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ATTITUDES OF EUROPEAN GRADUATE STUDENTS REGARDING THE ROLE OF ADVANCED TECHNOLOGIES IN ENERGY AND INDUSTRY FOR A GREEN ENVIRONMENT IN THE CONTEXT OF CLIMATE CHANGE AND THE EUROPEAN GREEN DEAL

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Abstract

This study explores the attitudes of European students towards the role of advanced technologies in energy and industry in fostering a green environment, particularly in the context of climate change and the European Green Deal. Survey results highlight a strong recognition of the importance of sustainability-related knowledge, including topics such as Green Agriculture, Zero Pollution, Circular Economy, and Green Sustainable Energy. The findings suggest that while students across Europe acknowledge the transformative potential of advanced technologies in achieving environmental goals, national contexts and current events, such as the ongoing conflict in Ukraine, influence perceptions of climate-related education and policy priorities. The survey results underscore the importance of incorporating green technologies into academic curricula to support the objectives of the European Green Deal.

Key words*: green technology, zero pollution, European Green Deal (EDG), sustainability education.*

INTRODUCTION

The European Green Deal (EGD) is a strategic policy framework aimed at achieving sustainability, economic modernisation, and climate neutrality by 2050, focusing on the circular economy, biodiversity, and sustainable agriculture. Key initiatives - including the Bio-Based Industries Consortium and the integration of digital technologies, green innovation, and renewable energy - are central to achieving these objectives. However, existing studies reveal disparities in progress across EU nations, underscoring the need for a systemic approach combining policy, research, and technological innovation (Stefanidis et al., 2024). The transformation of the energy system is crucial for long-term sustainability, with industrial decarbonisation relying on strategies such as fuel substitution, carbon capture, and circular economy practices (Fernández Gómez, 2022). Other studies explore the EGD's impact on sustainable agriculture, noting that large farms are better positioned to maintain income levels, while small farms may face reduced production and income. This disparity calls for further research on farm incomes, subsidies, and food security across the EU (Pawłowski & Sołtysiak, 2024). Another approach suggests that to attain climate neutrality, the industrialised Member States are the most prepared, Southern/Eastern states have moderate capacity, and Central/Eastern states require targeted investment (Ciot, 2022). In this regard, three European universities (USAMV Bucharest, Romania; Politehnica Bucharest, Romania; UAB Barcelona, Spain; Porto, Porto, Portugal; Uzhhorod University, Uzhhorod,

Ukraine) have developed, since 2023, a study regarding graduates' opinions on the role of advanced technologies in energy and industry for a green environment in the context of climate change and the EGD.

MATERIALS AND METHODS

The study was conducted using a Survey Questionnaire sent online (Radu et al., 2018; Radu et al., 2019; Radu et al., 2020) to graduate students of five European universities involved in the study. A maximum of ten completed survey questionnaires were received from graduate students from each university. A maximum of ten completed Survey Questionnaires were received from graduate students at each university. As of the beginning of 2025, the distribution of respondents (graduate students) from the five universities was as follows: Romania 15%, Spain 27%, and Ukraine 42%.

In a specific questionnaire template distributed online, graduate students were asked to assign scores ranging from 1 to 5 to certain questions, which were interpreted in terms of relevance as follows: Score 1: Not important; Score 2: Low relevance; Score 3: Medium relevance; Score 4: High relevance; Score 5: Very high relevance. In this survey, the responses to six specific questions were chosen and analysed, as follows: 1. Do you appreciate as being important for you as a graduated student to have knowledge regarding Zero Pollution?

2. Do you consider that basic knowledge of climate change will impact your overall activity?

3. Do you consider that basic knowledge on Biodiversity will have a positive impact on your upcoming activity?

4. Do you agree that the understanding of the main issues of Green Agriculture will be fruitful for your future activity?

5. Do you consider it will be effective the graduate students can be able to use knowledge regarding Industrial Strategy for Circular Economy?

6. Do you agree you must be able to use and apply the principles of Green Sustainable Energy? The graduate students were previously informed about the aims of this study. Participation in the survey was voluntary. The Survey Questionnaires distributed and received did not contain personal information such as name, address, phone number, or email address.

