-measures (pre and post) research design. I wanted to understand the potential for environmental literacy instruments to capture the effects of outdoor environmental education. From doing this I learned about the instrument itself, in terms of validity and reliability, strengths and shortcomings. From this learning, I was able to make insightful comments about the concept of environmental literacy and its instrumentation.

This research design was rigorous in terms of ecological validity, approximating a natural experiment where the functions of the phenomenon under observation are least disturbed. After the data collection phase, I analyzed the data and then discussed the empirical results in light of the relevant literature. To address the research question, I observed the changes that environmental literacy theory has brought to our understandings of environmental learning.

All research is subject to limitations, which stem from theoretical, methodological, or practical restrictions. These limitations are presented in this chapter, after the study conclusion section. After that follows a section discussing the openings for future research, the policy recommendations, and then the more generic contributions that are generated by the study findings. This thesis concludes with a reflective piece which contemplates what I

have learned from the process of conducting this study, which does not necessarily coincide with what I initially set out to learn.

Study Conclusions

Environmental literacy theory has changed the way we think about environmental learning. This has been mostly a conceptual change, rather than a change at the level of methods or instrumentation used to capture the effects of environmental education. Indeed, there is substantial continuity in how the constructs of environmental knowledge, attitude, and behaviour have been assessed by the relevant literature over the past fifty (50) years. However, at the level of theory, environmental literacy has brought important conceptual ramifications. Firstly, environmental literacy theory has helped us understand the complexities of environmental learning. Environmental literacy is now understood as a multi-faceted concept that consists of many different components. Some of these components, like skills and affective dispositions, are easier to study by qualitative methods, while some other components have been assessed though a sufficient number of quantitative measurements. Hence, the present experimental design focuses on assessing three environmental literacy components that have already been measured with adequate reliability by previous studies (Marcinkowski et al., 2014).

The instrument used in this study was able to capture significant improvement in students' responses concerning their civic environmental behaviour after their participation in outdoor environmental education groups. A detailed –qualitative– analysis of lesson plans used by teachers during this research indicated that the survey instrument managed to capture an improvement in the civic environmental behaviour in those programs that focused on providing strategies of concrete environmental action. These behavioural changes were not associated with improved knowledge of environmental science issues, but rather with improved knowledge of how to act to address these issues. Indeed, as the findings suggest,

learners' environmental behaviours improved without any observed improvement in the environmental literacy component that pertains to environmental knowledge. Hence, the evidence did not support the full Knowledge–Attitudes–Behaviour (KAB) model often taken as the underpinning of environmental literacy.

In most environmental literacy instruments, the cognitive component centres around knowledge of environmental science. In MSELS, knowledge component consists of questions on knowledge of ecological science (McBeth et al., 2011). In GELI the majority of the items in the cognitive component also covers principles of ecological science and knowledge of global environmental issues, while a small part inquires about nation-wide environmental issues (Kyriazi, 2018). Knowledge of action strategies is absent from the cognitive component of environmental literacy instruments (e.g. Cisde, MSELI, and MSELS). However, knowledge of action strategies appears as an essential component of environmental learning, already in the early models that have identified the factors contributing to environmentally responsible behaviours (Hines et al., 1987). Education experts have noted the importance of offering knowledge of action strategies in changing learners' environmental behaviours (St.Clair, 2003).

Both the literature and this study's empirical findings suggest that environmental literacy does not always depend on knowledge of environmental science (St.Clair, 2003). However, current models of environmental learning continue to place disproportionate emphasis on generic knowledge of environmental issues or knowledge of environmental science rather than on knowledge of action strategies. The underlying assumption is that an increased understanding of environmental science concepts would lead to attitudinal changes and improved environmental behaviour (Colwell, 1976). However, in educational practice, it would make more sense to begin with the basic knowledge most relevant to the real-life

problem — which means always "working toward localization of environmental issues, a strategy borrowed from other forms of political literacy" (St.Clair, 2003, p.74).

Localization of environmental issues means to educate learners on how global environmental issues affect local communities – and, vice versa, to promote understanding on the impact of individual and collective civic and economic choices on global environmental resources. This way, environmental learning starts from the places where we live and work. By fostering a holistic understanding of the interconnectedness between the living and physical systems, students become more aware of the repercussions of their own actions on the environment and consider how to minimize their ecological impact. Using the local natural and community systems as the context for environmental learning makes more sense than to focus on the technical dimensions of global environmental problems.

Indeed, a number of programs observed in this study included place-based activities in their curricular content. However, the cognitive component of GELI and relevant environmental literacy instruments centre on environmental science knowledge, and hence these instruments cannot capture place-specific knowledge and skills. Some of the possible changes that would strengthen environmental literacy as a measurement approach may be inclusion of localised variables (questions on local environmental knowledge) into the knowledge component. In-depth understanding of the science behind global environmental challenges is perhaps desirable, but knowledge of local environmental history, land uses, and resource management by the local communities is also important. The inclusion of more local themes into environmental education entails less reliance on a formal KAB model, since there will be less emphasis on environmental science knowledge. At the level of assessment, an environmental literacy approach could be supported by the inclusion of a background questionnaire to allow fuller consideration of respondents' local environmental knowledge in relation to their experience and life circumstances. Specific examples of the items that could

be included in this background questionnaire were discussed in the previous chapter (The Appropriateness of Content for an Environmental Literacy Approach).

Furthermore, using the local natural and community settings as the context for environmental learning will entail a different level of participation of learners into local-level decision making. By working toward localized variants/ manifestations of environmental issues, learners can acquire knowledge of action strategies on how to start addressing these issues through their civic behaviours. In order to change the citizenship behaviors of large numbers of learners over long periods of time, it is important to work on delivering knowledge of action strategies (Simmons & Volk, 2002).

The findings of the present study suggest that the concept of environmental literacy provides a viable framework for assessing the impacts and outcomes of outdoor experiential environmental education. However, to rely on a single environmental literacy instrument entails that the assessment is restricted to limited environmental literacy components. The validity of the instruments could be further enhanced by employing a combination of tools that would enable triangulation of data. In order to capture a broader array of the effects of outdoor experiential environmental education, future research is encouraged to (a) include more items on civic environmental action in its assessment instruments, and (b) extend the cognitive component to include knowledge of environmental issues and knowledge of action strategies on a local level. Furthermore, empirical evidence from this and from previous studies suggest that experiential outdoor learning experiences enhance learner's understanding of environmental issues and also enable them to adopt environmentally responsible action strategies (Bögeholz, 2006; Chawla, 1999; Louv, 2008).

Limitations of Study

In this section, I discuss the methodological limitations that derive from the process of the inquiry. I start by discussing the composite nature of environmental literacy, which cannot be covered (in its full extent) by any of the existing data collection instruments. Indeed, no environmental literacy instrument claims to cover the entirety of environmental literacy components and sub-components. Then, in order to discuss the environmental literacy instrument's alignment, I explore the correspondence between the instrument's components and the curricular content. I conclude this section by discussing measurement concerns owing to cases where the students left parts of the questionnaires blank (incomplete data).

Methodological Limitations: The Complex Nature of Environmental Literacy

An inherent limitation of this research design is that it relies on an instrument (GELI) that reduces the assessment of environmental literacy to three of its components: environmental knowledge, attitude, and behaviours. This is not unusual for an environmental literacy instrument (Kyriazi, 2018). Thus, a limitation of this method is that it cannot capture aspects of environmental literacy that are not included in the associated instrument.

Environmental literacy instruments differ in the type and amount of environmental literacy components and sub-components that they include, depending on the theoretical frameworks that each instrument follows. Different instruments use adjacent definitions on what environmental knowledge, attitudes, and environmentally responsible behaviours stand for. The instrument (GELI) that was employed in this research is influenced by the Erdogan and Ok (2011) typology, which includes 41 sub-components grouped into six major components of environmental literacy. This updated typology in GELI is informed by the most recent theoretical understandings in the field, and includes the following sub-components in the behavioural component: interpersonal and public persuasion,

governmental and political action, legal action and law enforcement, other forms of citizen action. In turn, this typology draws from earlier works, such as the Erdogan and Marcinkowski (2007) framework of environmental literacy sub-components.

However, as is the case with many environmental literacy instruments, GELI does not cover the full scope of theoretically imagined environmental literacy components. For example, GELI omits three major environmental literacy components: environmental skills (practical environmental skills), environmental competencies (e.g. to identify, analyze, and propose solutions for environmental issues), and environmental awareness (awareness of the interdependence between biotic and abiotic ecosystemic components) (Hollweg et al., 2011). Hence, the instrument assesses limited components of environmental literacy, and thus it cannot claim that it has captured a comprehensive representation of students' environmental literacy levels. A more nuanced, interdisciplinary study could have combined quantitative with qualitative methods to construct a more comprehensive understanding of learners' environmental literacy. A comprehensive method for the assessment of environmental literacy should also include: (i) Values of survival for the individual and its community, (ii) Place-specific knowledge and skills, (iii) Cognitive elements of local history, arts, culture oral tradition, (iv) Awareness of the local flows of food, water, energy and materials, (v) Understanding of the cross-scalar impact of local actions.

Another methodological limitation stems from the fact that the current method relied on two (rather than multiple) environmental literacy measurements of the students who participated in the experiment (pre and post-test measures). Certainly, a qualitative or mixed methods approach could offer the possibility of a closer, continuous observation of student learning in the program. On the other hand, the present research design has the advantage that it caused minimal intrusion into the school's educational routine –hence, the observed educational phenomena remained considerably unperturbed.

Instrument Alignment

In this section, I will discuss the alignment between the three constructs measured by GELI (environmental knowledge, attitude, and behaviour) and the content that is covered by the Greek environmental education curriculum. In order to discuss the instruments' alignment with the taught content, I will start by discussing the curricular goals mandated for the examined programs. In the 2003 Environmental Education Curriculum, a number of criteria were developed for the assessment and evaluation of environmental education programs in Greece, including the degree to which environmental education programs meet the general goal of developing students' knowledge, skills, values, stances, and behaviours towards the natural environment. The curriculum allows teachers to formulate specific goals for their year-long environmental education programs, stating that the formulation of these goals "needs to lead to measurable outcomes" (Pedagogical Institute, 2003, p.645). However, the Greek curricula and ministerial directives do not describe specific processes on how these outcomes should be measured, and as a result environmental education programs are required to self-evaluate at the end of the school year, the results of which are rarely announced (Kalathaki, 2012).

Every start of the school year, teachers deliberate with their students in the environmental education groups to develop the themes of their lessons, and then submit the prospective environmental education lesson plans for the various year-long programs. In the ministerial curriculum, there are nine general environmental education themes that are proposed for development by the school groups (e.g., water, energy, biodiversity, and species extinction). Each theme is accompanied by specific educational goals. The educational goals in the theme of water are: students' ability to interpret the cycle of water, cite the various uses of water, identify causes of water pollution, adopt measures in order to alleviate water pollution, realize the importance of water, foster attitudes toward conservation of water

resources, and develop environmental awareness concerning the rational use of water resources (Pedagogical Institute, 2003, p. 641-642).

In terms of content, GELI appears to be aligned with the Greek curricular content: indeed, there is a significant overlap between the themes proposed by the curriculum and the items covered by the instrument, including water and energy use, biodiversity and ecosystem functions (Kyriazi, 2018). For example, the program *Fresh Water* covered the theme of fresh water sources and the use of water. At this point, there appears to be a significant overlap between the curricular content and the instruments' components. However, in the actual environmental education program, students learned about the freshwater sources and use of water, plus the causes of freshwater pollution that are *specific* to their island, and this local knowledge of environmental issues may not necessarily be identical with similar issues in another island or region. Similar place-specific content was also covered by the other two environmental education programs observed in Kalymnos, *Memories of the Earth* and *Sustainable Trails* (see chapter 4), and this type of local knowledge of environmental issues would not be captured by an instrument like GELI, which covers either broader national or global environmental knowledge components.

One of the purposes of environmental education is to improve learner's environmental attitudes, and help them build sensitivity and awareness concerning the impact of their actions on the local, regional and global environments. However, when it comes to instrument alignment in environmental attitude and behaviour, there might be an issue stemming from the subtle differences in the distinction between environmental attitudes and environmental behaviour. The differences between these two components (attitudes and behaviour) are not as clear-cut as it is often implied in the literature. Instead, their conceptualizations depend on which sub-components are included or omitted by each of the individual instruments that are being applied by empirical research. Hence, the following

section discusses these issues in light of the porous conceptual border between attitudes and behaviours.

