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Comments on the problem solving methodology in Civil Engineering education in Brazil

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ABSTRACT

Academic works have indicated that didactic methods for teaching engineers fail to professionally prepare, despite international efforts to create competent engineering students. Indeed, studies on teaching in engineering in general, particularly in civil engineering, throughout the world are scarce or in their incipient stages, at least in relation and comparison to the material dedicated to the subject by mathematicians. In order to improve teaching and learning in engineering, the aim of this paper was to discuss if certain aspects of the modern technique used in mathematics could be applied to teaching in engineering, more specifically the problem-solving methodology, since engineering teaching lacks a well-developed self-epistemology.

PALAVRAS-CHAVE: Teaching. Learning. Engineering. Problem solving methodology.

INTRODUCTION

An important issue in teaching is ensuring that students leave the university in adequate conditions, efficiently prepared to face the labor market, and that they continue to acquire knowledge after graduation (Oliveira et al., 2001, Cintra & Oliveira, 2001).

Certain professions such as Civil Engineering play a fundamental role in society and, in terms of responsibility for human life, provide comfort and healthy living conditions. Civil engineering is an activity that provides technical solutions for society, having a social function (Dantas, 1992), and, on a larger scale, it is used as an economic indicator in many countries.

This is a matter of concern because academic works have indicated that didactic methods utilized in the teaching of engineers fail to adequately prepare them for the profession (Telles apud Cintra & Oliveira, 2001), despite international efforts to develop competent engineering students (Borrego and Bernhard, 2011).

Studies on teaching in engineering in general and in civil engineering, specifically, are scarce or are in their incipient stages (Jesiek et al., 2010), at least in relation to and comparison to the material dedicated to the subject by mathematicians, for example.

Nevertheless, in 1918 concern regarding engineering schools and pedagogic consistency was demonstrated in an isolated article on engineering education in the USA (Mann, 1918).

In the 2000s, in the United States, an effort was made in an attempt to improve the quality and quantity of research in engineering education (Jesiek, Newswander, Borrego, 2009).

On the other hand, the teaching concepts in mathematics have been studied for a long time. Platonic, Aristhotelic, Kantian or Cartesian concepts applied to teaching were observed and analyzed in terms of learning adequacy (Machado, 1987; Piaget and Beth, 1980).

Indeed, the use of playful techniques, informatics, new technologies in general, problem solving and modeling were and are still tested in philosophic and practical aspects (D´Ambrósio, 1998; Biembengut, 2014), even the history of mathematics is used to improve teaching (D´Ambrósio, 2008).

It is, then, reasonable to question whether or not the teaching of engineering is consistent with modern theories of education or, at least, whether or not engineering teachers are attempting to follow modern education in their classes, bearing in mind the similarities in epistemology that the example of mathematics provides.

Disconnection between practical engineering and engineering education is a reality that only recently began to be discussed (Jesiek et al., 2010; Borrego and Bernhard, 2011) in an attempt to link research and practice towards common development, however specific pedagogical methods have not been particularly focused upon.

Putatively, to improve engineering teaching, teachers should consider the didactic and pedagogic aspects of their classes, not just the technical or scientific terms (Oliveira, 2000), since engineering teaching is best supported by a conservatism type of education (Belhot and Oliveira Neto, 2006).

It is a historic fact that students experience issues in learning mathematics, but the causes of these problems have been studied extensively in an attempt to find a solution, for instance, the case of the Movement of Modern Mathematics (D'Ambrosio, 1991). Nevertheless, this kind of study addressing engineering students is very rare, at least for professional disciplines; however, there are studies performed by Felder and Silverman (1988) on methods for teaching engineering.

Due to the identical epistemological and intellectual aspects, mathematics and engineering naturally present similarities in their learning, therefore, their teaching methods must have many points in common and engineers could learn from the seasoned and experienced field of mathematics.

According to the above, the objective of this paper is to discuss whether or not certain aspects of the modern technique of mathematics could be applied to engineering teaching, specifically, the problem solving methodology.

For the purpose of this work, classic and current articles of the teaching and learning of mathematics, as well as those of the teaching and learning in engineering, were used to analyze the use of the problem solving methodology within a modern concept provided by modern education theories.