Data collection and analysis

Until September 2024, a total of 40 valid responses had been received. The geographic distribution of participants was as follows: 28% from Ukraine, 28% from Romania, 26% from Portugal, and 18% from Spain. Although the sample size is modest, the random selection of participants from each institution helped minimize selection bias and offered a degree of representativeness within the target population.

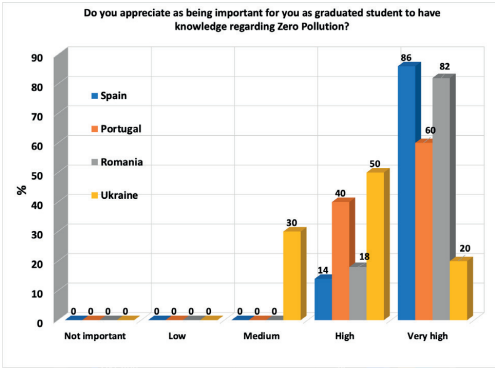
Given the exploratory nature of the study and the limited sample size, data analysis was primarily descriptive. No inferential statistical tests were applied. The goal was to identify prevailing trends and general patterns in student perceptions of and attitudes toward the role of advanced technologies in energy and industry for a green environment in the context of climate change and the European Green Deal.

RESULTS AND DISCUSSIONS

Regarding the statement, "Do you consider it important as a graduate student to have knowledge about Zero Pollution?" the majority of respondents from European countries gave the maximum score (Figure 1a), i.e., 86% of respondents from Spain, 82% from Romania, and 60% from Portugal. In contrast, only 20% of respondents from Ukraine gave the maximum score. Overall, 60% of all respondents considered it strongly important to know about Zero Pollution and assigned the highest score to this question. Additionally, 32% of respondents rated this statement as highly important, while only 8% provided an average rating (Figure 1b).

For the statement "Do you consider that basic knowledge of climate change will impact your entire activity?", 91% of Romanian respondents and 60% of Portuguese respondents stated that basic knowledge of climate change would have a very high impact on their overall activity (Fig. 2a). In contrast, only 29% of Spanish respondents considered this statement to have a very strong impact, as did 20% of Portuguese

respondents. Meanwhile, 43% of Spanish respondents believed that knowledge of climate change would have a high impact (Figure 2a).
Among Ukrainian respondents, 20% stated that basic knowledge of climate change would have a very strong impact on their entire activity, while 30% believed it would have a high impact. Responses indicating medium, low, or no importance did not exceed 15% in any country.
Overall, 53% of all respondents considered this statement to have a very strong impact (Figure 2b), while 24% believed it would have a high impact. Additionally, 18% of respondents rated the importance of this statement as medium, and only 5% considered it of low importance (Figure 2b).



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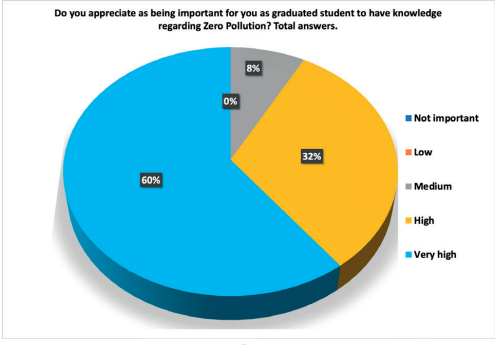

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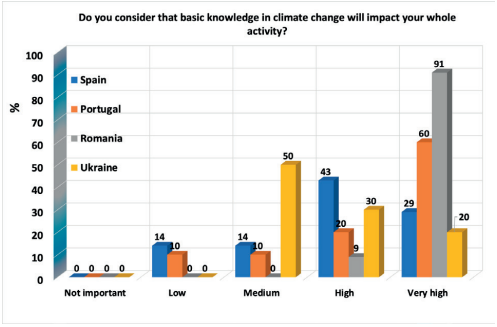
Figure 1. Distribution of responses to the question: "*Do you appreciate as being important for you as graduated student to have knowledge regarding Zero Pollution*?"
a) Answer distribution by country; b) Overall answer distribution across all respondents

Regarding the response to the statement: "Do you consider that basic knowledge of biodiversity will have a positive impact on your upcoming activity?", the respondents from Romania strongly agree with this statement in proportion 82% (Figure 3a).