Despite the fact that the relevant literature was able to establish sufficiently reliable measurements of environmental attitudes and behaviour, the conceptual borders between these two environmental literacy components are not strictly defined. This is owing to the diversity of approaches to environmental literacy, since different instruments are informed by different theoretical frameworks. For example, in some cases environmental affect is conceptualized as an independent constituent of environmental literacy (McBeth et al., 2008), while in other cases (like here) it is merged with the environmental attitudes component (Erdogan and Ok, 2011).

Since GELI follows the Erdogan and Ok (2011) typology, Environmentally Responsible Behavior consists of the following 9 sub-components: intention to act, incentive to act, personal responsibility, preservation and ecological conduct, consumer behaviour, interpersonal and public persuasion, citizenship and political action, legal action and law enforcement, other forms of civic action (Kyriazi, 2018, p. 29). Note that for Kyriazi and for Erdogan & Ok, 'intention to act' is considered as a behavioural component of environmental literacy, even if for other researchers intention to act might well be regarded as a subset of environmental attitudes. However, for Erdogan and Ok (2011) behavioural *intention* (intention to act) is assigned to the behavioural component, while environmental affect is embedded in the environmental attitudes component (p. 2379-2380).

One set of researchers regards behavioural intention separately, as a step that precedes actual behaviours in the KAB predictive string (Kollmuss & Agyeman, 2002), while other researchers have merged behavioural intention (or commitment to environmental action, or intention to act) into the behavioural component of environmental literacy (Fietkau & Kessel, 1981; Erdogan & Ok, 2011; Kyriazi, 2018). Taking an intermediate position, Klöckner (2013)

accepts intention to act as a distinct component, but he considers it as a direct predictor of environmental behaviour. Furthermore, for Kollmuss and Agyeman (2002), the relationship between environmental attitude and pro-environmental behaviour is mediated by the perceived 'cost' of pro-environmental behaviour. Hence, the conceptualizations of environmental attitudes and environmental behaviours by various environmental literacy models' instruments might differ according to the theoretical framework in use, and the definitions can be expected to shift as we view these components from different theoretical lens. Given the lack of universal agreement on the distinctions between attitudinal and behavioural environmental literacy components. The conceptual differences between attitudes and behaviours are subtle and depend on the instruments that are being employed in each case.

Measurement Concerns

In this research, the researcher managed to get a census (full participation) from all students in the six classes included in the study, which sets the basis for a rigorous research. However, a number of students returned blank sections in parts of the test. In particular, there was a particularly high percentage of students from the control group who did not complete the attitudinal component, which is possibly what causes a skewed post test frequency distribution of the environmental attitude variable (Appendix B). Out of the 48 students of this study's control group that the researcher was able to pair pre- and post-test questionnaires, 13 did not complete the attitudinal past of the instrument in either the pre or post phases of data collection.

In order to gauge the potential threat to validity due to this issue, I compared the demographic characteristics of students who completed the test versus those who left the respective test parts uncompleted. The comparisons showed that that there is no statistically significant difference in the demographic characteristics of completers and non-completers

However, differences on variables not measured could exist between students who completed the test versus those who did not complete certain parts of the test.

In light of this discussion, failure to reject the null hypothesis in environmental attitudes is not to be blindly trusted. Eventually, conclusive answers to the question concerning the effect of experiential environmental education on environmental attitudes will have to be referred to future research. Eventually, an observation has value if it can be confirmed through converging rationales, and this is why I believe that both *in situ* and *in natura* designs would be useful and productive.

Directions for Future Research

This section on future research relates to the previous section which discussed the limitations of the present study. Future research can combine different methodological traditions in order to provide a more comprehensive answer concerning the potential of an environmental literacy approach to capture the effects of environmental education. Prospective research using qualitative, quantitative, and mixed methods will be necessary to provide more nuance on the learning outcomes of environmental education. Indeed, there are encouraging findings from recent research that has used a mixed methods combination of both qualitative and quantitative instruments in order to capture the effects of outdoor environmental education (Goldman et al., 2013). These more nuanced understandings of educational outcomes can help us in capturing the effects of environmental education efforts – and eventually, provide more insight into the processes of environmental learning.

Furthermore, future research could attempt to capture the effects of outdoor environmental education using instruments that include locally adaptable items and focus on place-based learning and local knowledge. These instruments could be revised so that they will be a better fit to locally based experiential education programs and the place specific

knowledge that they impart. Indeed, the Greek system promotes an interdisciplinary version of environmental education which encourages local teachers to work on the development of place-specific knowledge and skills future research. Hence, in order to capture the place - specific cognitive component of environmental education in Greece, the knowledge component of GELI could be developed further to incorporate more place-specific items. Thus, future research could seek for the impact of environmental education on students' understanding of local and global ecological issues and relevant dispositions and behaviours, after modifying the knowledge part of the instrument so that it becomes more relevant to the programs' place specific content.

Quantitative research is one way to address the research question that pertains to the outcomes of outdoor environmental education. However, in this quasi-experimental design, the students were not randomly assigned into treatment and control groups. One way to avoid any pre-test differences between treatment and control groups in experimental research is a randomized control trial (RCT). Future research could explore whether the significant improvement in environmental behaviour after exposure to outdoor environmental education can be reproduced through a randomized assignment of students into experimental (treatment and control) groups.

Another promising topic for future research is the determination of the personal and social factors that influence pro-environmental concern and behaviour. Empirical findings from this – and other – research suggest that there should be less reliance on a formal KAB model. The linear path espoused by the KAB model cannot be the only route leading to pro-environmental behaviours. Correlation studies have suggested that the variability of environmental attitudes (in the general population) explains only 12.0 % of the variability in directly observed environmental behaviours (Marcinkowski & Reid, 2019). Future studies

can seek to explore these 'hidden variables' that were identified as missing from the attitude-behavior relationship in the earlier sections (Liska, 1984).

Future research can examine whether the current findings can be reproduced in different research settings. In doing so, hours of outdoor experience can be included as an independent variable (manipulation) in order to assess its the effect of learners' environmental literacy levels. In previous research, experience of natural regions is cited as the strongest of measured predictors of environmentally responsible behaviour (Erdogan, 2009). In this study, it is possible that the behavioural change appearing as an effect participation to environmental education is merely an artifact of students' experiential contact with natural regions. Perhaps what we do as environmental educators is to provide the social and pedagogical context in order for learners to get into experiential contact with nature. Future research is encouraged to probe for the signal that produced the observed effect, by manipulating the amount of outdoor experience in order to investigate whether the effect could be maximized. On a second level, the overlap (partial and semi-partial correlations) between the variables that influence pro-environmental behaviours remains to be determined. There are indications that perhaps some form of outdoor experience mediates the effects of experiential outdoor education, but that is a question to be explored by future research.

Policy Recommendations

A policy recommendation indirectly supported by the findings of this study is the need for additional support to outdoor learning practices. Even though the exact paths and mechanisms of environmental learning remain to be explored, the longitudinal benefits of outdoor exposure have been established in the relevant literature. As is discussed below, there is already a substantial body of research supporting the idea that teacher, school administrations and curriculum developers should be encouraged to provide more opportunities for direct, experiential contact with nature. In that respect, the findings of the

present study which associate exposure to outdoor learning with improvements in learners' environmental behaviours are perhaps worth consideration by education specialists at various levels of decision making.

Qualitative and quantitative research offers convergent rationales concerning the beneficial effects of outdoor experiential education. The relevant literature presents substantial evidence supporting that experiential contact with nature during childhood produces multiple benefits for individuals' physical and mental development (Engemann 2019; Braus & Milligan-Toffler, 2018; Adams & Savahl, 2017; Hartig, Mitchell, de Vries, & Frumkin, 2014; Louv, 2008). Beyond the demonstrated substantial benefits of experiential, outdoor learning for the mental and physical health of individuals, there is relevant research that indicates the importance of outdoor experience during childhood in shaping individuals' environmental concerns and behaviours (Palmer, 1993; Chawla, 1998, 1999; Bögeholz, 2006). In that respect, the empirical findings of this study come to complement the body of research that substantiates the relationship between outdoor, experiential learning and the development of environmentally responsible behaviour.

Based on the findings of this and other relevant research, educational systems are encouraged to support outdoor experiential programs. Focusing more specifically on the Greek environmental education policy and curriculum, the association of experiential environmental education with improvements in the behavioural components of environmental literacy could be read as a supportive for its curricular goals. Indeed, experiential learning is an essential component of Greek environmental education (Bakirtzis, 2015). The Greek Environmental and Sustainability Education curriculum sets specific cognitive and behavioural goals for each grade of primary and secondary education. These goals include issue identification, problem solving, and civic participation ([Greek] Pedagogical Institute, 2003, Malandrakis, 2017). The Greek curriculum cites specific pedagogical methods and

available resources in support of these goals, including the consideration of environmental education topics related to students' direct experience and immediate environment as one of its five pedagogical priorities (Pedagogical Institute, 2010, p. 3-4). Hence, it is not only important for the school administration, but also for teachers and educational officers to be informed about the effects of experiential environmental education, especially based on research applied on the local student population. A final point in that I would like to add to policy recommendations is the need for supporting relevant research. Research policy stakeholders and constituents, including the State Scholarships foundation (Ίδρυμα Κρατικών Υποτροφιών), the Pedagogical Institute (Παιδαγωγικό Ινστιτούτο), the Institute for Educational Policy (Ινστιτούτο Εκπαιδευτικής Πολιτικής) are encouraged to support future research aiming to further investigate the reported beneficial effect of outdoor experiential education on civic behaviours relating to the natural environment. Lastly, in the context of broader education research, policy makers, institutes that support educational research, education departments, and curriculum developers are encouraged to endorse research on environmental literacy assessments as a means to improve the effectiveness of environmental education.

Contributions to Knowledge

This study applied an environmental literacy instrument (GELI), which was already validated in the Greek context, in order to provide an informed answer to the question of whether environmental literacy is a valid way to consider the effects of environmental education. The application of the instrument in a pre and post test research design which involved a treatment and a control group has revealed a positive effect on students' self-reported environmental behaviours. By associating outdoor learning experiences to an improvement in pro-environmental behaviour, this study contributes to the body of literature that discusses the evidence-based learning outcomes of environmental education (Rickinson,

2001; Ardoin & Merrick, 2013). As such, this study shows that the concept of environmental literacy provides a potentially powerful approach in assessing the outcomes of environmental education.

The empirical findings of this study are in line with previous research that has used both qualitative and quantitative methods to demonstrate the significance of outdoor experience during childhood in shaping individuals' environmental concerns and behaviours, including their participation in environmental action (Palmer, 1993; Chawla, 1998, 1999; Bögeholz, 2006). In particular, the empirical data from this study suggest that outdoor experience directly supports pro-environmental behaviour. In that respect, this study contributes to the body of research that explores the relationship between outdoor, experiential learning and environmentally responsible behaviours. Again, more research is needed in order to improve our understanding on the educational stimuli and learning mechanisms that lead to improved environmental behaviours.

Different instruments have been employed by a number of studies worldwide, aiming to capture the learning outcomes of environmental education. There have been considerable adaptations in the versions of these instruments according to the different settings where they have been applied, in order to fit the cultural and educational realities of each place. In analysing the empirical findings of this study vis-à-vis the existing literature, I realized that these instruments evolve under the influence of developing theory. Specifically, the concept of environmental literacy has particularly influenced our understanding (and assessment methods) of environmental learning.

Firstly, environmental literacy theory has placed emphasis on citizenship skills, including a pivot that centres on the development of learners' empowerment and action. Indeed, researchers working on the development of environmental literacy instruments have

started to incorporate these theoretical directions into their methods of measurement. Accordingly, the instrument that was employed (GELI) has included a civic action dimension in its behavioural component, influenced by the most recent understandings of environmental literacy (Hollweg et al., 2011 in Kyriazi & Mavrikaki, 2013). Secondly, environmental literacy theory encourages us to work toward localization of environmental issues – a strategy borrowed from other forms of political literacy (St.Clair, 2003). However, as I discuss below, the employed instrument has not incorporated localized variables in its cognitive component, thus retaining a focus on environmental and ecological science. Hence, current environmental literacy instruments continue to exclude important environmental literacy components.

