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CAREER DEVELOPMENT PATHWAYS FOR ENVIRONMENTAL ENGINEERING STUDENTS

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Abstract. *The paper entitled "Career development pathways for environmental engineering students" investigates the ways in which young specialists can be supported to build relevant and sustainable careers in a global context dominated by the green transition and the new demands of the circular economy. At a time when European and international policies emphasize reducing environmental impact, efficient use of resources and the implementation of green technologies, the field of environmental engineering becomes essential for achieving sustainable development goals. The main purpose of the research is to identify the directions of professional evolution for graduates of university programs in the field, in correlation with the increasingly complex demands of the labor market and the dynamics of technological innovation. The proposed analysis is based on an integrated approach, which combines the educational perspective with the economic and technological one. Career opportunities are highlighted in areas such as waste management, pollution control, renewable energy, resource efficiency and ecological systems design. The research results show that, in addition to technical and scientific skills, future environmental engineers need to develop transversal skills – critical thinking, digital skills, entrepreneurship, interdisciplinary communication and innovation capacity. The conclusions of the paper emphasize the need to strengthen partnerships between universities, the economic environment and public institutions to create flexible professional paths, relevant internship programs and lifelong learning mechanisms. These elements are fundamental for preparing young engineers to face the new challenges of the green economy and for their active integration into a sustainable and innovation-oriented society.*

Keywords*: skills, challenges, opportunities, evolution, professional training*

INTRODUCTION

Environmental Engineering is one of the strategic areas of sustainable development, being oriented towards preventing, reducing and managing the impact of human activities on the natural environment. In recent decades, against the backdrop of accelerating climate change, increasing pressure on natural resources and rapid urbanization, environmental engineering has acquired a central role in achieving global environmental protection and green transition objectives.

In the current context, characterized by intensifying climate change, pressure on natural resources and the transition to a circular economy, the training of specialists in environmental engineering has become a priority, both for the academic environment and for the labor market. The need for specialists in this field is constantly growing, determined by climate change, resource depletion and increasingly strict national and European regulations (for example, the European Green Deal). (EUROPEAN CENTRE FOR THE DEVELOPMENT OF VOCATIONAL TRAINING, 2024; UNITED NATIONS, 2015)

The educational and professional path for students in the field of Environmental Engineering can be vast and sometimes unclear due to its interdisciplinary nature. Graduates must be prepared to address challenges related to waste management, water and air quality, soil contamination and sustainable development.

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In Romania, but also in the European Union, public policies and development strategies (e.g. European Green Deal, 2020; UN 2030 Agenda for Sustainable Development) emphasize the importance of training specialists capable of managing, preventing and remedying anthropogenic impacts on the environment. (EUROPEAN COMMISSION, 2022; UNITED NATIONS, 2015) The environmental engineer thus becomes a key player in the design of clean technologies, in the development of ecological management plans and in the implementation of solutions for the circular economy. According to the European Green Skills Report, the demand for environmental specialists will increase by over 20% by 2030, due to the expansion of investments in green infrastructure and decarbonization technologies. (EUROPEAN CENTRE FOR THE DEVELOPMENT OF VOCATIONAL TRAINING, 2024)

Environmental Engineering is a multidisciplinary profession, located at the intersection of engineering sciences, natural sciences and resource management. The rapid evolution of green technologies and the adoption of European policies on sustainable development have led to the emergence of a wide spectrum of professional roles and functions adapted to the diverse needs of the green economy. (EUROPEAN COMMISSION, 2020)

The following are the main professional categories in the field of Environmental Engineering, divided into technical, analytical, management and consulting functions, such as: (MOLDOVAN, R., TĂNASE, V., 2022; INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2022; WORLD ECONOMIC FORUM, 2023)

● **Technical and operational functions**. These functions involve the direct application of engineering knowledge to control and improve environmental quality, using specific technologies and processes.

a) *Environmental engineer*

- Responsibilities: design, implementation and monitoring of environmental protection systems (wastewater treatment, emission reduction, waste management).

- Skills: knowledge of physico-chemical processes, use of modeling software (AutoCAD, GIS), compliance with ISO 14001 standards.

b) *Environmental process engineer*

- Responsibilities: optimization of technological processes from the perspective of resource consumption and environmental impact.

- Skills: energy efficiency analysis, technological audit, integration of circular economy principles.

c) *Environmental monitoring technician*

- Responsibilities: measurement and recording of air, water and soil quality parameters.

- Skills: operation of measuring equipment (probes, analyzers, spectrophotometers), data interpretation, reporting to authorities.