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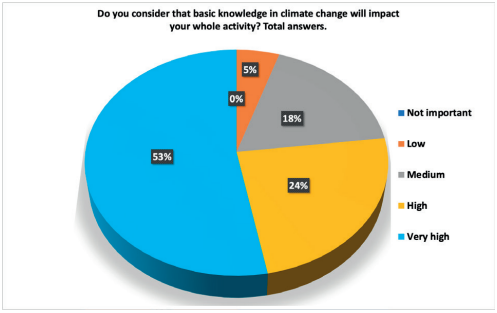

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Figure 2. Distribution of responses to the question: "*Do you consider that basic knowledge of climate change will impact your overall activity?*"
a) Answer distribution by country; b) Overall answer distribution across all respondents

The respondents from Spain and Portugal strongly agree with the statement in proportions of 43% and 40%, respectively, and highly agree in proportions of 43% and 50%, respectively. The respondents from Ukraine moderately agree with this statement in a proportion of 50% (Figure 3a). Overall, 53% of all respondents strongly agree with this statement, while 24% highly agree (Figure 3b).
For the statement "Do you agree that understanding the main issues of Green Agriculture will be beneficial for your future activity?" 100% of Romanian respondents are very high agree that understanding the main issues of Green Agriculture will be beneficial for their future activities. Similarly, 57% of Spanish respondents and 40% of Portuguese respondents very highly agree with this statement (Figure 4a). Only 10% of

respondents from Ukraine very highly agree with this statement, while 40% highly agree, as do the Portuguese respondents (Figure 4a). The percentage of respondents who rated this aspect as low or not important does not exceed 10% for students from each country involved in this study. Overall, 53% of all respondents considered this statement to have a strong impact (Figure 4b), 24% considered that this statement had a high impact, 18% gave an average rating, and only 5% of all respondents considered that this statement had a low importance (Figure 4b).

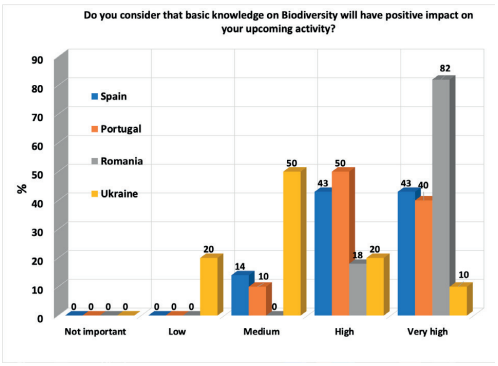


Figure 3. Distribution of responses to the question: "*Do you consider that basic knowledge on Biodiversity will have positive impact on your upcoming activity?*"
a) Answer distribution by country; b) Overall answer distribution across all respondents

In contrast, only 20% of Ukrainian respondents considered this statement to have a very strong impact. Additionally, 43% of Spanish respondents believed that this statement would have a high impact (Figure 5a). A per cent of 40% of Ukrainian respondents and 30% of Portuguese respondents considered it effective for graduates to be able to apply knowledge regarding the Industrial Strategy for the Circular Economy. Responses indicating medium, low, or no importance scores for this statement did not exceed 14% in any country (Figure 5a). Overall, 54% of all respondents considered this statement to have a very strong impact (Figure 5b), while 32% believed it would have a high impact. Additionally, 11% of respondents rated this statement as of medium importance, and only 3% considered it of low importance (Figure 5b).

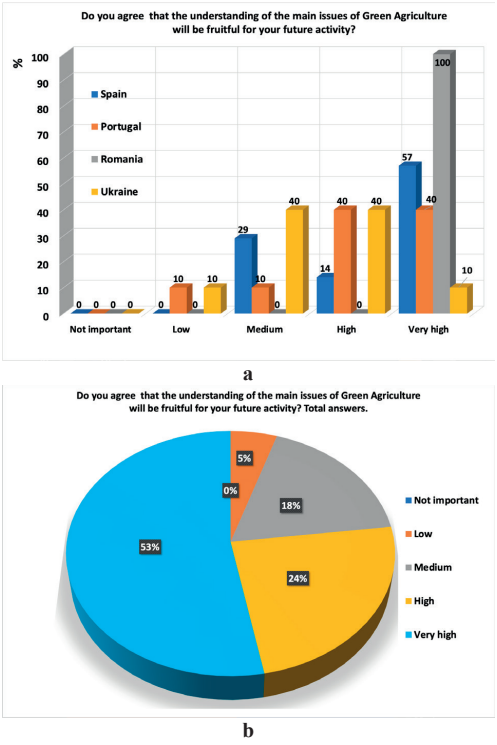
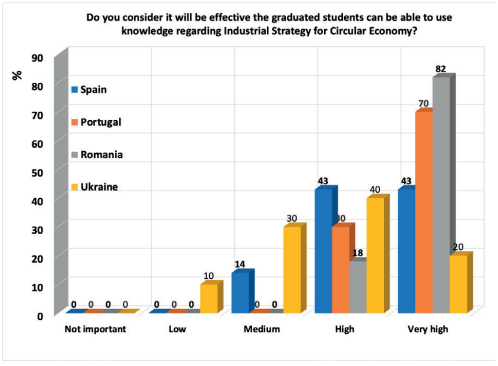


Figure 4. Distribution of responses to the question: "*Do you agree that the understanding of the main issues of Green Agriculture will be fruitful for your future activity?*" a) Answer distribution by country; b) Overall answer distribution across all respondents

Regarding the statement "Do you agree that you must be able to use and apply the principles of Green Sustainable Energy?", 82% of Romanian respondents, 28% of Spanish respondents, and 40% of Portuguese respondents strongly agreed with this statement (Figure 6a). In contrast, only 20% of Ukrainian respondents strongly agreed. Additionally, 71%

of Spanish respondents and 50% of Portuguese respondents highly agreed with this statement (Figure 6a), along with 40% of Ukrainian respondents and 18% of Romanian respondents. Responses indicating medium, low, or no importance for this statement did not exceed 10% in any country (Figure 6a). Overall, 50% of all respondents very strongly agreed with this statement (Figure 6b), while 39% highly agreed. Only 11% of respondents rated this statement as of medium importance (Figure 6b).



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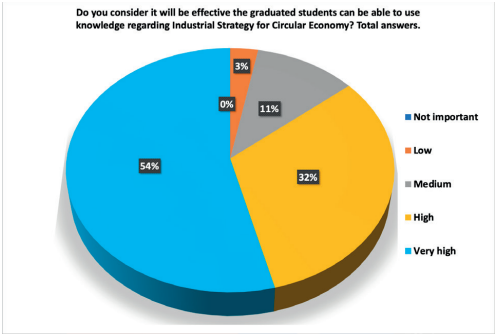

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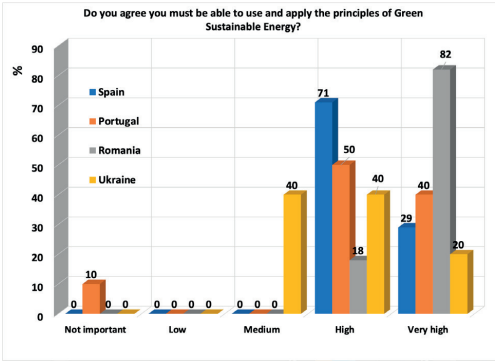
Figure 5. Distribution of responses to the question: "*Do you consider it will be effective for graduate students to apply knowledge regarding Industrial Strategy for Circular Economy?*" a) Answer distribution by country; b) Overall answer distribution across all respondents

The survey analysis reveals significant regional differences in graduate students' views on environmental knowledge. Respondents from Romania showed the strongest support for environmental topics, with the highest ratings for Zero Pollution awareness, Green Agriculture, and Green Energy. Spanish and Portuguese respondents also expressed considerable interest, though with less intensity, while Ukrainian responses were notably lower, likely due to the ongoing conflict. Overall, there was strong consensus on the importance of climate change, biodiversity, and sustainability in shaping future careers, highlighting the need for increased emphasis on environmental education across Europe



