Training program in teaching for Engineering for the Americas (EftA)

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Abstract

Being a professor-engineer in engineering courses is common in universities in Latin America and the Caribbean, so it is likely that pedagogical practices are not the subject of reflection, since the activity, in most cases, would focus on the contents. Therefore, in this article, we review various pedagogical training proposals for engineers and anticipate a teacher-training program endorsed by LACCEI, an organization focused on collaboration, education, practice, research, and innovation in Engineering and Technology. The issue of training is a priority; for example, recently, the recognition of the iPEER (International Professional Engineering Educator Registered) title was achieved through the project "Pedagogical training of engineering educators—EnTER" (created in 2018). This was achieved with the support of the only professional regulatory body that oversees engineering teaching professionals, the International Standard Classification of Occupations (ISCO), with code 2311 (ISCO Code 08) as "Higher education teaching professional: Engineering educator" [4–6]. Thus, this article will show how the reviewed programs are structured, and will provide a proposal for engineering that seeks to reflect, innovate, and rethink its teaching practices. Some research shows that engineering teaching practices closely linked to the concept of traditional science are recognized, but in most cases, they do not incorporate into their practices how the contents taught are related to social, environmental, and explicitly human social issues [7–9]. This training program will provide teachers with the necessary tools to consider teaching in their curricular spaces at this time of complexity. The importance of specific training for the best performance of engineering professionals in teaching has been recognized.

Keywords

Training, Teaching, EftA, Engineering, Education, Americas, LACCEI.

Introduction

One of the challenges of this century is the training of engineers who teach classes at various universities in Latin America. This study proposes a training plan within the framework of the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI).

LACCEI, founded in 2003, is a nonprofit organization consisting of institutions that offer academic programs in Engineering and Technology with the goal of collaborating with other LACCEI partners. The mission of LACCEI is to facilitate and promote global collaboration in the advancement and continuous improvement of engineering and technology education, practice, research, and innovation, linking Latin America and the Caribbean to the rest of the world [1]. In 2005, in Rio de Janeiro, the Organization of American States (OAS) selected LACCEI as part of the "Engineering for the Americas (EftA)" action plan to advance the accreditation and quality assurance of engineering programs in the Americas [2]. Today, the LACCEI has more than 250 member institutions from three continents and twenty-four countries.

One of LACCEI's objectives is to promote and encourage training through initiatives that aim at the development of engineering with necessary certifications. The Training Program for Teaching Engineering in the Americas (EftA) is a program for teacher training in engineering. It focuses on a crucial axis that will support engineering teachers with the necessary tools to teach in university classrooms, thereby allowing for complexity, diversity, and innovation in their teaching practices.

Being a teacher is complex. Being a good teacher is a title that very few of us know how to achieve. As Bain points out, extraordinary teachers not only “know their subject extremely well,” but also use their knowledge to “think their own way of reasoning about the discipline, analyzing its nature, and evaluating its quality [3]. “That ability to think metacognitively.” This is one of the most significant characteristics of extraordinary teachers: Therefore, it is not enough to be excellent professionals and knowledgeable in specific fields, with unquestionable skills and technical knowledge. However, this time demands that teachers recognize transdisciplinarity as the focus of their teaching. For example, the iPEER (International Professional Engineering Educator Registered) title was recently achieved through the “Pedagogical Training of Engineering Educators (ENTER) Project (created in 2018). This was achieved with the support of the only professional regulatory body that oversees engineering teaching professionals, the International Standard Classification of Occupations (ISCO), with code 2311 (ISCO Code 08) as “Higher education teaching professional: Engineering educator" [4–6].

Some investigations show that teaching practices closely linked to the concept of traditional science are recognized in engineering; however, in most cases, they do not explicitly incorporate into their practices how the content taught is related to social, environmental, and social issues [7–9]. This training program is designed to equip educators with the necessary resources to apply pedagogy and teaching methodologies within their curriculum, addressing common concerns such as: "I'm uncertain about how to effectively implement a specific teaching approach"; "I'm unsure of how to integrate new content into my lessons";

"I find it challenging to apply theoretical concepts I've learned in courses or training"; "It's easier to replicate what I experienced as a student"; etc. These concerns have been repeatedly expressed during our training sessions for engineering instructors, based on our extensive experience working within engineering faculties for over two decades. The training will focus on real-world teaching scenarios and the unique demands faced by each teacher in their respective institutions.

