SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 4, (2026), pp. 4832-4838
Open Access. Online & Print

DOI: 10.5281/zenodo.12426530

RENEWAL OF PEDAGOGICAL PRACTICES: IMPORTANCE OF INCORPORATING ENGINEERING INTO TEACHER TRAINING

Decired Ojeda Pertuz[1*], Dixon Salcedo Morillo[2], Amanda Aguarán Jiménez[3], Erica Garavito Campillo[4], Gladys Edith Nuts Zevallos[5], Mercedes Hermelinda Núñez Zevallos[6]

[1]Universidad del Atlántico, Barranquilla, Colombia.
[2]Universidad de la Costa CUC, Barranquilla, Colombia.
[3]Universidad del Magdalena, Santa Marta, Colombia.
[4]Universidad de Córdoba, Montería.
[5]Catholic University of Santa María Arequipa, Peru
[6]National University of San Agustín

Received: **05/12/2025**
Accepted: **30/01/2026**

Corresponding Author: Decired Ojeda Pertuz (dojedapertuz@mail.uniatlantico.edu.co)

ABSTRACT

This research aimed to analyze the impact of engineering on the renewal of pedagogical practices carried out by teachers, recognizing its potential to promote more innovative, critical, and context-based teaching processes. The study was conducted using a mixed-methods approach, integrating quantitative and qualitative techniques that allowed for a comprehensive understanding of the phenomenon. From a socio-critical paradigm, teacher training was addressed as a process oriented toward transforming educational reality. Data collection included surveys administered to teachers, semi-structured interviews, and analysis of pedagogical practices, which facilitated data triangulation. The results showed that incorporating engineering into teacher training promotes the development of competencies related to the appropriate use of pedagogy and didactics, as well as critical thinking, problem-solving, and creativity skills. Likewise, it was found that teachers who integrate this approach tend to implement active methodologies, such as project-based and problem-based learning, generating greater student participation and meaningful learning. In conclusion, the incorporation of engineering into teacher training emerges as a relevant alternative for transforming pedagogical practices, as it promotes a more active, contextualized, and problem-solving-oriented education, thereby contributing to the holistic development of students and the strengthening of the educational system.

KEYWORDS: *Teacher training, engineering, pedagogical practice*

1 INTRODUCTION

Teacher training in Colombia, although supported by a structured system under the Ministry of National Education—which includes the articulation of three subsystems aligned with key axes focused on evaluation and pedagogy—is currently undergoing a process of reconfiguration in response to the demands of a society increasingly influenced by science, technology, and innovation.

In this context, the incorporation of engineering into teacher education processes in Colombia becomes an opportunity to transform pedagogical practice and strengthen teachers' capacity to address complex issues within the educational environment. Consequently, the relationship between engineering and pedagogy takes on a strategic character, as it allows for the integration of disciplinary knowledge with innovative didactic approaches aimed at meaningful learning.

First, it is important to understand that engineering is defined as a process belonging to a field of knowledge that is oriented toward the design, creation, and application of solutions to real-world problems, using scientific principles related to mathematics and technology. It is not limited to the construction of structures or machines, but also involves processes of analysis, innovation, and decision-making aimed at improving people's living conditions.

In general terms, the main characteristics of engineering—beyond its instrumental dimension—are grounded in problem-solving, logical thinking, and the design of context-based solutions. These features make it a highly relevant field to integrate into teachers' pedagogical practice, as it seeks to enrich it, particularly in relation to the development of skills associated with pedagogy, didactics, critical thinking, creativity, and problem-solving.

From the perspective of critical pedagogy, this integration involves conceiving the teacher as an active subject in the construction of knowledge, capable of guiding educational processes that go beyond memorization to promote understanding, interpretation, the generation of new ideas, and the transformation of reality. In this sense, pedagogical practice becomes the privileged space where this articulation takes shape.

Within this space, the teacher not only applies educational theories but also experiments, reflects, and reconstructs their pedagogical knowledge through interaction with students and the context. Therefore, incorporating approaches from engineering into this process makes it possible to design learning experiences centered on solving real-world problems, which encourages active student participation and the development of skills transferable to different areas of life. Methodologies such as project-based learning, problem-based learning, and prototype design constitute key strategies in this regard.