SOME HISTORICAL DATA

Problem solving is an ongoing activity for human beings (Caon and Cardona, 2015; Rodrigues and Magalhaes, 2012) and older reports reveal that problem solving was first documented by the Chinese, Egyptians and Greeks (Stanic and Kilpatrick; 1989) with examples such as the Hind Papyrus, Moscow Papirus (Disperati, 2015), and, more recently, the discovery of the resolutions of trigonometric problems in the clay tablet known as Plimpton 322 devised by the Babylonians (Mansfield and Widberg, 2017).

Indeed, the Greeks demonstrated some heuristics steps for problem solving, including the 1) task, 2) indication, 3) thesis, 4) construction, 5) demonstration and 6) conclusion method used until today (Groenwald et al., 2004).

However, problem resolution as a method of teaching started in Germany with the Theory of Mental Discipline, which was the basis of the scholastic curriculum of the country (Onuchi et al. 2014). The idea was to have students repeatedly solve a set of exercises with emphasis placed on the final result, as opposed to the learning process itself. The Theory of Mental Discipline was developed by the German psychologist Christian Wolff in 1740 (Onuchi et al. 2014).

A significant contribution to the teaching of mathematics was made by the psychologist American Lee Thorndike (Jonçich, 1968) and what is known as Connectionism based on the hypothesis that learning consists of the addition, elimination and organization of connections (Rius, 1991; Onuchi et al. 2014). According to Thorndike, the theories of educational psychology and experimental education were successful educational practices of that time (Santos, 2016).

Thorndike disagreed with the Theory of Mental Discipline (Santos, 2016) but defended the traditional discipline with emphasis on university training (Thorndike, 1905) with reasoning based on cooperation, organization and habit control in an attempt to break away from memorization (Thorndike, 1917), thus creating the philosophy of conductionism (Groenwald et al., 2004).

According to Santos (2016), in the history of American mathematics up until 1910, the teaching of mathematics was based on "the discipline of mind", which was definitely challenged by Thorndike in 1927 with the publication of "The Thorndike Algebra" in which he changed the points of view of teachers and students and became known as the father of psychology in the teaching of mathematics (Resnick and Ford, 1981).

Frizzarini and Cargnin (2016) heavily criticized this theory reporting that it is based on exercise and repetition, emphasizing the product as opposed to the process of teaching and learning (Rius, 1991).

However, it was succeeded by the Significant theory of William Brownell, who opposed Thorndike (Esteban, 2010), and the resolution of problems became a theory proposed by George Polya in the book "The art of solving problems" published in 1945 (Frizzarini and Cargnin, 2016).

In this book, the following steps to solving problems were presented: 1) understand the problem, 2) establish a plan, 3) execute the plan, and 4) examine the solution. Polya shows a deeper and more comprehensive view of the problem solving methodology (Onuchi et al., 2014).

The work of Polya was better understood and valued by other works performed by Kilpatric, Biggs, Fischbein, Shimada (Frizzarini and Cargnin, 2016), after the emergence of the psychology theories of Gestalt and Cognitivism in the 1960s, affirming that the human mind is not an automatic mechanism that produces automatic answers (Groenwald et al., 2004).

PROBLEM SOLVING IN MATHEMATICS AND ENGINEERING

Even after a long time of research, discussion, reflection and transformation, problem solving is still not applied in classes in which traditional principles for teaching mathematics continue to prevail (Rodrigues and Magalhaes, 2012; Groenwald et al., 2004; Belhot and Oliveira Neto, 2006).

In fact, the use of new teaching technologies seems to occur scarcely (Groenwald et al., 2004) due to common concerns regarding the teaching of mathematics and the same could be happening with engineering teachers. Different countries have expressed similar concerns in relation to the teaching of mathematics, presenting many convergence points regarding 1) problem resolution, 2) quotidian mathematics and 3) math problems encountered in other disciplines, according the National Curricular Parameters in Brazil (Brasil, 1998).

The brief historical reflections above indicate the long amount of time that researchers have dedicated to the study and change of math teaching, although conservatism is the main method used to teach the discipline until today, which demonstrates the difficulty in changing ingrained behaviors.

Mathematics serves as the basis for exact sciences. Indeed, it provides the language, concepts for description analysis, modeling and simulation for these sciences and for engineering. Mathematics provides the tools for projects, simulations (Onuchic, 2012) and basic data for professional disciplines which, therefore, have identical epistemology.