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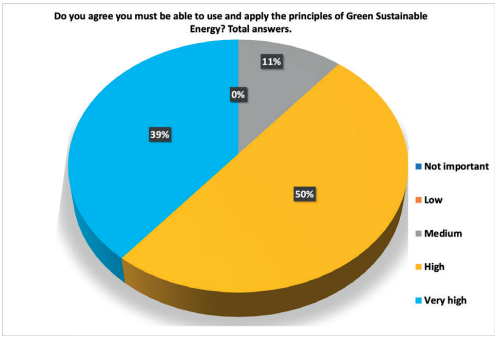

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Figure 6. Distribution of responses to the question: "*Do you agree you must be able to use and apply the principles of Green Sustainable Energy?*" a) Answer distribution by country; b) Overall answer distribution across all respondents

Yang et al. (2023) highlight that while the Circular Economy (CE) model offers significant environmental benefits by repurposing waste, its success requires a comprehensive approach, integrating economic and social factors alongside environmental considerations. Industrial eco-parks, offer a promising model for enhancing waste recovery, resource utilisation, and energy efficiency (Nyangchak, 2022; Yang et al., 2023; Glockow et al., 2024).

Other experts emphasise the need for stronger links between the bioeconomy and circular economy in the context of the Sustainable Development Goals (SDGs) (Shobande et al., 2024). The systematic review identifies significant gaps in the literature, including a lack of standardised methodologies, geographic imbalance with a focus on Europe and Asia, and insufficient attention to social dimensions like poverty and food security (Ferrez & Pyka, 2023; Niwalkar et al., 2023). The studies performed by Kumar et al. (2023) stress the critical role of Circular Economy (CE) and green energy in advancing environmental sustainability. Moreover, it underscores the importance of investing in renewable energy to reduce CO_2 emissions. By integrating CE with green energy, businesses can develop innovative models, create cross-industry value chains, and seize sustainable commercial opportunities. The adoption of a closed-loop system focused on waste reduction and resource efficiency fosters technological advancements, further contributing to ecological sustainability (Santeramo, 2022; Kumar et al., 2023; Paleari, 2024).

CONCLUSIONS

Based on the survey responses, the following key conclusions can be drawn regarding graduate students' perceptions of environmental and sustainability topics in the context of the European Green Deal. A high degree of awareness regarding Zero Pollution was observed, particularly in Spain, Romania, and Portugal. However, Ukrainian respondents showed less enthusiasm, likely due to the impact of the ongoing war. Overall, 60% of respondents viewed Zero Pollution as extremely important, signaling its relevance to future academic and professional pursuits. Climate change knowledge was seen as impactful by the majority of respondents, especially from Romania and Portugal, where 91% and 60%, respectively, viewed it as a critical factor for their future endeavours. While fewer Spanish respondents shared this view (29%), Ukrainian responses reflected a broader range of opinions, with 50% perceiving it as highly impactful. In total, 53% of respondents recognized the strong influence of climate change knowledge. Knowledge about biodiversity was especially valued by Romanian students, with 82% strongly agreeing that it would positively affect their careers. Spanish and Portuguese respondents demonstrated substantial support, with 43% and 40%, respectively. Across all respondents, 53% strongly agreed, showing consensus on the importance of biodiversity in shaping future professional paths. The importance of Green Agriculture was universally acknowledged in Romania (100%), with substantial support in Spain (57%) and Portugal (40%). On average, 53% of all respondents saw Green Agriculture as a crucial factor in shaping sustainable practices. Knowledge about the Circular Economy Industrial Strategy was viewed as important, particularly by Romanian and Spanish respondents (82% and 43%, respectively). Overall, 54% of all respondents considered it essential for sustainable industrial practices. Green Sustainable Energy knowledge was most strongly endorsed by Romanian respondents (82%), with somewhat less support from Spanish (28%) and Portuguese (40%) students. Nevertheless, 50% of respondents across Europe placed a high value on this knowledge.

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