● **Analytical and control functions**

a) *Environmental Analyst*

- Responsibilities: collection and analysis of environmental samples, preparation of compliance reports, interpretation of pollutant data.

- Skills: analytical chemistry, microbiology, use of laboratory instruments, data processing.

- Workplaces: accredited laboratories, research institutes, environmental agencies.

b) *Environmental Auditor*

- Responsibilities: verification of the compliance of an organization's activities with environmental legislation and standards.

- Skills: knowledge of ISO 14001, ISO 45001 management systems; assessment and reporting skills; professional independence.

- Activity: internal and external audits, environmental performance assessment, recommendations for improvement.

c) *Environmental Impact Assessor* (EIA Specialist)

- Responsibilities: coordination of the impact assessment process for major projects (infrastructure, industry, construction).

- Skills: specific legislation (European Union Directives on EIA - Environmental Impact Assessment Directive and SEA - Strategic Environmental Assessment Directive), GIS skills, multi-criteria analysis.

- Collaborators: consulting firms, environmental authorities, investment banks.

● **Management and coordination functions**

a) *Environmental manager*

- Responsibilities: planning, implementing and monitoring environmental policies at the organizational level.

- Skills: leadership, project management, knowledge of environmental regulations, ESG reporting (disclosure of environmental, social and corporate governance data).

- Strategic role: developing sustainability plans and reducing the corporate carbon footprint.

b) *SSM and environment manager*

- Responsibilities: integrating health, safety and environmental protection requirements in the workplace.

- Skills: specific legislation, risk management training, implementing compliance procedures.

c) *Sustainability program coordinator*

- Responsibilities: coordinating green transition projects, environmental education, CSR reporting.

- Skills: communication, strategic planning, managing public-private partnerships.

● **Consulting, innovation and education functions**

a) *Environmental consultant*

- Responsibilities: advising companies on the implementation of environmental legislation, obtaining permits, developing green strategies.

- Skills: legislative analysis, drafting technical documentation, inter-institutional communication.

- Role: intermediary between organizations and authorities.

b) *Green technology expert*

- Responsibilities: designing and implementing innovative solutions in areas such as renewable energy, biotechnologies, advanced recycling.

- Skills: interdisciplinarity, applied research, knowledge of international trends (smart cities, clean energy).

c) *Teaching staff and researcher*

- Responsibilities: training future generations of engineers, conducting studies and applied research projects.

- Skills: scientific communication, research methodology, grant coordination.

New economic and technological directions are leading to the emergence of emerging professions, including: (IONESCU, M., PETCU, L., 2023)

• *Circular Economy Specialist* – designs resource reuse flows and smart recycling;

• *Carbon Accounting Expert* – measures and reports GHG (greenhouse gas) emissions at the organizational level;

• *Energy Transition Consultant* – integrates renewable sources and energy efficiency solutions;

• *ESG Manager* – coordinates corporate sustainability reporting;

• *Contaminated Land Remediation Specialist* – applies biochemical and physical decontamination technologies.

Environmental engineering is a field of study with strategic relevance for the training of young professionals of the 21st century. Through its interdisciplinary nature, oriented towards innovative and sustainable solutions, this field offers students a career with significant social and economic impact. The training of future environmental engineers is not only an educational objective, but a social and ecological mission, essential for building a sustainable future.

MATERIAL AND METHODS

Environmental engineering students are faced, even during their studies, with the need to build a coherent and flexible professional path, which responds to both their own interests and the needs of society and the labor market. This path involves not only the accumulation of theoretical knowledge and technical skills, but also the development of transversal skills, such as communication, critical thinking, teamwork and innovative spirit.

The purpose of this paper is to analyze the main professional development paths available to students and graduates of environmental engineering programs, to highlight the role of the university in supporting them and to propose concrete directions of action to increase the employability of young environmental engineers.

The paper is based on a documentary analysis, aims to identify, analyze and detail the main professional development paths available. In a professional environment in continuous transformation, the skills acquired by environmental engineering students and graduates play a determining role in professional success. With the transition to a green and digitalized economy, the labor market requires specialists capable of combining technical expertise (hard skills) with transversal skills (soft skills) that allow for adaptability, collaboration, and innovation. (WORLD ECONOMIC FORUM, 2023)

RESULTS AND DISCUSSIONS

The transition to a green and digitalized economy has generated an increased demand for specialists with complex skills, able to integrate engineering knowledge with management and innovation skills. In this context, simply completing a university program is no longer sufficient for a successful professional insertion.

The formation of a competitive professional profile requires the active involvement of students in extracurricular activities, internships, volunteering and complementary training programs, including postgraduate studies.

