

**FROM ENGINEER-PROFESSOR TO PROFESSOR OF ENGINEER: TEACHING IN
(TRANS)FORMATION**

***DE ENGENHEIRO-PROFESSOR A PROFESSOR DE ENGENHARIA: A DOCÊNCIA
EM (TRANS)FORMAÇÃO***

***DE INGENIERO-PROFESOR A PROFESOR DE INGENIERÍA: LA DOCENCIA EN
(TRANS)FORMACIÓN***



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How to reference this article:

FERREIRA, D. M.; NACARATO, A. M. From engineer-professor to professor of engineer: Teaching in (trans)formation. **Revista Ibero-Americana de Estudos em Educação**, Araraquara, v. 19, n. 00, e024091, 2024. e-ISSN: 1982-5587. DOI: <https://doi.org/10.21723/riace.v19i00.18454>



| Submitted: 08/09/2023

| Revisions required: 22/12/2023

| Approved: 05/03/2024

| Published: 20/07/2024

Editor: Prof. Dr. José Luís Bizelli

Deputy Executive Editor: Prof. Dr. José Anderson Santos Cruz

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RESUMO: Neste artigo, objetiva-se problematizar a formação do engenheiro-professor, a partir da própria trajetória do perfil dos cursos de Engenharia, que não têm como propósito a constituição didático-pedagógica do futuro engenheiro. Esse profissional atua como docente no Ensino Superior, na maioria das vezes, após ter feito um curso de bacharelado e pós-graduação no campo específico de trabalho, focado apenas em sua formação técnico-científica. Busca-se então, por meio de entrevistas narrativas com seis engenheiros-professores, compreender o que eles narram sobre suas constituições como docentes, e como construíram suas práticas de sala de aula, por meio do olhar da reflexividade, no conceito de (Schön, 2000). Constata-se que a graduação não os constitui professores e as instituições nas quais atuam não favorecem espaços formativos. Cabe ao próprio engenheiro-professor o papel de construir sua própria trajetória, muitas vezes pautada numa reflexão solitária sobre erros e acertos de sua prática.

PALAVRAS-CHAVE: Docência em engenharia. Ensino Superior. Entrevista narrativa. Reflexividade. Trajetória docente.

RESUMEN: *En este artículo, el objetivo es problematizar la formación del ingeniero-docente, desde la propia trayectoria del perfil de los cursos de Ingeniería, que no tienen como finalidad la constitución didáctico-pedagógica del futuro ingeniero. Este profesional se desempeña como docente en la Educación Superior, la mayoría de las veces, luego de haber realizado un curso de licenciatura y posgrado en el campo específico de trabajo, enfocado a su formación técnico-científica. A través de entrevistas narrativas con seis ingenieros-profesores, busca comprender lo que narran sobre sus constituciones como docentes y cómo construyeron sus prácticas a través de la mirada de la reflexividad, en el concepto de Schön (2000). Parece que la graduación no los convierte en profesores y las instituciones en las que trabajan no favorecen los espacios de formación. Corresponde al propio ingeniero-profesor construir su propia trayectoria, muchas veces a partir de una reflexión solitaria sobre los errores y aciertos de su práctica.*

PALABRAS CLAVE: *Docencia en ingeniería. Educación superior. Entrevista narrativa. Reflexividad. Trayectoria docente.*

ABSTRACT: *In this paper, the objective is to analyze the formation of the engineer-teacher, based on the trajectory of the profile of Engineering courses, which do not have as their main purpose the didactic-pedagogical constitution. This professional acts as a teacher in Higher Education, most of the time, after having taken only a bachelor's and postgraduate course in the specific technical-scientific field of work. The aim is through narrative interviews with six engineer-teachers, to understand what they narrate about their constitutions as teachers, and how they built their classroom practices. through the look of reflexivity, in the concept of Schön (2000). It appears that graduation does not make them professors and the institutions in which they work do not favor pedagogical training spaces. It is up to the engineer-teacher himself to build his own trajectory, often based on a solitary reflection on the mistakes and successes of his practice.*

KEYWORDS: *Engineering teaching. Higher education. Narrative interview. Reflexivity. Teaching trajectory.*

Introduction

The technical training of engineers has always been focused on adapting to the current job market, as it will always seek professionals with the skills to perform different activities, in different sectors, as Pereira and dos Santos Junior (2018) discuss in detail. However, if this challenge alone were not enough, the intense technological evolution of the moment could be added to this training, whether through specific computational tools or even communication, which requires constant reformulations in undergraduate courses.

In this demand to adapt to the new needs and technological advances required, lies the challenge of training this engineer. In the Engineering course that will train you, regardless of the chosen modality, there are several teachers graduated from common areas such as Physics, Calculus and others; however, the majority of them are engineers working as teachers. This observation leads us to question how the didactic-pedagogical constitution of this professional happens, who, until then, was concerned with technical areas, but who must now include in his activities the art of contributing to the integral development of people. Ferreira and Nacarato (2023) present a state of the art on what has been researched, in Brazil, in relation to the pedagogical constitution of this trained engineer who takes up teaching. Among the thematic units analyzed that permeate the 17 national works (dissertations and theses), the (non)existence of specific training for teachers who work in engineering courses is the one that appears most frequently.

