INTEGRATING ACTIVE TEACHING METHODS INTO THE DEVELOPMENT OF PROFESSIONAL SKILLS IN ENVIRONMENTAL ENGINEERING STUDENTS

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ABSTRACT: *This paper analyzes the importance of active teaching methods in higher education, with a focus on the field of Environmental Engineering. Emphasis is placed on the correlation between modern teaching strategies and the development of essential professional skills for future environmental engineers. Models for integrating participatory methods, such as project-based learning, problem-based learning, and case studies, into specific disciplines are proposed. The study includes an analysis of their effectiveness in relation to traditional methods, based on the literature and practical examples.*

Keywords: *active teaching methods; specialized teaching; professional skills; environmental engineering; educational sustainability; technical education; environmental education; effectiveness of active methods*;

1. Introduction

In the context of profound changes affecting educational systems globally, higher education is called upon to respond more promptly to the demands of contemporary society, characterized by rapid change, complexity, and uncertainty. The professional training of students in the field of Environmental Engineering must take into account new ecological, technological, and social challenges, which require not only the accumulation of theoretical knowledge, but also the development of complex professional skills that are adaptable and applicable in various practical contexts. In this sense, the integration of active teaching methods becomes an essential requirement for ensuring a relevant, interactive education geared towards developing critical thinking, innovative spirit and problem-solving skills (Fig. 1).

Active teaching methods-such as project-based learning, case studies, cooperative learning, brainstorming, debate, or problem-based learning-promote the direct involvement of students in the teaching and learning process. They encourage active participation, taking responsibility for one's own education, and integrating personal experience into the learning

Fig. 1. Active teaching methods

process. By applying these methods in Environmental Engineering courses, students not only develop specific professional skills – such as technical, analytical, and design skills – but also acquire transversal skills such as effective communication, teamwork, adaptability, and sustainable resource management.

Environmental Engineering, as an interdisciplinary field, involves both understanding natural processes and applying modern technologies to protect and restore the environment. Therefore, teaching methods must respond to this complexity, stimulate systemic thinking and holistic approaches in analyzing and solving environmental problems. Traditional methods, based predominantly on frontal exposure, are no longer sufficient to train specialists prepared to manage the current challenges of climate change, pollution, or the sustainable use of natural resources. Therefore, higher education in this field must reinvent itself, adopt new educational paradigms, and create learning contexts that reflect the professional reality in which students will work.

In addition, the integration of active methods contributes to increasing motivation for learning, forming an attachment to the field of study, and creating a student-centered educational environment in which the student is perceived as an active partner in the training process. By translating theoretical content into practical activities relevant to their future profession, students become more involved, more aware of their role in society, and better prepared for the specific challenges of the environmental engineering profession.

This paper aims to analyze the role of active teaching methods in developing the professional skills of students in the field of Environmental Engineering, presenting the theoretical foundations, concrete examples of application, as well as the advantages and limitations of these approaches from the perspective of educational efficiency.

2. Active teaching methods in the context of specialized teaching

Active teaching methods are an essential component of the modern educational process, especially in the context of higher education in the field of Environmental Engineering. These methods are based on the direct involvement of students in the learning process, stimulating critical thinking, problem-solving skills, and the application of knowledge in real-life contexts. In contrast to traditional methods, which focus on the one-way transmission of information, active methods promote collaboration, autonomy in learning, and the development of transversal skills. In the field of environmental engineering, where the complexity of real-world problems requires an interdisciplinary approach, active methods allow students to integrate theoretical knowledge with practical activities, analyze the impact of technical decisions, and propose sustainable solutions. At the same time, they contribute to the formation of a responsible mindset towards the environment and the community. The current educational context requires the continuous adaptation of teaching strategies, and the integration of active methods becomes a necessary condition for relevant and effective professional training, preparing students for the dynamic demands of the labour market and society as a whole (Fig. 2).

Unlike traditional methods, which focus on one-way teaching and passive accumulation of information, active methods promote direct student involvement in the learning process. These include:

- Project-Based Learning (PBL)
- Case studies
- Simulations and modeling

Figure 2. Learning methods – UAB Environmental Laboratory

- Problem-based learning
- Structured debates

These methods contribute to the development of the ability to analyze, synthesize, and apply knowledge in real or simulated contexts.

