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The value of responsibility through Problem-Based Learning PBL, in the analysis of electrical circuits

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ABSTRACT
This paper documents and analyzes the implementation of some cases of basic electrical circuits Ohm's Law, using the PBL (Problem Based Learning) methodology in a course in electrical circuits belonging to the race of Electrical Engineering, College of Mechanical and Electrical Engineering, Unit Zacatenco the National Polytechnic Institute in Mexico, the goal is that the problems are handled in the context of circuit theory, are transverse so as to achieve the problems seen in at least three knowledges on the subject, (know-how, knowledge and know how to be) where mainly promotes accountability (how to be) to use correctly the amounts of electric current in the team, to offer both to themselves and to their fellow security by magnitudes of electric current that the human body can withstand.
KEYWORDS: *PBL, competences, responsibility, electrical circuits.*

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I. INTRODUCTION

The transmission of electrical energy was originally carried out in direct current (DC), but the ease of transformation and transmission of alternating current (AC) led to its use and installation on a large scale, limiting the use of direct current too few applications. It was not until the second half of the twentieth century that the advances and development of semiconductor devices and Power Electronics gave the possibility of converting alternating current into continuous and vice versa, with high performance devices.

In the Higher School of Mechanical and Electrical Engineering unit Zacatenco, the Electrical Engineering degree is offered, which lasts for 9 semesters, in which the subject of electrical circuit analysis begins to be offered from the fourth semester of engineering; Curriculum reform is currently under way and it is beginning to emigrate gradually towards the competency approach; However, there is still a lot of work.

In Mexico as in other countries, its graduates are looking to face new challenges imposed by scientific and technological development, not only from the technical point of view but also human considering, the set of interpersonal and social relationships that must be established in the middle of the so-called universal crisis of values [Molina A.A., 2000].

On the other hand, we must not forget that we live in the knowledge society, where there is a rigorous advance predominantly intelligence and knowledge, as the main factors of social and economic progress [Morin, E., 1984]; but also this society is characterized by accelerated knowledge in the production of more knowledge, which multiply exponentially in the production of patents, specialties and which in turn makes some other knowledge obsolete [Lopez, J.A., 2000] ; but without falling into contradictions, since it is not the same to have information than knowledge, since the fact of possessing a quantity of information does not necessarily imply that you have enough knowledge, since theoretical, conceptual and axiological frameworks are required to give it sense, thus avoiding that the information generates ignorance for this cause [Mohamad, J.A., 2006]. Because of this, Higher Education is increasingly facing new challenges, since with large accumulations of new information that has been generated, professionals capable of handling and operating information with knowledge must be prepared without losing their human conditions.

Nowadays, the engineer's own activity is projected more towards technological innovation than towards invention (reproduction of utilitarian knowledge), which implies cooperative relationships without authoritarianism; Leaving aside being an individual entity, to become an active entity protagonist of social development, through interaction with other subjects, including those of different professional profiles. In these relationships, permanent learning processes appear based on a theoretical and conceptual framework that constitute their academic training; which can be said that they are not only disciplinary knowledge and skills but they must know how to drive from and to society, which expresses the knowledge of working in groups, socially and economically interpreting needs and demands, directing processes through participation , dialogue and communication, in search of valuable information for competitiveness [Fernandez, F. H. and Duarte, J.E., 2013].

Therefore, it is necessary that the academic training of engineers be developed through a model of professional competences that serve as the basis for a new curricular and pedagogical development [Molina A.A., 2000]; thus defining a professional competence as the set of skills, attitudes and responsibilities that describe the learning outcomes of an educational program and that enable the development of a professional activity. These competences are classified into two categories mainly, [Sanchez et al., 2007]: transversal or generic competences that are not related to the technical knowledge of the degree, but must have all degrees with an academic level, being able to be systemic, instrumental and interpersonal and on the other hand the technical or specific competences that are those that are related to the technical knowledge of the degree and can be conceptual, procedural and professional.

However, a professional competence covers many dimensions of knowledge, because when talking about learning to learn, it presupposes the fact that a certain knowledge, skill or personal quality is acquired does not end there; but permanently, the professional, throughout his life, is transformed as an integral human being; It is also a dialectical process that begins in the classroom, at home and in the community that will last forever [Perrenoud, P., 2008]; When it comes to knowing how to learn to know, this dimension includes the development of cognitive skills, preparing the student to face situations, problems that now do not exist but will occur in the future; So a graduate of higher education must know how to foresee the future development of his professional sphere and be prepared for what will happen. Knowing how to learn to understand, includes practical skills, these calculation skills include concrete actions in solving mathematical problems, as well as modeling phenomena or processes; This has been developed more academically, that is, it is one of the conceptions of the so-called problem teaching, resulting in something positive in the learning outcomes but does not mean problematizing the subjective relationship of the student with the profession, as the only way to make the process of shaping your professional identity problematic [Laurencio, 2005].