It is not a novelty to talk about pedagogical or teacher training in engineering, since 1851, various theoretical currents related to the same subject have been raised. Although this article does not aim to make a state-of-the-art statement, we recognize that "engineering pedagogy" is a theoretical line built from the approaches of technical training versus teacher training [10]. In 1954, Lohman [10] proposed the concept of technology using the engineering didactic approach. He defined technology by its function of "transforming the natural world" (cf. [10], p. 619). The task of an engineer is to develop the technology. Therefore, engineers must be qualified to solve the technical design problems. By contrast, the activity of scientists is focused on discovering relationships in the world and, therefore, solving problems of scientific knowledge. Invention and discovery require different ways of thinking, and therefore, different methods of academic training. In the 1990s, engineering pedagogy was based on services; thus, this vision of engineering pedagogy had to do with the development of didactic concepts for the preparation of future engineers for their leadership roles in changing the structures of production and service [11].

Those looking at the discipline itself brought with them models of what and how to teach future generations. Kersten et al. [15] stated that teaching should take design into account in the planning, implementation, and evaluation of teaching and learning in engineering, considering several factors: economics (in relation to products and services); science and research methods; social needs; and the subject as an individual and its peculiarities. This implies that the design of teaching proposals implies that.

With the creation of the International Society for Engineering Pedagogy (1972) and international exchanges of experts, especially Adolf Melezinek, a curriculum was created that served as the basis for various engineering pedagogical training programs that are being conducted. in more than thirty-two countries [12–14]. Studies, actions, and training programs are known in Europe, the United States, Latin America, and Chile [15], [16]. On this basis, it is preferred that all training proposals have the competencies of engineering education professionals that allow for a general program in accordance with world standards so that it can later be accredited with a symbol of quality.

According to various authors, some of the competencies that a training program must have are research, management, innovation in engineering pedagogy, time management, effective interaction, improvement of learning interactivity, systems analysis in education, psychology and pedagogical communication, interaction with interested parties, sustainable development, digital education, problem-based, project-based, and practice-oriented learning, assessment of learning outcomes, course design, engineering innovation processes, and lifelong learning [4], [17].

The IGIP Annual Symposium contributes to integration processes in professional training and promotes academic mobility. Engineering pedagogy centers are accredited according to international IGIP standards. An important task of the International Society of Engineering Pedagogy is not only the modernization of the scientific and methodological foundations of university engineering pedagogy in accordance with the urgent tasks of professional education, but also the improvement of the methodology of engineering and technical pedagogy [18].

Undoubtedly, one of the priorities in teacher training programs for engineering is to do with the models or approaches taken to think about this training. Rüütmann [19] suggests that basic didactic models, such as the science of engineering pedagogy, the didactic staff, and the quadruple instruction model, are of great importance in understanding and guaranteeing effective teaching in the discipline. It is understood that the didactic staff of the science of pedagogy constitutes the basis of the essential pedagogical competencies of engineering teachers, along with specialized competencies. The basic teaching model of the Science of Engineering Pedagogy follows the principles of an iterative process, making it an effective tool for the design of a study program, study plan, syllabus, course, or conference. Finally, the integrated quadruple instruction model of Engineering Pedagogy Sciences is the basis of integrated course design and one of the preconditions for effective teaching and learning, as well as the basis of the teaching competencies expected of engineering teachers. Teachers' pedagogical competencies are becoming increasingly important in evaluating the quality of higher education. The most effective field for the pedagogical continuing education of engineering teachers is engineering science pedagogy, which offers adequate and relevant teaching models to ensure effective teaching and learning, and integrated course design based on informed decisions, analysis of learning, reflection, and metacognition.

On the other hand, Martynov and Sheinbaum [20] suggested that for the training of engineering teachers, it is necessary to consider it as a multidimensional and multivariate system of division of labor, an open, dynamic, and interdependent system. The authors consider that the activity should become the basis of the new methodology of engineering pedagogy, which creates tools to train new generations of engineers through the continuing professional education of university teaching staff.

