Learning Objects for the teaching on Electric Circuits using the Theory of the Registration of the Semiotic Representation by Raymond Duval

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ABSTRACT

The purpose of this work was to develop the construction and the adjustment of the Learning Objects, used as an additional resource in the classes of the discipline "Electric Circuits", emphasizing the graphic analysis of information that is equated and solved with complex numbers. It had as theoretical base the Registration of the Semiotic Representation by Raymond Duval and aimed at making the learning process easier by the use of different ways of registering and, therefore, enabling a greater contextualization and signification to the learning process. The Learning Objects, with the necessary adjustments, are used as support to the construction of mathematical concepts related to the analysis of circuits under steady state, which, for involving electrical quantities, such as tension and electrical current, require the solution of sinus and cosinus equations, which are not always easy to be solved. In addition, it is important to consider that the graphic visualization facilitates the understanding of concepts, when it comes to more complex circuits, despite the fact that the conversion of the representation of a phenomenon is not a trivial and automatic activity. The real understanding of the relation among the electrical quantities is determinative for the development of a professional and this is exactly the purpose of the use of the resources, stimulating the significant learning and enhancing the methods of analysis.

Key-words: Semiotic Representation . Learning Objects. Electric circuits). Steady state. Complex numbers.

1. INTRODUCTION

The aim of this paper is to developed as the theoretical Registration of the Semiotic Representation, Raymond Duval (2009), particularly on the semiotic and cognitive organization of graphical representations, assuming the possibility to analyze graphically electric circuits in steady state using complex numbers.

The introduction to the process of teaching and learning has concerned professionals in various fields who seek educational options to overcome difficulties, especially in the classroom. Electricity presents conceptual difficulties, misconceptions, use of language and erroneous reasoning, which students often have, for example, in the study of electrical circuits.

Understanding the significance of the relationship between the electrical quantities is critical for the formation of professional and it is with this objective that seeks to use resources, encouraging significant learning, enabling and optimizing analytical methods.

The graphical representation constitutes an important resource for data analysis and processing of information. For the student is not enough to read a graphic, but knowing organize and operate in an objective way the data contained in this form of representation.

Comprehend the cognitive processes needed to understand the representation in the form of graphs (phasors) depends on specific treatments, such as interpreting data, using the same data in different forms of representation. Knowing how to read and interpret information, data, graphics and tables, ie, the quantification of the diversity of information is crucial in higher education, in order to establish a consistent relationship between knowledge of the physical phenomenon and the processing of information arising from this.

Therefore, it is up to the teacher to clarify the object of study to be taught, which are the registers of semiotic representation inherent in the activity and work with two types of representation of processing, treatment and conversion.

This project aims firstly, with the to support the Registration of the Semiotic Representation by Raymond Duval, to develop learning objects for studies and analysis of electric circuits in steady state, using complex numbers.

It is proposed as a secondary purpose to direct students of electrical engineering, from learning objects, to understand the relationship between the theory and the practical of electrical circuits in steady state using complex numbers, through dynamic and interactive simulations in different registrations, ie sinusoidal equations and co-sinusoidal or representations using numbers and graphics in the complex plane. Under the cognitivist perspective, Duval presents the theory of the Registration of the Semiotic Representation, which emphasizes that the mathematical activity should aim the development of reasoning skills, analysis and visualization of the student.

For Duval (2009) there is a diversity of semiotic representations that are grouped into four major registers:

- natural language;
- the algebraic and formal written;
- geometric figures and
- graphical representations.

From this group of semiotic representations, Duval brings the notions of treatment and conversion as cognitive operations directly involved in the apprehension of mathematical knowledge and construction of concepts.

The treatment of a representation refers to operations in a registration of representation, therefore, is said to be "within one registration." The conversion of a representation is related to the operations in which the initial registration is turned in another record. For this reason, it is said to be an "outside processing."