Furthermore, it is necessary to keep in mind that math education is not an exact science. It is more empirical and multidisciplinary in nature and aims to help other human beings, where the main goal is student learning (Onuchic, 2012).

In this way, it seems reasonable that the teaching of exact sciences seeks the use of pedagogic and didactic modern methods to teaching based on mathematics education. This is a new area of study (Onuchic, 2012) that, with improved mathematics teaching, will support correlated scientific areas.

A proposal for quality math teaching is the implementation of modern technologies (Bernardinis et al., 2015a) and the same could be proposed for teaching engineering because mathematics education is organized to generate the appropriate math knowledge for different types of students (Onuchic, 2012).

For the purposes of this work, analysis will be performed on the use of the problem solving methodology because it aims to develop metacognitive abilities, favoring reflection and questioning by apprentices (Mendes, 2009), allowing an approach to non-mathematical problems without the use of techniques or application of algorithms (Caraça, 1989), developing critical reasoning (Lupinacci and Botin, 2004), boosting comprehension and deduction coherently, making students responsible for their own knowledge (Ferreira, Silva, Nunes, 2015), all useful skills for future engineering professionals.

Furthermore, the purpose of the problem solving methodology is for students to use the context to apply the critical thinking (Lupinacci and Botin, 2004) associated with investigation, interrogation, discussion, elaboration of complex processes, catenation of ideas using math and non-math proceedings in order to facilitate comprehension, and the generation of hypothesis formulation, analysis, generalization, and evaluation (Groenwald et al., 2004).

All of these aspects are essential to a high-quality university education and the establishment of conditions that produce a more qualified professional.

Belhot and Oliveira Neto (2006) claim that the use of problem solving unaccompanied by the correct method to orientate the process could cause problems for students, including: lack of awareness of the mental processes involved in solving the problem, failure to employ a systematic and organized method in solving the problem, trying to solve the problem without comprehending it, and failure to explore conventional alternatives.

It is not difficult to verify that most methods of teaching engineering are based on long exercises (Ferreira, Silva, Nunes, 2015), similar to the method of the mental discipline theory (Groenwald et al., 2004), which have been framed into traditional education and criticized for using technical information that is distant from society (Ferraz, 1983, Bernardinis et al., 2015a).

Although the proposal of teaching using the problem solving methodology has been widely commented on among math education researchers, it remains an unknown technique by the majority of educators in schools (Groenwald et al., 2004). Keeping in mind that the use of a list of mechanically solved problems is not part of the problem solving methodology (Belhot and Oliveira Neto, 2006), this is a continuation of the type of teaching used in the nineteenth century.

In fact, according to Stanic and Kilpatrick (1989), the problem solving methodology has been known to be difficult to understand by teachers and there is also some difficulty in translating the data from research on this subject into applicable teaching practices.

Working with similarities in epistemology between mathematics and engineering, students, in general, present difficulties in learning mathematics in the classroom, and the same could occur with engineering students, due to lack of interest or accommodation associated with the lack of motivation of teachers since elementary school (Prediger, Berwanger and Mörs; 2009). This generates positive feedback in the behavior of students and teachers where the passivity of some tends to diminish the motivation of others and vice versa; this is also occurring in higher education, generating loss of motivation in both students and teachers (Massa, 2015).

From the perspective of the problem solving methodology, the problem must be challenging, real, interesting, unknown, not be a direct application of an algorithm, and present an adequate level of difficulty (Dante, 1998), because, if it is not, students may lose motivation (Rodrigues and Magalhaes, 2012) and increasing enthusiasm for learning in mathematics and exact disciplines is dependent on the teacher’s motivation as well as the teacher/student relationship (Lupinacci and Botin, 2004).

In general, good class requires good student receptivity, i.e., a positive feedback; in fact, the success of problem solving applied in classes is dependent on the teacher, since he is the tutor who chooses the problem and its level of difficulty (Lupinacci and Botin, 2004), however, students and teachers should be mutually interested (Bernardinis et al., 2015a).

The general purpose of the new techniques of teaching, according to modern education, is to think efficiently, supporting the efficiency concept of substituting determinism for teleology, thus reductionism will be complemented by expansionism (Belhot and Oliveira Neto, 2006).

