

Notes on Competencies in Engineering Education*

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The subject covered in this text is an excerpt of a larger project and presents discussions on teacher's competencies, in engineering education, and also technical and scientific competencies. There is a growing demand for engineering teachers and this raises concern with regards to the formation of these professionals in Brazil. This paper begins with the information collected by electronic mail sent to professors of all Electrical Engineering postgraduate programs in Brazil. The questions/suggestions requested included the advice that could be given to postgraduate students about to enter the teaching profession. This research, grounded in the studies of Braslavsk, Perrenoud, Masetto and Zabalza, among other studies, indicated a convergence towards three engineering professor competencies: in-depth knowledge about the subject to be taught (technical and scientific), knowing the teaching content and to know how to teach this content (pedagogical-didactic competence). In light of these questions, a didactic and pedagogical approach course is proposed, to be addressed collaboratively in the engineering postgraduate program. One suggestion regards addressing case studies or problems experienced by teachers, where the teacher chooses problems or cases grounded in theories, and students assigned to solve them in the best possible way. This could represent an initial setting to discuss and consider the engineering teacher role. In engineering education and pedagogic formation there is a gap that needs to be closed, especially during the doctoral or master program, as this is when the engineering teacher or teaching candidate qualifies technically and scientifically to engage in researching and teaching.

Keywords: engineering education; engineering learning; engineering teaching; early-career professionals

1. Introduction

In the recent years has been increased the concern about the formation of future engineering professors, especially because of the demand. "In 1973, Brazil offered a little more than 100 Engineering courses, this number has increased over 2000 courses throughout the national territory. This necessary increase came out in 1996 and in the last years; approximately 100 courses have been created yearly" [1]. In the 1970s, at the height of the country's economic growth, many infrastructure works were underway and the formation of engineers was indispensable for the developing country. With the economy stabilized again in recent years a new important moment has emerged for engineering education. In Brazil, the Special Undergraduate Program (PEG) of "Universidade Federal de Santa Maria" (UFSM) for the "Teacher Formation for Professional Education" explains that "The Federal Network of Professional, Scientific and Technologic Education undergoes the greatest expansion its history in the last years, demanding the necessity to develop a faculty staff capable of operating in professional and technological education, mainly in the courses responsible for the initial and continued professional formation and for the middle level technical professional education" [2].

With the expansion of academic engineering programs in Brazil, the job supply for engineers in the teaching career also expands, especially for those coming from postgraduate programs. Young engineers generally leave postgraduate programs and ingress in institutions that oftentimes have an infrastructure that is lower than they experienced before graduating, and have experienced before graduating, and have to assume the responsibility of teaching classes and training professionals who will soon be working in the field. According to Zabalza [3], immediately after signing the work contract, the teacher stands before a group of students and the teaching adventure begins, in many cases with scarce resources at his disposal. This situation should raise concerns for the educational institutions that hire professors, as well as those that qualify them.

The engineer training received during his undergraduate and postgraduate studies is the master pillar; however, postgraduate and undergraduate programs usually focus solely on the (required) scientific and technical education. This brings us to the following question: is this expertise combined with personal effort sufficient to support, for instance, forming an engineering teacher to engage in teaching engineering courses? Zabalza [3] argues that it is important to break from the idea that

academics do not need training and if necessary, they should pursue it individually.

In Brazil, most of the teaching positions in public higher education require knowledge that extends beyond the specific didactic knowledge, since apart from the specific knowledge test, the candidate must present a class to the examination board. What competencies are stipulated in the didactic test and what are the necessary competencies for an engineering teacher to administrate classes?

There are several works in Brazil on the engineering student competencies, especially after the National Course Guidelines for the Undergraduate Engineering Courses were established, which address the competencies and general skills to form future engineers [4]. However “talking about the student’s development of competencies implies discussing the competencies of the own teacher-educator” [5]. In their studies, some authors have also discussed the teachers’ competencies. Among others, Perrenoud [9] is the most comprehensive studies on teachers’ competencies. However, Zabalza [6] and Masetto [7] approach the competencies of university teachers.

The competencies for teachers have been discussed by renowned authors and what is seen is that each author may be referring to a distinct group of teachers and in different activity levels and modalities that extend beyond their reality, formation, theoretical conception and educational practice and even the teacher’s work. Thus, this complexity should be acknowledged before understanding the teachers’ desired competencies because the setting in which the author is inserted in and lives influences how he thinks and acts.