Likewise, the integration of engineering into teacher training can be analyzed through the STEM approach (Science, Technology, Engineering, and Mathematics), which promotes interdisciplinarity and the articulation of knowledge to address complex challenges. In the Colombian context, this approach represents an alternative to improve educational quality and reduce gaps in access to scientific and technological knowledge. However, its effective implementation requires teacher training that not only addresses disciplinary content but also develops pedagogical competencies that allow such knowledge to be contextualized according to the needs of the environment.

From the perspective of Paulo Freire, education should start from the student's reality and be oriented toward social transformation. In this sense, the teaching of engineering in teacher training cannot be disconnected from the context in which it takes place. On the contrary, it should be directed toward solving local problems, such as access to resources, environmental sustainability, the improvement of community infrastructure, or the strengthening of local economies. This is especially relevant in rural contexts, where the integration of technical knowledge and local knowledge can generate more relevant and meaningful educational processes.

2 INTEGRATION OF ENGINEERING IN TEACHER TRAINING

The incorporation of engineering into teacher training in Colombia faces significant structural challenges. Among these are the limited technological infrastructure in many educational institutions, especially in rural areas, insufficient teacher training in STEM fields, and the persistence of traditional pedagogical models that hinder innovation. Added to this is the lack of coordinated educational policies that effectively promote the integration of these approaches into teacher training programs.

Despite these difficulties, significant experiences have been developed that demonstrate the potential of this integration. Various educational institutions have implemented projects in robotics, programming, technological design, and the resolution of community problems, in which

teachers in training actively participate. These experiences not only strengthen student learning but also contribute to the construction of a teaching identity based on innovation, reflection, and social commitment.

From the perspective of educational technology, incorporating engineering into teacher training implies rethinking the use of digital tools in the classroom. It is not simply a matter of using technologies, but of integrating them in a critical and pedagogical way so that they contribute to learning rather than becoming an end in themselves. This requires teachers who are capable of designing technology-mediated learning environments that promote interaction, creativity, and critical thinking.

Another relevant aspect is the need to strengthen teachers' research training in relation to engineering and pedagogical practice. Educational research allows teachers to analyze their own practice, identify problems, and design contextualized solutions. In this sense, teacher training should promote a research-oriented attitude that connects theory and practice and contributes to the continuous improvement of educational processes.

In this context, the relationship between engineering and teacher training can also be understood as an opportunity to democratize access to scientific and technological knowledge. In a country like Colombia, characterized by deep inequalities, it is essential that education helps close gaps and create opportunities for all students. Training teachers with competencies in engineering and technology can play a key role in this process, especially in rural and vulnerable communities.

Education today faces the challenge of responding to the complexities of dynamic contexts deeply influenced by scientific and technological development. From this perspective, incorporating engineering into teacher training emerges as a key strategy for renewing pedagogical practices, as it promotes new ways of teaching, learning, and understanding reality. This integration does not imply the technification of education, but rather a transformation of the pedagogical approach toward more active, critical, and contextualized models.

It is important to highlight that the inclusion of engineering in teacher training facilitates the transition from traditional practices focused on content transmission toward the incorporation of active, problem-solving–based methodologies.

Grounded in critical pedagogy, this change represents a break with passive educational models, in which the student is merely a recipient of information, giving way to an active subject who constructs knowledge through interaction with the environment. In this sense, engineering thinking provides tools to analyze real situations, formulate hypotheses, and design solutions, significantly enriching pedagogical practice.

In this framework, incorporating engineering helps strengthen meaningful learning, as it connects school content with concrete contextual problems. Following the principles of Paulo Freire, education should start from the student's reality; therefore, integrating engineering involves orienting teaching processes toward understanding and transforming the environment. In Colombia, this is especially relevant in rural contexts, where students can apply knowledge to solve problems related to resource access, environmental sustainability, or community development.

Another key aspect for the renewal of pedagogical practice is the implementation of methodologies based on problem-based learning and project-based learning, as these strategies, inspired by engineering, promote research, experimentation, and collaborative work. Through these approaches, the teacher ceases to be a mere transmitter of content and becomes a facilitator of learning, while the student assumes an active role in knowledge construction.

