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The engineer and his constitution as a teacher: State of the Art in brazilian researches

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ABSTRACT

Introduction: the teacher who works in higher education, most of the time, comes from a bachelor's degree or postgraduate course in the specific field of work, without a didactic-pedagogical training for teaching. This is the case of most Engineering courses. **Objective:** thus, the objective of this study is to carry out a state of the art on what has been researched, in Brazil, in relation to the pedagogical constitution of this training engineer who assumes teaching. **Methodology:** for the mapping of research, the Capes Theses and Dissertations Bank and the Brazilian Digital Library of Theses and Dissertations (BDTD) were used. This search, without temporal restriction, identified 17 academic works (14 master's dissertations and 3 doctoral theses) on the exercise of teaching by engineers, distributed between the years 2001 and 2019. **Results:** as a result, four categories stood out in the analyzed works: the existence (or not) of a specific training for the engineer-teacher, the identity of the engineer-teacher, the teaching knowledge in engineering and also a brief discussion about being an engineer-teacher or teacher-engineer. **Conclusion:** in addition to the growing number of research studies each year, these reveal a progressive concern with the training of this teaching professional.

KEYWORDS

Teaching. Engineering. Professor training. University education. Professor's knowledge.

O engenheiro e sua constituição como docente: Estado da Arte em pesquisas brasileiras

RESUMO

Introdução: O professor que atua no ensino Superior, na maioria das vezes, vem de um curso de bacharelado ou pós-graduação no campo específico de trabalho, sem uma formação didático-pedagógica para a docência. Esse é o caso da maioria dos cursos de Engenharia. **Objetivo:** assim, o objetivo deste estudo é realizar um estado da arte sobre o que tem sido pesquisado, no Brasil, em relação à constituição pedagógica desse engenheiro de formação que assume a docência. **Metodologia:** Para o mapeamento das pesquisas utilizou-se o Banco de Teses e Dissertações da Capes e da Biblioteca Digital Brasileira de Teses e Dissertações (BDTD). Essa busca, sem restrição temporal, identificou 17 trabalhos acadêmicos (14 dissertações de mestrado e 3 teses de doutorado) sobre o exercício da docência por engenheiros, distribuídos entre os anos de 2001 e 2019. **Resultados:** como resultado, destacaram-se quatro categorias nos trabalhos analisados: a existência (ou não) de uma formação específica para o engenheiro-professor, a identidade do engenheiro-professor, os saberes docentes na engenharia e ainda uma breve discussão sobre ser engenheiro-professor ou professor-engenheiro. **Conclusão:** além de haver uma crescente quantidade de pesquisas a cada ano, estas revelam uma preocupação também progressiva com a formação desse profissional docente.

PALAVRAS-CHAVE

Docência. Engenharia. Formação de professores. Ensino superior. Saberes do docente.

El ingeniero y su constitución como docente: estado del arte en la investigación brasileña

RESUMEN

Introducción: el profesor que trabaja en la enseñanza superior, la mayoría de las veces, proviene de una licenciatura o posgrado en el área específica de trabajo, sin una formación didáctico-pedagógica para la enseñanza. Este es el caso de la mayoría de las carreras de Ingeniería. **Objetivo:** el objetivo de este estudio es realizar un estado del arte sobre lo que se ha investigado en Brasil en relación a la constitución pedagógica de ese ingeniero en formación que asume la docencia. **Metodología:** para mapear la investigación, se utilizó la Base de Datos Capes de Tesis y Disertaciones y la Biblioteca Digital Brasileña de Tesis y Disertaciones (BDTD). Esta búsqueda, sin restricción temporal, identificó 17 trabajos académicos (14 disertaciones de maestría y 3 tesis de doctorado) sobre el ejercicio de la docencia por ingenieros, distribuidos entre los años 2001 y 2019. **Resultados:** cuatro categorías se destacaron en los trabajos analizados: la existencia (o no) de una formación específica para el ingeniero-profesor, la identidad del ingeniero-profesor, el conocimiento docente en ingeniería y también una breve discusión sobre ser ingeniero-profesor o profesor-ingeniero. **Conclusión:** además del creciente número de investigaciones que se realizan cada año, éstas revelan una preocupación progresiva por la formación de este profesional de la enseñanza.

PALABRAS CLAVE

Docencia. Ingeniería. Formación de profesores. Enseñanza superior. Conocimiento del maestro.

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1 Introduction

Teacher qualification has been the subject of study in several educational research, from undergraduate scientific initiations to post-doctoral projects. This professional is considered a key player in the transformation processes of education. However, when it comes to university teaching, there are no longer so many works discussing this subject, and the number reduces even more when the research area is the pedagogical training of bachelors who function as teachers, for example, teaching engineers, the object of analysis of this article.