In short, thinking about the way of teaching has been the product of research and experiences that show the need to focus on training to scale up or improve student retention practices and inter-and transdisciplinary views of the specificity of a field in relation to what surrounds it.

We have varied antecedents in Latin America that show that in recent times, engineering has had little growth because these careers are perceived as very long and difficult, adding to the fact that the initial years have become more difficult for those who join these careers [21]. Therefore, thinking about teaching would give us the possibility of providing a reflective look at the practice that allows us to identify, analyze, and act so that more students continue their studies in these careers, and, above all, more are encouraged to study it. If teaching is a fact that could influence the difficulties of the first years, devices

would be thought of as allowing accompanying student trajectories while also focusing on teaching support [22-23].

On the other hand, UNESCO has published two benchmark reports on engineering a decade apart [24–25]. The first was widely recognized as one of the most important engineering documents and has aroused considerable public interest [25]. Although some fundamental aspects of the profession and the responsibility of engineers remain, the number of times has changed significantly in the ten years since its publication. The second UNESCO report on engineering, entitled "Engineering for sustainable development: Meeting the Sustainable Development Goals," published in 2021, was presented in the context of accelerating actions to meet the Sustainable Development Goals (SDGs) [24]. The report also highlighted the importance of engineering education, the development of new engineering competencies, and the ability to accredit engineering training programs to international agencies, emphasizing the following competencies: multidisciplinary and interdisciplinary, adapting to change, creativity and flexibility, hands-on experience, leadership, sustainable development, and employability in engineering curricula [24]. Introducing these competencies into engineering training programs at the student and teacher levels will promote high quality for future engineers.

LACCEI, as an institution that cares for and deals with engineering in the Americas, proposes this training program to make engineering teaching practices focus on being competitive with the times, and to allow future generations to have the necessary tools to understand the complexity of today's world. This document proposes specialized training in the pedagogical area aimed at engineers who work as university professors. The importance of specific training for the best performance of engineering professionals in teaching has been recognized. This proposal seeks to strengthen engineers' teaching dimensions, allowing them to make their educational practices consistent with the challenges that arise in current teaching. The proposal is organized into modules, each focusing on specific aspects of university education [26].

Methodology

To design this training program, reviews of similar programs at different latitudes were considered. Tables I and II show a synoptic table with the six training programs analyzed (two from Latin American institutions, two from the United States, and two from Europe) that have been coded A-F, respectively.

As previously mentioned, this article has two objectives: to review other programs and present our own training program. During the design of the program, we investigated the most common training interests of engineering professionals; when the plan was executed, we made the necessary adjustments that allowed us to adapt and place what was planned in the realities most inherent to the teaching of engineering careers. In this way, we can affirm that we frame ourselves in an action research study that allows us to generate and promote participation, reflection on practice, and contrast ideas and ways of doing that guide us and reveal ways to innovate and train engineers., and engineers [27-30].

Next, we specify the categories used to review the programs, namely, the language of dictation, the profile required to participate, the requirements that the organization or institution has foreseen, the type of program (if it is a course, workshop, etc.), the structure of the program (by modules and/or units), the certification and/or accreditation they hold (especially the scope of recognition), the duration of the program, and, finally, the type of study (if it is in-person, virtual, or hybrid). In this analysis, we did not consider programs on digital platforms such as Coursera or MOOCs.

When a more exhaustive analysis was performed to group what was analyzed, we established three dimensions: administrative, training, and innovative or technological (Table III). In the first (administrative dimension), we grouped all the aspects linked to the type of program, language, certification, and duration. We observed that the majority were in English (especially because they are programs in the United States and Europe) and were structured into courses or workshops. This organization of the training process is recognized because it allows professionals to have flexible training that allows them to combine work, academics, and training. This is consistent with the fact that it is organized into four or five modules. However, we note that there are programs that range from 40 to 900 h. This is one of the biggest differences we noticed. They are all supposed to be organized in a similar way, but the density linked to time seems to be something we will continue to investigate.

Table I. Programs for engineering educators: Part 1.