In this scenario, it is of fundamental importance that this engineer-teacher understands as soon as possible that his role is not just to transmit technical knowledge, but to form:

Knowing how to teach is not transferring knowledge, but creating possibilities for its own production or construction. When I enter a classroom, I must be open to questions, to curiosity, to students' questions, to their inhibitions; a critical and inquiring being, restless in the face of the task I have – that of teaching and not that of transferring knowledge (Freire, 1996, p. 47, our translation).

Considering the importance of this more human, more formative and less knowledge-transmitting perspective, this work aims to seek evidence of how the engineer-teacher constitutes himself as a Higher Education teacher. Even if not formally, the fact is that this engineer becomes a teacher and becomes a trainer of new engineers who, one day, may become teachers. As a trainer, he does not have a repertoire of pedagogical knowledge for teaching, as discussed in Ferreira and Nacarato (2022).

Pimenta and Anastasiou (2014) point out four factors that not only impact the lack of pedagogical training of university professors, but also characterize their profile. The first is related to an expansion in private Higher Education Institutions (HEIs) and a consequent increase in the demand for university teachers. The second is training focused on research, especially in master's and doctoral courses. The third involves professionals who divide their time between teaching and another profession, such as Engineering. Finally, we have the unemployment rate in the training area, leading some to “opt” for teaching.

It is necessary, then, to critically reflect on what engineer-teachers narrate about their constitutions as teachers, about the way they constructed their classroom practices. The very nominal reference as an engineer-teacher is related to his professional identification: by placing the title of engineer at the front, it semantically demonstrates the precedence of this area in his life, and perhaps not only a temporal precedence, but also one of sufficiency. Or perhaps, as Zabalza (2004) states, there is a lack of definition for this professional regarding the identity of a university professor, leading him to identify with his specialty, in this case Engineering, and, consequently, to invest more in this area. Santana (2008) links the term with the employment contract regime: as normally in private institutions the employee is hired on an hourly basis, this professional then continues to be an engineer-teacher, after all he spends more time on Engineering than on teaching.

Understanding the origin of the role played by this engineer may be the way to reduce a possible dichotomy between the knowledge necessary for engineering and the pedagogical knowledge required by teaching. From this perspective, in order to seek evidence of how the engineer-teacher is formed, we proposed to interview six engineers who work as teachers in private institutions. This text is an excerpt from doctoral research developed in the format of multiple articles (*multipaper*) by the first author (Ferreira, 2022). In it, we aim to problematize the training of the engineer-teacher based on the trajectory of the profile of Engineering courses that do not have as their purpose the didactic-pedagogical training of the future engineer, but aim at technical training.

We initially present a brief history of the didactic-pedagogical training of the engineer-teacher, considering the legislation; then, we explain the methodological procedures used in the research. Subsequently, the speeches of the interviewed teachers are intertwined with those of authors who problematize the training of teachers who work in Higher Education, in the dilemma between research and teaching, and the need for reflective practice. To conclude, we defend the relevance of continuous training for the engineer-teacher based on reflexivity.

Didactic-pedagogical training of the engineer-teacher

By raising the issue of the pedagogical constitution of the engineer-teacher, we seek to bring to light a discussion that is often ignored, since, apparently, everything is working: competent and successful professionals in the industry who consider themselves teachers who teach well their academic content and manage to train engineers who will keep this cycle running. However, it is not that what has been done so far is bad or has not worked, but technological, generational and communication transformations have brought changes that affect the life of the engineer-teacher and the training of professionals, bringing the need of new perspectives for this process.

When discussing the importance of possible changes in teaching action in Higher Education, Masetto (2012, p. 9) highlights that one of the main bases underlying this discussion is related to the superior organizational structure of this segment of education in Brazil, since the initial model implemented was the Napoleonic model, which has as its principle:

[...] train professionals through the teaching process in which knowledge and professional experiences are transmitted from a teacher who knows and knows to a student who does not know and does not know, followed by an assessment that indicates whether the student is capable or not to exercise a certain profession. If so, you receive the diploma or certificate of competence that allows you to practice professionally. If not, repeat the course (Masetto, 2012, p. 9, our translation).

This model, which still governs many Engineering courses, is related to the traditional class format, in which the student is considered the receiver and reproducer of the knowledge transmitted by the central figure in the process, the teacher, who evaluates him through tests. From this perspective of a common sense that “those who know how to do, know how to teach”, the teacher model constituted in technical rationality is considered, that is, “professional practice consists of the instrumental solution of problems through the application of theoretical and technical, previously available that comes from scientific research” (Contreras, 2002, p. 90, our translation).