Despite several national journals and events on education, there is only one regular national event that deals with engineering education, the Brazilian Congress of Engineering Education (Cobenge), linked to the Brazilian Association of Engineering Education (Abenge¹). This association, created in 1973, based on the recommendation of a Commission of Specialists in Engineering Education of the Ministry of Education (MEC), is the only one in Brazil that links Education to Engineering. Even so, of the 12 objectives presented, only 2 are specifically linked to the engineer-teacher.

This reduced number may be since bachelors do not have teaching as the main purpose of their professional activity or, on the other hand, that researchers who have a degree as one of their functions always seek studies in their areas of technical training. Another possibility would be the valorization (or lack thereof) that the Higher Education Institution (HEI) itself directs to teaching from a time when a more pragmatic² and technical characteristic of the engineer was sought, it migrated to the overvaluation of academic degrees, to the detriment of professional experience. In both cases, there is almost no concern about training or teaching experience, since, as a rule, all those who have the title of engineer and, consequently, the mastery of technical knowledge are considered qualified to teach in the field of Engineering.

This article aims to answer the following question: what has been investigated in Brazil about the pedagogical constitution of the engineer-teacher? It aims to conduct a state of the art on what has been researched in Brazil in relation to the pedagogical constitution of this training engineer who assumes teaching.

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¹ To find out more, visit: <http://www.abenge.org.br/abenge.php>.

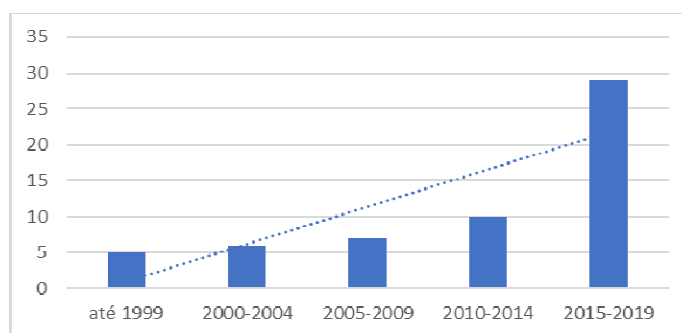
² Pragmatism considers that a proposition is true according to its effectiveness. This philosophical current judges an idea by its functionality and not by how it looks or sounds, considering knowledge based on experience valid and experience as the norm of action. Founded by Charles Peirce (1839-1914), and later discussed by William James and John Dewey, it emerged in the United States at the end of the 19th century and reached its maximum expression, both in the United States and in Europe, at the beginning of the 20th century. The term was created by Peirce as a result of his reflections on Kant's use of the adjectives "pragmatic" and "practical" (OUTHWAITE; BOTOMORE, 1996).

2 Methodology

The study began with a survey of research already developed in Brazil on the subject, based on consultation with the Bank of Theses and Dissertations of the Coordination for the Improvement of Higher Education Personnel (Capes) and the Brazilian Digital Library of Theses and Dissertations (BDTD), accessed in January 2021. As descriptors, the terms "engineering teacher", "engineer teacher", "engineer teacher", "engineer teacher" and "engineer teacher" were used concomitantly³. The entire period of available production (from 1999) was considered, but the first work located was in 2001 and the last, at the time of the research, was 2019.

Initially, the choice of these words aimed to restrict the search to works linked only to teaching in Engineering, to understand the research discussions on the main object of this study: the training engineer teaching in an engineering course. Initially, 29 papers were found in the Capes Database and 41 in the BDTD, totaling 70 texts, distributed over time, as shown in Graph 1.

Graph 1 Number of theses and dissertations



Source: the authors.

It is possible to observe, from the trend line in Graph 1, a significant growth in studies on the teacher who teaches engineering. In other words, the number of studies focusing on the education of teachers who teach engineering, their professional development, their identity, their pedagogical construction, their relationship with students, their knowledge, their competences, and their professional practices has increased.

To map this growing production, diverse types of studies with the most varied denominations can be found. They can, however, be separated into two main groups: reviews that map and reviews that evaluate and synthesize (VOSGERAU; ROMANOWSKI, 2014).

Considering the focus of our study, we opted for the reviews that map, of which the state of the art seems to us the most appropriate, since it allows to establish, from previous productions, a global vision of recurring themes, while the relationship between them can point to future research needs.

³ For the concomitant search of descriptors, the "OR" connective is used in both databases.

According to Noronha and Ferreira (2000, p. 191), *state-of-the-art research*, also known as state of knowledge, "analyzes the bibliographic production in a given area [...] providing the state of the art on a specific topic, highlighting new ideas, methods, sub-themes that have received more or less emphasis in the selected literature." Thus, they allow to go beyond a simple mapping by interpreting the multiple approaches to a given subject, while they can be the starting point for new directions: "The results achieved by a given researcher are often taken up by other theoretical or applied scientists, who continue the study, advancing science or producing technology or products based on them." (MUELLER, 2000, p. 1). (MUELLER, 2000, p. 25).