Category	Program A	Program B	Program C
Language	English	English and Russian	English, Spanish, and Portuguese
Participant profile	Engineers or related	Engineers or related	General
Program type	Courses	Courses	Courses, workshops, conferences
Program structure	4 modules	3 modules	In modules (4 or 5)
Program certification	Accredited by the organization itself		
Duration	600 hs.	900 hs.	150 hs.
Modality	Virtual and in person	Virtual and in person	Virtual

Table II. Programs for engineering educators: Part 2.

Category	Program D	Program E	Program F
Language	Spanish	English	English
Participant profile	Engineers or related	Partner Engineers	Engineers or related in US
Program type	Courses	Course paths	Courses and workshops
Program structure	4 modules	5 paths	Without structure
Program certification	Accredited by the organization itself		
Duration	40 hs.	Variable per path	Variable
Modality	Virtual and in person	Virtual	Virtual

Table III: Dimensions.

Dimension	Category
Administrative	Language
	Program type
	Program certification
	Duration
Training / Formative	Participant profile
	Program structure
Technological/innovative	Modality

The dimension of greatest interest to us is the second one. The components of the programs analyzed were found to be similar. For instance, one module is focused on theories of learning and teaching, while another module is dedicated to teaching strategies, yet another to evaluation, and yet another to engineering project writing. In longer programs, there is an opportunity for integrative projects. Upon comparing the learning objectives, it is evident that all programs aim to equip the participants with the necessary tools to enhance their teaching skills. However, it was noteworthy in this dimension that the profiles of the participants lacked specificity. It is unclear from the available data whether they are first-year or higher education teachers, if they enroll in these programs because their universities recognize the need, or if they do so purely out of self-interest.

From the technological dimension, we notice that the proposals are characterized as virtual and/or hybrid. As expected, this guarantees greater participation and promotes an environment that can be simulated through one's own practice. However, there is no explicit content related to technology in the teaching services.

We believe that this is because they are face-to-face, which hinders the mobility of Latin American professionals. Therefore, we believe that our proposal, aimed at professionals from Latin America and the Caribbean, will be a valuable opportunity for those wishing to train. LACCEI is an organization with academic backing that promotes specific training not only in the technical field of engineering, but also in teaching, which we require so much in universities.

Program

The program was organized into various phases, and the phases inherent to the training program are described here. In this phase, five modules related to various aspects of teaching were planned with a focus on university pedagogical practices. This training plan is based on an eclectic approach drawn from various currents. Situated learning is a pedagogical approach that focuses on the practical and contextualized application of knowledge in real-world situations. It is based on the premise that learning is most effective when embedded in relevant and authentic contexts, allowing students to develop transferable skills and to understand the practical utility of what they are learning. This approach involves solving concrete problems, collaboration, and reflection on experiences [31–33].

However, emerging pedagogies provide the necessary tools for innovative educational contexts that arise in response to the changing demands of society and technology. These pedagogies include project-based learning, online learning, mobile learning, and other disruptive methodologies. They seek to improve student participation, personalize learning, and integrate advanced technological tools to enrich their educational experiences [34–39]. At this point, we cannot stick to a single look. It is necessary to adopt different principles that allow us to focus on located learning to permanently revisit practical and applied experiences. Situated learning and emerging pedagogies seek to transform education by fostering a direct connection between learning and its application in authentic contexts and by preparing students to meet the challenges of the modern world.

General Objectives

- Strengthen the pedagogical skills of engineers as university professors.
- Promote the design and implementation of effective teaching strategies aligned with learning objectives and general and professional skills.
- To foster innovation and the use of educational technologies in engineering education.
- Develop formative assessment skills to monitor and improve the teaching-learning process.
- Stimulates creation of an inclusive and participatory learning environment.

Modules

The planned modules are as follows.

- Module 1: Pedagogical Perspectives for Engineers
    - Learning theories applied to engineering education.
    - Curriculum design: Approaches to planning teaching.
    - Writing and reading as scaffolding for learning and teaching.
    - Capstone projects in engineering education.
- Module 2: Teaching-Learning Methodologies in Engineering.
    - Problem-based learning and projects.
    - Collaborative learning and teamwork.
    - Use of simulations and virtual laboratories.
    - Integration of emerging technologies in engineering education.
- Module 3: Formative Assessment and Feedback
    - Evaluate versus qualify as foci of learning.
    - Design of instruments, criteria, and guidelines necessary to accompany learning.
    - Effective feedback and continuous improvement.
    - Self-assessment and peer assessment in the engineering context
- Module 4: Communicate, Disseminate and Socialize.
    - Reading, writing, and speaking in teaching contexts.
    - Writing to publish in engineering and be part of the engineering community as a teacher, student, and/or professional.