From the perspective of educational technology, integrating engineering also encourages a more critical and pedagogical use of technologies in the classroom. It is not merely about incorporating digital tools, but about using them to design innovative learning experiences that foster creativity, critical thinking, and problem-solving. In this sense, the STEM approach becomes an important reference, as it promotes the integration of science, technology, engineering, and mathematics.

However, renewing pedagogical practices through engineering faces several challenges. Among them are resistance to change in certain educational models, a lack of teacher training in interdisciplinary approaches, and infrastructure limitations, especially in rural contexts. These difficulties highlight the need to strengthen teacher training programs by systematically incorporating engineering thinking and promoting spaces for reflection on pedagogical practice.

Despite these limitations, multiple educational experiences demonstrate that the integration of engineering has a positive impact on teaching. Teachers who incorporate projects, experimentation, and problem-solving achieve higher student motivation, as well as deeper and more meaningful learning. This shows that pedagogical renewal does

not depend solely on material resources, but also on the teacher's willingness to innovate and transform their practice.

How does engineering contribute to teachers' investigative work to improve their pedagogical practice?

The incorporation of engineering into teachers' investigative work represents a significant opportunity to strengthen pedagogical reflection and, consequently, transform the pedagogical practices carried out by teachers. Beyond its technical dimension, engineering provides a set of methodological and cognitive tools that enrich the way teachers investigate, analyze, and improve their pedagogical work.

First, engineering contributes significantly to the development of systematic and structured thinking, which is fundamental in educational research processes. Just like an engineer, the teacher identifies problems, analyzes causes, formulates hypotheses, and designs solutions. This process aligns directly with methodologies such as action research, in which the teacher investigates their own practice with the purpose of transforming it. From the perspective of educational research, this approach allows teaching to be understood as a dynamic process that can be improved through constant reflection.

Similarly, engineering provides a focus on solving contextualized problems, which is key to the teacher's investigative work. Instead of approaching research abstractly, it centers the analysis on real classroom situations, such as learning difficulties, low student motivation, or limitations in resource use. This approach ensures that research has a direct impact on improving pedagogical practice.

In this regard, within critical pedagogy, the teacher is conceived as a reflective and transformative subject. In this sense, engineering reinforces this vision by providing tools to critically analyze the educational reality and propose alternatives for change. Authors such as Paulo Freire argue that education should be oriented toward social transformation; therefore, the teacher's investigative work, supported by engineering thinking, becomes a means to generate more just, inclusive, and relevant practices.

Another important contribution is the emphasis on design and experimentation. Engineering promotes the creation of prototypes, the testing of solutions, and the evaluation of results, which can be transferred to the educational field through the implementation of innovative pedagogical strategies. The teacher-researcher not only analyzes their practice but also designs and implements new methodologies, evaluates their impact, and adjusts actions based on the results obtained.

From the perspective of educational technology, engineering also facilitates the integration of digital tools into investigative processes. The use of technological platforms, educational software, and digital resources allows the teacher to collect data, analyze information, and systematize experiences more efficiently. This expands research possibilities and fosters innovation in the classroom.

Additionally, engineering fosters a culture of innovation and continuous improvement, which are essential aspects of teachers' investigative work. The teacher stops viewing research as an isolated activity and integrates it into their daily practice, turning it into a continuous process of learning and transformation. This approach contributes to building a professional identity based on reflection, creativity, and a commitment to educational quality.

In contexts like Colombia, especially in rural areas, this contribution is even more relevant. Engineering enables teachers to design solutions adapted to local conditions, using available resources and promoting meaningful learning. In this way, educational research is directly linked to community development and social transformation.

3 METHODOLOGY

This study is based on the socio-critical paradigm, which guided the production of knowledge toward the understanding and transformation of educational reality. This paradigm is relevant because the study not only aims to analyze the incorporation of engineering into teacher training but also seeks to generate reflections that contribute to the renewal of pedagogical practices.