In continuity with previous environmental literacy instruments, GELI centres in environmental science knowledge in its cognitive component. The influence of techno-scientific, knowledge-centred approaches (such as the KAB model) is indeed persistent in both teaching and assessment practices of environmental education. However, by now the literature has accumulated sufficient evidence suggesting that environmental literacy does not always depend on an in-depth understanding of environmental science. Especially in the cases of outdoor, experiential education, environmental learning does not seem to proceed through a linear way, leading from environmental knowledge to improved attitudes and behaviour. Instead, the empirical data from this study suggest that outdoor experience supports pro-environmental behaviour directly. Hence, future research is needed to shed light on the ongoing dynamic interactions between environmental literacy components during the experience of outdoor environmental education.

As mentioned above, the behavioural component of GELI differs from those of its preceding instruments by that it places increased emphasis on learners' socio-political action. Early environmental literacy instruments such as Cisde, MSELI, and MSELS included a few or no questions on learner empowerment and civic action. Instead, the behavioural

components of these original instruments focused on *individual* environmental action; most of the questions in the instruments' behavioural part centred around learners' household-related behaviours such as waste management routines at their homes or practices concerning the conservation of energy and tap water in their households (McBeth et al., 2011, p.158). GELI's behavioural component, on the other hand, differs from the existing instruments in that it mostly comprises of questions on learners' civic and community action. The difference is that in GELI, most questions in the behavioural component inquire about learners' *collective* environmental behaviours (Kyriazi and Mavrikaki, 2013, p.164). For example, GELI's requests information on whether participants intervene when they take notice that someone is actively harming the environment, also whether they spontaneously pick up litter to throw away in the rubbish bin, whether they take part in campaigns for the clean-up of public spaces, and other civic life activities.

Kyriazi and Mavrikaki's decision to place increased emphasis on civic behaviours follows the work of Erdogan and Ok (2011, p.5) who conceptualised that environmentally responsible behaviour consists of nine subcomponents including civic action (Kyriazi, 2018, p. 29). Moreover, their work is theoretically supported by recent definitions which consider participation in civic life as an integral part of on environmental literacy (Hollweg et al., 2011, p.2-3). These definitions are preceded by earlier works that have suggested "an orientation toward learner empowerment and action as the final measure of program effectiveness" (St.Clair, 2003, p. 71). Hence, it is reasonable to assume that in this study, GELI captured aspects of students' environmental behaviors which previous instruments were not prepared to investigate.

In its cognitive and affective components however, GELI was much akin to the previous instruments. Specifically in the cognitive components, there are indications that the programs provided learners with place-specific environmental knowledge (such as the local

sources of water) that the instrument was not prepared to capture. Hence, current instruments continue to miss out on important environmental literacy components. This study contributes some important pointers towards the sort of instrument that would work in capturing the cognitive component of outdoor, experiential environmental education programs. Future research is invited to work on specifying the type of localized items that would capture the effects of place-based, experiential learning. All things considered, this research provides empirical evidence supporting that an environmental literacy approach is relevant in capturing the learning outcomes of outdoor environmental education programs that focus on providing learners with knowledge and experience of action strategies.

Concluding Remarks

When I embarked on this research, I was hoping that environmental literacy assessments could contribute to a better understanding of environmental education learning outcomes. Furthermore, I believed that if these learning outcomes could be associated with specific educational interventions, that would enable the development of an evaluative framework for Greek environmental education. However, this process is more complicated than I originally thought.

The international literature suggests that environmental education programs can be evaluated based on their demonstrated capacity to improve students' environmental literacy levels (National Environmental Education Advisory Council [NEEAC], 2015; Ardoin and Merrick, 2013, p.3). The works of Bogner (1998, 1999), McBeth et al. (2011), and others, have opened the way for a more systematic evaluation of environmental education programs, as appropriate to the objectives, goals, and priorities of each national context. Accordingly, the association of Greek environmental education with significant improvement in students' environmental literacy components would have opened the way to propose an environmental

literacy assessment instrument (such as GELI) as a method for the evaluation of environmental education programs.

Concluding this research however, and after considering the relevant findings, I do not believe that the associated instrument (GELI) can serve as the basis for an evaluative framework for Greek environmental education – at least not at this point – and that is for a number of reasons. One obvious reason has to do with the empirical results of this study. The only significant effect of the observed environmental education programs on the measured environmental literacy components was a moderate sized improvement in pro-environmental behaviour. Even though pro-environmental behaviour is indeed one of the intended outcomes of environmental education, it is debatable whether a behavioural outcome can constitute an adequate indicator for a valid assessment the effectiveness of environmental education programs. The evaluation of environmental education programs cannot be based solely on self-reported behaviours, especially in cases where the funding of these programs is connected to evaluation outcomes. Alternatively, program evaluation could be connected to *actual* rather than self-reported behaviours, however that would be practically and ethically problematic. Eventually, even if the associated instrument is not ready to use as an evaluative framework for Greek environmental education, this study has increased methodological and substantive knowledge regarding the effectiveness of environmental education.

This study has obtained measures of high school students' environmental knowledge, environmental attitudes, and environmentally responsible behaviour, aiming to capture the effects of environmental education programs. The literature suggests that educational research has obtained similar measures since the early 1970s. Nevertheless, back then, these measures were not described as environmental literacy components – environmental literacy and multi-literacies theory only emerged in in the early 1990s. Hence, when environmental literacy emerged as a term and theory, an important part of the literature that discusses the

relationship between environmental knowledge, environmental attitudes, and environmentally responsible behaviour was already in place. Even as the terminology has evolved since the introduction of the environmental literacy and multi-literacies theory, the instrumentation and methods for the assessment of environmental knowledge, environmental attitudes, and environmentally responsible behaviour have been largely preserved.

However, it would be erroneous to assume that the introduction of environmental literacy theory was trivial for the field of environmental education. Instead, the introduction of the environmental literacy theory has caused a slow but observable change in the methods that we are using to assess the outcomes of environmental learning. Environmental literacy theory has placed emphasis on (a) students' citizenship skills, so as to develop learner empowerment and action, and a way to do this is to (b) work toward localization of environmental issues (a strategy borrowed from other forms of political literacy). However, researchers working on the development of environmental literacy instruments were slow to incorporate these directions into the respective instruments. Characteristically, the employed instrument (GELI) has been updated -on one hand- in its behavioural component by including a civic action dimension, but on the other hand it lacks localized variables in its cognitive component. More research is necessary in order for the assessment methods to keep up with educational curricula, especially as the teaching ethos rapidly evolves towards the adoption of participatory and experiential learning practices. These learning practices are led by the latest theoretical developments that are expressed by environmental literacy theory, and hence assessment methods should be updated to follow suit. A lesson I've learned from conducting this research is that an assessment method (and any method) does not work in vacuum; instead, it follows the evolution of an overarching theory. Empirical data must be at the service of a theoretical framework or it will always be partial and de-contextualised.

References

Adams, S., & Savahl, S. (2017). Nature as children's space: A systematic review. *The Journal of Environmental Education, 48*(5), 291–321.

Adkins, C., & Simmons, B., (2002). *Outdoor, experiential, and environmental education converging or diverging approaches?*. Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools.

Alahouzos, G., Yannikouris, P., Ekmektzian, P., Kardoulias, E., Klidaras, S., Manouzellos, N., Poullas, … Paou, M. (2015). *Sponge fishing and processing.* Kalymnos, Greece: 1st Technical School of Kalymnos (In Greek).

Ackermann, R. T., Duru, O.K., Albu, J. B., Schmittdiel, J. A., Soumerai, S. B., Wharam, J. F., … Gregg, E. W. (2015). Evaluating Diabetes Health Policies Using Natural Experiments. *American Journal of Preventive Medicine, 48*(6), 747–754. https://doi:10.1016/j.amepre.2014.12.010

American Psychological Association. (2015). Guidelines for psychological practice with transgender and gender nonconforming people. *American Psychologist, 70*(9), 832–864.

Ardoin, N., & Merrick, C. (2013). *Environmental education: A brief guide for U.S. grantmakers*. Retrieved from https://people.stanford.edu/nmardoin/sites/default/files/Grantmakers%2010.6.pdf

Asghar, A. (2004). *Exploring children's cognitive and affective skills related to conservation of mass using Fischer's dynamic skills model: What goes on in their minds and hearts?* (Unpublished doctoral dissertation). Harvard University, Boston.

Bakirtzis, K. (2015). Environmental education pedagogy and experiential learning. *For Environmental Education, 8*(53). Retrieved from https://www.peekpemagazine.gr/article/η-παιδαγωγική-της-πε-και-η-βιωματική-εκπαίδευση (In Greek).

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology, 27*(1), 14–25. http://doi:10.1016/j.jenvp.2006.12.002

Basu, D. (1977). On the elimination of nuisance parameters. *Journal of the American Statistical Association,* 72, 355–366.

Beard, C., & Wilson, J. P. (2006). *Experiential learning: A best practice handbook for educators and trainers* (2nd ed.). London: Kogan Page.

Bernard, H. R. (1976). Kalymnos: The island of the sponge fishermen. *Annals of the New York Academy of Sciences, 268*(1), 291–307. https://doi.org/10.1111/j.1749-6632.1976.tb47652.x

Begg, C. B. (1994). Publication bias. In H. Cooper, & L. Hedges (Eds.), *The handbook of research synthesis* (pp. 399-409). New York, NY: Russell Sage Foundation.

Bell, D. (2009). Education for sustainable development: Cure or placebo? In G. Toner, J. Meadowcroft (Eds.), *Innovation, Science, Environmental, Special Edition: Charting Sustainable Development in Canada 1987–2007* (pp. 106–130). Montreal, Québec, Canada: McGill-Queen's University Press.

Bland, J. M., & Altman, D. G. (1995). Calculating correlation coefficients with repeated observations: Part 2—Correlation between subjects. *BMJ, 310*(6980), 633.

Blum, N., Nazir, J., Breiting, S., Goh, K. C., & Pedretti, E. (2013). Balancing the tensions and meeting the conceptual challenges of education for sustainable development and climate change. *Environmental Education Research, 19*(2), 206–217.

Bluhm, W., Hungerford, H., McBeth, W., & Volk, T. (1995). A final report on development and pilot-testing of the "Middle School Environmental Literacy Instrument". In R. Wilke (Ed.), *Environmental literacy/needs assessment project: Final report* (pp. 8-29). Stevens Point, WI: University of Wisconsin-Stevens Point.

Bögeholz, S. (2006). Nature experience and its importance for environmental knowledge, values and action: recent German empirical contributions. *Environmental Education Research, 12*(1), 65–84. https://doi.org/10.1080/13504620500526529

Bogner, F. X. (1998). The Influence of Short-Term Outdoor Ecology Education on Long-Term Variables of Environmental Perspective. *The Journal of Environmental Education, 29*(4), 17–29. https://doi.org/10.1080/00958969809599124

Bogner, F. X. (1999). Empirical evaluation of an educational conservation programme introduced in Swiss secondary schools. *International Journal of Science Education, 21*(11), 1169–1185. https://doi.org/10.1080/095006999290138

Bogner, F. X., & Wilhelm, M. G. (1996). Environmental perspectives of pupils: the development of an attitude and behaviour scale. *The Environmentalist, 16*(2), 95–110. https://doi:10.1007/bf01325101

Bogner, F. X., & Wiseman, M. (1999). Toward measuring adolescent environmental perception. *European Psychologist, 4*(3), 139–151.

Bogner, F. X., & Wiseman, M. (2002). Environmental perception: Factor profiles of extreme groups. *European Psychologist, 7*(3), 225–237. https://doi.org/10.1027/1016-9040.7.3.225

Borenstein, M. (2009). Effect sizes for continuous data. In H. Cooper, L. V. Hedges, & J. C. Valentine (Eds.), *The handbook of research synthesis and meta-analysis* (2nd ed., pp. 221-235). New York, NY: Sage Foundation.

Borden, R. J., & Schettino, A. P. (1979). Determinants of environmentally responsible behavior. *The Journal of Environmental Education, 10*(4), 35-39.