    - Engineering writing standards: norms, styles, etc.
- Module 5: Science and Knowledge in Engineering Education
    - Scientific processes in engineering education.
    - Bibliographic bases and academic scientific research in engineering.
    - Open science in engineering education.

Duration

The program will have a duration of 140 h and will be distributed throughout the courses of the different modules.

Program Methodology

The training will be conducted online through activities that include lectures, case studies, group discussions, and practical classroom applications. Active participation of participants will be encouraged, and the exchange of experiences and good practices will be promoted. The Virtual Campus will have resources that favor autonomous learning processes and group and interdisciplinary reflection through work in different teams with multiple knowledge and experiences. Asynchronous and synchronous activities are conducted in different formats and environments. The training will have the permanent presence of a teaching team (responsible teachers and academic tutors) who will accompany each stage of the course and guide, evaluate, and provide feedback on the learning processes, preparation of compulsory activities, and final integration work.

Evaluation and Accreditation

To obtain certification, the participants must take all modules, comply with the obligatory activities, and deliver and approve the final project. Certification is issued by the LACCEI.

The central idea of this training proposal is that it aligns with the competencies of the ENTER's learning outcomes. Table IV shows the correspondence of each proposed module with the ENTER competencies.

Web Platform

The Training program in teaching Engineering for the Americas will be implemented on a web platform that allows the management of user participants, courses, teachers, materials, and finances. The system is implemented on a platform as a service (PaaS) and software as a service (SaaS) on Amazon Web Services with various Cloud Computing services (text similarity detection, text redaction, etc.). Users can manage their different profiles and the system of badges necessary for program accreditation. Payments can also be managed online through PayPal or bank transfers. Teachers can create courses and materials freely but under the standards defined by the academic committee of the program. The implementation of the platform will allow stakeholders to track the entire program and will be flexible to the different needs and changes of participants and teachers.

Table IV: Training proposal and ENTER's learning outcome.

ENTER Learning outcomes	Training	Comments
Innovations in Engineering pedagogy	**Module 1:** Pedagogical perspectives for Engineers	
Time management	**Module 1:** Pedagogical perspectives for Engineers	
Effective interaction	**Module 4:** Communicate, Disseminate and Socialize	Workshop. Rewrite to publish. Issued in October 2023
Enhancement of learning interactivity	**Module 2:** Teaching-learning methodologies in Engineering	
Systems analysis in education	**Module 4:** Communicate, Disseminate and Socialize **Module 5:** Science and knowledge in Engineering Education	
Pedagogical psychology and communication	**Module 1:** Pedagogical perspectives for Engineers **Module 2:** Teaching-learning methodologies in Engineering	
Interaction with stakeholders	**Module 4:** Communicate, Disseminate and Socialize **Module 5:** Science and knowledge in Engineering Education	
Sustainable development	**Module 5:** Science and knowledge in Engineering Education	
Digital education	**Module 1:** Pedagogical perspectives for Engineers **Module 2:** Teaching-learning methodologies in Engineering	
Problem-based, Project-based and Practice oriented learning	**Module 2:** Teaching-learning methodologies in Engineering	
Learning outcome's assessment	**Module 3:** Formative assessment and feedback	
Course design	**Module 2:** Teaching-learning methodologies in Engineering	
Engineering innovation process	**Module 5:** Science and knowledge in Engineering Education	
Lifelong learning	**Module 2:** Teaching-learning methodologies in Engineering **Module 5:** Science and knowledge in Engineering Education	

Impact on Engineering Education

Since its inception, LACCEI has made strategic alliances with different institutions such as CONFEDI, ASIBEI, ACOFI, GEDC, ENTER, ASEE and IEEE[1], among others, and in

[1] CONFEDI: Federal Council of Engineering Deans; ASIBEI: Ibero-American Association of Engineering Teaching Institutions; ACOFI: Colombian Association of Faculties of Engineering; GEDC: Global Engineering Deans Council; ASEE: American Society for Engineering Education.