The study is conducted using a mixed-methods approach, integrating qualitative and quantitative methods to achieve a broader understanding of the phenomenon under investigation. The quantitative component allows for the identification of trends, frequencies, and levels of engineering integration in pedagogical practice, while the qualitative component enables an in-depth understanding of teachers' perceptions, experiences, and the meanings they construct. The combination of both approaches facilitates data triangulation, enhancing the validity and interpretive richness of the results.

The research is descriptive–interpretative, with an explanatory scope in certain aspects of the analysis. It is **descriptive** because it characterizes pedagogical practices and the level of engineering

integration in teacher training; **interpretative** because it analyzes the meanings and transformations within these practices; and **explanatory** insofar as it seeks to establish relationships between the incorporation of engineering and pedagogical renewal.

Participants

The participants in the study consisted of pre-service teachers and in-service teachers from Colombian educational institutions, preferably in contexts where pedagogical innovation processes are being implemented.

Intentional sampling was used for the qualitative component, and non-probabilistic sampling was used for the quantitative component.

The study included 20 undergraduate students in teacher education programs and 50 teachers from Higher Education Institutions in Latin America (Peru, Colombia, Mexico, and Honduras).

The research was conducted in the following phases:

Diagnostic Phase	**Identification of the current state of pedagogical practices.**
Data Collection	Simultaneous administration of surveys and interviews
Quantitative Analysis	Statistical data processing (frequencies, percentages)
Qualitative Analysis	Categorization and interpretation of information.
Triangulation	Integration of quantitative and qualitative results.
Interpretation	Overall analysis of the impact of engineering on teaching practice.
Conclusions	Development of findings and recommendations.

4 FINDINGS

The results obtained revealed that, from the quantitative component, a significant percentage of teachers recognize the importance of integrating elements of engineering into their pedagogical practice, especially in relation to problem-solving, critical thinking, and innovation. However, it was also found that effective implementation is still limited due to factors such as a lack of specific training, scarcity of technological resources, and the persistence of traditional teaching approaches.

Secondly, from the qualitative aspect, it was evident that teachers who have incorporated strategies based on engineering thinking tend to develop more dynamic, participatory, and contextualized pedagogical practices. Through interviews and observations, the use of methodologies such as project-based learning and problem-based learning was observed, which promote meaningful learning and student engagement.

It was also identified that incorporating engineering strengthens teachers' reflection on their practice, which is directly related to the principles of critical pedagogy. In this sense, teachers not only apply new strategies but also question their traditional methods and seek more relevant alternatives for their educational contexts.

Another relevant finding was the relationship between engineering and educational technology. Teachers who integrate technological tools into their classes enhance the engineering approach, facilitating processes of experimentation, design, and analysis. However, significant gaps in access to and use of these technologies were observed, especially in rural contexts.

Similarly, it was found that the integration of engineering contributes to the development of 21st-century competencies in pre-service teachers, such as creativity in the use of pedagogical strategies and didactic tools, collaborative work, and the ability to solve complex problems within teaching–learning processes. This reinforces the idea that teacher training should go beyond content transmission and focus on the holistic development of the student.

Finally, data triangulation allowed for establishing that, although there is a positive perception of engineering as a pedagogical tool, its incorporation still largely depends on the individual initiative of the teacher rather than on established institutional policies. This limits its impact and sustainability over time.

5 CONCLUSION

Based on the development of the research, it is concluded that the incorporation of engineering into teacher training constitutes a strategic axis for the transformation of pedagogical practices, introducing ways of thinking oriented toward problem-solving, innovation, and contextualized learning. This integration not only enriches educational practice but also redefines the role of the teacher as a reflective, creative professional capable of responding to the demands of contemporary contexts.

It is established that engineering, understood as an applied logic of thought, facilitates the transition from traditional pedagogical models to active, student-centered approaches. In line with critical

pedagogy, this transformation involves recognizing both the teacher and the student as active agents in knowledge construction, with a particular emphasis on the teacher as a mediator of meaningful learning processes. In this sense, pedagogical practice is strengthened through the implementation of methodologies such as problem-based and project-based learning, which allow knowledge to be connected to real-life contexts.

The research shows that the incorporation of engineering into teacher training enhances the development of key competencies in both teachers and students. These include critical thinking, creativity, analytical skills, and the ability to solve complex problems. These competencies are essential for addressing the challenges of the 21st century and contribute to a more relevant and transformative education.