Knowing how to learn to be includes human values, the qualities inherent in the personality of the individual; value is a concept whose essence is its value, being valuable, that is, value refers to those objects and phenomena that have a positive social significance and play a double function: as a cognitive instrument and as a means of regulation and orientation of human creativity, [Perrenoud, P., 2006]; At any time in life, moral values are present as part of the content in movement with the other values, as they are present in them, the foundation and purpose of any act of human behavior; professional responsibility, honesty, human solidarity and other moral values, owe their performance and aspect to it, which is totally valid for any university specialty; So we also have the sensitivity to possible damage to the environment caused by technological development and that is where the engineer must be able to reconcile all the factors involved so that the ecological damage is the minimum, for which he must possess culture [Tirado L.J., 2007]. Knowing how to live together refers to the balance of the individual with his social environment, especially with the people around him in his social environment, as well as the solution and the needs of the society that can give rise to points of view found, where every engineer must have adequate communication skills, where he can dialogue to solve his problems, as a leader and educator for his subordinates [Tirado, L.J., 2007].

All this knowledge is directly related to teamwork skills, since as mentioned the current engineer does not work alone, usually is part of an interdisciplinary collective consisting of specialists, technicians and workers; where they will have to learn independently that they have at all times their status as group leader; This means that you will always be an active person, so it is convenient to relate your training to active methodologies where one of them is Problem Based Learning (PBL), known as Problem Based Learning (ABP) [Molina O. J. A. 2003].

This methodology originates from the Faculty of Medicine of the Canadian University of McMaster, in the mid-1960s; since the students of that discipline, in addition to acquiring knowledge, they also had to obtain a series of skills and abilities for their work [Paineán B. O. 2012].

The ABP methodology is a teaching-learning strategy in which both the acquisition of knowledge and the development of skills and attitudes are important, in the ABP, a small group of student's meets, with the support of a tutor, to analyze and solve a problem selected or specially designed to achieve certain learning objectives. During the process of interaction of students to understand and solve the problem, in addition to learning their own knowledge of the subject, they can develop a diagnosis of their own learning needs, that understand the importance of working collaboratively, that develop skills of analysis and synthesis of information, in addition to committing to its learning process; the steps of the ABP process are shown below [Saez P. D. 2008]:

1. The problem arises (designed or selected)
2. Learning needs are identified
3. Information learning is given
4. The problem is solved or new problems are identified and the steps are repeated

Its main advantages are:

a. Students with greater motivation
b. Most significant learning
c. Development of thinking and learning skills
d. Integration of a work model
e. It allows greater retention of information
f. It allows the integration of knowledge
g. The skills he develops endure
h. Increase your self-direction
i. Improves your understanding and development of skills, as well as interpersonal and teamwork

II. INVESTIGATION METHODOLOGY

In the Electrical Engineering degree, there are three Electrical Circuit Analysis subjects, one of the first, taught in the fourth semester of the degree, which corresponds to direct current; taking place in two theory sessions of 1.5 hours each and a laboratory session of 3 hours a week; giving a total of 54 hours of theory and 54 hours of laboratory that are taught in 18 weeks per semester.

The methodology focuses on the first course of Analysis of Electrical Circuits I, corresponding to direct current; since the general competence of the subject as well as its knowledge are shown in Table 1; and the synthetic agenda, in Table 2.

Table 1: General competence and knowledge

General Competence: Analyzes resistive circuits in direct current to check the behaviors of the magnitudes of voltage, current and power based on the laws and theorems of the theory of circuits in stable state and in transient state.		
Cognitive (knowledge)	Procedural (do)	Attitudinal (to be)
• Mental and analytical ability for mathematical processes. • Concepts of: electrical load, resistance, capacitor, inductor, electrical voltage, current intensity, power, energy, electrical circuit, circuit configurations (series, parallel, mixed) • Ohm's Law, Kirchhoff Laws, electrical network topology. • Methods and theorems of analysis of electrical networks in direct current. • Stable state and transient state in an RC, RL and RLC circuit in direct current.	• Have manual skills. • Recognize a resistor of an inductor and capacitor. • Differentiate a power supply from a passive element. • Know how to connect a series, parallel or mixed circuit. • Know how to use a direct current measuring instrument correctly. • Know how to analyze the behaviors of current, voltage and power in a given configuration. • Ability to handle new information technologies.	• Be respectful to others. • Be patient with yourself and others. • Know how to work collaboratively • Be responsible with the entrusted activities • Have the ability to react calmly, in emergent situations. • Ability to be organized • Ability to communicate with others and make decisions • Have professional and social responsibility • Be creative for design development.