As representing electrical circuits can be realized by equations sinusoidal and co-sinusoidal and relationships between elements of the circuits by complex numbers, the analysis becomes much simplified if the graphical representation can be introduced. This means the use of different registers of representation for electrical phenomena involved and the necessary knowledge of the theory of Duval to optimize the applicability of these resources in the Learning Objects that want to develop and use.

2. LEARNING OBJECTS

Looking for a productive teaching, some important and prestigious educational institutions searched their own definitions for learning objects. One of the most recognized and respected institutions in engineering, the Institute of Electrical and Electronics Engineers (IEEE) has defined learning objects as "an entity, digital or non-digital, that can be used and reused or referenced during a process technological support to teaching and learning.” (INSTITUTE OF ELETRONICS AND ELETRICAL ENGINEERS, [200?]).

The objects to be used will be built using the software Mathcad, which is very appropriate for graphic constructions from equations used to represent electrical circuits.

3. ELECTRICAL CIRCUITS IN STEADY STATE

The analysis circuit steady state is important because the sinusoidal voltages supplied by alternating current generators are very nearly pure sinusoidal functions; furthermore, the periodic wave can be replaced by a constant term and a series of sinusoidal terms and co-sine (Method for Fourier analysis of the waveform).

In order to understand better and make a simplified circuit analysis in steady state, phasors are used to represent voltages and currents and an impedance to account for complex circuit elements. (EDMINISTER, 1972; GUSSOW, 1985).

The term phasor is used to represent quantities which have an direction. This is a technique of analysis in which the circuit voltages and currents are sinusoidal processed into complex numbers, called phasors, and in which the resistances, inductances and capacitances are converted into complex numbers thus corresponds to equivalent impedances.

The importance of phasor notation for the analysis of the sinusoidal regime due to the fact that the linear circuit excited by sinusoidal sources, voltages and currents, in all nodes and the circuit components are also sinusoidal with the same angular frequency.

If we consider a series RL circuit with an applied voltage:

$$v(t) = V_M \; e^{\,\omega j t} \tag{1}$$

and applying Euler's formula:

$$v(t) = V_M \cos\omega t + \;\mathbf{j}\; V_M \;\mathbf{sen\,\omega t} \tag{2}$$

The Kirchoff's Law for voltages and currents in this kind of circuit is:

$$Ri(t) + \; L\,\frac{di\;(t)}{dt} = V_M \;\; e^{j\omega t} \tag{3}$$

This linear differential equation of first order has a particular solution in the form:

$$i(t) = \;\; K\, e^{j\omega t} \tag{4}$$

The relationship between voltage and current shows that the impedance is a complex number with a real part and an imaginary part:

$$Z = R + J\omega L \tag{5}$$

Also, for a series RC circuit, with the same applied voltage:

$$V_M\, e^{j\omega t} \;\; = Ri\;(t) + \;\frac{\mathbf{1}}{c}\int i\;(t)dt \tag{6}$$

$$i(t) = \;\; K\, e^{j\omega t} \tag{7}$$

The relationship between voltage and current is now the impedance:

$$Z = R - J\;\left(\frac{\mathbf{1}}{wc}\right) \tag{8}$$

Again, the impedance is a complex number with a real part **R** and an imaginary part $-J\;\left(\frac{\mathbf{1}}{wc}\right)$.

This suggests that the circuit elements can be expressed in terms of a complex impedance which can be situated in the complex plane (graphical representation).

So far, voltages and currents were expressed as a function of frequency, which characterizes a change of registration for the phenomenon at issue.

Whether by resolution of the equations used to describe voltages and currents, by complex numbers for representation of circuit elements or graphic representation in the complex plane, it is important not to lose the sense of the representation of the object of study, when using the conversion between registers of representation of the variables of interest.

4. COMPLEX NUMBERS

Complex numbers emerged in the sixteenth century as findings of general procedures for solving algebraic equations of third and fourth degree.