After the initial survey and the discarding of 13 duplicate titles, the next step was to refine the search made for the selection of works more adherent to the theme related to the constitution of the engineer-teacher. Initially, the titles of the works were evaluated, leading to the exclusion of 22 for lack of specific link with teaching. Next, 35 abstracts were evaluated, regarding the objectives and methodology. At this stage, another 16 papers were discarded, since they indicated another focus (for example, only students or focusing on the exercise of engineering and not teaching). Finally, the remaining 17⁴ papers were read in full.

Each of the researches brings several contributions to the area of Engineering Education and has perceptions linked, in some way, to the teaching of the engineer-teacher. Their main characteristics were systematized as follows: a) theoretical framework adopted, focusing on research problems and concepts; b) methodology used, and methodological paths adopted in each study; c) data analysis, how each author performed their analysis.

The chosen works are listed in chronological order in Chart 1, presenting the author with his respective advisor, the title of the work, the place where the research took place, the level (M for master's and D for doctorate) with the year of defense and a point that we highlight as being interesting to understand the reason for the choice.

Table 1. List of theses and dissertations

Author / Advisor	Title	Location	Level Year	Highlight
Célia Mara Sales Buonicontro / Magali de Castro	<i>The construction process of the pedagogical practice of the Engineer-Teacher: a study in the Mechatronics Engineering Course at PUC-Minas.</i>	Pontifícia Universidade Católica de Minas Gerais	M 2001	The author seeks to understand the construction of the pedagogical practice of the engineer-teacher focusing on Bourdieu's habitus theory. It does, documentary research with eight teachers (open interview) of the Mechatronics Engineering course of PUC-Minas and 24 students (questionnaire).
Regina Rogério / Walter Antonio Bazzo	<i>Teacher training: a look at professional education</i>	Universidade Federal de Santa Catarina	M 2003	Bibliographic review and semi-structured interviews with 15 teachers, the author seeks to dialogue about teacher training in professional education with teachers from the Federal Center for Technological Education of Santa Catarina, discussing pedagogical practice and the interaction of

⁴ Two papers were not available for reading and were also discarded at this stage.

				knowledge.
Wanderlei Aguilera Hidalgo / Marília Claret Geraes Duran	<i>Engineering teachers: a first approximation of their conceptions of teaching knowledge</i>	Universidade Metodista de São Paulo	M 2006	The author focuses the research on the teaching knowledge of the engineer, the knowledge-base in training and the importance of experience. He conducts five interviews, as well as using the narrative of one of them and his own practice.
Vanessa Oliveira De Moura Álvares / Silvana Malusá Baraúna	<i>The teacher-engineer facing the challenges of pedagogical training in higher education</i>	Universidade Federal de Uberlândia	M 2006	Quali-quantitative research with engineers (electrical, civil, computer and production) at a private university in Uberlândia, Minas Gerais (MG), based on the need for specific pedagogical training for engineers and the responsibility of the HEI in this role.
Lilian Rose A. N. Garcia de Santana / Silas Borges Monteiro	<i>When engineers become teachers</i>	Universidade Federal de Mato Grosso	M 2008	Study on how engineers become teachers, based on the concept of Nietzsche's experiences and Schön's reflective professional. It uses listening to the experiences of FAET teachers at UFMT, obtained through oral narratives, with the Lattes Curriculum as a reference axis.
Cláudia Angélica Do Carmo Reis / João Bosco Laudares	<i>Engineer-teacher: the social representations about teaching technological education of Minas Gerais</i>	Centro Federal de Educação Tecnológica de Minas Gerais	M 2009	The author seeks to identify the social representations of engineer-teachers about teaching by interviewing 11 engineer-teachers working in the undergraduate program of Cefet-MG (Federal Center for Technological Education of Minas Gerais), basing her work on the Theory of Social Representations.
Sabrina Rodero Ferreira Gomes / Zeila de Brito Fabri Demartini	<i>The vocational education teacher: training and pedagogical practice</i>	Universidade Metodista de São Paulo	M 2010	The author researches the teacher of professional education of the Paula Souza Center, focusing on their training and pedagogical practice. It also makes research about the degree courses for bachelors in Brazil, known as Special Program of Pedagogical Formation of Teachers. It uses a questionnaire with 10 teachers.
Cecilia Maria Macedo Dantas / Elena Mabel Brütten	<i>The development of teaching in engineering: a study at the federal university of campina grande (UFCG)</i>	Universidade Federal do Rio Grande do Norte	M 2011	This work seeks to know the perception of the teaching practice of teachers-engineers of the Civil, Electrical and Materials Engineering courses of the Federal University of Campina Grande (UFCG) through bibliographic research and questionnaire.
Marinez Carginin-Stieler / Marcelo Carvalho Minhoto Teixeira	<i>Engineering education: aspects of pedagogical training for teaching in Electrical Engineering</i>	Universidade Estadual Paulista	D 2014	The author studies graduate programs in Electrical Engineering to understand the education of engineers and the methodologies of teaching Engineering. She used a questionnaire for students and teachers of these programs. In addition, she offered an extracurricular course on "Teaching Practices".
Marly Nunes De Castro Kato / Geovana Ferreira Melo	<i>University teaching: the agronomist professor in the construction of his professorship</i>	Universidade Federal de Uberlândia	M 2015	Research with agronomists from the Federal University of Uberlândia (UFU), seeking to understand the learning of teaching, linked to training, knowledge, and identity. It is based on scientific productions in the area, documentary analysis and questionnaires.
Wladimir Lauz Medeiros / Luiz Fernando	<i>Teacher-engineer or engineer-teacher: the construction of the</i>	Universidade Federal do Rio Grande	M 2015	This research investigates the identity and practices of the engineer-teacher or the teacher-engineer. It is based on a

Mackedanz	<i>identity of the professional in higher education</i>			bibliographic study and semi-structured interviews with seven teachers, inspired by the clinical method (informal conversations).
Silvia Helena dos Santos Costa e Silva / Francisco das Chagas Silva Souza	<i>When engineers become teachers: formative trajectories of teachers of the electrical engineering course (IFPB/João Pessoa)</i>	Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte	M 2015	The research was conducted with six electrical engineers from the Federal Institute of Paraíba (IFPB) using the (auto)biographical method and the interviews organized into categories.
Jhannes Alberto Vaz / Irene Jeanete Lemos Gilberto	<i>From Engineer to Teacher: The Construction of Teaching Professionalism</i>	Universidade Católica de Santos	M 2016	The author uses articles published in Engineering Education journals (such as Cobenge), as well as semi-structured interviews with three engineers from Rio de Janeiro, aiming to investigate the process of training engineers for teaching.
Moises Gregorio Da Silva / Maria Zeneide Carneiro Magalhães de Almeida	<i>The engineer's teaching habitus: ways of being and teaching</i>	Pontifícia Universidade Católica de Goiás	D 2017	Research on the teaching practice of the engineer teacher and his ways of being, thinking, acting, and teaching. Based on Pierre Bourdieu, it uses historical foundations and semi-structured interviews with 10 civil engineers from the Federal Institute of Aparecida de Goiânia.
Luciana Guidon Coelho / José Aquiles Baesso Grimoni	<i>Analysis of the need for teacher training and proposal of a training and professional development program for engineering teachers</i>	Universidade de São Paulo	D 2017	The author investigates the need for a teacher training and professional development program for teachers of Engineering and other Exact Sciences. A questionnaire was sent to professors from the University of São Paulo (USP), postgraduate students from the same institution and professors from outside USP.
Jose Renato Spina Martins / Irene Jeanete Lemos Gilberto	<i>The (trans)formation of the engineer-teacher: learning to teach in higher education</i>	Universidade Católica de Santos	M 2018	Research based on semi-structured interviews with three civil engineers from different educational institutions in Baixada Santista. The work seeks to understand how the engineer becomes a teacher.
Elita De Medeiros / Clóvis Nicanor Kassick	<i>Professional teacher or professional teacher: a brief look at the training of teachers in a civil engineering course in Santa Catarina, Brazil</i>	Universidade do Sul de Santa Catarina	M 2019	Based on semi-structured interviews conducted at a university in the south of Santa Catarina, the author seeks to understand the identity of the civil engineer as a teacher. It makes a good bibliographic review and uses the WebQDA software to analyze the Collective Subject Discourse.

Source: the authors

From the reading of the works, we grouped these works into thematic units, which, according to Picheth (2007, p. 30), is a common element in the state of the art: the researcher makes "the reading of the selected materials from the perspective of units of analysis, that is, the researcher identifies categories that he wants to map [...] and depending on the objectives of the investigation, it is also extended to theoretical-methodological aspects." In this analysis, we explored and highlighted the four thematic units that appeared the most: a) the existence (or not) of a specific training for the engineer-teacher; b) the identity of the engineer-teacher; c) the teaching knowledge in Engineering; d) "the teacher-engineer or engineer-teacher?".

3 The existence (or not) of specific training for the engineer-teacher

The discussion on teacher education permeates all the texts presented, either directly or indirectly. For this reason, this unit was chosen as the first to be discussed, but we will specifically use the texts by Rogério (2003), Alvares (2006), Vaz (2016), Coelho (2017) and Martins (2018).

When commenting on training, Martins (2018) addresses the history of Engineering and its changes over time. Thus, it historically contextualizes how the training of the engineer who becomes a teacher takes place. It begins with the description of the first formal structures for the teaching of Engineering: "[...] the first engineering schools taught their students techniques and processes according to the method of scholasticism, making them competent to design and build structures for military or civil purposes, using natural resources". (MARTINS, 2018, p. 40). He continues his exposition until he reaches the latest considerations of the MEC and the São Paulo State Research Support Foundation (Fapesp) for the year 2017. It is worth noting that only in 1973 did the inspection system of the Federal Council of Engineering and Agronomy (Confea) and the Regional Council of Engineering, Architecture and Agronomy (Crea) draw up a resolution combining the ideals of the government of the time. It included the teaching modality in the engineer's attributions, thus fostering the first experiences of creating master's and doctoral courses in Civil Engineering.

The fact is that - regardless of historical temporality and the creation of laws, resolutions, courses, or incentives - even today, the concern with the training of university teachers is up to the teacher's own conscience. That is, it depends on whether he wants to better understand the entire teaching-learning process, as Álvares (2006) cites. According to the author, despite being a complex professional activity and determined by a diversity of factors, there are few initiatives by HEIs to foster this pedagogical training, which could occur both at undergraduate and postgraduate levels.

Vaz (2016), who also begins his text with a historical review, highlights the appreciation that, to be a good teacher, it would be enough to be a renowned engineer. He states that, only since 1996, with the Law of Guidelines and Bases (LDB No. 9394/96), a concern with the preparation for the exercise of teaching was made official, but not at graduation. According to article 66, "the preparation for the exercise of higher education teaching will be done at postgraduate level, primarily in master's and doctoral programs." At undergraduate level, little concern is given to teacher training; in no course are subjects linked to teaching offered. Only two points could be associated with a possibility of preparation for teaching, a gateway to this differentiated look at the engineer's education: monitoring and scientific initiation.

In relation to monitoring, according to article 84 of this same Law, "higher education students may be used in teaching and research tasks by their respective institutions, exercising monitoring functions, according to their performance and their study plan." Thus, Vaz (2016)

notes that while this can be an excellent opportunity for undergraduate students to have a first contact with teaching, the number of students who exercise it is small (few disciplines offer vacancies, there is a monitor for several classes, a function that is always restricted to students with superior performance).

Another gateway to teaching, while still an undergraduate, is scientific initiation. Scientific initiation has existed for a long time in higher education, but it expanded at the end of the 20th century, with the autonomy provided by Law 9394/96, allowing universities to implement their own programs like the Institutional Program for Scientific Initiation Scholarships (Pibic). Of the few teachers who, in interviews and research in the analyzed works, assumed to think about teaching since graduation, some had their opportunity in research (ÁLVARES, 2006; COELHO, 2017; VAZ, 2016). According to Vaz (2016), although the relationship between scientific initiation and teaching is not clear, it would be a "first step", since it is through it that many are willing to continue their studies in the master's degree and then, from the research, enter the teaching career.

In postgraduate studies, in 2002, the Capes Social Demand Program made the teaching internship in postgraduate studies mandatory, through article 18 of MEC/CAPES Ordinance No. 76/2010 (COORDINATION FOR THE IMPROVEMENT OF HIGHER EDUCATION STAFF, 2010). However, an aggravating factor is that, for HEIs that offer both master's and doctoral programs, the internship is mandatory only in the latter. Considering that, in private HEIs, most of the teachers in practice are masters, it is understood that these professionals do not have any teaching experience as postgraduate training when they enter teaching.

Another visible point in postgraduate studies is the offer of disciplines linked to teaching. According to Coelho (2017, p. 157), "postgraduate disciplines for pedagogical preparation/training are scarce and often do not fulfill their function." Cargnin-Stieler (2014) research on the offer of teaching training disciplines in postgraduate courses in Electrical Engineering in Brazil. However, when reflecting on how she evaluates this offer, one can easily extend it to other engineering disciplines, concluding that, in most of the courses analyzed, most of the subjects are offered in a watertight way, without many possibilities of choice, in addition to maintaining a very traditional menu.

Although it is an opportunity to gain experience about teaching issues and allow spaces for reflections on the teaching-learning process, it is not an isolated discipline made during graduate school that trains the engineer for teaching. Rogério (2003) points out that it is necessary to have a continuing education that allows the recognition of behaviors so that, through a critical reflexivity and a (re)signification of social relations, the construction of the identity of this teacher occurs. Since identity occupies a given importance, it will be the theme of the next thematic unit.

4 Identity of the engineer-teacher

Of the works analyzed, Reis (2009), Dantas (2011), Kato (2015) and Medeiros (2019) seek to discuss the identity of the engineer who becomes a teacher, leading us to reflect on what would be the elements that collaborate for the construction of this teaching. Among the authors who support the research on identity in these works, we can mention: Antônio Nóvoa, Claude Dubar, Selma Pimenta (some with Léa Anastasiou) and Pierre Bourdieu as the greatest number of occurrences.

The problem of the bachelor's identity in the exercise of teaching is not a privilege of Engineering, although little explored in this area. Medeiros' (2019) work begins with a state of the art on the teacher in higher education, excluding the results linked to the degree. Of the almost 80 works analyzed - including articles, dissertations and theses related to the theme - only 2 specifically address engineer-teachers.

Despite the few texts specifically related to the subject, the author states that, in the identity construction of the bachelor-teacher, and consequently of the engineer, the entry into the teaching career in Engineering is still extraordinarily strong, marked by the acquisition of skills and techniques focused on the transmission of content. This occurs to the detriment of didactic-pedagogical training and directly affects the way this engineer sees himself, what his teaching identity would be.

Another interesting feature of the university teacher's identity - certainly even more accentuated for the engineer-teacher due to his training characteristic - is discussed by Dantas (2011), it is the tendency to try to build his identity and develop his work in an individual and very pragmatic way. In his book on technological education, Bazzo (2020, p. 26) highlights: "[...] those who assume the condition of engineer-teachers end up learning to be teachers - when this actually happens - through their own experience, which, in general, occurs as a solitary effort, without the benefits of a rational systematization of procedures."

Among the theoretical bases used to present the identity of this professional, all the studies refer to the need to understand the teacher by perceiving him/her in his/her social relationships. In these relationships, in the experiences of their own history, confronted with representations, values and ideas shared with the group of teachers with whom they work, their identity is being built. According to Kato (2015, p. 44), "[...] teachers build their identity as they exercise their professional practice, which, in turn, is imbued with interpersonal relationships, conflicts, challenges, contradictions and ambiguities typical of the teaching-learning process."

Gatti (2003, p. 196) reminds us that teachers

are essentially social beings, with their personal and professional identities, immersed in a group life in which they share a culture, deriving their knowledge, values, attitudes from these relationships, based on the representations constituted in this process which is both social and intersubjective. It is also necessary to consider the

role of broader events, whether social, political, economic, or cultural, with their determinants that permeate group or community life.

Understanding the professional identity of these teachers is inseparable from understanding their training processes, their conceptions, their practices, and their knowledge. This understanding includes the view they have of their role as a teacher by appropriating what others attribute to them, as quoted by Dubar (2005, p. 135): "identity is never given, it is always constructed and should be (re)constructed in a greater or lesser and more or less lasting uncertainty."

Reis (2009) extends this concept by defending the inseparability of personal and professional dimensions and the adherence to new values by calling the teacher an agent subject. He understands that professional development mediated by social, cultural, and historical contexts is signified and provokes new actions. For Tardif (2014, p. 230),

a teacher is not only someone who applies knowledge produced by others, he is not only an agent determined by social mechanisms: he is an actor in the intense sense of the term, that is, a subject who assumes his practice from the meanings he himself gives it.

Dantas (2011) and Vaz (2016) question the responsibility of the HEI in preparing this engineer who is starting teaching and record, for several reasons, the absence of institutional spaces aimed at building a collective identity of this teacher. The absence of this space reinforces the feeling of loneliness, makes it impossible to improve good educational strategies and leads this professional to run the risk of having a painful process in practice and in the construction of his identity, and may even fail. Pimenta and Anastasiou (2014, p. 142) state in this regard that "the teacher is left to his own devices and, if he is very prudent, he will avoid extreme situations in which the flaws in his performance are evident. In this situation, how can a professional identity be created? In the process of building their identity with existential, social, and pragmatic foundations, the knowledge that will make up the engineer's teaching is developed.

5 Teaching knowledge in engineering

If teaching is understood as a profession, some specific knowledge is necessary for its construction. According to Costa and Silva (2015), when studying the knowledge of teaching with engineers, one enters a field that requires specific knowledge, skills, dispositions, and competencies for the exercise of this professional activity.

In undergraduate courses, there is a training process to understand this knowledge, which does not happen in bachelor's courses, such as engineering. In this case, it is usually sufficient to have the title of engineer to be considered qualified to teach in the field of engineering and, consequently, to become a teacher who trains future engineers, who in turn may become teachers. This creates a vicious circle that perpetuates the pragmatic aspects of engineering education that have been implemented since the emergence of the first faculties.

Currently, the Law of Guidelines and Bases of National Education (LDB), Law No. 9.394, of December 20, 1996, in its art. 66, establishes that "[...] the preparation for the exercise of teaching in higher education will be done at the postgraduate level, mainly in master's and doctoral programs". (BRASIL, [2021]) However, in relation to postgraduate programs, the concern ends up focusing on the training of good researchers, usually considering teaching only because of good technical improvement.

Despite all these difficulties, engineers continue to be teachers, because it is understood that the training of engineering teachers is not limited only to their academic career or to the courses and processes acquired along this path, but is added to the knowledge acquired throughout life, practice, relationships with students and life itself. Buonicontro (2001) and Silva (2017) discuss this concept based on Pierre Bourdieu's habitus. The notion of habitus considers the consequences of the social position from which the individual originates; through it, the subject begins to reproduce the characteristics of its group of origin, even without knowing or being aware of it. Thus, we can say that the engineer, at the beginning of his career, will bring to his daily teaching all the pragmatism and conceptions learned in the function previously exercised, as well as mirroring the teachers he had previously.

Maurice Tardif (2014) and his book "Teacher knowledge and professional training" are the basis for the discussion of knowledge in the works of Rogério (2003), Álvares (2006), Reis (2009), Kato (2015), Medeiros (2015), Costa e Silva (2015), Silva (2017), Martins (2018), Medeiros (2019). The author considers that teachers' knowledge comes from various sources and from different professional and personal moments, including the years prior to their own training in their field: "In short, even before they officially start teaching, teachers already know, in many ways, what teaching is because of all their previous school history." (TARDIF, 2014, p. 20). That is, the construction of the teaching knowledge of engineers does not happen in a linear way but must be considered in cognitive and social aspects.

In view of the need for a dual competence for the engineer-teacher, the scientific and the pedagogical, Hidalgo (2006), when researching the knowledge mobilized by engineers, discusses the linkage of this knowledge, that is, the way they are (or should be) articulated and organized to be taught. Silva (2017) recognizes that the engineer-teacher must have proficiency in specific knowledge of engineering education, regardless of what it is. He adds, however, that the need for teaching and pedagogical knowledge is undeniable and unquestionable. And he quotes Tardif (2014, p. 13): "contrary to the worker in an industry, the teacher does not work only an 'object', he collaborates with subjects and in function of a project: to transform students, to educate and instruct them."

One point not discussed in any of the papers is the implication of various levels of qualification in the construction of teaching knowledge. Currently, engineering professors at public institutions hold doctoral or post-doctoral degrees, since rules and evaluation systems were created to force teachers to have a minimum doctoral qualification and to work on an exclusive dedication regime; this group represents half of the higher education professors in

practice (INSTITUTO NACIONAL DE PESQUISAS EDUCACIONAIS ANÍSIO TEIXEIRA, 2019).

On the other hand, private institutions, usually for cost reasons, fulfill the minimum required by the MEC, with most of their teaching staff consisting of masters and specialists to the detriment of the number of doctors. Even so, it can be seen from the various interviews included in this state-of-the-art study that, regardless of whether they hold a master's or doctoral degree, these engineers have little or no knowledge of teaching, except for what they have learned through their experiences and their relationship with the environment in which they live and interact.

Thus, despite their qualifications, working arrangements or awareness of their knowledge, some professionals see themselves as teachers while others retain their original title of engineer. What would be the ideal?

6 Engineer-teacher or teacher-engineer?

In this state of the art are based on works such as those by Zabalza (2004) and Pimenta and Anastasiou (2002). Both try to understand the interrelations between professional practice and teaching practice. The first makes an important point by stating that there is, for this professional who has become a teacher, a certain lack of definition as to the identity of university teacher when asked about his profession, which usually leads him to identify more with his specificity (Engineering, in this case) than with his teaching activity. In addition, Pimenta and Anastasiou (2002) state that there is not only vagueness, but also the feeling that the title of teacher alone suggests a lesser identity, since socially it puts it on an equal footing with high school and elementary school teachers.

According to Coelho (2017), the engineer's entry into teaching life, especially in higher education, was most often unplanned. For the author, two references constitute the basis that underlies this teaching: the world of work and the academic universe. In the world of work, it is considered that "those who know how to do, know how to teach", that is, the engineer teaching classes. In the academic universe, a concern with the degree prevails, and the professional usually understands himself as a teacher (sometimes a researcher), regardless of the content to be taught, as Santana (2008) adds.

In this same discussion, Medeiros (2015) began his interviews by asking the engineer-teacher: "What is your profession?". Curiously, he found three classes of response, showing that there is no pattern or identity convergence: only teacher; teacher and engineer (without specific prioritization); and only engineer.

Santana (2008) identifies that teachers, by basing their beliefs and conceptions on experiences, sometimes link their title to their work regime. When they are hired on an exclusive dedication basis, they say that they are teachers and complement this characterization

with expressions such as university professor or engineering professor to be differentiated from other levels of education.

From the teacher's point of view, there is also a crossroads. As Gomes (2010) rightly states, if he maintains the link with the productive sector, in addition to teaching, he is labeled as someone who makes a "beak" in teaching, who has it as a second option; if he decides to take up teaching fully, he is usually labeled by colleagues and even by students as outdated and out of the market, especially in private HEIs, whose peculiar characteristic is more direct and practical classes.

Bourdieu (2003) credits this difficulty to the concept of field, which is defined as a locus centered on specific interests in which a competitive struggle takes place between the actors who are involved and characterize the area (the field) in question. The fields have specific traits and because they are not watertight, they allow the engineer-teacher to move between at least two fields of social space: engineering and teaching. According to Buonicontro (2001, p. 121),

the engineer-teachers, when reflecting on issues related to the academic field and the engineering field, sought to find these interrelationships in their academic training, in the performance of their engineer-teachers, in the activities they carried out as students and as engineers and in the activities currently carried out in the Mechatronics Engineering Course at PUC Minas.

Thus, if, on the one hand, there are research engineers who enter the academic career focusing on the research part and, as a counterpart to this, also teach, on the other hand, there is the industry engineer who, for various reasons, ends up entering higher education, not with the intention of investigating, but of teaching classes in his training area. In the first case, the professional usually identifies a priori as a teacher. In the second case, they recognize themselves as engineers.

According to Reis (2009, p. 37),

as teacher-engineers, have possibilities to participate in applied research, to keep up to date with modern technologies, and to use appropriate engineering language in academia, on the other hand, the status of teacher gives them greater respect in industry. The increase in cultural capital and the possibility to use the appropriate language of academia in engineering are also perceived by engineer-teachers.

Engineering education is a sine qua non condition for teaching, according to Costa and Silva (2015). Thus, regardless of the order in which it is presented, engineer-teacher or teacher-engineer, the fact is that, over time, this concept is being (re)constructed and the professional is (re)signifying who he is in the exercise of his activities, which demonstrates, at the same time, a movement, a path traveled, be it more of Engineering or more of teaching and an inseparability between the two identities.

7 Final considerations

The qualitative approach to research is often strange to engineers, who are normally used to numbers and quantitative information. However, for the engineer who assumes the teaching profession, it is fundamental to rescue the importance of this type of research. In surveys with interviews, teachers even recognize the need for a more humanistic, social, and formative perspective, pedagogically speaking. However, it seems daring, almost strange, to insist, within a context of pragmatic and technicist valorization, that a realignment of the current paradigm be developed: the engineer-teacher as a mere transmitter of knowledge based on rituals standardized by former teachers he had throughout his training.

In authoring this paper, we tried not only to review what has been researched on the engineer-teacher, but also, focusing on qualitative research, to break the taboo that there is this separation between the area of Exact (Engineering) and Human (teaching). Are not teachers human? Aren't student's human? Isn't engineering done for society? As Bazzo (2020, p. 272) says, "there are no such watertight areas. We are all in the same 'boat' of the human area."

From the survey conducted in the digital libraries of Capes and BDTD, 70 works with descriptors linked to engineers and teaching were found. Of these, 17 were chosen to be read in full for this state of the art, with a temporal distance of 18 years between the first (2001) and the last (2019). Despite different perspectives on the pedagogical constitution of the engineer-teacher, some issues permeate several works.

The first thematic unit that appears the most, tries to answer whether what has been investigated about the pedagogical constitution of the engineer-teacher is related to the existence (or not) of a specific training for him. This is a subject that permeates all the works with intensity. And those who are willing to delve into this subject conclude that this training is almost non-existent, that, when it exists, it ends up being watertight and that, eventually when it happens, it occurs on the personal initiative of the engineer-teacher himself. Thus, the lack of this training ends up impacting the identity constitution of this engineer who became a teacher.

The second thematic unit presented seeks to understand how the identity of this professional is constituted who, after years of being forged to think technically when exercising the function of engineer, sleeps as an engineer and wakes up having to act under a new identity: that of teacher. When trying to build their identity as a teacher, the engineer then tries to do this by molding it to the training received in the Engineering course: in an individual and very pragmatic way, turning to the transmission of content and thinking that teaching can be detached from social relations. However, it is necessary for this professional to understand that his identity will be built on the experiences of his own history, confronted with representations, values and ideas shared with the group of teachers with whom he works, and his practice is inseparable from the social mechanisms that surround him. Teachers are left to their own devices to pursue this identity construction, which should be collective, making the process painful and often didactically unsuccessful.

The third thematic unit sought to understand what research informs about what specific knowledge, skills, dispositions and competences the engineer uses in the exercise of teaching and, more specifically, about its origin, since, in their technical training, there was little or no awakening to the teaching profession and to the knowledge necessary to exercise it. According to Pierre Bourdieu's concept of habitus, this process is not limited to their academic training, but is also constructed by the reproduction of characteristics of their group of origin, even if not consciously. Thus, the foundation of this discussion considers that the knowledge of engineers to practice teaching comes from various sources and from different professional and personal moments, including the years prior to their own training in Engineering.

The fourth and last thematic unit presented maps how this professional identifies himself - engineer-teacher or teacher-engineer - and the link between this chosen title and his professional identification. The lack of planning for entering teaching, the dedication of a smaller number of working hours than those employed in engineering or even the beginning of the teaching journey leads the professional to identify as an engineer. On the other hand, those who first identify themselves as teachers are those who do not work in industry, usually have exclusive dedication or have been teaching for a long time. In this case, they often associate engineer with the term teacher just to distinguish themselves from other levels of education.

This research allowed us to map what has been investigated in Brazil about the pedagogical constitution of the engineer-teacher, raising evidence that, in the identity as an engineer, pragmatic technicality, the reproduction of knowledge and individuality in the exercise of the profession prevail, while teaching calls this subject to social interactions. In the conflict between these two attributions, the teaching identity is being polished through classroom experiences, knowledge is being built on the needs that arise, and the (re)signification of their experiences makes the lack of formal training for teaching to be circumvented. This is evidenced in the works that interviewed engineer-teachers; that is, despite the difficulties faced, the engineer views teaching positively and feels fulfilled when exercising it.

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