Machado (2008) makes a historical retrospective of ministerial ordinances, decrees, laws, and courses that attempt to create national proposals on technical pedagogical training, recording the beginning of this demand in 1909, but only in 1917 was there a first initiative in response to this demand, with the creation of the Escola Normal de Artes e Ofícios *Wenceslau Braz* (president at the time). However, the school created at that time in the Federal District

lasted only 20 years; and, of 5,301 enrollments received during this period of operation, only 381 completed the course, indicating a huge lack of interest in training of this type.

In relation to educational legislation, the first inclusion of the subject took place in 1942, with the Organic Law of Industrial Education of 1942 in Art. 54 (Brazil, [20 --]a), with some considerations of what the teaching staff should be like for technical training, considering only the secondary level (and most common at the time).

From 1946 to 1963, there was an agreement signed between Brazil and the United States for educational exchange and the creation of the Brazilian-American Industrial Education Commission (Cabi), responsible for introducing TWI (*Training Within Industry Service*) in Brazil, an immersion training method, used as a didactic reference in the pedagogical practices of Senai (National Industrial Learning Service), officially created a few years earlier. In the 1960s, according to Machado (2008), the first regulations for teaching in professional education appeared by the Ministry of Education (MEC), but all of them were still linked to technical education equivalent to secondary level and not higher education, and always associated with a category of “special courses” and not with technical training itself, which until that moment was still separated into agricultural, commercial and industrial. In the laws of the time that regulate the professional duties of engineers, teaching appears for the first time as a possibility (Martins, 2018).

The University Reform established by Law no. 5540/68 (Brazil, [20--]b) follows a trend of the time to determine minimum curricula and was born with the difference that, from then on, the training of teachers for Secondary and Technical Education should take place in a higher-level course. However, there is one detail: exceptions would be made in the absence of specialist teachers with higher education.

According to Sagae (2016, p. 3, our translation), “Brazilian universities have always had improvised teachers, without specific preparation to practice the teaching profession.” Souza and Rodrigues (2017) describe that, for Higher Education teachers, it was only from the 1980s that, in addition to a bachelor's degree in a specific area and professional experience, specialization (and later master's and doctorate) began to be required; that is, a qualification that reinforces the professional's technical knowledge and mastery of a specific area and a clear apathy towards any type of pedagogical training requirement for that level.

Kawashita (2003) highlights the various past reforms, considering the Federal Constitution of 1988 and the Law of Guidelines and Bases (Brazil, 2023) as the main ones. However, even though the latter is concerned with the qualifications of the teaching staff (at

least a third with masters and doctoral degrees) it does not even mention university teaching training, thus disregarding that, “in the teaching act, theories are present, decisions are made and options are made; [it] involves alternative positioning and choices” (Kawashita, 2003, p. 35, our translation), forgetting that the teacher should have tools and clarity that he is forming a citizen for society, and not just a technical professional.

Despite all the progress that has been made in legislation related to Higher Education, the Law of Guidelines and Bases is complemented by Decree no. 5773, of 2006, only regarding the supervision and evaluation of HEIs, maintaining the existing silence in relation to pedagogical knowledge that the bachelor should have. However, these professionals in their field of training, such as engineers, continue teaching, linking “becoming a teacher” to personal and technical development that, despite being individualized, ends up representing an entire category. This is the problem that we intend to analyze based on the voices of teacher-engineers. Next, we present the methodological procedures of the research.

Methodological procedures

The empirical research was carried out through narrative interviews with engineer-teachers, considering that in addition to the teacher producing meanings for the experiences lived by narrating them, he also reflects on them and on his professional identity, enabling new interpretations of what has been experienced and a reconstruction of a history of teaching, according to Nacarato (2015). Furthermore, interviews are not only used as sources of data, considering that narratives are part of the story, but, as stated by Bolívar, Domingo and Fernandes (2001, p. 55, our translation), “a way of giving the voice to teachers about their concerns and their lives, which – normally – have been silenced in educational research.” The narrative interview is opposed to the question-answer model, it is initiated by a generative question and used, according to Jovchelovitch and Bauer (2012), based on the method proposed by Fritz Schütze, in which the interviewee is encouraged to narrate important episodes of their life based on themes proposed by the researcher, in an attempt to reconstruct social events based on the perspective of the interviewees.

The interviews followed the four steps proposed after defining the topic to be investigated. They are: initiation (formulation of the initial topic), central narration (not interrupted, just encouraging encouragement to continue), question phase (without seeking

specific opinions or understandings) and concluding speech (stop recording, take notes and answer specific questions).

The analysis material consists of excerpts from interviews carried out with six engineers from different areas of activity who became teachers without specific preparation for this. All are identified by pseudonyms, chosen to guarantee the anonymity of participation in accordance with the approval of the initial research project by the Ethics Committee (CAAE 13461319.6.0000.5514) according to Table 1.

The interviews were transcribed and approved by the deponents. For the analysis, we did several readings and re-readings, searching for thematic units. One of them, which caught our attention, concerns didactic-pedagogical training, since reflections on it are present in all narratives, which is why it is the focus of this article. We cut out the testimonies' statements and sought to take a look at the comprehensive-interpretative dimension of the meanings that the teacher-engineers attributed to the narrated trajectories. In the narratives, we highlight the statements that, according to our understanding, refer to the meanings that the interviewees attributed to what they experienced.