In this context, new teaching techniques play a fundamental role in uncovering new approaches in disciplines. Problem solving has the potential to reveal a new perspective on learning in many opportunities in the classroom, since the techniques for the resolution of exercises provide training in the 4 steps of the Polya method and include the proposal of constructing a problem based on the reality of the engineering professional, one of the proposals of the problem solving methodology (Lupinacci and Botin, 2004).

In fact, in this method, one of the most important in mathematics education, problems are proposed and explored, not only solved (Lupinacci and Botin, 2004), and, in some cases, there may be more than one solution (Ponte, 2005)

In the problem solving methodology, one of the many purposes is to encourage students to go beyond the routine and to stimulate the pleasure of thinking, with emphasis on the process in order to facilitate the finding of different solutions and the making of comparisons. Therefore, this must occur in open situations because it requires active action from students to obtain the answers themselves (Lupinacci and Botin, 2004), which has been effective according to proven practices (Caon and Cardona, 2015).

The use of the problem solving methodology favors a motivational and challenging environment that engages students in an elaborate process of thinking (Ferreira, Silva, Nunes, 2015) and encourages them to recognize and to apply deductive and inductive reasoning, to use special thinking and graphic proportions, to evaluate conjectures and mathematical arguments, to generate contra-examples, to follow logical arguments and to validate their own thinking (Mendes, 2009).

In this method, the use of newly learned formulas to solve a problem is not characterized as a true problem (Carraher, 1986, Caon and Cardona, 2015); it is necessary to stimulate students to manage procedures and to use previous knowledge, favoring the use of critical thinking (Lupinacci and Botin, 2004) to facilitate the acquaintance with and management of information that enhances the learning of the proposed concept, thus generating self-confidence (Brasil, 1998). In short, it is a heuristic, not a mechanical, process (Caon and Cardona, 2015).

It is very important highlight that there are problems in teaching mathematics according the modern theories, however, an increasing awareness among new teachers of the need to improve math learning seems to be taking place (Groenwald et al., 2004) and these problems occur in an environment where there are specific courses for teachers' training in mathematics.

By correlation, it would be difficult to implement these new educational concepts in a university engineering classroom, but attempts to use real problems associated with professional practice could improve learning and would most likely hold the student's attention, which is an important aspect in engineering teaching (Ferreira, Silva, Nunes, 2015).

Accordingly, teaching in courses where there is no teachers' training, as in engineering for instance, is more concerning. It is a fact that teachers, in general, imitate ancient teachers (Lima and Alves Neto, 2015), mainly beginners who were insecure when initiating their professional career at the university (Smaniotto and Gentil, 2014) and engineer-teachers that do not have any previous preparation for teaching, such as the teaching internship required in the training of math teachers.

Other problems are associated with aspects such as the comfort level of the teachers: "have always done it this way", "why change?", "was tried, but did not work" (Belhot and Oliveira Neto, 2006).

From this perspective, i.e., the engineer-teacher without didactic preparation would not stray from ancient conservatism and the non-evolution of students' behavior in a hodiernal world with mutant essence (Lester and Koehler, 2003; Lesh and Zawojewski, 2007), but, on the other hand, applications in collaborative, active learning and teamwork have been receiving more attention in engineering learning (Belhot and Oliveira Neto, 2006).

There are many possibilities for teaching differently from conservatism, suggested by the problem resolution methodology, such as the organizing of problems for students to learn the necessary algorithms in solving exercises, for instance. Methods for teaching engineering must be studied in detail for each discipline, however, the initial purpose of this work was to indicate the problem resolution methodology as an applicable method for teaching engineering disciplines, at least, those directly associated with mathematics such as calculus, physics, materials, hydraulics, material structures, paving, concrete construction and others.

The problem resolution methodology could be a way to invigorate the teaching of mathematics (Rodrigues and Magalhaes, 2012), as well as exact disciplines.

The use of the problem resolution methodology is difficult for the teacher to work into the classroom (Ferreira, Silva, Nunes, 2015; Caon and Cardona, 2015), at least for most, and, therefore, teachers need to learn about and be prepared to use this method (Dante, 1998; Rodrigues and Magalhaes, 2012). In this process, it is necessary spend time on class preparation, dedication, and organization to generate a successful teaching-learning process (Ferreira, Silva, Nunes, 2015).