However, throughout this time we must not forget to make them consistent that when they proceed, they have to work the part of their being, because their attitude is very important along with their knowledge and procedures; but as can be seen within the synthetic agenda, it is not explicitly contemplated, but in Table 1, although it is not enough.

Table 2: Synthetic content

Unit I. Units and definitions
Unit II. Resistive Circuits
Unit III. Useful Techniques for Circuit Analysis
Unit IV. Inductance and Capacitance
Unit V. RL and RC circuits without sources
Unit VI. Application of Unitary Step Excitation Function
Unit VII. RLC circuits

Due to the above, it is that through the ABP, certain cases involving the presence of ethical values are used, mainly that of responsibility both with oneself and when working as a team, since another important factor to mention is that from 7 years to date, 80% of the students entering the electrical engineering career, come from other specialties and do not know certain dangers that they may have when handling high magnitudes of electric current, even being direct current in scope of milliamps; Although they are given the safety rules in the laboratory and when they start developing the content with them, they are irrelevant as well as some safety standards, even when dealing with the issue of powers of ten in the expression of electrical quantities such as: current intensity, electrical voltage, electrical power, electrical resistance, in others; students have a hard time differentiating a value of 10 microamperes, (10 µA) from a value of 10 milliamperes, (10 mA); besides that they still lack to know how much that dimension is; or how it could impact either for a benefit, meet an objective or cause an accident, and that finally also implies a bad theoretical analysis, as well as problems in experimental development, damaging certain devices, sensitive to large quantities of current or power and even to put yourself at risk.

III. APPLICATION OF THE METHODOLOGY

That is why when this methodology is developed they are presented as resistance quantities, the one that the human body has, when it is subjected to different current quantities under different conditions, see Table 3.

Table 3: Effects of electric current intensity on the human body

Effects of electric current intensity	Current intensity in Men	Current intensity in Women
• Sensation threshold	0.0010 A	0.0007 A
• Mild discharge (no loss of muscle control)	0.0018 A	0.0012 A
• Severe discharge (loss of muscle control, respiratory distress)	0.0230 A	0.0150 A
• Possible ventricular fibrillation (3 s discharge)	0.100 A	0.100 A
• Possible ventricular fibrillation (1 s discharge)	0.200 A	0.200 A
• Heart muscle activity ceases	0.500 A	0.500 A
• Burn tissue and organs	1.500 A	1.500 A

It is mentioned that at least in the management of electric energy, people are exposed to possible electric shocks, however they are not the only way to have accidents; since there are other types of hazards and that these can be avoided by proceeding in their laboratory experiences and in their daily lives in a safe and responsible manner; knowing of the human body that magnitudes of electrical voltage, electrical resistance and current intensity are involved, for this the following images are shown, as appropriate, see figure 1.

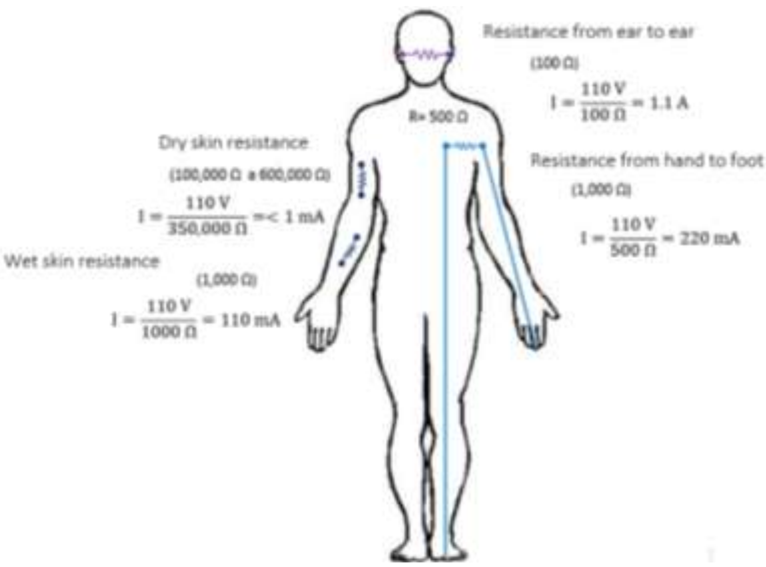


Figure 1. Electric current intensity values in the human body.