Table 1 – Participant information.

Pseudonym	Training area	Title	Teaching time	Courses he/she teaches	Age (approx.)
Edith	Electrical engineering	Doctor	20 years	Electrical Eng. Mechanical Eng. Production Eng.	50
Ginni	Electrical engineering	Doctor	20 years	Electrical Eng. Computer Eng.	40
Pierre	materials Engineering	Doctor	25 years	All	60
Elmina	environmental engineering	Doctor	4 years	Environmental Eng. Civil Eng.	30
Henry	mechanical Engineering and Civil	Specialist	30 years	Mechanical Eng. Production Eng.	60
Mark	Computer Engineering	Teacher	10 years	Computer Eng. Electrical Eng.	35

Source: Own preparation.

Initially, we analyzed the narratives from the perspective of the dichotomy between training to work as an engineer or researcher and as a teacher and the challenges at the beginning

of teaching. Subsequently, we problematize, based on the voices of teacher-researchers, the role of continued training and reflection in teaching.

In theory, Engineering; in practice, teaching.

Engineering can be characterized as being an extremely technical area that uses science for practical purposes, that is, it is the application of scientific knowledge of Physics, Mathematics and Economics to solve problems and project things for the benefit of society:

The contemporary view of engineering is that of a craft that is required to solve technological problems and leverage the progress of the society in which it is inserted, acting sometimes as technology, sometimes as science, governed by social, environmental, economic and technical impacts, each time more in this order of the solutions it adopts. From this perspective, engineering education is, and must continue to undergo, changes, adopting guidelines that favor the training of the citizen-engineer rather than the technician-engineer (Loder, 2002, p. 54, our translation).

If initially there was already a challenge for the teacher to train someone as an engineer, now the intention of training citizen-engineers will demand increasingly more from this professional. However, the biggest challenge still seems to be that, for the engineer who until then had only technical training, starting a higher education teaching career is usually something sudden, as indicated by Pimenta and Anastasiou (2014, p. 8, our translation): “professionals slept and researchers from different areas and agreed with teachers.” In interviews, you can see this:

I was in industry, and the University was still small [...]. My intern recommended me and I went there. I spoke with the coordinator and the director at the time. And that was it. This was at the end of the year; and, when March arrived, the secretary called me and said: “Teacher, come here, bring your desk and your class starts today.” I said: “What?!” And I went, right? [...] The coordinator called me at the end of the year and said: “People liked it, and I wanted you to teach more classes.” (Prof. Henry).

My professional life began this way: with the aim of working as an engineer in technology and that's it. I never thought about being a teacher [...]. But I started to be a teacher by chance: I was invited to sit on some [course conclusion] projects. There, they thought: “Why don't you come and teach? Have you never thought about that?” At the time, I replied that I could think about it... And then the other year, I remember that there was a subject that lacked a teacher and they then nominated my name. As it was a very short period and I had already been recommended, I ended up joining (Prof. Mark).

Regardless of how much professional experience this engineer has and the good intention of teaching interesting classes, it is certain that formal pedagogical knowledge is non-

existent and teaching practice experiences are minimal. The main characteristic that guides this engineer at the beginning of his teaching career is based on mistakes and successes that adjust his role, according to the reports:

Butterflies in the stomach in the first class..., it seems like we never feel prepared. In recent years, not so much. But, the night before the first class, it's always that uncomfortable sleep from Sunday to Monday [...]. So, after the first class, let's go! Because we never had any pedagogical discipline..., any preparation to teach. Nothing, nothing! Only the successes and failures (Prof. Pierre).

I was a disaster at teaching, can you believe it? The students didn't understand me at all. I was there at the front in my doctorate, with all that in my head and teaching very easy things. Still, they didn't understand me! Wow, it was a hassle! It took me a while to get the hang of teaching. At first, I thought I must have been the worst teacher in the world! (Prof. Edith).

The MEC, through the Chamber of Higher Education (CES), when publishing a public consultation on the renewal of the National Curricular Guidelines for Engineering courses (Brazil, 2018), records the problem of the lack of pedagogical training of engineers who go on to act as teachers in Engineering courses. It also signals the lack of training in academic management, from the organization of the course to the activities developed to meet the training needs according to the profile of the graduate, without, however, doing anything effective to change the scenario. In Resolution no. °, April 2, 2019, there is only Art. 14 on the teaching staff (Brazil, 2019, p. 6) delegating, however, to the undergraduate program itself to maintain a permanent training program, but without specific links with teaching:

§ 1 The undergraduate course in Engineering must maintain a permanent Training and Development Program for its teaching staff, with a view to valuing the teaching activity, greater involvement of teachers with the Pedagogical Project of the Course and its improvement in relation to the training proposal, contained in the Pedagogical Project, through the conceptual and pedagogical domain, which encompasses active teaching strategies, based on interdisciplinary practices, so that they assume greater commitment to the development of the desired skills in graduates.