A good suggestion for class preparation is the use of the steps proposed by Onuchi (2009) and those provided by Felder and Silverman (1988) as techniques to reach all types of students.

It should be kept in mind that the teaching practices are intrinsically difficult because of the required knowledge, abilities and actions that the teacher needs in order to keep good intra and interpersonal relationships that allow them to deal with the unforeseen in classroom (Lima and Alves Neto, 2015). Neglecting teacher training facilitates the perpetuation of traditional teaching, where the teacher is simply a communicator (Godoy, 1983).

Teachers of engineering courses with educational backgrounds in math could start using modern education methodologies to prepare students for following disciplines; however, teachers with technological backgrounds need to attend courses for higher education teaching in order to be better prepared to introduce new methodologies or to, at least, become knowledgeable of these methods.

In fact, if teachers of basic disciplines use modern teaching technologies and teachers of specialized disciplines do not use them because they do not know about them, the result will be a regression in students' learning.

The use of new educational technologies in engineering could help to transform the conservative way of teaching in this area, based on intuitive (abstract), auditory, verbal, deductive, passive and sequential factors (Felder and Silverman, 1988) and the application of mechanized teaching of complex content such as calculus may not facilitate learning and/or increase the student resistance (Ferreira, Silva, Nunes, 2015).

There seems to be an inconsistency between the learning of engineering students and teachers in many aspects that potentially diminishes student performance and increases frustration in the profession (Felder and Silverman, 1988).

It is necessary to separate the concept of the resolution of the exercises in relation to problem solving, i.e., in the first case, the variables are known as well as the sequence to the solution while, as for problem solving, the variables should be unknown and in uncertain conditions. The confusion of these concepts could be a problem for new engineers in the work force (Belhot and Oliveira Neto, 2006).

In general, higher education teaching in Brazil is based on technical and mechanical models that are no longer capable of meeting the modern requirements of society (Moraes and Torres, 2004).

It is frequently thought that higher education teaching requires masters and doctorates degrees, but a didactic education may also be required (Fernandes, 1998) because, putatively, these degrees prepare researchers, not necessarily teachers (Garcia, 2013), or the disciplines offered associated to teaching are insufficient (Onuchic, 2012) for adequate teacher preparation.

In this context, the literature specifies lack (Belhot and Oliveira Neto, 2006), although some articles have indicated methods and examples for solving problems mainly for elementary and secondary education. (Lupinacci and Botin, 2004; Chiréia, 2010; Clement and Terrazan, 2011; Silva, 2012; Caon and Cardona, 2015; Freitas, Goi and Giuliani, 2015; Frizzarini and Cargnin, 2016). As for higher education, works are scarce (Belhot and Oliveira Neto, 2006; Ferreira, Silva and Nunes, 2015; Larias and Paseto, 2016) because, in terms of teacher behavior, modern educational techniques contextualize, indicating the need for reflexive teaching and epistemology of practice (Schön 1997; D'Ávila and Sonneville 2009) and suggesting that teaching as a professional practice is not fit fot higher education classes of today (Massa, 2015).

In fact, the study of modern teaching techniques in higher education is in its infancy and is a new area of investigation (D'Ávila, 2008; Pimenta e Anastasiou, 2010; Garcia, 2013) with few articles bringing examples of the use of such new methodologies (Barros and Sousa, 2015).

Despite the problems observed in mathematics teaching and, by correlation, in engineering teaching, the problem resolution methodology seems to be a sound suggestion for use in engineering classes and it is more accessible with regards to understanding for teachers based on the similarity of language. Also, studies on other modern technologies could be introduced such as modeling, the use of games, digital medias, and inter alia.

CIVIL ENGINEERING EDUCATION

Specifically, regarding Civil Engineering, the ancient process of construction is being modified because the concepts of concise production are in opposition to Taylor-Ford principles (Parchen, Scheer and Parchen, 2007), which has led to the necessity to enlarge the educational base to improve qualification (Cattani, 2001).