Braus, J., & Milligan-Toffler, S. (2018). The children and nature connection: Why it matters. *Ecopsychology, 10*(4), 193–194. https://doi:10.1089/eco.2018.0072

Breunig, M. (2008). The historical roots of experiential education. In K. Warren, D. Mitten, & T. Loeffler (Eds.), *Theory and practice of experiential education* (pp. 77-92). Boulder, CO: Association for Experiential Education.

Brody, M., & Storksdieck, M. (2013). Evaluation and analysis of environmental education programs, materials, and technologies and the assessment of learners and learning. In R. B. Stevenson, M. Brody, J. Dillon, A. E. Wals (Eds.), *International handbook of research on environmental education* (pp. 285-288). New York and London: Routledge.

Brundtland, G. (1987). *Our common future: The World Commission on Environment and Development*. Oxford: Oxford University Press.

Brügger, P. (2004). 25 years past Tbilisi: Environmental teaching or cheating? In W. L. Filho & M. Littledyke (Eds.), *International perspectives in environmental education* (pp. 129-138). Frankfurt: P. Lang.

Carpi, A., & Egger, A. E. (2008). Comparison in Scientific Research. *Visionlearning, 1(*5). Retrieved from: https://www.visionlearning.com/en/library/Process-of-Science/49/Comparison-in-Scientific-Research/152

Carver, R. (1996). Theory for practice: A framework for thinking about experiential education. *Journal of Experiential Education, 19*(1), 8–13. https://doi.org/10.1177/105382599601900102

Cebrian, E., Uriz, M. J., Garrabou, J., & Ballesteros, E. (2011). Sponge mass mortalities in a warming Mediterranean Sea: Are cyanobacteria-harboring species worse off?. *PLoS One*, *6*(6), e20211. https://doi.org/10.1371/journal.pone.0020211

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Chapman, S., McPhee, P., & Proudman, B. (1992). What is experiential education? *Journal of Experiential Education, 15*(2), 16–23. https://doi:10.1177/105382599201500203

Chatzifotiou, A. (2005). National policy, local awareness: Implementing environmental education in the primary schools of northern Greece. *Environmental Education Research, 11*(5), 503–523. https://doi.org/10.1080/13504620500169650

Chawla, L. (1998). Significant life experiences revisited: A review of research on sources of environmental sensitivity. *Environmental Education Research, 4*(4), 369–382. https://doi:10.1080/1350462980040402

Chawla, L. (1999). Life paths into effective environmental action. *Journal of Environmental Education, 31*(1), 15–26. https://doi.org/10.1080/00958969909598628

Christophilopoulou, E. (2010, April 09). Oration of the Deputy Minister of Education at the Ministerial Session for Education [Video]. YouTube. http://www.youtube.com/watch?v=zjRifxWIRWU

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York, NY: Harper & Row.

Csikszentmihalyi, M. (1997). Flow and education. *The NAMTA Journal, 22*(2), 2–35.

Colwell Jr, T. B. (1976). A critique of behavior objectives methodology in environmental education. *The Journal of Environmental Education, 7*(3), 66–71.

Davies, R. (2018). *Residential outdoor education in Scotland: change over time and the impacts of socio-economic deprivation on access* (Unpublished doctoral dissertation). University of Stirling, Stirling, UK.

Deloudi, M. (2002). Possibilities for experiential learning in the context of the flexible school schedule. *Educational Review*, *6*, 145–159 (In Greek). Retrieved from http://www.pi-schools.gr/download/publications/epitheorisi/teyxos6/deloudi.PDF

Dewey, J. (1938). *Experience and education*. New York, NY: Kappa Delta Pi.

Dewey, J. (1958). *Experience and nature (1925)*. New York, NY: Dover.

Duraiappah, A. K., & Muñoz, P. (2012). Inclusive wealth: A tool for the United Nations. *Environment and Development Economics, 17*(3), 362–367. https://doi.org/10.1017/s1355770x12000150

Ellis, P. D. (2009). *Thresholds for interpreting effect sizes*. Retrieved from https://www.polyu.edu.hk/mm/effectsizefaqs/thresholds_for_interpreting_effect_sizes2.html

ELSTAT (2011). *Population census 2011: Resident population by nationality, sex and education levels*. Athens: author

Emmons, K. M. (1997). Perceptions of the environment while exploring the outdoors: A case study in Belize, *Environmental Education Research*, *3*(3), 327–344. https://doi.org/10.1080/1350462970030306

Engemann, K., Pedersen, C. B., Arge, L., Tsirogiannis, C., Mortensen, P. B., & Svenning, J.-C. (2019). Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. *Proceedings of the National Academy of Sciences, 116*(11), 5188–5193. https://doi:10.1073/pnas.1807504116

Erdogan, M., & Ok, A. (2011). An assessment of Turkish young pupils' environmental literacy: A nationwide survey. *International Journal of Science Education, 33*(17), 2375–2406. https://doi:10.1080/09500693.2010.550653

Erdoğan, M. (2009). *Fifth grade students' environmental literacy and the factors affecting students' environmentally responsible behaviors* (Unpublished doctoral dissertation). Middle East Technical University, Ankara, Turkey.

Erdogan, M., & Marcinkowski, T. (2007, November). An analysis of K-8 environmental education research in Turkey, 1997–2007. *NAAEE Annual Conference*. Talk presented at 36th North American Association for Environmental Education Annual Conference and Research Symposium, Virginia Beach, USA.

Ernst, J., & Monroe, M. (2004). The effects of environment-based education on students' critical thinking skills and disposition toward critical thinking. *Environmental Education Research*, *10*(4), 507–522. https://doi.org/10.1080/1350462042000291038

Fermeli, G., Roussomoustakaki-Theodoraki, M., Chatzikosta, C., Geitlich, M. (2009). *Curricular guidelines on interdisciplinary activities: Environmental education*. Athens:Greek Ministry of Education.

Fien, J., Scott, W., & Tilbury, D. (2001). Education and conservation: Lessons from an evaluation. *Environmental Education Research, 7*(4), 379–395. https://doi.org/10.1111/j.1523-1739.1991.tb00380.x

Fietkau, H.-J., & Kessel, H. (1981). *Umweltlernen: veränderungsmöglichkeiten des umweltbewusstseins: Modelle, erfahrungen*. Koenigstein, Hain: Schahn, J. and Giesinger.

Fox, R. (1999). Enhancing spiritual experience in adventure programs. In J. Miles & S. Priest (Eds.), *Adventure programming* (pp. 455-461). State College, PA: Venture Publishing.

Frederickson, L. M., & Anderson, D. H. (1999). A qualitative exploration of the wilderness experience as a source of spiritual inspiration. *Journal of Environmental Psychology, 19*, 21–39. https://doi.org/10.1006/jevp.1998.0110

Gamst, G., Meyers, L. S., & Guarino, A. J. (2008). *Analysis of variance designs: A conceptual and computational approach with SPSS and SAS*. New York, NY: Cambridge University Press.

Gadotti, M. (2010). ESD and education for all: synergies and potential conflicts. *International Review of Education*, 56(2-3), 221–234.

Gavrilakis, C. (2006). *Planning, development and formative evaluation of a virtual working environment for the planning of environmental education programs* (Unpublished doctoral dissertation). University of the Aegean, Mytilene, Greece.

Georgopoulos, A., Birbili, M., & Dimitriou, A. (2011). Environmental education (EE) and experiential education: A promising "marriage" for Greek pre-school teachers. *Creative Education, 2*(2), 114.

Georgopoulos, A. (2014). *Environmental education: Identity issues*. Athens: Gutenberg.

Geisinger, K. F. (1994). Cross-cultural normative assessment: Translation and adaptation issues influencing the normative interpretation of assessment instruments. *Psychological Assessment, 6*(4), 304–312. https://doi:10.1037/1040-3590.6.4.304

Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology, 49*(3), 141–157.

Goldman, D., Assaraf, O. B. Z., & Shaharabani, D. (2013). Influence of a non-formal environmental education programme on junior high-school students' environmental literacy. *International Journal of Science Education*, *35*(3), 515–545.

Greek Ministry of Education (2019). *Directive 190790/Δ7/4-12-2019: Planning and implementation of school activities programs*. Athens, Greece: Greek Ministry of Education, Division of Program Support and Education for Sustainability (In Greek).

Greek Ministry of Education (2017). *Directive Φ.16Α/ΜΚ/205575/Δ1 /24-11/2017: Educational visits and learning activities in Environmental Education Centres for the 2017-18 school year*. Athens, Greece: Greek Ministry of Education, Division of Primary and Secondary Education Curricula (In Greek).

Greek Ministry of Education (2016a). *Curriculum of daytime high schools, grades 7, 8, and 9*. Ministerial Decision 93381/δ2/7-6-2016. Athens, Greece: Greek Ministry of Education (In Greek).

Greek Ministry of Education (2016b). *Educational visits to Environmental Education Centres for the 2016-17 school year*. Directive 200064/ Δ2 23-11-2016. Athens, Greece: Greek Ministry of Education (In Greek).

Greek Ministry of Education (2015). *Curricular guidelines for experiential learning educational activities in middle school* (Governing Board Act 37/07-07-2015). Athens, Greece: Greek Ministry of Education (In Greek).

Greek Ministry of Education (2014). *Update on the programs and educational visits to Environmental Education Centres for the 2014-2015 school year* (Document 208971 /Δ2 /22-12-2014). Athens, Greece: Greek Ministry of Education (In Greek).

Greek Ministry of Education (2013). *Restructuring of secondary education and other decrees* (Legislative Act 4186/2013 [ΦΕΚ 193/A/17-9-2013]). Athens, Greece: Greek Ministry of Education (In Greek).

Greek Ministry of Education (2011). *Procedures of appointment and responsibilities of teachers in Environmental Education Centres* (Ministerial Decree 83691/Γ7/22-7-2011). Athens, Greece: Greek Ministry of Education (In Greek). Retrieved from https://www.minedu.gov.gr/publications/docs2011/diadikasies_kpe_ya_110725.pdf

Greek Ministry of Education & European Union (2010). *Call for proposals for the operational plan "Environmental Education Centres: Activities for students"* (Document 11941/23-8-2010). Athens, Greece: author (In Greek).

Greek Ministry of Education (2010). *Update of the programs provided by Environmental Education Centres for the 2010-2011 school year* (Directive 157598 /Γ7 13-12-2010). Athens, Greece: Greek Ministry of Education (In Greek).

Greek Ministry of Education (2007). *Directive 117302/Γ7/19-10-2007: Planning and implementation of school activities: Career planning, environmental education, health education, cultural education, Comenius- Leonardo da Vinci and e-Twinning programs*. Athens, Greece: Greek Ministry of Education, Integrated Section of Curricular Studies, Professional Development and Innovation (In Greek).

Greek Ministry of Education (1990). Act 1892/1990 (ΦΕΚ 101 τ. Α), article 111 par. 13 (In Greek).

Gregory, J. (2006). Principles of experiential education. In P. Jarvis (Ed.), *The theory and practice of teaching* (pp. 114-129). London: Routledge.

Hart, P. (1996). Problematizing enquiry in environmental education: Issues of method in a study of teacher thinking and practice. *Canadian Journal of Environmental Education, 1*(1), 56–88. ttps://doi.org/10.1080/01626620.2018.1486751

Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and health. *Annual Review of Public Health*, *35*, 207–228.

Hattie, J., Marsh, H. W., Neill, J. T., & Richards, G. E. (1997). Adventure education and outward bound: Out-of-class experiences that make a lasting difference. *Review of Educational Research*, *67*(1), 43–87.

Heintzman, P. (2009). The spiritual benefits of leisure. *Leisure/Loisir*, *33*(1), 419–445.

Hellbrück, J., & Kals, E. (2012). *Umweltpsychologie*. Wiesbaden: Springer.

Hollweg, K. S., Taylor, J.R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C. and Zoido, P. (2011). *Developing a framework for assessing environmental literacy*. North American Association for Environmental Education.

Hajer, M., Nilsson, M., Raworth, K., Bakker, P., Berkhout, F., de Boer, Y., … Kok, M. (2015). Beyond cockpit-ism: Four insights to enhance the transformative potential of the Sustainable Development Goals. *Sustainability*, *7*(2), 1651–1660. https://doi:10.3390/su7021651

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *The Journal of Environmental Education*, *18*(2), 1–8.