§ 2 The institution must define indicators for evaluating and valuing teaching work in the activities carried out on the course.

This lack of political appreciation of pedagogical training ends up being reflected in other spheres. Much has been said and researched about the pedagogical training of engineers, however, whether through the *engineer-teach-engineer cycle* or simply due to the lack of specific legislation, for these engineer-teachers, the term *pedagogical training* appears to be

something necessary, but never prioritized, understanding that time and experience would resolve this situation:

I was worried: “How was I going to teach?” So, I started teaching very early: I took classes in São Paulo, in Ribeirão Preto. I traveled a lot! [...] little by little, I got my bearings: where I'm going, what the tests should be like, how to deal with students (Prof. Edith).

I came in more to help and in the end, I realized that I really took over the class! It was a huge challenge... I was learning how to teach, I mean, I don't know if I learned that [laughing] but, let's say, learning how to behave, how to prepare to teach and not just knowing content. That was in 2012 and I still remain, right? I matured a lot in that time (Prof. Mark).

If in public HEIs the engineer-teacher divides his activities with research, in private institutions, it is more common for him to share his hours dedicated to teaching with activities linked to companies and industries. In both situations, it is also possible to understand that, for the teacher, there is a similarity between the work of the engineer and his team with that developed by the teacher in class, being able to simply transfer these skills from one environment to another:

Research helps in teaching! You know, when you are a researcher, you have to guide. I was a laboratory coordinator and I had five or six students under my supervision and we published a lot in regional and local conferences. As you have to coordinate, it has to have results; So, you have to find a way. You know, you have to guide both the practical part and the study part, because you have to guide them: what they have to study, look at what's missing, what path it takes, until publication. So, it helped a lot, we just need to find a way to clearly teach everything we research (Prof. Edith).

I think maybe the industry guys in private schools, they have an advantage: these guys are used to dealing with people, to doing and also giving training in companies. They are good! Many with public speaking courses that the company prepares. IBM of life, Motorola, Bosch, any of the big ones. He is the engineer who works with people, who trains his employees. And the guys are really good [emphasis]! They have technique! They are very well trained and prepared (Prof. Henry).

If the engineer himself understands that his experience in Engineering is sufficient to be a Higher Education teacher, institutions are no different. When hiring engineers to teach, institutions, whether private or public, prioritize the engineer's technical training, creating a culture of valuing technical knowledge that comes from industry or specialized academic training.

According to Coelho (2017), these trends are responsible for the shift away from teaching appreciation and performance in the field of Pedagogy. Postgraduate courses in

different areas of Engineering prioritize specific technical knowledge and almost never offer subjects that help engineers in their teaching practice, as experienced by some teachers:

You know, this behavioral issue of education? [...] Thinking about this, I see myself using the knowledge from my undergraduate tutoring much more than the knowledge from my master's and doctorate in my classes. Because the master's and doctorate improved my training and even intended to prepare you to be a researcher, but it doesn't teach you how to treat, how to perform your teaching role, if I had difficulties in the classroom, with methodology, updating the methodology, with relationships with the student. They prepare just to be a researcher, for sure (Prof. Ginni).

I wasn't prepared. We do master's and doctorate degrees... master's degrees are fine; I even understand not preparing us [...]. However, when you enter your doctorate, you have little material, few disciplines to study, and a lot of time for research in the laboratory or in the field and occasionally a class, like: “go on, go teach a class instead of a teacher one day there” or “will teach in another teacher's place another day.” But I never learned what it was to put together a teaching plan, I never learned what it was to put together an activity plan (Prof. Elmina).

The Teaching Internship Program (PED) tried to change this scenario. It was established by the Foundation for the Coordination of Improvement of Higher Education Personnel (Capes) on February 26, 1999 through Circular Letter no. 028/99/PR/CAPES and is understood as “an integral part of the training of masters and doctors.” As provided for in Ordinance MEC/Capes no. 76/2010 (Capes, 2010), it is mandatory for all students who are on scholarship from this foundation, but with the detail that, for programs that have both the master's level as for doctorates, the obligation is restricted to students of the latter.

Therefore, despite being a good opportunity to influence such a neglected scenario, some problems arise: not all postgraduate students are Capes scholarship holders; and, while in the public network 66% of teachers have doctors, in the private network 70% are masters and specialists (Inep, 2020), therefore, naturally, they are exempt from participating in the PED. Santos *et al.* (2019), in relation to the PED, still consider that, despite it being a positively good experience, the teacher must consider that the postgraduate student is a student in training and not a substitute teacher: the success of the program depends on the training function carried out by the teacher who welcomes the intern. Often, the intern does not have proper support from the teacher and has to face the challenge alone:

So, I went there, did a master's degree in Rio Grande do Sul. There I was forced to teach a teaching internship subject and, then, I went to the classroom. You know, I was still a student and, so, when you enter a teaching internship as a student, you look at the class you have to teach and you remember your class in the morning and say: “the class in the morning was a pain, and I'm

going to arrive tonight and I'm going to reproduce what the professor...?" Then you stop and think: "if it sucked for me, it will suck for the students!" So, I kind of tried to change what I didn't like and do better. But that's subjective, isn't it? Because, well, I don't like this type, but, you know, depending on the student, they might even like it. But I saw that it often worked! (Prof. Elmina).