In this context, to be a better engineer that serves society, he must receive a better education (Dantas, 1992; Cordeiro et al., 2008) to cultivate abilities such as the reading of international techno-scientific literature, the analyzing of structures and technical mathematical process, the planning and execution of measures, experiments and manufacturing processes, as well as the synthesizing of new structures according to specifications and restrictions (Kihlman, 1988).

Society needs civil engineers with new competencies, flexibility and autonomy in constant learning, and inter alia since the formation of the engineer must be done considering the needs of the country and the welfare of the society (Cordeiro et al., 2008), however current engineer training fails to address social skills (Bernardinis et al., 2017).

Engineers need to know more than formulas and concepts. They must be prepared to make decisions, to search for information and apply it, as well as have a global vision to analyze the problem, i.e., learn to learn (CARVALHO et al., 2001).

Specifically on civil engineering education in Brazil, some articles that present "Engineering Education" in the title are about the history and curricular purposes, not on the teaching issues or the use of new teaching methodologies (Cordeiro et al., 2008; Macedo and Sapunaru, 2016), however, Cordeiro and colleagues (2008), and report that good engineering must be based on mathematics, physics, chemistry and biological knowledge, in addition to aspects of citizenship (Bernardinis et al., 2017). For that, it is necessary to modernize engineering education.

The change in civil engineering education in Brazil has faced the strong preconceptions of docents and students that think that engineering courses prepare for business training and negate the validity of basic and humanistic disciplines (Laudares, Paixao, Viggiano, 2009).

Therefore, the construction of disciplines in Engineering Education with in-depth studies on the inherent features of the formation of an engineer is urgent. In the first step of this work, the use of the already studied methods of math education is proposed (see above) due to the long history of research on the theme as well as the epistemological similarities.

It does not mean that Engineering Education should depend on Mathematics Education, but it is necessary to draw upon the experience of mathematics in order for engineering to construct its own epistemology. In fact, the creation of the research field in Engineering Education is necessary (Jesiek, Borrego and Beddoes, 2010).

According to Jesiek and colleagues (2010), Engineering Education research has become globalized and the authors cite the importance of cultivating an international community of engineering education researchers. Indeed, many groups in Europe, Australia, Asia, America have been formed for discussion on the theme, but there is still great distance between educational engineering research and practice (Jesiek, Borrego and Beddoes, 2010).

The recent organization efforts engineers have taken regarding engineering education in the world should be encouraged in Brazil.

In fact, to eliminate or reduce the deficiencies of conservatism teaching in all cases, especially in civil engineering, it is necessary to stimulate new research in the educational field with the purpose of creating teaching methods that are adequate for engineering (Belhot and Oliveira Neto, 2006).

New education methodologies have been scarcely used in Brazil in civil engineering but, when applied, good results are obtained (Ferreira, Silva and Nunes, 2015; Lopes and Martins, 2017), such as better student performance, participation in classes and increased curiosity (Larias and Paseto, 2016), promoting a change from passive to active learning.

An attempt to use active methodologies in the curriculum of a Civil Engineering course generated positive results with most students such as team working, demonstrating critical thinking and increasing the capacity to learn by themselves.

However, some problems occurred in the implementation because some teachers did not trust the methodology, they did not help in the classes, or the classroom space was not sufficient for the purpose (Sesoko and Mattasoglio Neto, 2014).

A parallel approach to conservative teaching was done using card games in a civil engineering transport class using a PBL [Problem Based Learning] method, however, the practical results were not verified objectively (Bernardinis et al., 2015a, 2015b). An incentive to construct a group of studies in Engineering courses is occurring at the Federal University of Paraná, the Federal University of Ceará, and the Federal University of Juiz de Fora (Bernardinis et al., 2017) with the application of new technologies such as PBL (Cordeiro et al., 2017) and gamification with good results (Bernardinis et al., 2015a, 2015b, Bernardinis et al., 2017), as well as the use of virtual reality and simulation with the purpose of improving engineering teaching (Carvalho et al., 2001, Bernardinis et al., 2017).

Instructional material plays an important role in the process of teaching-learning, mainly for technological courses in engineering. In fact, in a practical and successful example, the use of card games in a particular class caused the students to achieve better scores than those in others in which this methodology was not applied (Bernardinis et al., 2015a, 2015b).