In addition, it is described that the conductive parts of electricity of the human body are: blood, tissues and muscles. Oxygenated blood is a good conductor of electricity because it is electrolyte. When the electric current circulates through the human body, it behaves according to the physical laws that apply to electrical conductors generally of copper or aluminum, so Ohm's Law should be applied, see equation 1, to know the current intensity flowing through it.

$$I = \frac{V}{R} \quad (1)$$

Where:

I = Intensity of electric current in Amperes, which is symbolized by the letter [A].
V = Electric voltage in Volts, its symbol is the letter [V].
R = Electrical resistance in ohms, its symbol is the letter [Ω].

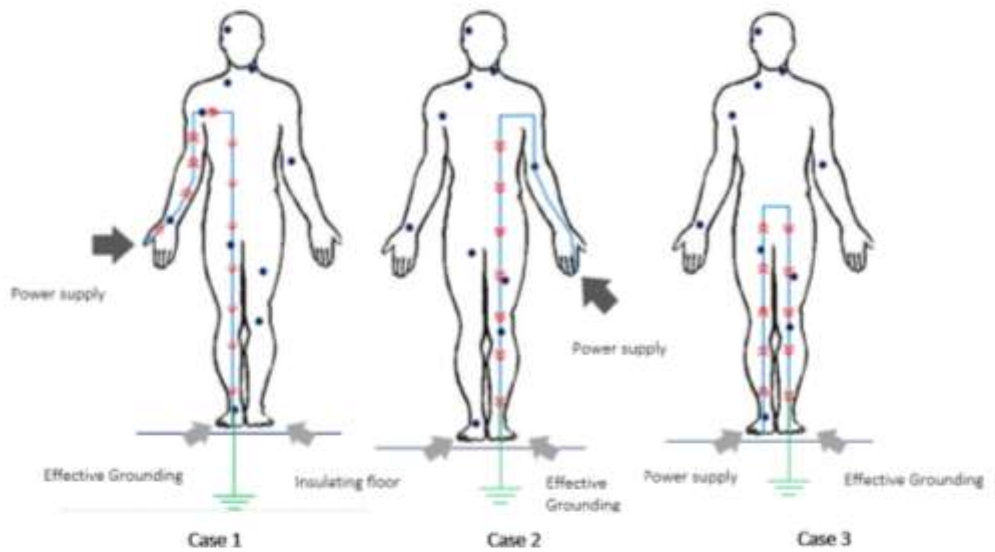
When the person makes contact with some energized point, it must be done in addition to contact with another point that is at a different voltage, so there is a potential difference between two points of the body and an electric current intensity can circulate [Oropeza A .J, 2008].

Below are at least three cases of different current paths through the human body, with which they show:

Case 1. The trajectory of the current from the right hand to the right foot causes the current to pass through the arm and shoulder, which is not critical since the current does not pass through the heart, see figure 2.

Case 2. The path of the current from left hand to left foot causes the current to pass through the heart, see figure 2.

Case 3. The trajectory of the current from right foot to left foot causes the current to pass through critical parts of the body that are vitally important, see figure 2.



In the application of this methodology, the group is first probed to know what characteristics it has, then the group is divided into pairs and even into triads if the group is large, since as you can see the cases are not as laborious but relevant. However, it is important that each team work collaboratively, since they are emphasized that the qualification will be individually and that the participation of all the members of the group are important and they are asked to investigate for this type of magnitudes of intensity of electrical current, which values of tension and resistance must have but based on Mexican and world norms, being of the technical, medical and labor context and how they are related; As the management of a norm is not so simple, you have to constantly motivate them so it is also important that the teacher works as an advisor and guide, to analyze what type of results they are obtaining, in this way the development of critical thinking is encouraged and lead them to the search for information to further develop their problem-solving skills, making them more aware, since the following questions are added:

If they were in such a case, how would they proceed? Explain
What would happen if the person were elderly or were a child of 5 or 7 years?
The rules mention something about it. How do they explain it? What consequences would it have?
What would happen if the person had a pacemaker? And besides it was Ing. Electrician
Did it help you to know this context of Ohm's Law?

IV. CONCLUSIONS

This methodology not only addresses issues from the basic technical or engineering point of view, but also the aspect of knowing how to be clearer for students, since they value the safety standards that are implemented in laboratories, they become more careful in the way they proceed in their experiments as well as in the handling of the equipment, they realize that there are official documents that also involve the technical part and the labor part, there is a greater ease in handling the prefixes of the electrical quantities, they begin to have better ability to relate values of electrical voltage and electrical resistance, they realize that through them you can limit the current intensity, it also helps them to interpret the electrical power; it brings them closer to their career and they even see the impact they have on other subjects in their laboratories.

Some professors comment that the methodology despite the fact that the problems proposed are specific in turn are laborious and sometimes lack time to advise and apply the methodology. However, they comment that it is innovative because at least in this subject at this level this type of case had not been applied in this way.

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