With the restrictions imposed by the PED, the chances of experiencing teaching in a formative way end up being very restricted during the engineer's training. Private classes, tutoring and scientific initiations are usually the only complementary activities to the specific technicality of the areas selected to study, according to De Moura and Nacarato (2021).

However, contrary to this, Zabalza (2004, p. 111, our translation) considers that, if all professions require specific preparation, teaching is no different: "teaching is a complex task in that it requires consistent knowledge about the discipline or of their activities, about the way students learn." The exercise of teaching, when summarized as knowledge of a certain technical area or the perspective that "teaching is learned by teaching", will bring challenges and a lack of more effective pedagogical practices for the teacher. At first, engineers suffer when faced with the classroom and the expectations that exist for their new role, bringing to light not only the gaps in their pedagogical knowledge, but also tensions and anxieties:

When I arrived to teach, I was in a panic! He opened the door to the room, and I just wanted to go back! The first day I entered the classroom, I didn't know whether to cry or laugh, just out of despair! [...] I wasn't disappointed, but I thought it was much easier. I said: "Guys, being a teacher must be really cool!" You think about status, about vacations twice a year. Then you discover that no, that is not the case. So, I think he was much more fanciful at the beginning, something more romanticized about the profession (Prof. Elmina).

In my time there was no PED, there was no internship for you to learn how to teach. There was nothing like this: lesson planning is like this. Anything! I never had any pedagogical guidance. Difficult, huh? As an Engineering teacher, you go and teach. How do I know how to teach? I did as everyone does, as you did: if turn [emphasis]! (Prof. Pierre)

Students test you, especially when you are just starting out, and they realize your fragility. They will test you. We, in fact, are tested every day. It's just that we start to have tricks that provide our tools. [...] Teaching is very different from working technologically in the area studied. So, we learn this role by doing. We didn't have training (Prof. Mark).

The beginning of engineering teaching, as well as the following years of the career, is characterized by countless challenges that arise with each new class, new curricular component or problem faced and which can trigger frustrations and feelings of failure or can be used as a learning opportunity. The difference lies in the epistemological perspective he develops for his actions, requiring this engineer to systematically reflect on the way he performs his role.

Teaching in (trans)formation

Even though most engineers did not have the possibility of training in pedagogy during their initial training nor were they valued for doing so throughout their teaching career, it is certain that they end up building a pedagogical practice based on their experiences: “engineer-teachers they end up learning to be teachers – when this actually happens – through their own experience, with a solitary effort without the benefits of a rational systematization of procedures” (Bazzo, 2011, p. 13, our translation).

For teaching, it is important to acquire new knowledge, despite the engineer's ideal pedagogical training going through the problem that each party involved in the process conceives it in a different way: students, colleagues, educational institution, legislation, and the teacher involved in the situation. According to Masetto (2012), there is no history of investment and interest in teacher training in Higher Education by any of these parties involved, with both the incentive and investment restricted to technical training.

Due to its role in promoting knowledge, teacher training, even if technical, should not, in any way, end with the completion of postgraduate studies, or better yet, it should not end at all. Continuing training is something that can be the foundation for achieving the expansion of a reflective perspective, making you an active subject of your own practice:

From the moment we started to reflect..., reflect on the role I had, I started to transform from someone who taught classes to someone who wanted to train students. When I understood that my role was not just to teach concepts..., in fact, we have to stop for a moment and start to reflect a little more, think a little more about how to act, how to position ourselves in relation to the student (Prof. Mark).

The term *reflection* is often trivialized, considering that every human being reflects. It is also used in training courses and in works that refer to them, but much more as a related adjective than as a “theoretical movement for understanding teaching work”, according to Pimenta (2012, p. 22, our translation). In this concept, the reflective attitude allows university professors to become participants in the process by seeking training that is not only focused on passing on technical information, but rather on possibilities for action and training, for building knowledge, adjusting their practices to the situations that emerge. We think like Nobre-Silva, Toledo and Da Silva (2019, p. 3) when using the term *reflexivity* as a

teaching practice imbued with critical thinking, to a professional active in seeking to overcome the problems faced in their practice, who seeks to develop research, group work, who acts considering the social, political and

economic aspects of the context in which they are inserted (Nobre-Silva; Toledo; Da Silva, 2019, p. 3, our translation).

Nóvoa (1992, p. 25, our translation) states that “training is not constructed through accumulation (of courses, knowledge or techniques), but rather through work of critical reflexivity on practices and permanent (re)construction of an identity guys.” In the field of teacher training, theory and practice are presented as dichotomies, always in constant discussion. According to Gatti *et al.* (2019, p. 177, our translation), “the criticisms mainly concern the fragile articulation between theory and practice, between specific knowledge and pedagogical knowledge, between universities and school.”