Holsman, R. H. (2001). The politics of environmental education. *The Journal of Environmental Education*, *32*(2), 4–7.

Hug, A., & Hug, J. W. (2010). Challenges and opportunities for evaluating environmental education programs. *Evaluation and Program Planning*, *33*(2), 159–164.

Hughes, J. D. (1975). *Ecology in ancient civilizations*. University of New Mexico Press.

Huang, Y. S. (2019). *Implementing Education for Sustainable Development (ESD): A policy ethnography of Taiwan's environmental education act* (Unpublished doctoral dissertation). McGill University, Montreal, Québec, Canada

Hull, G. A., Mikulecky, L., St Clair, R., & Kerka, S. (2003). *Multiple literacies. A compilation for adult educators*. Columbus: Ohio State University. Retrieved from https://eric.ed.gov/?id=ED482361

Institute of Educational policy (2015). *Guidelines for experiential learning activities for in daytime and evening high schools, 2015 – 2016* (Act 37/07-07-2015 of the governing board). Athens, Greece: Greek Ministry of Education (in Greek).

Igbokwe, A. B. (2012). Environmental literacy assessment: Exploring the potential for the assessment of environmental education/programs in Ontario schools. *International Journal for Cross-Disciplinary Subjects in Education*, *3*(1), 648–656.

Igbokwe, A. B. (2016). *Environmental literacy assessment: Assessing the strength of an environmental education program (EcoSchools) in Ontario secondary schools for environmental literacy acquisition* (Unpublished doctoral dissertation). University of Windsor, Ontario, Canada

Ingman, B. C. (2011). Henry David Thoreau: Spirituality and experiential education. *Curriculum and Teaching Dialogue*, *13*(1), 143.

IOBE [Foundation for Economic & Industrial Research] (2013). *Public and private education: A comparative analysis*. Retrieved from http://iobe.gr/docs/research/RES_05_F_14020214_REP_GR.pdf

Jacobson, S. K., & McDuff, M. (1997). Success factors and evaluation in conservation education programs. *International Research in Geographical & Environmental Education, 6*(3), 1–18.

Jensen, B. B. (2002). Knowledge, action and pro-environmental behaviour. *Environmental Education Research, 8*(3), 325–334. https://doi.org/10.1080/13504620220145474

Johnson, B., & Manoli, C. C. (2008). Using Bogner and Wiseman's model of ecological values to measure the impact of an earth education programme on children's environmental perceptions. *Environmental Education Research, 14*(2), 115–127.

Journal of the Greek Government (2014). *Results of the 2011 census of buildings and the country's permanent population*. Athens: author (In Greek).

Katsakiori, M., Flogaitis, E. & Papadimitriou, V. (2008). *Present condition of environmental education in Greece- Environmental Education Centres*. Athens, Greece: EKEBY.

Kalathaki, M. (2012). Evaluation criteria for a secondary school-based environmental education program. *For Environmental Education, I*(46), Period B΄ (In Greek).

Kalogerakis (2018). Memories of the Earth: Getting to know the geophysical environment of Kalymnos. In E. Moula, & I. Papadomarkakis (Eds.), *Cultivating 21st century skills through school-based activities* (pp. 191-204). Rhodes, Greece: Editors (In Greek). .

Keselman, H. J., Cribbie, R., & Holland, B. (1999). The pairwise multiple comparison multiplicity problem: An alternative approach to familywise and comparison wise Type I error control. *Psychological Methods, 4*(1), 58–69.

Khazem, D. (2018). Critical realist approaches to global learning: A focus on Education for Sustainability. *International Journal of Development Education and Global Learning*, *10*(2), 125–134.

Klöckner, C. A. (2013). A comprehensive model of the psychology of environmental behaviour: A meta-analysis. *Global Environmental Change, 23*(5), 1028–1038.

Kontaras, V. (2004). *Identification of the basic characteristics of environmental education centres* (Unpublished Masters thesis). University of the Aegean, Mytilene (In Greek).

Krnel, D., & Naglic, S. (2009). Environmental literacy comparison between eco-schools and ordinary schools in Slovenia. *Science Education International*, *20*, 5–24.

Kim, E. J. A., Asghar, A., & Jordan, S. (2017). A critical review of Traditional Ecological Knowledge (TEK) in science education. *Canadian Journal of Science, Mathematics and Technology Education*, *17*(4), 258–270.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. London: Prentice-Hall.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*(3), 239–260. https://doi.org/10.1080/13504620220145401

Kyriazi, P., & Mavrikaki, E. (2013). Proceedings from the 10th biannual Conference of the European Science Education Research Association (ESERA): *Development of an instrument to measure environmental literacy of post-secondary Greek students – Pilot testing and preliminary result* (pp. 164–171). Nicosia, Cyprus: ESERA.

Kyriazi (2018). *Ecology teaching as a framework for the development of the goals of Environmental education/ education for sustainable development* (Unpublished doctoral dissertation). University of Athens, Greece.

Le Grange, L. (2013). The politics of needs and sustainability education. In R. B. Stevenson, M. Brody, J. Dillon, A. E. Wals (Eds.), *International handbook of research on environmental education* (pp. 126-132). New York and London: Routledge.

Latouche, S. (1993). *In the wake of the affluent society: An exploration of post-development*. London, UK: Zed Books.

Leal Filho, W., Manolas, E., & Pace, P. (2015). The future we want: Key issues on sustainable development in higher education after Rio and the UN decade of education for sustainable development. *International Journal of Sustainability in Higher Education*, *16*(1), 112–129.

Leal Filho, W. (1996). Eurosurvey: an analysis of current trends in environmental education in Europe. In: G. Harris & C. Blackwell (Eds.), *Environmental education. Vol. 1: Monitoring change in education.* Aldershot: Arena.

Lewbart, G. A. (Ed.). (2012). *Invertebrate medicine*. West Sussex, UK: John Wiley & Sons.

Lee, J. H. (2012). Experimental methodology in English teaching and learning: Method features, validity issues, and embedded experimental design. *English Teaching: Practice and Critique, 11*(2), 25–43.

Lantieri, L. (Ed.) (2001). *Schools with spirit: Nurturing the inner lives of children and teachers*. Boston, MA: Beacon Press.

Leeming, F.C., Porter, B.E., Dwyer, W.O., Cobern, M.K. & Oliver, D.P. (1997). Effects of participation in class activities on children's environmental attitudes and knowledge, *Journal of Environmental Education*, 28(2), 33–42. https://doi.org/10.1080/00958964.1997.9942821

Leeming, F. C., Dwyer, W. O., & Bracken, B. A. (1995). Children's environmental attitude and knowledge scale: Construction and validation. *The Journal of Environmental Education*, *26*(3), 22–31. https://doi.org/10.1080/00958964.1995.9941442

Liang, S.-W., Fang, W.-T., Yeh, S.-C., Liu, S.-Y., Tsai, H.-M., Chou, J.-Y., & Ng, E. (2018). A Nationwide Survey Evaluating the Environmental Literacy of Undergraduate Students in Taiwan. *Sustainability*, *10*(6), 1730. https://doi:10.3390/su10061730

Lignou, G. (2016). *Estimate of per capita income in the municipalities of* Greece (Unpublished Bachelor's thesis). University of Thessaly, Greece.

Liska, A. E. (1984). A critical examination of the causal structure of the Fishbein/Ajzen attitude-behavior model. *Social Psychology Quarterly*, *47*(1), 61–74. https://doi:10.2307/3033889

Loughland, T., Reid, A., Walker, K., & Petocz, P. (2003). Factors influencing young people's conceptions of environment. *Environmental Education Research*, *9*(1), 3–19.

Louv, R. (2008). *Last child in the woods: Saving our kids from nature deficit disorder*. New York, NY: Algonquin Books

Madeley, J. (2015). Sustainable development goals. *Appropriate Technology*, *42*(4), 32.

McKeown, R., & Hopkins, C. (2003). EE ≠ ESD: Defusing the worry. *Environmental Education Research*, *9*(1), 117128.

Maiteny, P. T. (2002). Mind in the gap: Summary of research exploring inner influences on pro-sustainability learning and behaviour. *Environmental Education Research*, *8*(3), 299–306. https://doi.org/10.1080/13504620220145447

Malandrakis, G. (2017). Influencing Greek pre-service teachers' efficacy beliefs and self-confidence to implement the new "Studies for the Environment" curricula. *Environmental Education Research, 24*(4), 537–563. https://doi:10.1080/13504622.2016.1272672

Maulidya, F., Mudzakir, A., & Sanjaya, Y. (2014). Case study the environmental literacy of fast learner middle school students in Indonesia. *International Journal of Science and Research*, *1*(0), 6.

Marcinkowski, T., & Reid, A. (2019). Reviews of research on the attitude–behavior relationship and their implications for future environmental education research. *Environmental Education Research, 25* (4), 459–471. https://doi.org/10.1080/13504622.2019.1634237

Marcinkowski, T., D. Shin, K. Noh, M. Negev, G. Sagy, Y. Garb, W. McBeth, H. Hungerford, T. Volk, R. Meyers, & M. Erdogan. (2014). National assessments of environmental literacy: A review, comparison, and analysis. In M. Brody, J. Dillon, R. Stevenson, & A. Wals (Eds.), *International handbook of research in environmental education* (pp. 310-329). Washington, DC: AERA, and Abingdon, UK: Routledge.

Martin, W. W., Falk, J. H., & Balling, J. D. (1981). Environmental effects on learning: The outdoor field trip. *Science Education*, *65*(3), 301–309.

Mavrikaki, E., Kyridis, A., Tsakiridou, E. & Golia, P. (2004). Greek educators' attitudes and beliefs about the application of environmental education in elementary school. In W. Leal Filho & M. Littledyke (Eds.), *International Perspectives in Environmental Education* (pp. 29-36). Frankfurt am Main: Peter Lang.

Mavrothalassiti, A., & Farsari, I. (2011). Proceedings from the International Conference on Tourism: Tourism in an Era of Uncertainty: *Climbing tourists' environmental attitudes: Evidence from Kalymnos island, Greece* (pp. 462-476). Rhodes, Greece: International Association for Tourism Policy.

McBeth, B., Hungerford, H., Marcinkowski, T., Volk, T., Cifranick, K., Howell, J., & Meyers, R. (2011). *National environmental literacy assessment, phase two: Measuring the effectiveness of North American environmental education programs with respect to the parameters of environmental literacy* (Report No. NA08SEC4690026). Carbondale, IL: North American Association for Environmental Education.

McBeth, W., Hungerford, H., Marcinkowski, T., Volk, T., & Meyers, R. (2008). *National environmental literacy assessment project: Year 1, National baseline study of middle grades students. Final report.* Retrieved from https://www.noaa.gov/sites/default/files/atoms/files/Final_NELA_minus_MSELS_8-12-08_0.pdf

McBride, B. B., Brewer, C. A., Berkowitz, A. R., & Borrie, W. T. (2013). Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here? *Ecosphere, 4*(5), 1–20. http://onlinelibrary.wiley.com/doi/10.1890/ES13-00075.1/full

McBride, B. B. (2011). *Essential elements of ecological literacy and the pathways to achieve it: Perspectives of ecologists* (Unpublished doctoral dissertation). University of Montana, USA.

McDermott, R. (2011). Internal and external validity. In J. N. Druckman, D. P. Green, J. H. Kuklinski, & A. Lupia (Eds.), *Cambridge handbook of experimental political science* (pp. 27-40.). New York, NY: Cambridge University Press.

McKeown-Ice, R., & Dendinger, R. (2000). Socio-political-cultural foundations of environmental education. *The Journal of Environmental Education*, *31*(4), 37–45.

Meyers, R. B (2002). *A heuristic to distinguish environmental values and ethics, and a psychometric instrument to measure adult environmental ethics and willingness to protect the environment* (Unpublished doctoral dissertation). The Ohio State University, USA

Milfont, T. L. (2009). The effects of social desirability on self-reported environmental attitudes and ecological behaviour. *The Environmentalist*, *29*(3), 263–269.

Monroe, M. C. (2012). The co-evolution of ESD and EE. *Journal of Education for Sustainable Development*, *6*(1), 43–47.