Another example of a successful learner's innovation was the students, by themselves, looking for an alternative to higher-quality learning, establishing a study group involving many of the areas of Civil Engineering recognized in some universities in Brazil (Bernardinis et al., 2017).

Following, in a case of teaching with projects in Civil Engineering in Brasília University was cited, a kind of active methodology presenting good results for students (Larios and Paseto, 2016); the application of active methodology in two disciplines Calculus II and Resistance of Materials resulted in good student performance, in comparison to traditional methods, and an increase of presence in classes (Ferreira et al. 2016).

These could be approaches with positive or negative repercussions for students. Positive because of the new teaching method and negative because the natural resistance to changes by people, mainly teachers (Berbel, 1998).

The incongruence between practiced teaching and modern technological development is one of the motives for searching for a new approach to teaching, with the goal of producing a truly qualified professional that is prepared to enter the workforce (Bernardinis et al., 2015a, 2015b),

In addition, Bernardinis et al., (2017) cite other pedagogic alternatives including panel discussion, simulations and PBL as examples of methods to be applied to the teaching of Civil Engineering.

Accordingly, one of the new methodologies applied in the civil engineering teaching was the problem resolution methodology (Belhot and Oliveira Neto, 2006), which was applied with success and generated a motivating environment, pleasure in discovery, autonomy of students in learning and better use of creativity (Ferreira, Silva and Nunes, 2015).

Of the few number of works on new teaching technologies in engineering, some of them have been tested in the classroom, which is a start however some points need to be emphasized among researchers, according to Bazzo (1996), i.e., 1) curriculum, 2) teacher formation and, 3) evaluation and motivation.

Issues such as poor interpersonal communication, absence of stimulus promoting teamwork, limited computational abilities and dissociation between business practice and theory are some of the problems observed in undergraduate engineering students studying under the conservatism method in Brazil (Belhot and Oliveira Neto, 2006).

In this work, an effort was made to illustrate the problem in Civil Engineering Education, which could be applied to other areas of engineering, in relation to the training of teachers in the application of the problem solving methodology which may be a favorable improvement in the engineering curriculum since the problems solving methodology, as shown, increases learning motivation.

CONCLUSIONS

The improvement of engineering education depends on a change in the perception of teachers in relation to new teaching methodologies. As these methods are incipient in terms of engineering research, the use of the theoretical body already built by mathematical education was proposed, which provides many works on the mentioned methodologies.

Initially, the new strategy of the problem resolution methodology was indicated as being closer to the engineering epistemology and modifying methods for teaching engineering will not be so strange, since problem solving within society is one of the many functions of the engineer. As engineering courses do not train engineering-teachers, the problem of changing conservative teaching becomes more difficult and it is, then, necessary that the engineering-teacher attend graduate courses for better didactic preparation.

Furthermore, the perspective of engineers on modern proposals for the profession has to undergo a profound modification in teaching methodology. So, it is urgent that engineers seek to work to improve engineering education by following international research approaches in the teaching of engineering for professional practices such as the creation of study groups supported by scientific journals and the many societies of engineers.

In short, it is imperative that engineering-teachers in Brazil strive to adapt their classes to modern educational technologies and to communicate their attempts to colleagues at congresses, meetings, symposia, and especially in scientific journals, for if the problem of education in engineering falls on teachers, the solution, almost completely, depends on them.

Comentários sobre a metodologia de resolução de problemas na educação da Engenharia Civil no Brasil

RESUMO

Trabalhos acadêmicos têm indicado que métodos didáticos para o ensino de engenheiros falham na preparação profissional, apesar do esforço internacional para criar competências paras os estudantes de engenharia. Estudos sobre o ensino de engenharia, em geral, e para a engenharia civil, especificamente, são escassos, ou está em período incipiente, pelo menos, em relação ou comparado ao material dedicado ao mesmo assunto pelos matemáticos. Para melhorar o ensino e aprendizado em engenharia, o objetivo desde artigo foi discutir se alguns aspectos da moderna técnica de ensino de matemática poderiam ser aplicados ao ensino de engenharia, em especifico, a metodologia de resolução de problemas, desde que o ensino de engenharia ainda não tem sua própria epistemologia.

PALAVRAS-CHAVE: Ensino. Aprendizado. Engenharia. Método de resolução de problemas.

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