These experiences contribute to the consolidation of technical skills (hard skills), transversal skills (soft skills) and the creation of a professional network (networking) essential for access to the labor market.

Technical skills (hard skills) represent the foundation of engineering training, being closely linked to the knowledge of environmental processes, treatment technologies, measurement instruments and specific legislation. They are acquired through formal university education, specialized practice and field experience. (table 1)

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If hard skills define what a person knows how to do, soft skills define how they do it. They include personality traits, attitudes and professional behaviors that facilitate adaptation, communication and effective collaboration.

The main soft skills in environmental engineering are: (PETRESCU, A., 2023)

○ *Professional communication* – the ability to clearly convey technical data, reports and conclusions to colleagues, managers or authorities.

○ *Critical and analytical thinking* – objective interpretation of data and proposing solutions based on scientific evidence.

○ *Interdisciplinary teamwork* – collaboration with specialists from various fields (chemistry, construction, economics, legislation).

○ *Ethics and professional responsibility* – awareness of the impact of engineering decisions on the environment and society.

○ *Time and project management* – planning and meeting deadlines in the development of technical or research projects.

○ *Flexibility and continuous learning* – adapting to new technologies and environmental regulations.

○ *Digital and online communication skills* – using collaborative platforms, writing digital reports, using cloud applications.

○ *Leadership and positive influence* – coordinating teams and motivating members to achieve common goals.

Table 1

The main hard skills identified in the field of Environmental Engineering

Technical skills category	Description	Professional relevance
Environmental quality analysis and monitoring	Sampling, physicochemical and biological analysis, use of laboratory equipment.	Essential for environmental analyst, technician or auditor roles.
Modeling and simulation of environmental processes	Use of software programs (GIS, AutoCAD, MATLAB) for modeling pollution, water flows or emissions.	Especially sought after in technological research and design.
Design and implementation of environmental protection systems	Development of waste treatment solutions, wastewater treatment, air filtration.	Core competency for environmental engineers in industry.
Audit and legal compliance	Application of ISO 14001, ISO 9001 standards, assessment of compliance with environmental legislation.	Required in the positions of auditor, environmental manager, consultant.
Natural resource and waste management	Energy efficiency assessment, sustainable management of resources and waste streams.	Relevant for public administration and utility companies.
Digital and data analytics skills	Environmental data processing, databases and environmental information systems.	In all engineering branches, including for ESG reporting.

Source: own processing

Among the ways in which students can strengthen their professional profile in the field of Environmental Engineering, we specify: (IONESCU, M., PETCU, L., 2023)

● *Internships* – the bridge between theory and professional reality

Internships are one of the most important components of engineering training. They provide students with the opportunity to apply theoretical knowledge in concrete situations, observe technological flows, interact with professionals, and understand the specific responsibilities of the job.

Through activities carried out in industrial laboratories, treatment plants, consulting companies or environmental protection agencies, students: gain real practical experience in

sampling and data interpretation; learn safety procedures and compliance with environmental legislation; develop professional discipline and results orientation.

There are several types of internships, depending on the objectives and duration of involvement, such as:

• Mandatory university internships, integrated into the curriculum;

• Voluntary internships (carried out on one's own initiative, in partner companies or NGOs);

• Paid internships, offered by private companies or European-funded projects;

• Erasmus+ internships, which offer international experience and exposure to advanced technologies.

● *Volunteering and civic engagement* – training through social responsibility (PETRESCU, A., RĂDULESCU, L., 2022)

Volunteering activities in the environmental field offer students the opportunity to participate in greening projects, environmental education campaigns, reforestation, recycling activities or biodiversity monitoring.

These experiences, although unpaid, have a major formative value, contributing to the development of soft skills such as: civic spirit and social responsibility; teamwork; event planning and community project management; public communication and raising public awareness.

Through volunteering, students: strengthen their personal motivation for environmental protection; can obtain non-formal skills certificates recognized for employment; create an extensive professional network, interacting with specialists, NGOs and authorities.

Thus, volunteering becomes a natural complement to formal education, contributing to the formation of an involved and responsible engineer profile.

● *Master's studies and continuing education programs*

Master's studies offer the opportunity to deepen knowledge in a specific direction and represent a key stage for professional specialization. Participation in these programs allows the acquisition of advanced skills, such as: the use of risk simulation and assessment software; the development of sustainability strategies; the management of European projects; applied research and the writing of scientific articles.