In his studies Braslavsky [8, p. 17] conceptualizes competency as “the capacity to work with knowledge and awareness of this knowledge results.” Perrenoud [9, p. 13] assigns competency as “the capacity of mobilizing several cognitive resources to confront a certain kind of situation”. In 2002 the author updates his concept and defines “competency as an aptitude to manage a family of analogous situations, mobilizing in a correct, fast, pertinent and creative manner several cognitive resources: knowledge, capabilities, micro competencies, information, values, attitudes, schemes and perception, evaluation and reasoning” Perrenoud [10, p. 19]. Zabalza [6, p. 70] defines “competency” as the “molar construct to refer to the set of knowledge and skills that individuals need to develop some sort of activity”. In the Ropé and Tanguy apud Braslavsky’s words [8, p. 17] every competence involves at the same time knowledge, ways of doing, values and responsibilities for the obtained results. However, Perrenoud [10, p. 19], argues that “all these resources do not come from

the initial formation, or not even from continuous formation. Some of those must be built through practice”.

In his book Perrenoud [9] approaches a teacher’s work in a concrete manner and proposes a list of competencies that contribute to re-outline the teacher’s activity. A competency reference adopted in 1996 in Geneva was used as a basis for continuous formation, in which he actively participated for its elaboration. The author identifies approximately 50 competencies for the educator, and presented 10 families of competencies: 1) organize and direct learning situations; 2) administrate the learning progress; 3) conceive and help the differentiation mechanisms evolve; 4) involve students in their learning and their work; 5) teamwork; 6) participate in the school administration; 7) inform and involve the parents; 8) make use of new technologies; 9) confront the duties and ethical dilemmas of the profession; 10) administrate our continued formation [9].

In a study on the categories directed to the basic formation of competencies for teachers in Latin America, Braslavsky [8] argues that a teacher can conduct fertile teaching-learning processes in the 21 century with five competencies: 1) *didactic-pedagogic competence* linked to the capacity of acknowledging, know how to select, utilize, evaluate, perfect, recreate and create strategies for effective didactic interventions; 2) *institutional competence* to know how to establish productive pressure between self-affirmation, self-existence and the other actors of the complex educational process; 3) *productive competence*, related to the capacity to intervene as a productive citizen in today’s world and in the future to expand cultural horizons; 4) *interactive competencies*, such as the capacity to learn to acknowledge, comprehend and feel the other; 5) *specific competence*, the capacity of opening up to interdisciplinary work, a relevant competence for group work.

In Brazil, Masetto stands out for his works on pedagogical issues in higher education and adopts the conception of competencies described by the Swiss sociologist Perrenoud [7]. Addressing the competencies in higher education, according to Masetto [7] there are three basic competencies for university professors: 1) competency in a specific knowledge area such as a teacher’s knowledge level in order to take part in the learning-teaching process with professionalism; 2) pedagogical competency related to the capacity to master the teaching-learning process, the process of conceptualizing and administrating the curriculum, understanding the teacher-student and student-student relationship in the learning process, and proficiency in the educational technology; 3) competency in the poli-

tical dimension related to the teacher as a citizen committed to his community, time and civilization.

After outlining a conceptual reference framework about the competencies, Zabalza [6] brings up two questions about the competencies of a teacher. Answering them, the author analyzes the image and function of university teachers and addresses ten main competencies: 1) *plan the teaching-learning process*, why, when and how to plan; 2) *select and prepare the disciplinary concepts* in such a way learning can take place; 3) *offer comprehensive and well organized information and explanations (communicative competence)*, guided by communicative production, reinforcing comprehension, internal organization and the effective connotation of communication; 4) *managing new technology* as a study object, didactic resource and means of expression and communication; 5) *determine the methodology and organize the activities* associated with the organization of the learning spaces, method selection, selection and the development of instructive tasks; 6) *communicate and relate to students*, with the ability of working in crowded classrooms, constructing a leadership style and a positive atmosphere in the classroom; 7) *tutoring* guided by the several types of teaching, by the role of the university tutor, by the dilemmas of university tutorship, by the conditions to apply the tutorship and by tutoring as a personal commitment by the university teacher; 8) *evaluate* to guide and facilitate the learning process; 9) *investigate and reflect on teaching*, and 10) *identify with the institution and conduct teamwork*.

According to Zabalza [3], conducting research differs from teaching, as this field also requires its professional competencies in higher education which consist of knowing the content to be taught, the teaching-learning processes and specific skills such as communication, teaching, resource management, managing methods, evaluation, among others, and also a set of teaching attitudes such as empathy, availability, intellectual rigor, ethics, and other issues.

There are concerns about the formation of future engineers, besides the dropout rates¹ in the undergraduate courses, which according to Oliveira [11] was 48.19%, in 2001/2010 in Brazil, a fact that would remain unnoticed if there was not a shortage of engineering professionals in Brazil. A question to be discussed is if the teaching methodology currently used is capable to form (regarding quantity and quality) engineers to meet the needs of the domestic market. Zabalza [3] argues that what university

students learn depends on their interest, effort and capability, however this also depends on the teachers, the didactic resources adopted and the learning opportunities. Retaining students in higher education engineering courses, the school faculty will have to propose authentic engineering activities to enable them to apply their knowledge and interests, in other words, allow the students to undertake and get involved with complex problems, assisted by their teachers [12]. In view of the latest studies [2, 11, 13] teaching competency has been viewed as an important part in the formation of engineering teachers.

A group of professors from six universities addressed the issue of course dropout and retention in engineering courses, highlighting two crucial points: increase the number of university openings for students and teacher formation, and suggest a basic course for the recently admitted teachers, which should be mandatory, namely: pedagogy, didactics, psychology, sociology and correlated themes so that the engineering teacher can prepare himself/herself to teach classes and also to be an advisor-tutor [13]. However, not every teaching institution can offer basic pedagogical formation courses to the young teachers as desired by the authors, thus a proposal could be offered by the institutions that offer postgraduate courses concerning this situation as they are better equipped, not to mention that the engineer candidates to the teaching positions are still in the qualification process. Moreover, this opportunity is important for the engineering candidates for the teaching positions to think about being a teacher before embarking in this career. However, the authors' suggestion is relevant and it would be admirable if the teaching institutions that offer engineering courses had at least one engineering education research group. In this research and assessment area the group of teachers would be able to discuss and reflect on the teaching practices for engineering and also promote the teaching-learning process of their students, as well as promote research related to this theme. This would represent a lifelong teaching education to the teacher, and according to UNESCO report "Education: a treasure to be discovered" education throughout life is based on four pillars: learning to acknowledge, learning to do, learning to live and learning to become [14]. However, Zabalza [3] recommends the institutions should have a formation policy centered on the needs of its own development process, organize formative activities according to their institutional needs and challenge their education professionals to acquire competencies to face the new challenges they will encounter. This paper analyzes the results obtained with the extracurricular discipline, Teach-

¹ The author calculated evasion as the percentage of the difference between the number of entrants and the number of graduates after five years.

ing Practices in the “Post-graduate Program in Electrical Engineering” (PPGEE), “Universidade Estadual Paulista” (UNESP) “Faculdade de Engenharia de Ilha Solteira” (FEIS) in Ilha Solteira-SP, Brazil.

2. Teaching-learning methodology

With these and other background questions, the faculty members of the postgraduate electrical engineering programs were asked to give suggestions to those initiating a teaching career. Given that the faculty members of these programs are professors that have generally stood out in the career, and have also been teaching classes for some time, their experiences can help the candidates to teaching careers or young professors to deal with their concerns or difficulties early on. To Carbonneau and Hétu and Durand apud Perrenoud [9, p. 15] “the experienced teachers develop a valuable competence, such as simultaneously perceiving the multiple processes that can occur in a class”.

This study is grounded in studies of Perrenoud [9], Zabalza [6], Masetto [7] and Braslavsky [8], among other studies. The teacher perception of all Electrical Engineering postgraduate courses in Brazil was collected through electronic means, sent via emails. For this particular study, almost 200 suggestions were carefully analyzed and categorized, offered to young engineers that are candidates to teaching positions.

In order to contribute to the didactic-pedagogic formation of the PPGEE of UNESP/FEIS, in Ilha Solteira, SP, Brazil, for those inserted in or about to ingress in the teaching career, an extracurricular didactic-pedagogic course was offered. The “Teaching Practices” extracurricular discipline was also planned with great analysis expectancy regarding to how the postgraduate students would accept this formation in the Electrical Engineering program.

As a space for reflection and discussion, the discipline “Teaching Practice” was planned in such a manner so that the purpose of the first encounter was to clarify that the learning practice depended on collaborative work between the course attendants and the teacher [15]. The work proposal included forming a collaborative group that cooperates with each other, thus collaborating with them, because before teaching someone, it is necessary to learn first, research, think and discuss. This situation was considered keeping in mind that the attendants were already inserted in or about to enter the teaching career. In addition, a timeframe was proposed for the attendants to introduce themselves, their formation and experience in the education field. Timeframe was also destined to expose the objectives of the course, recommended biblio-

graphy, the contents that would be approached and the activities that would be developed.

The “Teaching Practice” course was designed for postgraduate student including postdoctoral researchers who are interested in pursuing faculty career by helping to expand their pedagogical competences. The groups of postgraduate students and postdoctoral researchers attended in ten-week program to work totaling 20 hours. Teaching the extracurricular course “Teaching Practice”, some “dynamic techniques and methods to energize the classes” were approached so that the attendants could experience and apply the techniques. The techniques suggested to be applied, which can be better adapted to the class addressed contents are: group work, text study, oral presentations, brainstorming and exploring ideas, symposiums, dialogued expositive class, workshop and directed studies so that every attendant (or pair) could at some point address some of the contents within at least ten minutes, as a learning process of the classroom experience. By diversifying the teaching learning techniques, the teacher enables the student to learn with less difficulty. It is crucial that the educator know and master the techniques to energize the classroom, besides knowing when to choose the right time to apply them, as well as creating other better suited techniques for the reality of their work [7]. Now, more than ever, teachers need to diversify their styles, complying with the students’ learning standards.

In order to reflect on the teachers’ required competencies, the studies about one of the main modern education thinkers were used, Philippe Perrenoud, who focuses on improving the comprehension of the educational processes, in his book “New teaching competencies”. In one of his proposals, he essentially discussed and reflected on seven of ten competencies: “1—Organize and direct learning situations, 2—Administrate the progression of learning, 3—Conceive and help evolve differentiation mechanisms, 5—Teamwork, 9—Face the duties and ethical dilemmas of the profession, 10—Administrate their own continued formation” [9].

Giving that this is an experimental course, the activities developed were systematically recorded in a Field Diary. Each student received a Field Diary and was asked to record their learning, difficulties, doubts, in other words, their thoughts about the process, enabling them to conduct a self-assessment and data triangulation. More than a register on the individual and collective learning, the Field Diary represents the work analysis material, (it should be noted that it is an experimental teaching formation proposal for the post-graduate students in electrical engineering) as a feedback.

At each meeting, at least one question was

1- Evaluation of extracurricular discipline offered.			
The course topics, in your opinion:	Exceeded expectations	Reached the expectations	Did not exceed expectations
Methods and techniques to invigorate the class			
Teaching competencies			
2 - Suggestions for improving the course.			
3 - Are you interested in attending a similar course?			

Fig. 1. Cutting out the questionnaire applied to evaluate the work proposal.

proposed to analyze and reflect on, also allowing the students the possibility to register their perceptions on the subject and how it relates to the teaching career and the challenges it shows. It is important to emphasize that the topic approached relates to the didactic-pedagogic difficulties that the young teachers could encounter when they initiate their teaching careers.

At the end of the course a questionnaire was applied in order to evaluate the work proposal, increase credibility and remove any doubt that could still remain in the Field Diary analysis. Alphabet letters identified the Field Diary, assuring the attendants' anonymity with regards to the recording of their learning, difficulties, doubts and reflections on the process, guided by the questions presented at each class. The procedure was approved by the Ethics Committee from UNESP—Univ Estadual Paulista, Presidente Prudente, São Paulo, Brazil (CAAE: 14012113.1.0000.5402).

3. Main results: actual benefits of the approach followed for promoting professional skills

Perrenoud, when discussing teacher training in the 21st century, suggests the creation of an observatory to provide a realistic picture of the dilemmas faced in everyday life, as well as the decisions they adopt and the professional gestures they materialize [10]. This situation was also evidenced by the postgraduate students who took part in the extracurricular discipline "Teaching Practice", when they expressed interest in the discussions and reflections conducted during the course, especially those with reported experiences, as seen in the following statement:

"I hope that our course ends with much discussion and much thought, and also that the professor completes the work presenting his views and experiences"(D-student's Field Diary).

Among the strategies utilized to do the classes more dynamic, the intention was to approach the active learning and the case study in a detailed manner as

these are techniques that can easily be implemented to engineering teaching practices. However, a choice had to be made, so the content approach was chosen such that everyone could participate and explain their contributions, considering that as teachers, they can form competent professionals. The ambition is that the future professional teaches classes keeping in mind that a teacher's activity depends on the knowledge acquired throughout his life and also the internal conception of education. The greatest interest, also the greatest engagement was perceived in the discussions and reflections that took place in cases or problems experienced in the classroom.

On the teaching competencies, the evaluation of 89% of the postgraduate students who attended the course reported that the course fully attended or surpassed their expectations. The same evaluation was perceived in the Field Diary with the following citations:

"The themes approached the discussions and the manner in which the course was conducted greatly contributed to the teaching practice. Several opinions on the same subject made me rethink how important it is to stop and listen, and when necessary change our class strategies" (H-student's Field Diary).

"The course brought up important questions on education and formation. It was really relevant to stimulate continued knowledge in this field. With the discussions and experiences exchanged, it contributed to my future teaching practices" (C-student's Field Diary).

"Every theme discussed and all raised questions are of very important for pedagogical matters. The ideas converge to improve the pedagogical practices" (G-student's Field Diary).

"The group discussions were very productive and relevant. The work developed in the course regarding the 10 competencies was quite helpful to understand that besides consolidated knowledge, it is very important for the teacher to use other competencies to involve and stimulate his students to yearn for knowledge. And this requires the teacher to administrate his/her own continued formation, in other words, we should always seek to broaden our knowledge and acquire new competencies. Besides, it is really important for the teacher to always be opened to transformations and changes whenever necessary" (H-student's Field Diary).

The records showed that the post-graduate students

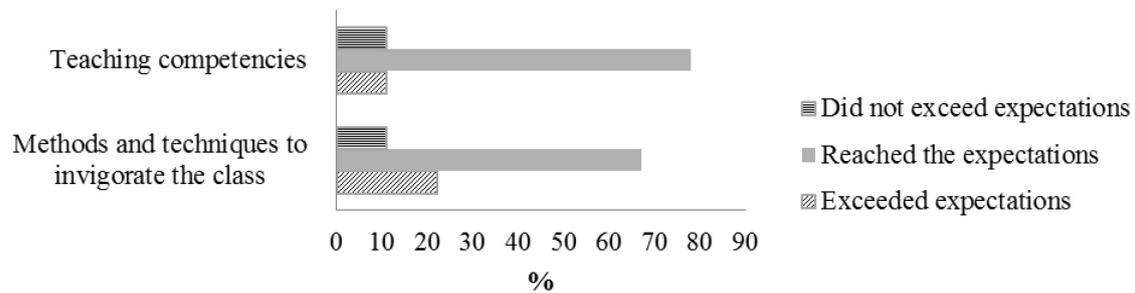


Fig. 2. Evaluation of extracurricular discipline offered to postgraduate students of UNESP/FEIS.

who participated in the “Teaching Practice” sought the skills related to ways of teaching. Moreover, reports of similar discussions in other environments or conventional training for engineering teachers were not perceived.

The main interest in new ways to teach was the reason why the postgraduate students sought the course. To illustrate this:

“In this class I want to better understand the teaching competencies” (F-student’s Field Diary).

Some records shed light on aspects regarding formation with the students’ evaluation of the book “Ten new skills to teach” [9], namely:

“The book is very good and every teacher should read it and use it as support material for how to achieve and perform in the classroom and in life” (F-student’s Field Diary).

“I find that this activity, about the book, could have been better explored, because the little that could be absorbed gave me tools to become more critical, to provide new ideas and to reflect on how I present myself as teacher to my students” (E-student’s Field Diary).

“Learn a little more about teaching ways. I think it is important to know about the ideas of several authors, such as ‘Perrenoud’ in order to reflect on how I will work in class and also develop myself and evaluate my competencies” (G-student’s Field Diary).

The expectations in the last meeting were encouraging, according to this comment:

“The expectations are the best possible because the whole course was very good and greatly contributed to our professional formation” (C-student’s Field Diary).

From the experience of offering this course to postgraduate students of the PPGEE at UNESP/FEIS interested in the teaching career, the acceptance and the need for formation among the young engineers were observed. After these studies, the competencies of the engineering teacher were approached, as the idea was to elaborate an initial formation plan based on these competencies for the engineer candidates vying for teaching positions. In this direction, Perrenoud [9] emphasizes the importance of conducting an actual study on the practices to elaborate an initial formation plan.

With the theoretical basis of the competencies described by the authors in the study and the analysis of the responses of the teachers surveyed, a convergence with the studies was found, enumerating three major competencies for engineering teachers:

1) Scientific technical competence, i.e., in-depth knowledge and understanding of the subject being taught, and analyze what they are teaching and why they are teaching it, which was also presented by Masetto [7] and Perrenoud [9]. According to Zabalza [3], the first ethical principle of a teacher, acknowledged by the Society for Teaching and Learning in Higher Education (with wide repercussions in universities in Canada and in the USA), refers to the comprehensive knowledge of the discipline they teach, this aspect cannot be discussed;

This is the first competence, without disagreements, because there is a consensus that with poor knowledge on the subject to be approached it would be impossible to solidify the learning process.

“The first recommendation to a young professor, according to my point of view, is to master the subject he/she will be teaching” (Professor 106).

So far, this competence is thoroughly developed in the undergraduate and postgraduate courses. However, the professors in the survey also suggested other guidelines:

“Having your course prepared beforehand, submit it to the evaluation of an experienced professor you trust. Do not fear having doubts in the classroom and know how to explain this to the students, always committing to bring the solution of the doubt to the next class (you have to keep your word)” (Professor 56).

Some of the reports convey the importance of the qualification and suggest to the candidates:

“To technically qualify in the field you will work” (Professor 31).

Be up to date with the innovations in your field:

“Update the material by reading new editorial publications, if necessary use experimental laboratories in which the student can apply the concept; utilize audiovisual resources” (Professor 189).

Teachers' interactions that enable the learning process, because despite being the only teacher in the classroom, this will help their teaching practice, with the experience of other experts on the subject [7].

Professor 194 states:

"First of all, it is very important to have the constant desire to learn and constantly develop competencies in the specific technical area as well as in the area of humanities and interpersonal relationships".

In addition to the scientific contents of the discipline to be taught, Zabalza [3] argues that performing in the teaching career also requires a solid formation in the didactic aspects related to the learning process. This is the second competence of the engineering teacher.

2) Didactic-pedagogic competence, how to teach, being aware of the teaching and learning processes, living the teaching learning experience, knowing the relationships between students and teacher, and mastering the techniques and new technologies. Knowing the teaching methods and choosing the one that best suits each content to be learned by students, and also create and recreate new ways of teaching. This is discussed by Braslavsky [8], Masetto [7], Perrenoud [9] and Zabalza [6], which demonstrates the importance of knowing other ways to learn and teach. Moreover, it is also the teacher's duty to choose these in a manner that enables a student to learn. Accordingly, Zabalza [3, p. 169] argues that:

"a pedagogically competent teacher communicates the objectives of the course to the students, is aware of the existence of alternative methods and strategies and selects the teaching method according to the research evidence (without excluding their thoughts and research of their own experience), which results in the most effective way to help students achieve the course objectives."

In the same direction, the professors in the survey gave their contributions:

"Dedication and precision for preparing class focus on the students' needs. Being mindful that learning truly takes place" (Professor 60).

The didactic-pedagogic competence can add to the pleasure of teaching:

"First, enjoy teaching in a classroom. Not mentioning the desire of teaching that you know in-depth" (Professor 79).

As for the didactic and pedagogical aspects, according to the research conducted, one of the concerns faced by the engineering professors is to know how to plan and adapt the evaluations to the activities developed. How to evaluate and encourage learning scientific knowledge [7, 9]? To some degrees this can be understood as a formation evaluation [16, 17]. Evaluation developed along the process, with the

intent of monitoring the development of the student's learning process—carried out with trust and the desire for improvement [18].

"I suggest to give great importance to the evaluation process, I believe it is the most important pedagogic activity" (Professor 31).

"Learn not only how to plan a class, but also about the modern pedagogical methods, which include planning the class and the materials to be used, the in-class methods also the evaluation methods" (Professor 53).

"The teacher must be consistent since the first day of class. He must prepare his teaching plan, stipulate how the evaluation will be conducted and follow through with what was established" (Professor 168).

It is described by Perrenoud as competencies that can be used with the technology available [9].

As a way to acquire classroom practice before entering the teaching career, the teaching internships and teaching assistances were discussed. This included participating in a didactics course, teaching methodologies, listening to successful professors, observing them, and when possible attending their classes and it was suggested they continue studying and also refine their skills with professional qualification. To exemplify:

"the obligation of taking at least one didactics course in the first term of your teaching career" (Professor 81).

"It would be interesting if 'Teaching Mastery Programs' were offered (. . .) it would be a great opportunity for introducing pedagogic preparation and making available a supervised teaching internship" (Professor 85).

The post graduate students with CAPES Social Demand grants, from Brazil, are obliged to take the supervised teaching internship, one term for master's degree and two terms for doctorate degrees [19].

It should be understood that the learning process also happens when the student formulates his own thoughts, hence the professor:

"should allow the students to ask questions when in doubt" (Professor 106).

This may promote learning as much as:

"the professor's dedication and commitment to teach and solve the occasional doubts" (Professor 106).

Teaching by implementing adequate methodologies can encourage the students to learn and this may require having to:

"study didactics and seek technical information, using courses or books. No one is born 'knowing' how to teach. Being liked is not didactics" (Professor 177).

A conclusion also reached by Loder et al. [13].

"Making use of methodologies and techniques that aim to improve class dynamics is something often neglected in higher education" (Professor 194).

Another suggestion was to involve the students with problems or questions so they can participate in developing the class.

“It is important that they have the philosophy that teaching, researching and learning are several aspects of a single and pleasurable activity. I believe that in the classes where a student has fun reasoning together, building together and being challenged in a constructive way are the classes that the students remember most at the end of the course” (Professor 11).

This can be understood as the student actively participating in the class, in other words, learning focused on the student, as discussed by Zabalza [18] and Biggs [20] as a way to deepen the learning process.

Without diminishing the research work, the dedication to teaching requires interest in teaching classes.

“It is important to like the classroom. Many in our field are only interested in the research work (. . .). I believe that this is an inversion of priorities” (Professor 54).

“Be honest and take pleasure in what you do” (Professor 3).

In higher education:

“it is important to like being a teacher and know how to conduct quality research” (Professor 36).

The research can also be related to how to teach and the difficulties faced by the teachers and students of engineering courses, such as dropout cases, class failures, and the students’ lack of motivation, not to mention the learning objects and the forms of teaching. The dialogue with the students can be considered as a way of reflecting on the learning process. Thus,

“The dialogue with students is also essential because it is through their comments that key points about specific difficulties can be observed, thereby elaborating plans to solve these difficulties” (Professor 70).

Reflecting on the teaching practice and:

“periodically conducting self-assessment” (Professor 189),

enables the teacher to analyze his own actions and adequate them according to his formation and principles. Dedicate the teaching time to teaching practices, in other words,

“Being aware of the students’ needs; being available for after class time; trying to engage the student; watching the language” (Professor 189).

Making time to talk to the students after class are some guidelines by Masetto [7]. In professor 189’s words:

“In the best manner possible, hold activities in which the student can present his work in front of the class;

encourage team work; stimulate bibliographic research”.

Thus, it may be necessary to know who you are working with, their needs and expectations. This is the third competence.

3) Knowing the context, i.e., whom to teach, it is a part of the social and political context of the course, the students and the job offers. This is the third competence, no less important than the others.

Among the suggestions to the engineers aspiring to enter the teaching career, the minimum time a professor remains in the career and the changes that take place in that time were discussed.

“But also keep in mind that we live in a society with a different dynamics from one, two or three decades ago” (Professor 3).

“I believe that the level of maturity of the students has diminished over the years, with that in mind, the teacher must obtain a holistic view of the students, in other words, the students have different formation, including family, previous schools, world view and many other aspects, and the teacher must often make use of these experiences in a favorable manner within the context of the discipline” (Professor 118).

“The digital media is part of everybody’s life and certainly the traditional expositive classes that by nature are very tiring, can and should find a new place to dialogue with the digital media: blogs, videos, interactive means that can be used in distance education, adding aggregated value” (Professor 3).

Along this line, there are several studies that highlight the importance of improving teaching, given that the student is not the same during the period teachers exercise their profession, which in higher education, on average, represents more than three decades, which is approximately three generations. Understanding a bit of this journey let us remember the early days of the teaching career, and the types of electronic devices they had at home.

According to the research conducted with the postgraduate electrical engineering programs in Brazil and the course offered to PPGEE in UNESP/FEIS, it can be stated that the postgraduate students interested in the teaching career are aware of the new changes and want to know how people learn. They have advanced, according to Perrenoud [10, p. 18]:

“The students who want to become teachers hold on to the illusion that only knowledge must be learned in order to transmit it. . .”

It was observed that the professors interviewed pointed to the importance of didactic pedagogic formation. However, in which part of the formation process does the engineer vying for teaching positions look for the competencies needed to teach?

University teachers have recently become aware that in order to teach they need pedagogic compe-

tence, because they are educators [7]. It is worth mentioning the initiative of the University of São Paulo (USP) that presented a proposal in the Brazilian Engineering Education Conference (COBENGE) in 2012, which proposed a professional master's degree in engineering education supported by studies on the need for this formation, including for engineers that already hold master or doctor degrees. The proposal was based on the example of other nine universities from the USA, Europe and Brazil (project), which was available during the postgraduate period a formation course to become a teacher, for engineers that will ingress in the teaching career [21].

Among the universities [21], two are referenced in the offer of postgraduate courses in engineering education: California University—Berkeley, SESAME-Graduate Group in Science and Mathematics Education is an academic interdisciplinary unit for the progress and comprehension of the teaching and learning practice in science, engineering and math [22].

The department of engineering education in Virginia Tech University was one of the first departments in the USA to offer post-graduate courses in engineering education. The program congregates theory with real life applications in order to prepare the students to become teachers and researchers in the evolving field of engineering education [23].

The Center for the Advancement of Engineering Education-CAEE, among other studies investigated the Engineering Teaching Portfolio Program-ETPP that was conceived to support the postgraduate engineering students interested in becoming teachers. Among the analysis there were more than 11 offerings between the spring of 2003 and summer of 2006 [24].

The competencies of the engineering teacher and the importance of teacher formation were discussed. However according to Zabalza, with a reference model about teaching competencies, the formation should address the different contents reflected by these competencies [3].

4. Future issues

In order to promote didactic-pedagogic competencies the offer of a discipline in the graduate and postgraduate engineering programs is suggested, as preconized by the Basis and Guidelines Law, from Brazil,

“the preparation to work in higher education teaching careers will be carried out at a postgraduate level, giving priority to the master's and doctorate's degrees” [25].

Hence, it is in this qualification area that the young engineer becomes a candidate for teaching careers

and with the proposal he would have the opportunity to participate in a pedagogic formation area before joining the teaching career. It is understood that the offering of this course implies in discussions of the social and academic role of the graduate and postgraduate courses in Brazil, and also the responsibility of those involved in the competent institutions that will evaluate the programs.

Studies have converged to a collaborative form of teaching a postgraduate course in engineering, with a didactic-pedagogic nature. One suggestion could be addressing case studies² and/or problems experienced, in which the professor chooses issues and/or cases, and the students, based on theories, seek to solve them in the best possible way. According to Perrenoud [9], teacher training should be geared towards learning via problems, resulting in the future teachers having to face the classroom experience and deal with their impressions, observations, achievements and errors, worries and joys as well as their difficulties to control the learning processes and group dynamics or a student's performance.

This could be a student-centered learning activity, given that these students will be future engineering teachers, will have to develop competencies, be creative and able to better address the potential difficulties they will face in their teaching career.

“(. . .) more practical examples. Bringing the experience of daily life to be discussed and find a better posture to implement given the recurring problems” (G-Student's evaluation).

This statement can be characterized by the case studies related to the problems experienced by engineering professors. Thus, it is a suggestion of how to develop the course beyond the technical and scientific competencies.

Associating with and participating in associations and events that discuss engineering education such as the Brazilian Engineering Education Association (ABENGE) and the COBENGE is a determinant factor to discuss and think about the teaching and learning practices. Being a part of those groups of engineering professors can lead to constant teaching learning, especially for teachers giving classes in engineering courses.

The teaching competencies are reflected in decision making, in the methodological choices appropriate to the educational objectives implemented and in the ethical requirements [5].

² It is a complex and valuable teaching technique in order to develop the ability to analyze concrete situations, encourage the competence of learning to analyze, criticize, make decisions, participate in groups and to respect other points of view, because may exist more than one solution, without a convergent solution [26].

5. Conclusions

This article contributes to the theoretical discussion and presents considerations on the competencies of the engineering teacher, as well as on the importance of pedagogical training during a postgraduate course.

The competencies of the engineering teacher are: in-depth knowledge of the subject being taught (technical and scientific), knowing the context they are teaching and how to teach it (pedagogical-didactic competence).

The convergence of studies led to offering a didactic-pedagogic discipline, to be addressed collaboratively in engineering postgraduate programs. One suggestion regards addressing case studies and/or problems experienced, with the teacher choosing problems or cases grounded in theories, and students assigned to solve them in the best possible way. This could represent an initial setting to discuss and consider the role of the engineering teacher.

An approach is needed in pedagogical education and engineering formation, especially during the doctoral or master's program—as this is when the engineering professor or teaching candidate qualifies technically and scientifically to then engage in research and teaching.

The discussions proposed in this work can also contribute to the teaching debates and pedagogical skills in the engineer's teacher training, mainly within the post graduate courses.

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