Mumford, L. (1946). *Values for survival: Essays, addresses, and letters on politics and education*. New York, NY: Harcourt, Brace and co.

National Environmental Education Advisory Council [NEEAC] (2015). *Report to the U.S. Environmental Protection Agency administrator*. United States Environmental Protection Agency. Retrieved from https://www.epa.gov/sites/production/files/2015-10/documents/final2015neeacreport-08_7_2015_2.pdf

NAAEE. (2004). *Excellence in environmental education: Guidelines for learning (K-12).* Washington, DC: United States Environmental Protection Agency.

Neumann, R. P. (1998). *Imposing wilderness: Struggles over livelihood and nature preservation in Africa*. Berkeley and Los Angeles, California: University of California Press.

O'Brien, S. R. M. (2007). *Indications of environmental literacy: Using a new survey instrument to measure awareness, knowledge, and attitudes of university-aged students* (Unpublished doctoral dissertation). Iowa State University, USA.

Oluwatayo, J. A. (2012). Validity and reliability issues in educational research. *Journal of Educational and Social Research*, *2*(2), 391–400.

O'Riordan, T. (2008). Some reflections on the conditions for favouring integrated sustainability assessments. *International Journal of Innovation and Sustainable Development, 3*(1-2), 153–162.

Orr, D. W. (1992). *Ecological literacy: Education and the transition to a postmodern world*. New York, NY: State University of New York Press.

Palmer, J. A. (1993). Development of concern for the environment and formative experiences of educators. *Journal of Environmental Education*, *24*(3), 26–30.

Palmer, J. (1998). *Environmental education in the 21st century: Theory, practice, progress and promise.* New York, NY: Routledge.

Pedagogical Institute (2010). *2010-2011 Environmental and sustainability education, revised curriculum.* Athens, Greece: author (in Greek).

Pedagogical Institute (2003). *Comprehensive curriculum for the design and development of interdisciplinary activities in environmental education* (ΦΕΚ 304, Τ.Β./13-3-2003). Athens, Greece: Author (In Greek). Retrieved from http://www.pi-schools.gr/download/programs/depps/31depps_Peribalontikis.pdf

Pedretti, E., Nazir, J., Tan, M., Bellomo, K., & Ayyavoo, G. (2012). A baseline study of Ontario teachers' views of environmental and outdoor education. *Pathways: The Ontario Journal of Outdoor Education*, *24*(2), 4–12.

Peterson, N. (2005). Factors influencing the development of environmental sensitivity: A model. In H. Hungerford, W. Bluhm, T. Volk, & J. Ramsey (Eds.), *Essential readings in environmental education* (pp. 295-299). Champaign, IL: Stipes Publishing.

Peterson, N. J. (1982). *Developmental variables affecting environmental sensitivity in professional environmental educators* (Unpublished Master's thesis) Southern Illinois University, USA.

Pe'er, S., Goldman, D., & Yavetz, B. (2007). Environmental literacy in teacher training: Attitudes, knowledge, and environmental behavior of beginning students. *The Journal of Environmental Education, 39*(1), 45–59.

Platsi (2018). Fresh water: A source of life. In E. Moula, & I. Papadomarkakis (Eds.), *Cultivating 21st century skills through school-based activities* (pp. 191-204). Rhodes, Greece: Editors (In Greek).

Pontikakis, F. (2018, March 27). *Political indifference degrades environmental education*. Chaniotika Nea (In Greek). Retrieved from https://www.haniotika-nea.gr/ipovathmisi-tis-perivallontikis-ekpedefsis/

Potvin, P. J., & Schutz, R. W. (2000). Statistical power for the two-factor repeated measures ANOVA. *Behavior Research Methods, Instruments, & Computers*, *32*(2), 347–356.

Priest, S. (1986). Redefining outdoor education: A matter of many relationships. *The Journal of Environmental Education*, *17*(3), 13–15. https://doi.org/10.1080/00958964.1986.9941413

Pierce C. A., Block, C. A. & Aguinis, H. (2004). Cautionary note on reporting eta-squared values from multifactor ANOVA designs. *Educational and Psychological Measurement 64(6),* 916–924. https://doi.org/10.1177/0013164404264848

Quale, A. M. (1993). *The development of an instrument to assess the environmental literacy of fifth* grade students in Wisconsin (Unpublished Master's thesis). University of Wisconsin – Stevens Point, WI, USA.

Rickinson, M. (2001). Learners and learning in environmental education: A critical review of the evidence. *Environmental Education Research, 7*(3), 207–320.

Roberts, J. W. (2012). *Beyond learning by doing: Theoretical currents in experiential education*. New York, NY and London, UK: Routledge.

Roe, B. E., & Just, D. R. (2009). Internal and external validity in economics research: Tradeoffs between experiments, field experiments, natural experiments, and field data. *American Journal of Agricultural Economics*, *91*(5), 1266–1271.

Roth, C. E. (1968). On the road to conservation. *Massachusetts Audubon, 52*(4), 38-41.

Russell, C. L., & Burton, J. (2000). A report on an Ontario secondary school integrated environmental studies program. *Canadian Journal of Environmental Education*, *5*, 287–304.

Russell, C. L., Bell, A. C., & Fawcett, L. (2000). Navigating the waters of Canadian environmental education. In T. Goldstein (Ed.), *Weaving connections: Educating for peace, social and environmental justice* (pp. 196-217). Toronto: Sumach Press.

Sata, Y., Wongpho, B., & Chankong, U. (2015). Development of a Learning activity management model with the community learning sources for environmental education. *International Forum of Teaching and Studies, 11*(1/2), 13.

Salmon, J. (2000). Are we building environmental literacy? *The Journal of Environmental Education, 31*(4), 4–10. https://doi.org/10.1080/00958960009598645

Sauvé, L., Brunelle, R., & Berryman, T. (2005). Influence of the globalized and globalizing sustainable development framework on national policies related to environmental education. *Policy Futures in Education, 3*(3), 271–283.

Sauvé, L. (1996). Environmental education and sustainable development: A further appraisal. *Canadian Journal of Environmental Education, 1*, 7–34.

Saylan, C., & Blumstein, D. (2011). *The failure of environmental education (and how we can fix it)*. Berkeley, California: University of California Press.

Schneider, R. J. (Ed.). (2000). *Thoreau's sense of place: Essays in American environmental writing*. Iowa city: University of Iowa Press.

Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick, New Jersey: Rutgers University Press.

Simmons, B., & Volk, T. (2002). Environmental educators a conversation with Harold Hungerford. *The Journal of Environmental Education*, *34*(1), 5–8.

Simmons, D. (1995). Working Paper #2: Developing a framework for national environmental education standards. In *Papers on the development of environmental education standards* (pp. 10-58). Rock Springs, GA: NAAEE.

Sobel, D. (2004). *Place-based education: Connecting classrooms & communities*. Barrington, MA: Orion Society.

Sohn, L. B. (1973). Stockholm declaration on the human environment. *Harvard International Law Journal, 14*(0), 423.

Spyropoulou, D., Koskolou, A., Mitsis, P., Paulikakis, G., & Fermeli, G. (2016*). Environmental and sustainability education curriculum.* Athens: Pedagogical Institute, Greek Ministry of Education (In Greek).

Spyropoulou, D., Mardiris, T., Stefanopoulos, N. (2012). Proceedings from the 6th PanHellenic Association for Environmental Education Conference: *The revised Environmental and Sustainability Education curriculum: Reading between the lines.* Thessaloniki, Greece: PEEKPE (In Greek).

Stables, A., & Scott, W. (2002). The quest for holism in education for sustainable development. *Environmental Education Research, 8*(1), 53–60.

Stables, A., & Bishop, K. (2001). Weak and strong conceptions of environmental literacy: Implications for environmental education. *Environmental Education Research, 7*(1), 89–97. https://doi.org/10.1080/13504620125643

St.Clair, R. (2003). Words for the world: Creating critical environmental literacy for adults. *New Directions for Adult and Continuing Education, 2003*(00), 69–78. https://doi.org/10.1002/ace.111

Stern, M. J., Powell, R. B., & D. Hill. (2014). Environmental education program evaluation in the new millennium: What do we measure and what have we learned? *Environmental Education Research, 20* (5), 581–611.

Stevenson, R. B. (2008). Tensions and transitions in policy discourse: Recontextualizing a decontextualized EE/ ESD debate. In A. Reid and W. Scott (Eds.), *Researching education and the environment: Retrospect and prospect* (pp. 31-44). London, UK: Routledge.

Stevenson, R. B. (2013). Researching tensions and pretensions in environmental/ sustainability education policies. In R. B. Stevenson, M. Brody, J. Dillon, A. E. Wals (Eds.), *International handbook of research on environmental education* (pp. 147-155). New York and London: Routledge.

Stokes, E., Edge, A., & West, A. (2001*). Environmental education in the educational systems of the European Union.* Final Report. Centre for Educational Research London School of Economics and Political Science. Commissioned by the Environment Directorate-General of the European Commission

Sullivan, G. M., & Feinn, R. (2012). Using effect size—or why the p value is not enough. *Journal of Graduate Medical Education, 4*(3), 279–282.

Talero de Husain, E. & Humaña de Gauthier, G. (1993). *Educaciónambiental – Capacitación de docentes de basica primaria* [Environmental education: A primary school teacher training program]. Ministerio de Agricultura, Instituto Nacional de los Recursos Naturales Renovables y del Ambiente.

Tanner, T. (1980). Significant life experiences: A new research area in environmental education, *Journal of Environmental Education, 11*(4), 20–24.

Teddlie, C., & Yu, F. (2007). Mixed methods sampling: A typology with examples. *Journal of Mixed Methods Research, 1*(1), 77–100.

Thomas, D. R., & Zumbo, B. D. (2012). Difference scores from the point of view of reliability and repeated-measures ANOVA: In defense of difference scores for data analysis. *Educational and Psychological Measurement, 72*(1), 37–43.

Thoreau, H. D. (Ed.) (1995). *Selections from the journals*. New York: Dover Publications.

Thoreau, H. D. (2013). *Complete works of Henry David Thoreau*. Hastings: Delphi Publishing.

Thoreau, H. D. (1878). *Walden*. Boston: James R. Osgood and Compary.

United Nations Educational, Scientific and Cultural Organization [UNESCO] (2002). *Decade of education for sustainable development*. http://unesdoc.unesco.org/images/0014/001416/141629e.pdf

UNESCO (1990a). *The Talloires Declaration.* http://www.ulsf.org/programs_tallories.html

UNESCO (1990b). *Environmental education*. UNESCO-UNEP International Environmental Education Program.

UNESCO. (1978). *Final report: Intergovernmental conference on environmental education.* https://unesdoc.unesco.org/ark:/48223/pf0000032763

UNESCO (1976). *Final report of the international workshop on environmental education*, Belgrade (Yugoslavia). https://unesdoc.unesco.org/ark:/48223/pf0000027608

UNESCO Institute for Statistics. (2012). *International standard classification of education: ISCED 2011*. UNESCO Institute for Statistics.

United Nations [General Assembly] (2014). *Open working group proposal for sustainable development goals* (A/68/970). New York, NY: United Nations Publications.

Vassiliou, I (2000). *The wild nature of Kalymnos*. Rhodes, Greece: 2nd high school of Kalymnos & Municipality of Kalymnos.

Volk, T., & McBeth, W. (1997). *Environmental literacy in the United States*. Washington, DC: North American Association for Environmental Education.

Webster, N. S. (2007). Sponge disease: a global threat?. *Environmental Microbiology*, *9*(6), 1363–1375.

Whitehead, A. L., Julious, S. A., Cooper, C. L. & Campbell, M. J. (2015). Estimating the sample size for a pilot randomised trial to minimise the overall trial sample size for the external pilot and main trial for a continuous outcome variable. *Statistical Methods in Medical Research, 25*(3), 1057–1073.

Wurdinger, S. D. (2005). *Using experiential learning in the classroom: Practical ideas for all educators*. Lanham, MD: Scarecrow Education.

Yanniris, C. & Garis, M. (2018). Crisis and recovery in environmental education: The case of Greece. In G. Reis & J. Scott (Eds.), *International perspectives on the theory and practice of environmental education: A Reader* (pp. 117-129). Cham, Switzerland: Springer Publisher.