2.1. Pedagogical foundations of active teaching methods

In the modern context of university education, the pedagogical foundations of active teaching methods are closely linked to constructivist and student-centered theories, which emphasize the active role of students in the learning process. In contrast to the traditional paradigm, in which the teacher is the main source of information, current approaches emphasize the construction of knowledge through experience, reflection, and interaction. According to constructivist theory, learning is not a passive process of accumulating data, but an active one, in which students construct meaning based on prior knowledge and direct experience.

Active teaching methods are designed to stimulate students' cognitive, affective, and behavioral engagement. Among the pedagogical premises that support them are discovery learning, experiential learning, and collaborative learning. These involve a reorganisation of traditional roles in the classroom: the teacher becomes a facilitator of the educational process, a guide who creates relevant learning contexts, while the student becomes an active participant, capable of taking responsibility for their own education.

The importance of these pedagogical foundations is even greater in the field of Environmental Engineering, where the complexity of the topics covered requires the development of analytical and critical thinking, as well as practical and transversal skills. In addition, active methods contribute to better information retention and the development of the intellectual autonomy necessary for research, design, or management of environmental issues. In a well-structured educational framework, these methods not only streamline the learning process but also contribute substantially to the training of professionals capable of responding to real challenges in the field.

Active teaching methods are rooted in modern educational paradigms, especially in constructivist, student-centered theories. These emphasize that learning is an active and personalized process, in which knowledge is constructed by the student, not passively transmitted by the teacher. The pedagogical foundations of these methods can be summarized in several key directions:

1. Constructivist theory of learning – considers that each individual constructs their own meaning of reality based on previous experiences. Application in teaching involves activities that encourage discovery, investigation, and critical reflection.
2. Experiential learning – inspired by David Kolb's model, it promotes the cycle of experience – reflection – conceptualization – application. In the field of Environmental Engineering, learning through projects or field activities supports this cycle.
3. Collaborative learning – active methods emphasize interaction between students: exchanging ideas, solving problems as a team, and developing social skills are essential for deep learning.
4. Student-centered – the teacher becomes a facilitator, and the student is the main actor in the educational process. This model increases internal motivation and autonomy in learning.
5. Contextualization of knowledge – active learning takes place in real or simulated contexts relevant to the student's professional future. In environmental engineering, case studies, community projects, or applications to environmental issues contribute significantly to the development of professional skills.

Based on these foundations, active teaching methods ensure comprehensive training tailored to the current requirements of higher education and the labor market. They develop not only technical skills, but also transferable skills-collaboration, critical thinking, adaptability-which are essential in the career of any environmental protection specialist.

2.2. Adapting active methods to the specific nature of environmental engineering disciplines

Environmental Engineering disciplines require integrated, interdisciplinary learning that combines theoretical knowledge in natural sciences with technical, economic, and social applications. This complexity requires the adaptation of active teaching methods to the

specific content and skills targeted, in order to provide students with a training path that is relevant and applicable in a professional context.

Firstly, active methods such as project-based learning or case studies are well suited to disciplines that analyze environmental impact, environmental legislation, or ecological risk assessment. Through these methods, students can simulate real-life processes of analysis, report writing, or decision-making, while also practicing critical thinking and autonomy.

Secondly, laboratories and practical activities can be improved through problem-based learning (PBL) methods, in which students start with a concrete problem-for example, the contamination of a water source or the management of a waste disposal site-and develop solutions through research, collaboration, and the application of theoretical knowledge.

Similarly, methods based on computer simulations and modeling are becoming essential in courses such as environmental process modeling or geographic information systems (GIS), as they enable active learning through the exploration of real-world scenarios in virtual environments.

In addition, participatory methods-debates, brainstorming, role-playing-can be integrated into courses that analyze the social dimension of environmental protection, ethics in engineering, or urban sustainability, stimulating empathy, negotiation skills, and understanding of multiple perspectives.

Adapting active methods to environmental engineering disciplines requires careful instructional design that takes into account the professional skills being pursued, the complexity of the content, and the educational potential of each method. Through this adaptation, student training becomes more effective, more practical, and closer to the reality of the profession they will practice.

3. Professional skills targeted in environmental engineering

Environmental engineering is an interdisciplinary field that aims to protect and manage natural resources, prevent pollution, and promote sustainable development (Fig. 3).