2022 it formed the Multi-Society Global Colloquium on Engineering Education, made up of 7 societies: AEEA, ASEE, CEEA/ACEG, CSEE, JSEE, KSEE[2]. In this way, the LACCEI fulfills part of its mission, which is to be the leading organization of engineering institutions that will enhance innovation, inspire collaboration in engineering education and research, and foster alliances between academia, industry, and government for the benefit of humanity, society, and nations. The committees and initiatives that currently work in LACCEI are: "Diversity and STEM Women," "Open Science for Engineering," "Student Chapters," "Council of Deans of Engineering of Latin America and the Caribbean of LACCEI," Online Learning and Laboratories," "Technological Development and Innovation," "International Accreditation," "Internationalization and Multiculturalism," "Foresight and Future Studies," and "Entrepreneurship and Innovation".

Additionally, we mention that one of the most successful activities carried out annually by LACCEI is the multi-conference, known as The OAS Summit of Engineering for the Americas, with the presentation of scientific and academic articles on various subject areas that are submitted to a double-blind peer review process; that is, the reviewers (at least two per paper) do not know the identity of the authors of the articles, and the authors do not know the identity of the reviewers in the process. In 2023, the twenty-first edition was held, with the reception of approximately 1,450 papers (full paper, work-in-progress, guest paper, and student competition). The proceedings were published under ISBN and ISSN numbers and archived with online access. The Full Papers (FP) included DOI and Scopus indexing, and the FPs and all other papers published in the proceedings were indexed in AXCES.info (our repository) and Google Scholar.

Therefore, the implementation of a pedagogical training program aimed at engineers will be aligned with the LACCEI philosophy to have a profound and positive impact on both social and university spheres. This approach seeks to not only strengthen engineers' technical skills but also cultivate their pedagogical and communication skills. Consequently, trained individuals effectively convey their technical knowledge and foster the development of problem-solving skills, critical thinking, and creativity in their students.

This program contributes to more equitable education by promoting diversity and inclusion in the engineering classroom, creating an enriched learning environment that is respectful of different perspectives. In addition, the pedagogical approach improves the relationship between teachers and students, stimulating collaboration and active participation. On a social level, this program not only raises the quality of engineering education, but also fosters the development of more committed people prepared to face the technological and scientific challenges of today's society.

Conclusions

The main objective of the proposed pedagogical training is to strengthen engineers' teaching skills as university professors. Through the thematic modules, the aim is to

[2] AEEA: African Engineering Education Association; CEEA/ACEG: Canadian Engineering Education Association/Association Canadienne de l'Éducation en Genie; CSEE: Chinese Society for Engineering Education; JSEE: Japanese Society for Engineering Education; KSEE: Korean Society for Engineering Education.

provide them with the necessary tools to design and implement effective teaching strategies, use educational technologies, evaluate them in a formative way, and create inclusive learning environments. Engineers will be able to offer quality education, promote the academic success of their students, and contribute to the development of engineering education at the university level.

It should be noted that in this paper, our purpose was not only to show an analysis of various proposals but, above all, to outline a proposal that we will test in the following months. Many analyses will derive from this that will allow us to know how situated and contextualized the differently designed modules are and what needs we are noticing in pedagogical training to adjust to the competencies, skills, and demands of teachers in the daily life of the classroom. The idea is that this proposal is fed by the necessary empirical evidence for further analysis of pedagogical practices and the training of engineering teachers.

The program described aims to enable LACCEI to focus on a new dimension: the training of engineers. Although LACCEI, through its conferences and various initiatives, promotes research and innovation in engineering, with this program, it would approach the educational dimension of those who train future generations.

Finally, we believe that pedagogical challenges will be complex and diverse because we consider that training should not be merely instrumental but should address the reflections, complexities, and diversities of university classrooms in which engineers train future engineers. Reflection and feedback were the axes of our training proposal throughout the course of the modules. We will not limit ourselves to using one methodology or another because the focus is on understanding what an engineer needs in his or her learning process, so that his or her teaching practices in this technological, innovative era focus on long-lasting learning. [40].

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