Yanniris, C. (2016). Place-based learning as a catalyst for change. *Pathways: Ontario Journal of Outdoor Education, 29*(1), 11–15.

Yanniris, C. (2015). 20+ years of Environmental Education Centers in Greece: Teachers' perceptions and future challenges. *Applied Environmental Education & Communication, 14* (3), 149-166. http://dx.doi.org/10.1080/1533015X.2015.1067578

Appendix A: Correlation matrix of independent, dependent, and demographic variables

Two way correlations for variables of the pooled Grade 9 & 10 hypothesis testing sample [N=97].		preK	preA	preB	postK	postA	postB	ΔK	ΔA	ΔB	GPA	Gender	Maternal_Education_level	Past Exposure to Environmental Education (quaternary)	Current Exposure to Environmental Education
preK	Pearson Correlation	1	.490**	.188	.751**	.526**	.292**	-.177	.099	.215*	.509**	.042	.125	.067	.126
	Sig. (2-tailed)		.000	.075	.000	.000	.005	.087	.397	.045	.000	.683	.233	.521	.221
	N	96	88	90	95	81	91	95	75	87	91	96	93	94	96
preA	Pearson Correlation	.490**	1	.274*	.575**	.659**	.171	.216*	-.263*	.026	.605**	-.301**	.253*	.440**	.223*
	Sig. (2-tailed)	.000		.012	.000	.000	.119	.045	.022	.819	.000	.004	.019	.000	.036
	N	88	89	84	88	76	85	87	76	82	85	89	86	87	89
preB	Pearson Correlation	.188	.274*	1	.253*	.258*	.630**	.138	.025	-.159	.163	-.095	.083	.285**	.053
	Sig. (2-tailed)	.075	.012		.016	.023	.000	.197	.837	.140	.130	.369	.445	.007	.617
	N	90	84	91	90	78	86	89	72	88	87	91	88	89	91
postK	Pearson Correlation	.751**	.575**	.253*	1	.558**	.356**	.517**	.069	.241*	.551**	-.240*	.132	.253*	.245*
	Sig. (2-tailed)	.000	.000	.016		.000	.001	.000	.559	.024	.000	.019	.207	.014	.016
	N	95	88	90	96	81	91	95	75	87	91	96	93	94	96

postA	Pearson Correlation	.526**	.659**	.258*	.558**	1	.317**	.185	.552**	.150	.493**	-.276*	.134	.302**	.190
	Sig. (2-tailed)	.000	.000	.023	.000		.004	.101	.000	.194	.000	.012	.236	.006	.087
	N	81	76	78	81	82	79	80	76	77	77	82	80	80	82
postB	Pearson Correlation	.292**	.171	.630**	.356**	.317**	1	.153	.132	.599**	.269*	-.049	.085	.271**	.308**
	Sig. (2-tailed)	.005	.119	.000	.001	.004		.151	.263	.000	.011	.643	.428	.010	.003
	N	91	85	86	91	79	92	90	74	86	88	92	89	90	92
ΔK	Pearson Correlation	-.177	.216*	.138	.517**	.185	.153	1	-.016	.089	.152	-.399**	.044	.263*	.187
	Sig. (2-tailed)	.087	.045	.197	.000	.101	.151		.893	.417	.153	.000	.674	.011	.070
	N	95	87	89	95	80	90	95	74	86	90	95	92	93	95
ΔA	Pearson Correlation	.099	-.263*	.025	.069	.552**	.132	-.016	1	.095	-.022	-.065	-.051	-.077	-.032
	Sig. (2-tailed)	.397	.022	.837	.559	.000	.263	.893		.427	.856	.574	.664	.515	.785
	N	75	76	72	75	76	74	74	76	72	72	76	74	74	76
ΔB	Pearson Correlation	.215*	.026	-.159	.241*	.150	.599**	.089	.095	1	.142	-.030	-.046	.110	.269*
	Sig. (2-tailed)	.045	.819	.140	.024	.194	.000	.417	.427		.196	.780	.675	.311	.011
	N	87	82	88	87	77	86	86	72	88	84	88	85	86	88
GPA	Pearson Correlation	.509**	.605**	.163	.551**	.493**	.269*	.152	-.022	.142	1	-.236*	.206	.214*	.361**
	Sig. (2-tailed)	.000	.000	.130	.000	.000	.011	.153	.856	.196		.024	.053	.043	.000
	N	91	85	87	91	77	88	90	72	84	92	92	89	90	92

Gender	Pearson Correlation	.042	-.301**	-.095	-.240*	-.276*	-.049	-.399**	-.065	-.030	-.236*	1	-.104	-.291**	-.366**
	Sig. (2-tailed)	.683	.004	.369	.019	.012	.643	.000	.574	.780	.024		.317	.004	.000
	N	96	89	91	96	82	92	95	76	88	92	97	94	95	97
Maternal_Education_level	Pearson Correlation	.125	.253*	.083	.132	.134	.085	.044	-.051	-.046	.206	-.104	1	.107	.233*
	Sig. (2-tailed)	.233	.019	.445	.207	.236	.428	.674	.664	.675	.053	.317		.312	.024
	N	93	86	88	93	80	89	92	74	85	89	94	94	92	94
Outdoor_Experience	Pearson Correlation	.325**	.401**	.517**	.231*	.292*	.343**	-.097	-.036	-.085	.196	.039	-.003	.179	-.039
	Sig. (2-tailed)	.003	.000	.000	.036	.013	.002	.388	.773	.468	.081	.728	.979	.107	.727
	N	83	76	78	83	72	80	82	66	75	80	84	83	82	84
Past_Exposure_to_EE_quter	Pearson Correlation	.067	.440**	.285**	.253*	.302**	.271**	.263*	-.077	.110	.214*	-.291**	.107	1	.371**
	Sig. (2-tailed)	.521	.000	.007	.014	.006	.010	.011	.515	.311	.043	.004	.312		.000
	N	94	87	89	94	80	90	93	74	86	90	95	92	95	95
Current_Exposure_to_EE	Pearson Correlation	.126	.223*	.053	.245*	.190	.308**	.187	-.032	.269*	.361**	-.366**	.233*	.371**	1
	Sig. (2-tailed)	.221	.036	.617	.016	.087	.003	.070	.785	.011	.000	.000	.024	.000	
	N	96	89	91	96	82	92	95	76	88	92	97	94	95	97

Appendix B: Skew in experimental groups and subgroups

Skew (adjusted Fisher-Pearson standardized moment coefficient)	pre K	pre A	pre B	post K	post A	post B
Pooled Grade 9 & 10 Treatment group (n=49)	0.1303	-0.0264	0.7057	0.2364	-0.5029	0.1621
Pooled Grade 9 & 10 Control group (n=48)	0.5968	-0.3508	0.8017	0.5155	-1.123	0.81234
Grade 9: Treatment group (n=27)	0.4027	-0.4323	0.4894	0.3920	-1.1510	0.9776
Grade 9: Control group (n=35)	0.3991	-0.7880	0.4315	0.2377	-1.2814	0.1075
Grade 10: Treatment group (n=22)	-0.0644	0.3179	0.8465	0.2600	0.4038	0.2244
Grade 10: Control group (n=13)	0.5768	0.2562	1.1357	0.1040	-2.9282	-0.9629

Appendix C: Translated GELI (Greek Environmental Literacy Instrument).

Part 1: Behavior

Instructions: Read carefully and then encircle the most appropriate answer. All answers are valid.

17. Before I buy a product I check to see if it has the symbol of recycling on it.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
19. When I find litter in public places (pavement, park, the beach) I collect these and throw away in the rubbish bin.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
20. I take part in campaigns for the cleaning up of public spaces.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
21. I intervene when I note that someone is actively harming the environment and try to talk him out of his behavior.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
23. I report to the media and/or the authorities about violations of the environmental code.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
25. I sign paper or on-line petitions on environmental issues.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
26. I complain to the local mayor and try to get him/ her employ measures for the protection of the local environment.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
27. I take part in campaigns to avert environmental degradation (protests, sit-ins, tree planting).	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
28. I participate in events where topics such as pedestrian walks, bike lanes and sources of pollution are discussed.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
29. I give money or my time to NGOs or other environmental protection organizations.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
30. I help to create recycling bins in my school.	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**

Part 2: Knowledge

Instructions. Encircle the correct answer for each one of the following questions. There is only one correct answer for each question. If you do not know the answer, encircle choice e): "I don't know".

---

1) Oxygen in the atmosphere comes primarily from

a) insects **b)** plants **c)** the soil **d)** the sun **e)** I don't know

2) Which of the following is considered <u>less</u> responsible for the greenhouse effect?

a) Destruction of forests on the planet.

b) The use of fossil fuels such as gasoline.

c) The use of hydroelectric power plants.

d) The great extent of agriculture and livestock on Earth.

e) I don't know.

3) Which of the following is a possible <u>result</u> of the accumulation of greenhouse gases in the atmosphere?

a) The decrease of CO_2 in the atmosphere.

b) The decrease of the sea level.

c) The movement of the Sahara Desert towards the south.

d) The increase of extreme weather phenomena.

e) I don't know.

4) The following substance(s) cause the depletion of the ozone layer when released

a) water vapor **b)** CO_2 **c)** SO_2 **d)** Cl^- and Br^- **e)** I don't know

5) The ozone layer depletion is considered an important environmental problem because it causes…

a) atmosphere gases to escape from the planet.

b) increase of harmful radiation that reaches the surface of the planet.

c) the shrinking of the Black Sea.

d) devastating earthquakes.

e) I don't know.

6) The main source of air pollution in the urban centres of the country (Athens, Thessaloniki and Patra) comes from…

a) vehicles.

b) burning of waste in illegal dump yards.

c) industrial units.

d) petroleum refineries.

e) I don't know.

7) Which of the following environmental problems is <u>not</u> caused by air pollution?

a) The increased acidity of lakes.

b) The corrosion of the Parthenon marbles.

c) The increase of respiratory problems within the population.

d) The increase of organic material in aquatic ecosystems.

e) I don't know.

8) The main source of acid rain is…

a) volcanic activity.

b) decomposing of organic material.

c) use of fossil fuel.

d) aerosols and refrigerants

e) I don't know.

9) The original source of energy for almost all living things is…

a) the soil **b)** the plants **c)** the sun **d)** oxygen **e)** I don't know.

10) A dead bird is decomposing. What happens to the energy that was stored in the bird's body?

a) Nothing happens to it. Once the bird is dead the energy is lost.

b) It passes through the organisms that decomposed the bird.

c) It is destroyed by solar radiation.

d) The bird used up its energy when it was alive.

e) I don't know.

11) Which of the following would give humans the most food energy from 500 kilos of edible plants?

a) Feed the plants to insects, feed the insects to fish, and then humans eat the fish.

b) Humans eat the plants.

c) Feed the plants to cattle then humans eat the cattle.

d) Feed the plants to fish then humans eat the fish.

e) I don't know.

12) Given the present pace of consumption, the global resources of coal, oil and natural gas…

a) will never be exhausted.

b) will become exhausted at some point.

c) will replenish.

d) Coal and oil will be exhausted while natural gas will not.

e) I don't know.

13) Which of the following is a <u>non</u>-renewable form of energy?

a) Natural gas.

b) Geothermic energy.

c) Eolic energy.

d) None of the above.

e) I don't know.

14) In Greece electricity production s primarily based on…

a) combustion of coal and petroleum .

b) combustion of natural gas.

c) solar and Eolic energy.

d) hydropower.

e) I don't know.

15) The total sum of water on the planet…

a) is increasing **b)** is decreasing **c)** remains the same **d)** has recently started to decrease **e)** I don't know.

16) What is the main source of pollution for the rivers, lakes and wetlands of Greece;

a) Domestic waste.

b) Acid rain.

c) Agricultural waste.

d) Industrial waste.

e) I don't know.

17) Pollution of Asopos river (Voiotia prefecture) is caused by…

a) domestic waste.

b) industrial waste.

c) agricultural waste

d) touristic development.

e) I don't know.

18) Phosphoric fertilizers are being used in gardens and agriculture. What happens when the phosphoric compounds end up in a lake?

a) The fish of the lake are poisoned.

b) There is an increase of algae.

c) Nothing special happens.

d) The lake glows in the dark.

e) I don't know.