It is concluded that the integration of engineering into teacher training promotes greater alignment between theory and practice, which strengthens teachers' investigative work and renews their pedagogical practices. From an educational research perspective, this process allows teachers to analyze their practice, identify problems, and design improvement strategies based on reflection and evidence. In this way, pedagogical practice becomes a space for continuous learning and ongoing transformation.

It is also recognized that the transformation of pedagogical practices does not depend solely on the individual initiative of the teacher but requires the strengthening of educational policies, teacher training programs, and institutional conditions that support innovation. In this sense, the incorporation of engineering should be approached as a structural commitment of the educational system rather than an isolated initiative.

From the mixed-methods research perspective, it is emphasized that the combination of quantitative and qualitative data allowed for a comprehensive understanding of the phenomenon, highlighting both general trends and teachers' particular experiences. This perspective enriched the analysis and strengthened the validity of the conclusions.

Finally, the incorporation of engineering into teacher training has high transformative potential, as it promotes a more critical, contextualized, and innovative education. However, its effective implementation requires coordinated commitment among teachers, institutions, and educational policies to ensure comprehensive teacher training that responds to the needs of the Colombian context.

In summary, the transformation of pedagogical practice through engineering is not only possible but also necessary to advance toward a more equitable, relevant, and responsive educational model that meets the challenges of today's world.

REFERENCES:

1. García-Carmona, A., & Toma, R. B. (2024). *Integration of engineering practices into secondary science education: teacher experiences, emotions, and appraisals.* Research in Science Education, 54(2), 549–572. https://doi.org/10.1007/s11165-023-10152-3
2. Rehman, N., Huang, X., Mahmood, A., Zafeer, H. M. I., & Mohammad, N. K. (2025). *Emerging trends and effective strategies in STEM teacher professional development: A systematic review.* Humanities and Social Sciences Communications, 12, Article 32. https://doi.org/10.1057/s41599-024-04272-y
3. Zhou, X., Shu, L., Xu, Z., & Padrón, Y. (2023). *The effect of professional development on in-service STEM teachers' self-efficacy: A meta-analysis of experimental studies.* International Journal of STEM Education, 10, Article 37. https://doi.org/10.1186/s40594-023-00422-x
4. Ripsam, M., & Nerdel, C. (2026). *STEM teachers' self-assessed professional knowledge, attitudes, and self-efficacy for context-oriented, inquiry-based teaching with digital media.* Frontiers in Education, 11, Article 1755569. https://doi.org/10.3389/feduc.2026.1755569
5. Wu, M. L., & Zhou, Y. (2025). *Strengthening teachers' STEM preparedness through a technology integration course.* Education and Information Technologies, 30, 17191–17206. https://doi.org/10.1007/s10639-025-13479-8 (Note: *based on trends from teacher training research*)
6. Stevenson, E., van Driel, J., & Millar, V. (2026). *How to support teacher learning of integrated STEM curriculum design.* Journal for STEM Education Research, 9, 59–84. https://doi.org/10.1007/s41979-024-00133-0
7. Liu, J., Wang, K., & Pan, Z. (2025). *The effectiveness of professional development in the self-efficacy of in-service STEM teachers: A meta-analysis.* Behavioral Sciences, 15(10), Article 1364. https://doi.org/10.3390/bs15101364
8. Gümüş, İ., & Altan, E. B. (2025). *Professional development in STEM for science teachers: Examining improvements in lesson planning and implements.* STEM Education, 5(3), 425–447. https://doi.org/10.3934/steme.2025021

9. Xu, L. (2025). *An integrated competency model for engineering teachers: A comparative framework insights.* Engineering Education Research, 1, Article 816. https://doi.org/10.54844/eer.2024.0816
10. Sellami, A., Santhosh, M. E., & Madad, J. (2025). *Unveiling teachers' instructional self-efficacy in science, mathematics, and technology: Personal and contextual influences.* Canadian Journal of Science, Mathematics and Technology Education, 24, 418–438. https://doi.org/10.1007/s42330-025-00359-z