Despite some existing proposals to reduce this dichotomy, for example, the teaching internship, as highlighted by Pimenta and Lima (2012), they all involve reflexivity. It is through the action of reflecting on the practice itself that the engineer transforms, as reflexivity is capable of (trans)forming this experience into experience: “Experience is what happens to us, what happens to us, what plays. Not what happens, not what happens, or what touches. Many things happen every day, but at the same time, almost nothing happens to us” (Larrosa, 2002, p. 2, our translation).

Schön (1992), in his studies on the training of reflective professionals, ended up popularizing the term reflective teacher; Based on John Dewey, it proposes a model of professional training based on action (“knowing how to do”, related, in this case, to Engineering) and reflection on practice (“unexpected situations”, linked to teaching for engineers). In other words, there are two key components of change in the engineer-teacher's practices: innovation that is linked to an action and critical reflection, which changes not only the action, but also the person carrying out the action. Considering Pimenta (2012, p. 19, our translation), Schön's proposal is related to the “valuation of professional practice as a moment of knowledge construction, through reflection, analysis and problematization of this, and the recognition of tacit knowledge, present in solutions that professionals encounter in action”, that is, the appreciation of practice occurs in relation to a reflected practice that allows the teacher to respond to unusual, problematic, uncertain and unique situations that he or she will experience.

According to Schön (2000), his theory of reflective practice can be developed in three main moments. They are: reflection in action (*in the original*), reflection on action (*reflection on action*) and reflection on reflection for action (*reflection on reflection for action*).

Initially, there is a “knowledge in action” related to the knowledge that manifests itself spontaneously in a class and is implicit in its performance. In reflection in action, the teacher's thinking is embedded in this action, and knowledge of it is the center of his professional practice, however, he will have to intervene in unusual situations related to it, situations that go beyond the border of the familiar and that cause surprise when these are still in progress: “our thinking serves to give new form to what we are doing, while we are still doing it” (Schön, 2000, p. 32, our translation).

This level is related to improvisation, since, “at this first point, the author imposes spontaneous knowledge on professional actions, independent of any prior knowledge” (Sacardo; Almeida, 2018, p. 8, our translation), which ends up working as if the teacher were dialoguing with the situation, paying attention to ambiguities in order to, without help from any other source, redirect them appropriately. This type of reflection can be seen in the teachers' statements, such as Pierre's, “*I did as everyone does, as you did: if will come [emphasis]*”, or even in Mark's, “*So, we learn this role, by doing it. We didn't have training.*” We understand that, at this level of reflexivity, those who call themselves engineer-teachers work.

Reflection on action consists of reflecting on a given practice in order to give a new form to what you are doing: the action is remembered, considered and evaluated, usually in relation to a broader purpose. In this format, a past experience involves a conscious memory, followed by an evaluation for decision making with the aim of modifying the planning and a future similar action.

When reflecting on a pedagogical difficulty in a given class that was given, for example, it is the moment that the teacher has to review pre-established concepts and conceptions, leading himself to an investigative and critical stance on his own practice. At this moment, the engineer-teacher is then responsible for “restructuring some of his action strategies, theories of phenomena and/or ways of conceiving the problem and inventing immediate experiments to test his new understandings” (Schön, 2000, p. 38, our translation), according to Prof. Elmina:

You look at the class you have to give and you remember your class in the morning and say: “the class in the morning was a pain and I’m going to get there this evening, what am I going to reproduce?” Then you stop and think: “if it sucked for me, it will suck for the students!” So, I kind of tried to change what I didn't like and do better (Prof. Elmina).

At this point of reflexivity, the hitherto engineer-teacher could call himself an engineer-teacher, assuming teaching as a precedence for teaching Engineering. An interesting detail is to be able to consider that, often, reflection on action (engineer-teacher) belongs to reflection on

action (teacher-engineer), since it ends up being an immediate response to some previous act that brings to the surface and that it is thought retrospectively, in an attempt to identify how the activity could have been developed and contributed to a different result than what happened.

The reflections on action and on action discussed consider that the teacher, or better yet, the engineer acting as a teacher, goes through moments when he realizes the need to change and then starts to act on this need, even if at the moment or after the event. In this condition, the professional increases his repertoire of possible solutions and transforms himself. Usually, these moments are related to some difficulty he faces during class:

It is also normal that on many occasions, surprised by something that takes us away from the usual situation, we think about what we are doing, or even think while we are doing something. This is what Schön calls reflection in action. It presupposes a reflection on the way in which we usually understand the action we carry out, which emerges so that we can analyze it in relation to the situation in which we find ourselves, and redirect it appropriately (Contreras, 2002, p. 107, our translation).