19) The eutrophication of an aquatic ecosystem can be caused by…

a) radioactive waste of nuclear factories.

b) petroleum leaks.

c) heavy metals in industrial waste.

d) overuse of fertilizers in agriculture.

e) I don't know.

20) The largest freshwater consumer in Greece is…

a) industry. **b)** agriculture. **c)** households. **d)** municipal parks. **e)** I don't know.

21) Within households, most water is consumed in…

a) the kitchen (cooking and dish washing).

b) the washroom (toilet and bath tub).

c) the laundry machine.

d) the iron.

e) I don't know.

22) Soil erosion…

a) is a major problem because the soil is usually filled with worms can not survive without it.

b) is a major problem because the soil is regenerated very slowly, so high levels of erosion may lead to permanent loss of vegetation in that area.

c) is a major problem because topsoil is necessary for the flow of groundwater. Erosion pollutes the underground reservoirs and humans can not have access to potable water.

d) is not a major problem, because the soil is quickly replenished.

e) I don't know.

23) Which of the following may cause soil erosion?

a) Use of fertilizers and artificial nutrients.

b) Deforestation

c) Cultivation with land benches

d) Overpopulation of land worms

e) I don't know.

24) Scientific reports have assessed that 35% of Greece is under desertification pressures. Which of the following phenomena is <u>not</u> a desertification factor for a Mediterranean ecosystem?

a) Climate change.

b) Overgrazing.

c) Bioaccumulation.

d) Wildfires.

e) I don't know.

25) Which of the following statements regarding an ecosystem is correct?

a) Energy within an ecosystem is recycled.

b) Matter within an ecosystem is recycled.

c) Both matter and energy are recycled within an ecosystem.

d) The quantity of available food is the only factor that determines the size of natural populations.

e) I don't know.

26) Two (2) abiotic components of an ecosystem could be…

a) bacteria and temperature.

b) water and soil.

c) lichens and soil.

d) temperatures and plants.

e) I don't know.

27) A polluter enters an ecosystem and kills a large number of insects. How can this affect the ecosystem?

a) Since it does not harm the plants, it does not affect the ecosystem.

b) Since it destroys part of the ecosystem, it places the whole ecosystem under risk.

c) Since it kills only insects, other animals will not be affected.

d) Most animals feed on plants, thus the ecosystem is not affected in a substantial way.

e) I don't know.

28) Some people wanted to act in order to protect deer in a forest. They thought it would be a good idea to kill out the wolves. Ten years after, wolves disappeared from the forest and soon the deer population boomed. Then, suddenly, all the deer all but disappeared. The people who wanted to protect the deer ignored that…

a) deer only live a few years.

b) forest fires killed most of the deer.

c) deer compete with other animals for their nutrition.

d) the deer ate all the available food and then starved.

e) I don't know.

29) A forest's falling leaves and small branches do not pile up over the years because…

a) abiotic components such as rain and wind carry these away.

b) decomposers break them down and their inorganic components return to the soil.

c) these are eaten by animals and used to build their nests.

d) None of the above.

e) I don't know.

30) The following food chain occurs in a pond:

Sun → green algae → small crustaceans → fish

Over the winter the surface of the pond froze and was covered with snow. Subsequently, most of the small crustaceans died out. Hat is the most plausible explanation?

a) The green algae were cut off from their source of energy.

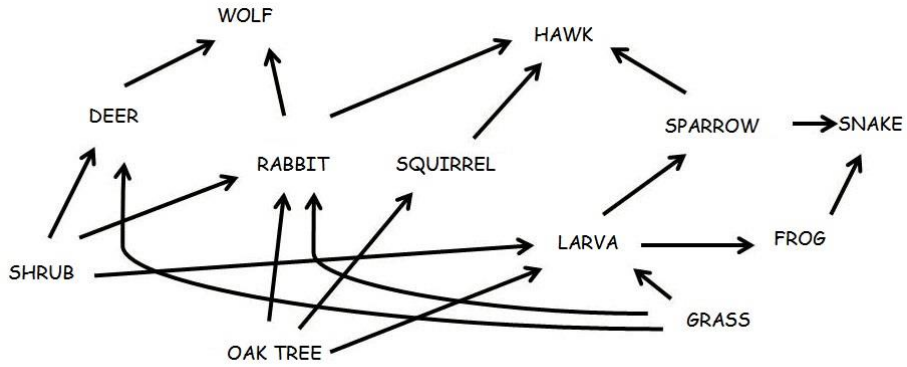
b) The small crustaceans could not survive the cold.

c) The fish ate most of the small crustaceans.

d) Most of the green algae were wiped out by disease.

e) I don't know.

32) What will happen in this ecosystem if all the larvae die because of insecticide overuse?



a) Bushes, oak trees and grass will disappear.

b) The population of frogs and sparrows will increase dramatically.

c) Frogs, sparrows and snakes will disappear.

d) The entire ecosystem will collapse.

e) I don't know.

31) The tree of Ailanthus altissima originates from China and was transplanted in the royal gardens of Athens at the times of king Otto. It is also referred upon as stinky willow because of the acute smell of its flowers. Recently, the green cover in the centre of Athens in gardens, flower beds, rubble, along highways, even between sidewalk slabs, marble and archaeological sites has increased significantly due to the large spread of Ailanthus. What do you think should be done?

a) These trees must be uprooted because Ailanthus has no natural enemies and will spread out of control.

b) We must maintain these trees because they are evergreen, create shade, produce oxygen and therefore is best suited for a region such as the urban environment of Athens.

c) These trees must be uprooted because they stink.

d) This tree has no place in Greece since it originates from China.

e) I don't know.

33) Every organism decomposes after its death. As a result, nutrients:

a) Are released back in the environment to be recycled.

b) Are destroyed by decomposing bacteria.

c) Are transformed to oxygen and water which evaporate.

d) Evaporate because of the heat that is produced during the decomposing process.

e) I don't know.

34) Why is the decrease of biodiversity such a great problem?

a) Because before the advent of humans, species did not become extinct.

b) Because humans are part of biodiversity and they could also face extinction along with so many other species.

c) Because life on Earth will be wiped out as a result of the decrease of biodiversity.

d) Because there will be less available water.

e) I don't know.

35) The rate of species extinction today is comparable with that of the time when dinosaurs became extinct. The <u>main cause</u> of this drop in biodiversity is…

a) the destruction of natural habitats by human activities.

b) pollution.

c) changes in the Earth's atmosphere as a result of human activities.

d) hunting.

e) I don't know.

36) What is the most important service that wetlands provide?

a) Wetlands propagate flooding.

b) Wetland ecosystems contribute to the cleaning of the water before it enters lakes and the sea.

c) Wetlands avert the overpopulation of unwanted plants and animals.

d) Wetlands are useful as dumps and landfills.

e) I don't know.

37) Which of the following is a possible consequence from the destruction of the planet's forests?

a) The dramatic increase of biodiversity.

b) Lessening chance that we will find the cure for life-threatening diseases.

c) The dramatic increase of wood stock for the future needs of heating, furniture and construction.

d) Less often extreme weather phenomena (cyclones, heat waves, flooding, droughts).

e) I don't know.

38) What does this green symbol in packaging stand for?

a) This packaging is recyclable.

b) This packaging is made of recyclable material.

c) The producer has made a financial contribution towards the recovery and recycling of packaging.

d) This packaging can be composted.

e) I don't know.

39) Which of the following statements concerning waste management <u>in Greece</u> is accurate?

a) A decrease has been noted in our country in the percentage of waste that is being recycled.

b) Except from the official landfills, a number of illegal dumps are known to operate in Greece.

c) Our country has no legal framework in place concerning the optimal management of waste.

d) The technology of energy production from waste has recently kicked off in Greece.

e) I don't know.

40) In the long run, which would be the optimal solution for the reduction of waste production?

a) Incineration.

b) Reduction of consumption.

c) Reuse.

d) Recycle.

e) I don't know.

41) Which of the following does not decompose in nature?

a) paper **b)** petrol **c)** cotton clothes **d)** synthetic polymers **e)** I don't know.

42) Sustainable development is…

a) the kind of development that exclusively promotes renewable energy sources.

b) any kind of development that promotes economic growth in a country.

c) all kinds of technological development that provide new resources or alternatives to an exhausted resource.

d) the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs

e) I don't know.

Part 3: Demographics

1a. Name _____

1b. Gender

Boy ☐ Girl ☐

2. Age: _____ **3.** Place of Birth _____

4. Place of permanent residence → Prefecture: _____ Municipality: _____

5. Schools attended (e.g. 5th High School of Kavala)

Primary: _____

Secondary: _____

Lyceum: _____

6. Direction of Studies: ☐ Classical ☐ Positive ☐ Technological

7. Last Year's Graduation Grade: _____ (roughly if you do not recall accurately)

8. Semester of attendance _____

9. What is the **highest** educational degree of your parents?

a. Father		b. Mother
☐	Primary school	☐
☐	High School	☐
☐	Lyceum	☐
☐	Bachelor's (Minor)	☐
☐	Bachelor's (Major)	☐
☐	Master's	☐
☐	PhD	☐

11. To what extent do you think that **your parents** are environmentally sensitized?

Encircle the appropriate answer:

Father:	not at all	slightly	much	greatly
Mother:	not at all	slightly	much	greatly

12. Are you or have you been a member of Boy/Girl Guides or Scouts?

Yes ☐ No ☐

13. How often **<u>do you or did you</u>** engage in the following activities over **<u>a single year</u>**?

• **Hiking**	not at all	1-2	3-4	6-8	10 and more
• **Fishing**	not at all	1-2	3-4	6-8	10 and more
• **Shopping in the mall**	not at all	1-2	3-4	6-8	10 and more
• **Sleep in a tent**	not at all	1-2	3-4	6-8	10 and more
• **Hunting**	not at all	1-2	3-4	6-8	10 and more
• **Nature photography**	not at all	1-2	3-4	6-8	10 and more
• **Biking**	not at all	1-2	3-4	6-8	10 and more
• **Team sport**					
(football, basketball, etc)	not at all	1-2	3-4	6-8	10 and more
• **Other sport: _____**	not at all	1-2	3-4	6-8	10 and more

14. Did you have in your life a specific figure (relative, writer, environmentalist/ ecologist, mythological hero, comic character, political leader, teacher, actor or else) who has positively impacted you with respect to the environmental cause? If yes who is [s]he?

_____

15. Are **you** or someone else in your family a **member** of an environmental or conservation organization, society, club or NGO (e.g. Greenpeace, WWF, MOM, Arcturus, Hellenic Ornithological Society, Archelon, MedSOS etc)?

NO ☐ YES ☐ If yes, which? _____

16. To what extent do you think that the following factors have contributed to your present environmental **knowledge**? Encircle the appropriate answer.

Family and friends	not at all	to a moderate extent	to a large extent	to a great extent
School	not at all	to a moderate extent	to a large extent	to a great extent
Television	not at all	to a moderate extent	to a large extent	to a great extent
Radio	not at all	to a moderate extent	to a large extent	to a great extent
Internet	not at all	to a moderate extent	to a large extent	to a great extent
Books, newsp. & journals	not at all	to a moderate extent	to a large extent	to a great extent

17. Do you think that specific events and experiences in your life have impacted on your interest or sensitivity on environmental issues? If yes, describe these events and at what age of yours did they happen.

Part 4: Environmental Sensitivity

Instructions: Read carefully and then encircle the most appropriate answer. All answers are valid.

1. It is not necessary to preserve the planet's natural resources because there will always be alternative ways.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
2. People severely maltreat the natural environment.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
3. I think that the "global environmental crisis" is an overstatement.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
4. Plants and animals are meant to be used by humans.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
5. People have responsibilities and ethical duties towards fellow human beings.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
6. People have responsibilities and ethical duties towards animals.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
7. People have responsibilities and ethical duties towards plants.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
8. People have responsibilities and ethical duties towards abiotic environmental components (e.g. rocks, water, atmosphere).	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
9. I am eager to buy less products each month, in order to alleviate environmental degradation.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
10. I am eager to ask from people who do not recycle to start segregation of waste in their houses.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
11. In order to save energy, I am eager to buy economy lamps and also close the light every time I step out of a room.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
12. I am eager to walk and use mass transport (even if I have a car) in order to help improve air quality.	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree