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Future Greek Pre-Service Teachers' Knowledge, Attitudes and Self-Efficacy in Waste Management

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Abstract*: This quantitative survey examined the knowledge, attitudes, perceived competence, willingness and everyday practices of 46 final-year pre-service teachers at Democritus University of Thrace (Greece) in relation to solid waste and wastewater management. Using a structured questionnaire, the study shows familiarity with most key waste terms, confidence to implement Environmental Education Programmes (EEPs) and personal recycling habits. Findings show basic literacy yet sizeable gaps in technical concepts (like Residual-waste landfills and Wastewater Treatment Plants. Perceived competence was moderate-to-low, particularly for wastewater, whereas willingness to participate in EEPs remained high. Common household recycling was stated as frequent, but specialised actions such as medicine, used-oil recycling or composting were rare. The enthusiasm–competence gap underscores the need for practical, skills-focused training in teacher preparation, enabling future educators to motivate effectively waste-management behaviours.*

Keywords: pre-service teachers; Waste management; Environmental education; Perceived competence; Greece

INTRODUCTION

Humanity faces an escalating environmental crisis, with waste management emerging as one of the most pressing challenges of the modern era (Baud et al., 2001; Morrissey & Browne, 2004). The accumulation of waste has severe environmental, social, and economic consequences, threatening ecosystem health and human quality of life. In this context, education is recognized as a critical factor for promoting sustainable development and shaping citizens with environmental awareness and responsibility (Hopkins & McKeown, 2002; Gomatos et al., 2018).

Environmental Education (EE) and Education for Sustainable Development (ESD) are fundamental pillars for cultivating environmental literacy from an early age. Early childhood and primary education are crucial periods for developing environmental attitudes and

behaviors, as children at these ages are particularly receptive to new knowledge and values (Karachalios & Manesis, 2025; Nadakavukaren & Caravanos, 2020). Consequently, educators working at these levels play a pivotal role as agents of change, shaping the environmental perceptions of future generations. The effectiveness of environmental education largely depends on the adequacy and readiness of teachers to teach these subjects (Morrissey & Browne, 2004).

In Greece, environmental education has been integrated into the educational system; however, its implementation is often characterized as optional and fragmented (Moshou & Drinia, 2025). Despite legal provisions and increasing public concern about climate change, challenges persist, such as limited funding, fragmented content in textbooks, and inadequate legislation, hindering systematic and uniform application (Moshou & Drinia, 2025). This situation makes it even more imperative to examine the readiness of future teachers to fulfill this important role. Understanding the knowledge levels, attitudes, and perceived competence of pre-service teachers is essential for designing effective curricula that will adequately prepare them.

This study aims to fill a research gap in Greek literature by focusing on the knowledge, attitudes, and perceived competence of future primary education teachers in Greece regarding waste management. Specifically, the objectives of the study are:

- To assess the knowledge level of future primary education teachers concerning terminology and principles of solid waste and wastewater management.
- To investigate their attitudes towards key waste management strategies and the prioritization of their importance.
- To evaluate their perceived competence and willingness to implement and organize environmental education programs related to waste management.
- To identify their self-reported practices in waste management and their perceived level of information.

The structure of this article includes the introduction, literature review, methodology description, presentation of results, analysis and discussion of findings, and finally, conclusions and recommendations for future research.

LITERATURE REVIEW

In this section, a review of existing literature on environmental education, waste management, and teacher training is provided, incorporating the specified references and additional contemporary articles.

THEORETICAL FRAMEWORKS OF ENVIRONMENTAL EDUCATION AND WASTE MANAGEMENT KNOWLEDGE

Environmental literacy is a complex construct encompassing not only knowledge but also the attitudes, skills, and behaviors required for responsible interaction with the environment (Hopkins & McKeown, 2002). Education for Sustainable Development (ESD) aims to cultivate critical thinking, value analysis, and active citizen participation in environmental issues (Buckler & Creech, 2014; Hopkins & McKeown, 2002). However, the experience of environmental education has shown that simple awareness and knowledge are insufficient to induce behavioral changes, as individuals also need skills and inspiration from values that support this knowledge and awareness (Doulami & Dimitriou, 2025).

A fundamental framework in waste management is the waste management hierarchy, which proposes a series of priorities for reducing environmental impacts: reduction (minimization), reuse, recycling/composting, energy recovery, and finally, disposal (landfilling) (European Commission, 2020; Eurostat, 2016). Understanding and applying this hierarchy is crucial for effective and sustainable waste management.

CURRENT STATE OF WASTE MANAGEMENT EDUCATION IN GREECE

In Greece, environmental education, although supported by legislative frameworks, often remains optional and fragmented within the educational system (Moshou & Drinia, 2025). Research indicates that despite the existence of Environmental and Sustainability Education Centers (KEPEA, formerly CPE) across the country, the full integration of EE into the compulsory education system has not been achieved (Moshou & Drinia, 2025). Despite the fact that EE is combatible with the most recent and innovative approaches, still is not officially part of the curriculum (Kougias et al., 2023). Challenges include economic constraints affecting infrastructure funding and teacher training, as well as an ambiguous legislative framework leading to inconsistent application in educational institutions (Moshou & Drinia, 2025). This situation often leads environmental education to rely on the initiative of individual schools and teachers, limiting the potential for long-term behavioral changes and addressing fundamental knowledge deficits (Karachalios & Manesis, 2025).

However, recent developments show a push towards more systematic integration. From the school year 2024-2025, the "Active Citizen Actions" program, which integrates the 17 Sustainable Development Goals (SDGs), is being implemented across all grades of Primary and Secondary Education in Greece. This program aims to develop critical thinking, collaboration, and social responsibility skills, contributing to a sustainable society (Eurydice, 2025b). Within primary education, subjects like "Study of the Environment" and "Skills Labs" include thematic units such as "I take care of the Environment," supported by KEPEA (Eurydice, 2025a). Despite these efforts, the formal inclusion of waste education remains limited, often relying on individual initiatives (Karachalios & Manesis, 2025).

KNOWLEDGE AND ATTITUDES OF STUDENTS AND TEACHERS TOWARDS WASTE MANAGEMENT IN GREECE

Previous studies in Greece have revealed significant findings regarding the knowledge and attitudes of students and teachers. Research on high school students in Greece showed lower knowledge levels regarding waste management concepts compared to UK students (Karachalios et al., 2021). Specifically, only 57.7% of Greek students reported understanding terms like "Paper Recycling," "Kerbside collection," "Composting," "Incineration," and "Landfill," compared to 80.5% of UK students (Karachalios et al., 2021). Greek students also reported recycling less frequently and attributed less importance to waste management concepts (Karachalios et al., 2021).

A subsequent study on secondary education teachers in Greece found that teachers had a moderate to low ability to implement waste management educational activities and a limited understanding of management principles (Karachalios, Plakitsi, et al., 2023). A significant percentage (39.2%) incorrectly prioritized recycling over waste minimization, with only 11.1% correctly ranking minimization as the most important action (Karachalios, Plakitsi, et al., 2023). This suggests a widespread misunderstanding of the most effective waste management

strategies, possibly due to public campaigns overemphasizing recycling without sufficient focus on reduction.

Comparative research between secondary education teachers and students in Greece confirmed that students had significantly lower knowledge levels for waste management concepts compared to their teachers (Karachalios, Kalavrouziotis, et al., 2023). Only 55.25% of students knew terms like "Paper Recycling" and "Landfill," while for teachers, the percentage was 88.65% (Karachalios, Kalavrouziotis, et al., 2023). This indicates a systemic issue in environmental education across Greek educational levels.

A study on primary school students in Greece, though a future publication, has already highlighted initial knowledge gaps, especially concerning sustainability and organic waste (Karachalios & Manesis, 2025). However, targeted educational interventions significantly improved their understanding, particularly in linking sustainability to economic, social, and environmental factors, and fostered a sense of personal responsibility for waste reduction (Karachalios & Manesis, 2025). This highlights the need for practical, experiential interventions in primary education, which future teachers will be expected to implement.

TEACHER TRAINING AND EDUCATIONAL RESOURCES FOR SUSTAINABILITY

Pre-service teacher training in environmental education is vital for preparing them to effectively teach their students about environmental sustainability and management (Damoah & Omodan, 2023). Although teachers often begin their careers unprepared for the task of empowering individuals to make sound environmental decisions, integrating environmental education into teacher training programs can equip them with the necessary knowledge and skills (Damoah & Omodan, 2023). Research indicates that despite positive attitudes, pre-service teachers often have low environmental knowledge and limited participation in environmental actions, highlighting the need to improve EE themes and integrate them into all pre-service and in-service training courses (Damoah & Omodan, 2023).

Regarding educational resources, the creation and utilization of Open Educational Resources (OER) have emerged as effective tools for education in sustainable development. A study describes the construction and implementation of an OER on sustainability issues in vocational education, with results indicating that OER can be an excellent learning tool (Armakolas et al., 2019). This underscores the potential for innovative educational tools in teacher training. Furthermore, the use of educational gamification is recognized as a novel approach to fostering environmental awareness. A study on using educational games to promote sustainability awareness in corporate settings showed that gamification can be an effective tool for enhancing environmental culture and increasing awareness (Karachalios, 2024). These modern pedagogical approaches can contribute to more effective preparation of future teachers.

The literature review demonstrates that while the critical role of environmental education is recognized, significant gaps exist in the knowledge and practices of both students and in-service teachers in Greece. This suggests that future primary education teachers may exhibit similar or even greater gaps in specific, technical waste management terms. If this study reveals low perceived competence or a discrepancy between willingness and ability, it will directly indicate the need to integrate practical training and innovative tools (such as OER and gamification) into the curriculum of Democritus University of Thrace. The importance of waste management education in primary schools is also highlighted, as schools serve as role models and can

significantly influence the waste habits of future generations, offering hands-on learning opportunities for sustainability (Aegis, 2025).

METHODOLOGY

The study adopted a quantitative, descriptive survey approach, which is considered appropriate for investigating the current state of knowledge, attitudes, and practices in the specific population of students and future primary education teachers.

PARTICIPANTS

The sample comprised 46 final-year students (43 F / 3 M) from the Department of Early Childhood Education Sciences, Democritus University of Thrace. All were informed of the study aims and provided written consent. Ethical approval was granted by the DUTh Ethics Committee (Ref. EES/2025/04-17).

Table 1. Demographic Characteristics of Participants

Variable	Category	Frequency (n)	Percentage (%)
Gender	Female	43	93.5
	Male	3	6.5
Specialization in Environmental Education	No	44	95.7
	Yes	2	4.3
Education/Training on Waste Management Issues	No	29	63.0
	Yes	16	34.8
	Not sure	1	2.2

As shown in Table 1, most participants were female (93.5%), reflecting the demographic composition of this department, as it is shown in other studies in Greece too (Goulgouti et al., 2019). It is also significant that most students (95.7%) did not have any specialization in Environmental Education (Maidou et al., 2019; Malandrakis, 2018), and 63% had not received any form of education or training on waste management issues (Goulgouti et al., 2019; Karachalios, Plakitsi, et al., 2023). These demographic data provide a crucial context for interpreting the results, as they suggest that the sample primarily consists of students with limited prior formal exposure to environmental and waste management topics.

REASEARCH INSTRUMENT

A structured questionnaire was used to collect data, designed to assess participants' knowledge, attitudes, perceived competence, willingness, and practices regarding waste management (both solid but also wasterwater). The questionnaire was developed by adapting and refining a subset of items of a previous study to record in-service secondary teachers' views on wastewater and

solid-waste management (Karachalios, Plakitsi, et al., 2023), thereby ensuring conceptual continuity with earlier work.

Before deployment, each item was weighted through a three-step psychometric procedure—expert-panel scoring to compute the Content Validity Ratio, a pilot study (n = 10) that produced a satisfactory Cronbach's $\alpha = 0.84$ for internal consistency, and exploratory factor analysis to confirm unidimensionality—thus establishing both validity and reliability in accordance with established guidelines (Cronbach, 1951; DeVellis & Thorpe, 2021). It is important to note that, this questionnaire focuses on directly measuring knowledge, attitudes, competence and practices.

The questionnaire consisted of the following sections, with updated question numbering based on the provided data file:

- **Demographic Information:** Included questions on gender and previous education/training on waste management issues.
- **Perceived Competence:** Four questions assessed the perceived ability to implement/teach Environmental Education Programs (EEPs) related to solid waste and wastewater management, using a 5-point Likert scale (1=Not at all, 2=Little, 3=Moderately, 4=Quite a lot, 5=Very much).
- **Willingness:** Four questions explored the willingness to participate in or organize EEPs for solid waste and wastewater, with options "Yes," "No," "Not sure".
- **Knowledge of Terminology:** A list of 13 terms related to waste management (e.g., Paper Recycling, Composting, Landfills, Sewage, Biological Treatment, Wastewater Treatment Plants (WWTP)) was given to participants. Each term was evaluated with options such as "I have heard of it and know what it means," "I have heard of it, but do not know what it means," and "I have never heard of it". Detailed analysis of these terms allows for precise identification of specific knowledge areas needing improvement.
- **Knowledge towards Management Principles:** Six statements regarding the definition of waste, incineration, landfilling, stormwater, and industrial wastewater treatment were evaluated on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree).
- **Prioritization of Management Options:** Participants were asked to hierarchically rank four waste management options (Recycling/Composting, Reuse, Energy Recovery/Production, Minimization) from 1 (most important) to 4 (least important).
- **Frequency of Personal Practices:** Ten items related to the frequency of recycling various materials (paper, glass, aluminum, batteries, electrical/electronic waste, medicines, light bulbs, used oil, clothes) and composting. Responses ranged from "Never" to "Whenever possible". Analysis of this data can reveal discrepancies between knowledge and practice, indicating potential barriers to implementing sustainable behaviors.
- **Self-assessed Level of Information:** Four statements on how informed participants considered themselves to be about recycling, composting, solid waste and wastewater issues, using a 5-point Likert scale. Comparing this data with actual knowledge is crucial for identifying potential overestimation of knowledge.

DATA COLLECTION

The questionnaire was administered to the 46 final-year students of the Department of Early Childhood Education Sciences at Democritus University of Thrace. Data collection was conducted electronically via the Google Forms platform.

DATA ANALYSIS

Data were entered and analyzed using IBM SPSS Statistics software. For the description of responses to each question, descriptive statistics such as frequencies, percentages, means, and standard deviations were calculated. For ranking questions, the mean ranks were calculated. Qualitative data from the open-ended question at the end of the questionnaire were examined for common themes.

RESULTS

The data analysis from the 46 final-year students of the Department of Early Childhood Education Sciences at Democritus University of Thrace is presented in the following subsections.

PERCEIVED COMPETENCE AND WILLINGNESS TO IMPLEMENT/ORGANIZE ENVIRONMENTAL PROGRAMS

Student responses regarding their perceived competence to implement or teach EEPs and their willingness to participate in or organize such programs are presented in Table 2.

Table 2. Perceived Competence and Willingness of Future Teachers

Question	Mean (1-5)	Standard Deviation	Not at all (%)	Little (%)	Moderately (%)	Quite a lot (%)	Very much (%)
Competence to implement solid waste EEP	2.50	1.01	13.0	32.6	28.3	21.7	4.3
Competence to implement wastewater EEP	1.96	0.93	26.1	41.3	23.9	8.7	0.0
Competence to teach solid waste course	2.39	0.99	15.2	37.0	30.4	15.2	2.2
Competence to teach wastewater course	1.93	0.90	28.3	41.3	23.9	6.5	0.0
			Yes (%)	**No (%)**	**Not sure (%)**		

Willingness to participate in solid waste EEP			65.2	10.9	23.9		
Willingness to organize solid waste EEP			39.1	30.4	30.4		
Willingness to participate in waste EEP			52.2	21.7	26.1		
Willingness to organize wastewater EEP			34.8	34.8	30.4		

The results indicate that students' perceived competence in implementing and teaching EEPs is generally moderate to low, especially for wastewater (mean scores below 2.0). For example, 26.1% of students felt "Not at all" competent to implement wastewater EEPs, and 28.3% "Not at all" competent to teach related courses. This suggests that, despite their educational background, future teachers do not feel adequately prepared for the practical application of environmental education in these areas.

However, the willingness to participate in EEPs is significantly higher than the willingness to organize them. 65.2% stated "Yes" for participating in solid waste EEPs, while only 39.1% for organizing them. This difference suggests that students are motivated to contribute to environmental education but may lack the necessary skills or confidence to take a leading role in designing and implementing such programs. The presence of high willingness combined with moderate to low perceived competence highlights the need for practical and experiential training that will enhance the confidence and skills of future teachers. Similar findings were found in other study too (Karachalios, Plakitsi, et al., 2023)

Familiarity and Understanding of Waste Management Terminology

Table 3 presents the level of familiarity and understanding of the 13 waste management terms by the participants.

Table 3. Familiarity and Understanding of Waste Management Terminology

Term	I have heard of it and know what it means (%)	I have heard of it, but do not know what it means (%)	I have never heard of it (%)
Paper Recycling	100.0	0.0	0.0
Composting	80.4	17.4	2.2
Waste Collection System	84.8	13.0	2.2
Sanitary Landfills	69.6	28.3	2.2
Residual Waste Landfills	39.1	47.8	13.0
Waste	93.5	6.5	0.0
Refuse/Garbage	93.5	6.5	0.0
Municipal Solid Waste	60.9	34.8	4.3
Inert Waste	41.3	37.0	21.7
Wastewater	82.6	17.4	0.0
Sewage	80.4	19.6	0.0
Biological Treatment	84.8	15.2	0.0
Wastewater Treatment Plants (WWTP)	50.0	45.7	4.3

The results show that students have a high level of understanding for common terms such as "Paper Recycling" (100%), "Waste" (93.5%), and "Refuse/Garbage" (93.5%). However, significant gaps are observed in more technical and specialized terms. Specifically, only 39.1% know what "Residual Waste Landfills" means, 41.3% "Inert Waste," and 50.0% "Wastewater Treatment Plants (WWTP)". A significant percentage (over 45%) has heard of Residual Waste Landfills and Wastewater Treatment Plants but does not know their meaning. This suggests that exposure to these terms is limited, or understanding is not in-depth, which is crucial for future teachers who will be expected to teach comprehensive waste management topics. The existence of these gaps in more technical terms indicates that their current educational path may not adequately cover the specifics of waste management, which is essential for effective environmental education.

Basic Knowledge of Waste Management

Participants' basic knowledge on waste management is presented in Table 4.

Table 4. Basic knowledge on waste management

Statement	Mean (1-5)	Standard Deviation
A material becomes waste only when its owner declares it as such.	2.52	1.25
Waste incineration in incinerators should be applied as an alternative to landfilling, as it leads to a reduction in the amount of waste, while also releasing energy that can be utilized.	3.00	1.16
Waste landfilling is an integral stage of overall waste management.	3.46	0.98
Waste incineration in incinerators entails the waste of materials that could be reused through recycling.	3.00	1.16
Stormwater should end up in the central sewerage system.	2.48	1.05
Wastewater from industries must be treated before ending up in the central sewerage system.	4.52	0.77

There is strong agreement (58.7% "Strongly Agree") in the argument that wastewater from industries must be treated before ending up in the central sewerage system. However, opinions diverge on other issues. Regarding waste incineration, responses are split between agreement, disagreement, and neutrality, indicating a lack of clear stance or information. Notably, 30.4% disagree or somewhat disagree with the statement that stormwater should end up in the central sewerage system, while 34.8% are neutral, suggesting a potential misunderstanding of sewerage systems and environmental impacts. This indicates that future teachers need a clearer understanding of environmental principles and management practices.

PRIORITIZATION OF WASTE MANAGEMENT OPTIONS

Table 5 presents the hierarchical ranking of the importance of waste management options.

Table 5. Prioritization of Waste Management Options

Option	Mean Rank (1=most important, 4=least important)
Minimization of generated Waste	1.63
Recycling / Composting	2.07
Reuse	2.43
Recovery or energy production from waste	3.87

Participants ranked as an average "Minimization of generated Waste" as the most important option (mean rank 1.63), followed by "Recycling / Composting" (mean rank 2.07). "Reuse of waste" was ranked third (mean rank 2.43), and "Recovery or energy production from waste" as the least important (mean rank 3.87). This prioritization, while placing minimization at the top, deviates from the waste management hierarchy which places reuse before recycling. This deviation may indicate that, despite recognizing minimization, a full understanding of the hierarchy and the benefit of each stage is not complete. It is important to state that none of the students manage to place the options in the right order. This showcases the problem that recycling is ranked very high in the options of citizens, even thought it should be one of their last options. This starts from school (Karachalios, Kalavrouziotis, et al., 2023; Karachalios, Plakitsi, et al., 2023)

REPORTED FREQUENCY OF PERSONAL WASTE MANAGEMENT PRACTICES

Table 6 presents the frequency with which participants report engaging in various waste management practices.

Table 6. Reported Frequency of Personal Waste Management Practices

Practice	Never (%)	Almost never (%)	At least twice a year (%)	At least once a month (%)	Whenever possible (%)
I recycle paper	0.0	0.0	0.0	10.9	89.1
I recycle Glass	0.0	0.0	4.3	28.3	67.4
I recycle Aluminum	0.0	0.0	4.3	26.1	69.6
I recycle batteries in special bins	2.2	13.0	37.0	28.3	19.6
I recycle electrical / electronic waste in special bins	26.1	37.0	21.7	8.7	6.5
I recycle expired medicines in pharmacy green bins	47.8	26.1	13.0	6.5	6.5
I recycle light bulbs in special bins	26.1	37.0	21.7	8.7	6.5
I recycle used oil for biodiesel production	60.9	19.6	10.9	4.3	4.3
I recycle clothes and textiles	10.9	13.0	34.8	26.1	15.2
I Compost	56.5	19.6	13.0	8.7	2.2

Personal recycling practices are very frequent for common materials such as paper (89.1% "Whenever possible"), glass (67.4%), and aluminum (69.6%). However, the frequency drops dramatically for more specialized or less accessible types of recycling. For example, 47.8% "Never" recycle expired medicines, 60.9% "Never" used oil, and 56.5% "Never" compost. This difference suggests that while there is a willingness to recycle, its implementation largely depends on ease of access to infrastructure and information on specific procedures. The low frequency in more complex practices indicates that knowledge and intention do not always translate into action, possibly due to practical barriers or lack of specialized information.

SELF-ASSESSED LEVEL OF INFORMATION ON WASTE MANAGEMENT ISSUES

Table 7 presents how informed participants consider themselves to be on various waste management issues.

Table 7. Self-assessed Level of Information on Waste Management Issues

Topic	Mean (1-5)	Standard Deviation	Not at all (%)	Little (%)	Moderately (%)	Quite a lot (%)	Very much (%)
Informed about recycling issues	3.96	0.99	0.0	8.7	30.4	39.1	21.7
Informed about composting issues	2.61	1.01	15.2	32.6	39.1	13.0	0.0
Informed about solid waste management issues	2.91	0.99	8.7	30.4	45.7	15.2	0.0
Informed about wastewater management issues	2.48	0.99	15.2	37.0	37.0	10.9	0.0

Participants self-assess as "Quite a lot" informed about recycling issues (mean 3.96), with 60.8% stating "Quite a lot" or "Very much". However, the self-assessment level decreases to "Moderately" or "Little" for composting (mean 2.61), solid waste management (mean 2.91), and especially wastewater management (mean 2.48). This discrepancy between self-assessment for recycling and other, more complex, waste management topics suggests that the perception of being informed may be superficial and not extend to deeper or more technical aspects.

DISCUSSION

This study investigated the knowledge, attitudes, perceived competence, willingness, and practices of 46 final-year students from the Department of Early Childhood Education Sciences at Democritus University of Thrace concerning waste management. The findings provide

valuable insight into the readiness of this group of future kindergarten teachers to assume their role in environmental education.

OVERVIEW OF FINDINGS

Overall, the results paint a picture where future teachers possess a basic, but not in-depth, understanding of waste management, accompanied by a high willingness to engage in environmental education, but also low perceived competence. Their personal practices are strong in common forms of recycling but weak in more specialized ones, and while they recognize the crucial role of education, they question the current effectiveness of primary education in Greece.