In addition to master's studies, there are multiple continuing education programs or professional certifications, internationally recognized, which can strengthen the professional profile: ISO 14001 Lead Auditor Certification (for environmental auditors); GIS and 3D modeling courses; ESG Reporting and Environmental Impact Assessment certifications; Specialization programs offered by the European Environmental Agency. These additional qualifications considerably increase employability and professional credibility.

● *Other ways to strengthen your professional profile*

- Participation in research projects and student competitions

Involvement in applied research projects or competitions such as the EcoInnovators Challenge or GreenTech Hackathon stimulates creativity and innovation. Students learn to: apply scientific methods of investigation; develop scientific reports and presentations; collaborate interdisciplinary; manage complex projects with deadlines and budgets.

- International mobilities (EUROPEAN COMMISSION, 2023)

Erasmus+ programs or bilateral partnerships offer opportunities to: learn in a multicultural context; participate in modern specialized courses; gain experience in a different educational system. Mobilities contribute to the formation of a European professional profile, open to cooperation and innovation.

- Building a Digital Professional Identity

In the digital age, an increasingly important component of your professional profile is your online presence: creating a professional profile on LinkedIn; publishing articles or reports in student magazines; participating in online conferences; engaging in professional communities. This digital visibility makes it easier to connect with potential employers and collaborators.

Strengthening the professional profile of environmental engineering students is a dynamic and multidimensional process, which goes beyond the limits of formal education. By combining academic activities with practical experiences, volunteering, international mobility and continuing education, students can build a coherent and attractive professional portfolio for the labor market.

Thus, the ideal professional development path includes:

○ *Internships* – applying knowledge and understanding the real work environment;

○ *Volunteering* – developing civic values and social skills;

○ *Postgraduate studies and certifications* – specialization and international recognition;

○ *Research and innovative projects* – strengthening scientific and digital skills;

○ *Networking and digital identity* – professional visibility and integration into the engineering community.

By cultivating these directions, students become not only employable, but also active agents of sustainable change, able to contribute to European objectives regarding environmental protection and sustainable development.

CONCLUSIONS

Developing a solid career in this field requires not only technical knowledge, but also flexibility, continuous learning, and the ability to work in interdisciplinary teams, in line with the goals of the green transition and sustainable economy. (DUMITRESCU, L., 2021)

Recent studies emphasize that the difference between a competent and a successful graduate is not determined exclusively by the level of engineering knowledge, but also by the ability to communicate, lead, think critically, and learn continuously. (POPESCU, M., IONESCU, D., 2021; EUROPEAN COMMISSION, 2022)

The transition to a carbon-neutral economy, established by the European Union through the *Fit for 55 Package* (2021), involves a profound transformation of occupations and skills in the labor market.

Environmental engineers thus become indispensable in emerging areas such as: renewable energy and energy efficiency, material recovery and circular economy, digitalization of environmental monitoring (IoT, Big Data, GIS), industrial waste management, as well as ecosystem impact assessment. Students, future graduates of Environmental Engineers, for success and integration into the labor market, would need: active involvement in the professional training process, development of soft skills and entrepreneurial spirit, building a digital professional identity, continuous training and additional certifications. (NICOLESCU, O., 2020; ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, 2022; WORLD ECONOMIC FORUM, 2023)

In this context, universities need to adapt their study programs to develop skills in: the use of digital technologies for environmental analysis, green project management, ESG (Environmental, Social, Governance) reporting, communication and ecological education. In order to optimize the educational process, increase the relevance of the skills formed and

facilitate the transition from education to the labor market, universities would need to: adapt the university curriculum to the requirements of the labor market, strengthen partnerships with the economic and institutional environment, develop transversal and digital skills of students, support mobility and internationalization in the field of environmental sciences, as well as support the transition to the labor market.

Professional success in Environmental Engineering depends on the balance between technical and transversal skills. While technical skills ensure professional competence, transversal skills guarantee adaptability and performance in complex and interdisciplinary contexts.

A complete environmental engineer must be:

• technically competent, able to use modern analysis and design tools;
• ethical and responsible, aware of the social impact of his activities;
• communicative and collaborative, integrated into a multidisciplinary team;
• innovative and open to change, prepared for the challenges of the green transition.

Therefore, universities and employers must collaborate to develop integrated training programs that combine theory, practice and continuous personal development.

Therefore, training a modern environmental engineer involves more than the transmission of knowledge – it involves the development of a systemic and ethical vision on sustainable development. (GĂNESCU, C., 2022) The role of universities is to offer the student a flexible educational environment, oriented towards practice and interdisciplinarity, while the student must demonstrate initiative and a desire for continuous learning. (MINISTERUL EDUCAȚIEI, 2024)

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