However, reflexivity should not only exist when something falls outside the expected standard. Going further, how can we awaken this engineer-teacher to something outside of the technical and cyclically repetitive role he plays? How can we encourage this engineer to adopt a reflective, transformative and dialogic teaching practice? Pimenta (2012) highlights the importance of preparing this teacher so that he has a reflective attitude in relation to his role as a whole. In this sense, it is unlikely that the teacher will reach this point alone.

Schön (2000) then proposes a third moment: reflection on reflection. This action is based on the act of thinking about reflection in action and consolidating the understanding one has of a given situation, identifying its limits while adopting a new teaching and planning strategy. As it requires a verbal description, it cannot normally be considered individually. Thus, it is in training spaces that there are opportunities to develop this reflexivity in an intentional way, as mentioned by Prof. Mark differentiates himself from others by having completed a master's degree in Education:

Another thing that made me mature was when I entered the master's program in Education. I had a totally different view of education, and that changed! Especially because, initially, when I entered, I took some subjects as a special student first, and that really opened my horizons. And of course, knowledge, writing..., looking at theorists, some things start to make sense. Other things, we still have more doubts [laughing] than making sense. But we have the opportunity to reflect a lot on this part [education] (Prof. Mark).

Few engineer-teachers naturally move towards continued pedagogical training that provides opportunities for this type of reflexivity to exist and develop. However, it is also necessary to have institutional spaces to discuss the pedagogical situations experienced, in which teachers can talk, share their experiences in the classroom and collaboratively construct proposals for the classroom. When reflecting on reflection for action, it is necessary to have dialogues with other experiences (practical or theoretical) so that the understanding of them is expanded and there is, then, the reconstruction of a future practice. This same thought is shared by Freire (2011, p. 75) when theorizing from practice:

To the habit of writing texts, I added the habit of discussing them, whenever possible, with two great friends with whom I worked [...] discussing findings and not just my texts, debating doubts, questioning ourselves, challenging us, suggesting us readings, surprising us (Freire, 2011, p. 75, our translation).

In order for there to be official training spaces, institutional support is essential, as is the formation of appropriate policies by these institutions and preferably by government bodies legislating in favor of this cause, without leaving responsibility solely to the teachers themselves. When this exists, it may be more common to find not simply engineers working in teaching, but rather professionals transformed by reflexivity, becoming teacher-engineers.

Final remarks

When training engineers, the teacher assumes great responsibilities by having to prepare them for a modern world, full of rapid and constant transformations. Even greater is the challenge for the engineer-teacher who, when initially established as an engineer, was trained to be a good “transmitter” of knowledge and concerned only with technical training.

Now, working as a teacher, it is up to this professional to seek ways to develop himself pedagogically and not just technically, as was expected until then. One path for him is the path of reflexivity, which can be considered an element of teaching training and performance, allowing him to seek new possibilities of action and a more humanistic training.

In his studies, Donald Schön criticizes the technical format of the undergraduate course curriculum that separates theory and practice, teaching and research and then defends a new model, in which a reflective practical moment should be inserted. In this work, we extrapolate this concept by considering as action the moment in which the engineer begins his activities as a teacher, that is, his teaching practice. Thus, Schön's (2000) three main elements of reflexivity in this scenario, reflection in practice, on practice and reflection on reflection for practice, are

not isolated, but are interconnected: one builds on the other and all need to be considered so that the whole is transformed.

Investing in changes, when talking about reflection on reflection in practice, means wanting teachers to move away from a model based on technical and traditional rationalism towards a formative model, based on reflection. Often, this type of training sounds more like rowing against a tide, since educational institutions have failed to create spaces for this. The manifestation of reflexivity should be provided by institutions through curricular spaces and times, linked to training strategies during the teacher's academic career. However, these institutions, at most, offer workshops from time to time, but these end up being technical training and not spaces for dialogue, reflection and, therefore, teacher training. In this case, it is up to the teacher himself to look for training processes, such as participating in events in the area of Education or taking postgraduate courses focused on teaching, valuing the understanding of the need for a shared and dialogical construction based on reflexivity.

Reflective teaching can benefit engineering teachers in three main ways: 1) move beyond the stage of just surviving in the classroom to a level of being able to reconstruct your theory from your practice; 2) teach and help free teachers from impulsive and routine attitudes, making them autonomous and critically reflective; 3) allow teachers to act more deliberately and intentionally, managing adverse situations in a more conscious and intelligent way. And finally, with this, this engineer-teacher can be (trans)formed into an Engineering teacher.

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CRediT Author Statement

Acknowledgments: Not applicable.

Financing: Not applicable.

Conflicts of interest: There are no conflicts of interest.

Ethical approval: The work based on narrative interviews with 6 engineering professors respected ethics during the research and is registered with the ethics committee under number CAAE 13461319.6.0000.5514.

Availability of data and material: Data and materials are not available for access.

Author contributions: Débora and Adair together were responsible for conceptualizing and defining the methodology. Data curation, as well as formal analysis, validation, writing and visualization were the responsibility of Débora. Adair provided supervision and writing review.

Processing and editing: Editora Ibero-Americana de Educação.
Review, formatting, standardization, and translation.