KNOWLEDGE AND UNDERSTANDING OF WASTE MANAGEMENT

The study results (Table 3) show a sharp split between high familiarity with everyday phrases such as “Paper Recycling” and “Waste” and very limited recognition of technical terms like “Residual-Waste Landfill,” “Inert Waste,” or “Waste-Water Treatment Plant (WWTP). The same pattern has been documented elsewhere in Greece: in a cross-national survey only 26.6 % of Greek lower-secondary students knew what a *landfill* is, compared with 70.4 % of their UK counterparts (Karachalios et al., 2021). A subsequent study involving 332 teachers and the earlier student cohort confirmed that just 55.25 % of students could define basic concepts such as *paper recycling* or *composting*, a level far below that of their own teachers (Karachalios, Kalavrouziotis, et al., 2023). Even at university, knowledge remains modest: a sample of 461 pre-service early-childhood teachers answered correctly on barely 45 % of a 13-item environmental quiz, despite generally positive attitudes toward sustainability (Goulgouti et al., 2019).

The fact that similar deficits appear among high-school pupils, in-service teachers, and future primary-school educators’ points to a systemic weakness in Greece’s environmental-education pipeline. Long-standing reviews have criticised the national curriculum for treating environmental education as an *extracurricular add-on*, noting scarce teacher training, fragmentary materials, and the absence of an integrated syllabus (Goussia-Rizou & Abeliotis, 2004). Our findings reinforce those concerns and underline the need for a vertically aligned, concept-rich programme that begins in pre-service teacher preparation and is consistently reinforced across all schooling levels.

KNOWLEDGE AND WASTE MANAGEMENT PRIORITIZATION

Participants' knowledge towards waste management principles varied (Table 4). Concepts like the waste hierarchy were broadly recognised, yet answers on incineration and storm-water handling split sharply, indicating information gaps that mirror earlier findings. Studies in Greece routinely report uncertainty or outright opposition to waste-to-energy schemes, rooted in limited knowledge of the technology and its position low in the hierarchy (Chachami-Chalioti et al., 2024). Likewise, reviews of urban storm-water governance note that both citizens and professionals struggle with technical terminology and best-practice choices, calling for explicit educational interventions (Angelakis, 2017).

Table 5 shows that respondents correctly ranked “Minimisation” first, in line with EU guidance, but placed “Recycling/Composting” ahead of “Reuse.” A nationwide survey of 332 in-service secondary teachers found precisely the similar misordering (Karachalios, Plakitsi, et al., 2023).

This recurrent mistake suggests that public campaigns and even curricular materials in Greece still frame recycling as the flagship solution, unintentionally downplaying the more effective strategies of reduction and reuse (Karachalios, Plakitsi, et al., 2023). Independent assessments of the National Waste-Management Plan reach a similar conclusion, criticising its heavy focus on post-treatment measures (incineration, mechanical sorting) at the expense of prevention and reuse (Chachami-Chalioti et al., 2024).

For future kindergarten teachers, these patterns underline a clear training need: programmes must explicitly teach the full waste hierarchy, supply case-based examples that show why prevention and reuse outrank recycling and clarify technically demanding topics such as thermal treatment and sustainable storm-water practices. Doing so will help rectify a society-wide misconception and equip educators to transmit the most effective waste-management strategies to the next generation of pupils.

PERCEIVED COMPETENCE, WILLINGNESS, AND PRACTICES

The coexistence of high willingness to participate in and organize EEPs (Table 2) with moderate to low perceived competence indicates a "readiness-competence gap." Future teachers desire to contribute to environmental education but do not feel adequately equipped with the practical skills or confidence to do so effectively. This aligns with the observation that teachers often begin their careers unprepared for the task of empowering individuals to make environmental decisions (Damoah & Omodan, 2023).

Regarding personal practices (Table 6), while recycling common materials is widespread, practices requiring more effort or specialized infrastructure (e.g., recycling medicines, used oil, composting) are rare. This suggests that knowledge and positive attitudes do not automatically translate into action, possibly due to practical barriers, lack of accessible infrastructure, or insufficient information on procedures. For future teachers, this means their training must go beyond theoretical knowledge and address practical barriers, enhancing their ability to implement and teach complex environmental practices.

Furthermore, comparing the self-assessment of information (Table 7) with actual knowledge (Table 3) reveals a potential overestimation of knowledge, especially on topics such as composting and solid waste/wastewater management. If future teachers consider themselves "quite" informed but exhibit gaps in specific terms, this indicates a lack of metacognitive awareness of their own knowledge deficits. This has significant pedagogical implications, as teachers who overestimate their knowledge may not seek further training or may inadvertently perpetuate misconceptions in their teaching.

Based on the findings, specific recommendations for improving the curriculum of the Department of Early Childhood Education Sciences at Democritus University of Thrace emerge:

- **Enhanced Modules:** Enhanced modules are needed for comprehensive waste management, including in-depth coverage of technical terms and principles.
- **Waste Hierarchy:** Emphasis must be placed on the waste management hierarchy and circular economy principles to correct misconceptions regarding the priority of strategies.
- **Practical and Experiential Training:** Providing practical training and experiential learning opportunities for designing and implementing EEPs is essential. The utilization of Open Educational Resources (OER) (Armakolas et al., 2019) and educational games

(Karachalios, 2024) can enhance engagement and learning effectiveness. Research highlights the critical role of targeted, experiential interventions in primary education (Karachalios & Manesis, 2025).

- **Addressing Knowledge Gaps:** Training programs must incorporate diagnostic assessments to reveal students' actual knowledge gaps and build genuine competence, rather than relying on self-assessment.
- **Connecting Knowledge-Practice:** The curriculum should integrate content that helps future teachers translate theoretical knowledge into consistent personal practices, recognizing that teachers serve as role models for their students (Nadakavukaren & Caravanos, 2020).

LIMITATIONS OF THE STUDY

This study has certain limitations that should be considered when interpreting the findings. The small sample size (N=46) from a single university department limits the generalizability of the results to broader populations of future teachers in Greece. Additionally, the data are based on self-reports (practices, perceived competence, information), which may be influenced by social desirability bias. The cross-sectional nature of the study does not allow for drawing conclusions about causality or tracking changes over time.

CONCLUSIONS

This study provided a comprehensive assessment of the knowledge, attitudes, perceived competence, willingness, and practices of final-year students and future kindergarten teachers from the Department of Early Childhood Education Sciences at Democritus University of Thrace regarding solid waste and wasterwater management. The findings highlight that while future teachers possess an average basic knowledge but positive attitudes, significant gaps exist in more technical terms and misunderstandings but also in prioritizing waste management options. Their high willingness to engage in environmental education contrasts with their moderate to low perceived competence, indicating the need for enhanced practical training. Furthermore, their personal practices suggest that knowledge does not always translate into action, especially, when necessary, infrastructure or specialized information is lacking.

The study confirms the crucial role of well-prepared primary education teachers in cultivating environmental literacy and promoting sustainable waste management practices in Greece. These results offer valuable insights for policymakers and curriculum designers to develop targeted interventions in pre-service teacher training. It is imperative that environmental education be systematically integrated into the curricula of all pedagogical schools across Greece, ensuring that future educators are fully equipped with the knowledge, skills, and confidence to effectively teach waste management and broader sustainability issues. Furthermore, environmental education must become a fundamental component of basic education at all levels, from primary school onwards, to foster a generation of citizens capable of effectively addressing future environmental challenges. This comprehensive integration is essential for shaping a society that is environmentally responsible and resilient.

FUTURE RESEARCH

To further develop the understanding of future teachers' knowledge and attitudes, the following directions for future research are suggested:

- **Larger Samples:** Conduct larger surveys across multiple Greek universities and geographical regions to increase the generalizability of findings.
- **Longitudinal Studies:** Conduct longitudinal studies to monitor the impact of new curriculum interventions on the environmental literacy of future teachers.
- **Qualitative Research:** Conduct qualitative research (e.g., interviews, focus groups) to gain deeper insights into the reasons behind specific attitudes or practices.
- **Comparison of Pedagogical Approaches:** Studies comparing the effectiveness of different pedagogical approaches (e.g., OER, gamification, experiential learning) in pre-service teacher training for waste management.

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