Developing professional skills in this field is essential to ensure that future engineers will be able to address environmental challenges with effective and innovative solutions. The professional skills targeted in environmental engineering education fall into several categories, each of which is crucial for preparing for a successful career in this sector.

1. Technical and scientific skills

Environmental engineers must acquire in-depth knowledge in areas such as environmental chemistry, microbiology, water technology, waste management, and soil protection. These skills are fundamental to understanding the natural and artificial processes that affect the environment and to developing technical solutions. Specific skills include:

- Analyzing and assessing environmental risks.
- Designing and implementing water and air treatment solutions.
- Applying technologies for waste and pollution management.

2. Project management and coordination skills

As part of their environmental engineering education, students learn how to coordinate complex projects involving multiple teams and interests, as well as how to manage resources.

Fig. 3. Students involved in practical activities

These skills are essential for implementing technical solutions within an efficient economic and legislative framework. Examples of skills include:

- Human and financial resource management in environmental projects.
- Organization and monitoring of environmental project implementation processes.
- Planning and evaluating the sustainability of environmental projects.

3. Skills related to environmental legislation and regulations

An environmental engineer must have a solid understanding of national and international legislation in the field. These skills are necessary to comply with environmental regulations and standards and to contribute to the development of environmental protection policies. The skills involved include:

- Knowledge of national and European environmental standards and regulations.
- Assessing environmental impact and drafting risk assessment reports.
- Promoting and applying the principles of sustainable development in environmental projects.

4. Communication and collaboration skills

An environmental engineer must have excellent communication skills, both to collaborate effectively with colleagues from various fields and to interact with various entities in the public and private sectors and environmental organizations. These skills are essential for the implementation of environmental projects. Communication skills include:

- Preparing technical reports and presenting them to authorities or the public.
- Interdisciplinary collaboration with engineers from other fields (civil, chemical, etc.) and with local and central authorities.
- Active participation in community education and awareness on environmental issues.

5. Innovation and research skills

Given that environmental issues are constantly changing, an environmental engineer must be able to develop and implement innovative solutions. Research also plays an important role in finding new green technologies and improving existing processes. Innovation and research skills include:

- Identifying and testing new and environmentally efficient technological solutions.
- Conducting studies and research to optimize environmentally friendly processes.
- Participating in the development and application of new technologies to reduce pollution.

6. Ethics and social responsibility skills

Ethics plays an important role in environmental engineering, given the impact of technical decisions on the community and the environment. Engineers must be socially responsible and adopt an ethical approach at all stages of their professional processes. These competencies are fundamental to developing solutions that promote sustainability and social well-being without endangering natural resources.

Ethical competencies include:

- Promoting ethical principles in the evaluation of environmental projects.
- Ensuring a balance between economic development and environmental protection.
- Implementing and promoting environmental projects that benefit local communities.

These skills are essential for training a well-rounded environmental engineer who can handle the day-to-day challenges in the field and actively contribute to protecting and conserving the environment. Training them involves both acquiring solid technical knowledge and developing the practical, ethical, and management skills needed by a professional in this field.

4. Practical applications in higher education

The integration of active teaching methods in higher education is an essential step in developing professional skills specific to the field of Environmental Engineering. Applying these methods in a real educational context, through interactive and applied activities, helps students develop technical and problem-solving skills that are essential for their future careers. Therefore, these methods can contribute significantly to the training of a new generation of professionals capable of responding to current environmental challenges.

Active methods can be integrated into disciplines such as Environmental Monitoring, Waste Management, Water Treatment Systems, or Renewable Energy. These areas are essential for training well-rounded environmental engineers, given the complexity and diversity of the challenges facing society today. In these contexts, active teaching methods, such as project-based

learning (PBL), case studies, or simulations, allow students to apply theoretical knowledge in real-life situations, thereby developing practical skills and critical thinking.

A concrete example of the application of these methods in environmental engineering education is the project on "Energy audit of the university campus." This type of project may involve collecting data on energy consumption, analyzing the energy efficiency of campus buildings, and identifying solutions to reduce consumption and carbon emissions. Students can be actively involved in the data collection process, using specialized tools and software to monitor energy consumption, as well as in the analysis of the results obtained. They can also prepare a technical-economic report that includes recommendations for improving energy efficiency, as well as proposals for implementing the identified solutions.

This approach not only develops technical skills in the field of energy auditing, but also research, communication, and critical thinking skills, which are essential in the training of an environmental engineer. Such projects can also contribute significantly to educating students about the importance of saving resources and protecting the environment, which are fundamental aspects of their professional training.

Another example of the practical application of active methods in the field of Environmental Engineering could be "Organizing a water pollution simulation laboratory." In this laboratory, students can analyze different types of pollutants (from chemicals to organic waste) and learn how to design water treatment systems that meet environmental requirements. In this process, students will interact with water treatment process modeling software and learn how to apply theory in practice.

Similarly, "Developing waste management projects" in courses dedicated to this topic may involve simulating a waste management system in a city or industrial area. Students can analyze waste flows, propose solutions for recycling and reusing materials, and assess the environmental impact of the proposed solutions. This could include implementing a selective waste collection system, evaluating the efficiency of the process, and identifying opportunities for improvement.

Water treatment systems are also an essential component of environmental engineering. Students can be involved in simulating a wastewater treatment system using real data and filtration techniques, ozonation, or other purification technologies. They can observe in practice how different methods influence water quality and analyze their costs and efficiency. These experiences give students the opportunity to understand real-life challenges and provide them with the tools they need to develop innovative solutions.

Active teaching methods applied in the field of Environmental Engineering, such as projects, simulations, and case studies, are an excellent way to prepare students for the future challenges of the field. By integrating them into specific disciplines, students not only develop technical skills, but also essential skills such as critical thinking, problem solving, and effective communication. These skills are fundamental to training environmental engineers who are able to respond effectively to challenges related to environmental protection and sustainability.

5. Effectiveness of active methods and impact on professional training

The effectiveness of active teaching methods is supported by numerous studies that highlight their positive impact on student learning and professional training. Active methods, such as project-based learning (PBL), case studies, simulations, and collaborative learning, are designed to encourage students to be active participants in the educational process, not just passive recipients of information. These methods allow students to apply theoretical knowledge in real-world contexts, develop problem-solving skills, and acquire essential competencies for their integration into the labor market (Fig. 4).

Recent studies show that the use of active methods increases information retention rates by up to 75%, compared to approximately 20-30% for passive methods (Freeman et al., 2014). This demonstrates that students who are actively involved in learning retain information more effectively, enabling them to apply what they have learned in a wide range of contexts. In addition, active learning stimulates critical thinking and creativity, which are essential elements in the training of an environmental engineering specialist.

Another significant benefit of active methods is the development of collaboration skills. Studies show that students who work in teams become

Fig. 4. Seminar/professional training session

more motivated and more easily develop transferable skills required by the labor market, such as communication, leadership, and teamwork skills. These skills are particularly important in the field of Environmental Engineering, where interdisciplinary collaboration and the ability to work with various stakeholders (local authorities, NGOs, private companies) are essential for implementing sustainable solutions.

We can say that the use of active teaching methods in higher education, especially in the field of Environmental Engineering, has a significant impact on the professional training of students. Through active involvement in the educational process, they acquire not only technical knowledge, but also practical skills and transferable competences, which are essential for their successful integration into the labor market.

6. Conclusions

The integration of active teaching methods into the professional skills training of Environmental Engineering students is an essential step in adapting education to the demands of the labor market. These active methods, which emphasize learning through practice, collaboration, and critical reflection, help students develop essential skills such as critical thinking, problem solving, and teamwork.

In the context of environmental engineering, these skills are fundamental to addressing current environmental challenges and contributing to the development of sustainable solutions.

The chapters presented highlight that the use of active teaching methods, such as project-based learning and case studies, promotes not only the accumulation of technical knowledge, but also the development of transferable skills that are essential for success in students' professional careers.

Applying these methods in specialized disciplines in the field of Environmental Engineering contributes to the training of professionals capable of addressing complex challenges related to environmental protection, climate change, resource management, and sustainable development.

In conclusion, integrating active methods not only improves the educational process, but also stimulates student engagement, thus contributing to the training of more competent environmental engineers who are prepared to face global challenges.

The effectiveness of these methods is reflected both in the rate of information retention and in the development of essential professional skills, providing adequate training for rapid integration into the professional field of Environmental Engineering.

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