The symbol $\sqrt{-\mathbf{1}}$ introduced by Girard in 1629, came to be represented by in 1777 by Euler. In 1637, Descartes introduced

the terms real and imaginary. The expression complex numbers was first used by Gauss in 1831. (BOYER, 2009; EVES, 2002; GORBI, 1997).
Girard (in 1628), Wallis (1685), Wessel (in 1797) and Argand (1790) represented geometrically the complex numbers as vectors in a Cartesian plane. Gauss defined the complex numbers in the form $a + bi$, where a and b are real numbers. Finally the geometric representation allowed the complex to be viewed and "accepted" as numbers.
The algebra of complex numbers can represent and operate vectors in the plane and allows quantities that vary sinusoidally (or co-sinusoidally) versus time, are represented by two-dimensional vectors (phasors) type A ($cos\theta + isen\theta$), which rotates in anticlockwise with angular velocity ω .
The voltages supplied by AC generators are represented by sinusoidal functions and co-sinusoidally. However, analysis of the circuit becomes complicated even when the equivalent circuits are relatively simple. Using phasors to represent voltages and currents, and a complex impedance to respond to the circuit elements, will simplify the steady state analysis. .

5. METHODS

It is intended to develop a proposal for a teaching tool, or learning objects, that do not seek just the reproduction of traditional classroom, with long texts, extensive lists of exercises, few animations and interactive resources limited, but a way dynamic, interactive and participative, in which the student has the opportunity to lead the elements, modules and simulations of Learning Objects, facilitating the understanding of the concepts presented. (MUSTARO at al., 2007; STUMP; MUSTARO, 2005).
After approaching the specified content, we intend to evaluate two groups of students through activities required in the planning subject. It should be emphasized that the main intention is not to verify the results with calculations, but to evaluate the understanding the concepts discussed and how the variation of the registers and the conversion between these registers, present in the learning objects used, may have contributed to the process learning.
The evaluation instrument can be applied to students of Electrical Engineering; at the same time, similar subject can be given to another class of the same series and with approximately the same number of students through the traditional teaching methodology, ie theoretical exposition by the teacher and intense training through fixing exercises. Will be randomly select on which of the classes will apply the new method.
If for each group the sample size is greater than thirty students or grades obtained in assessing adherence to have Normal distribution and the means obtained in the evaluations of the two groups will be compared using the Student t test. To choose between using test whether or not the assumption of equal variance, the variances are compared in the case of normal distribution of the evaluation scores obtained by each of the two groups, by means of the F test and if not adhesion in at least one of the groups by Levene's test. If any of the two groups have size less than thirty students and the grades obtained in the evaluation have not adherence to the Normal distribution, the means obtained in the evaluations of the two groups will be compared using the nonparametric Mann-Whitney test. (MONTGOMERY; RUNGER, 2012).
To compare the proportions of correct answers in evaluations with respect to certain subjects discussed there will be a test for proportions difference, exact or, in the case of samples with size exceeding thirty, using the approximation by the Normal distribution (MONTGOMERY; RUNGER, 2012).
Descriptive level (p-value) for a hypothesis test is the probability based on alternative hypothesis, obtaining estimates more unfavorable or extreme than the one provided by the sample (MAGALHÃES; LIMA, 2010). As the hypothesis tests are conducted using a significance level of 5% will be rejected hypotheses whose descriptive levels had values less than 0.05.

3. CONCLUSION

The development of learning objects, such as resources used by teachers in classes considered conventional, ie exposure by the teacher and supplemental learning through exercises fixation, it is intended that has as main objectives: to stimulate learning and enable this occurs effectively and efficiently.

The possibility of representing a physical phenomenon by means of graphs, which enable the analysis, complementing the information generated by equations, aims to provide a greater interest in learning and understanding the concept associated with it.

The results to be obtained with different groups of students, from equations for the construction of phasors and later record toward graphic registers of equations, conditions will emerge from the knowledge acquired, as well as the difficulties presented by students and provide subsidies to remedy them.

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