Teaching electrical circuits from a semiotic approach

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Abstract.In this paper we investigate how high school students relate the different semiotic representations that they use in order to make an analysis of electrical circuits, using Ohm's law and Kirchhoff's laws, as well how they move from an experimental didactic situation into a formal mathematical description in a reference frame of modeling in Natural Sciences and instrumental genesis.

1 Introduction

McDermott [1] notes that research on students' conceptual understanding of electricity and magnetism issueshas not been studied in great detail as in mechanics. We have that, there is little research madeabout the use of Semiotics in the teaching of physics [2], in this approach we found that in the Latin American researchers there is a preference for the analysis of graphs and their relationship with classical mechanics [3]. On the other hand, different studies in Mexico warn that, in a common way, the high schoolphysics courses or basic university courses oriented to the teaching of the physical-mathematical sciences do not consider the preconceptions of the students in the teaching of subjects, however its persistence is recognized [4]. Then, it is proposed to confront the students' preconceptions about Ohm's law and Kirchhoff's laws in the analysis of electrical circuits by performing various experimental activities belonging to different registers of semiotic representation in order to modify the conceptual scheme of the students. It is required then of the physical phenomenon can be understand, i. e, that the student can relate different electrical circuits configurations measurements that are being handled, that is, make a process of objectificationsymbolically mediated and critical discernment of expression forms [5].

2 Semiotic representations

Some researchers have found that high school students can learn scientific concepts effectively when they coordinate perceptions and actions than when they try to represent explanations offered by teachers [6].

Duval [7] proposes that for a student can relate a representation with the mathematical object that symbolizes and its concept, it is essential to master the three basic cognitive activities of semiosis; the formation of representations in a semiotic registry, their treatment and conversion, besides having the resource of coordination of different representation registers.

Touma's research [8] reports that, in the algebraic modeling of physical phenomena, the domain of the three cognitive activities of semiotics is important and necessary, as well as the coordination of representation records, but not enough for the student can access the conceptual content of the mathematical model that represents the phenomenon. This researcher states that in addition to the three cognitive activities mentioned and the coordination of records, one should consider the inductive construction of a mathematical model, understood as the cognitive process with which students construct a mathematical conceptual object from a semiotic representation of a phenomenon within the context of experimental sciences.

3 Teaching intervention

We show the results obtained in the construction of mental models and the learning gain in high school students of the National Polytechnic Institute of Mexico about Ohm's law and Kirchhoff's laws. The conceptual questionnaire (Brief Electricity and Magnetism Assessment) BEMA was used as a pre and posttest, [9] and some collaborative teaching activities were used, such as Didactic Sequences and Interactive Lectures Demonstration [10], also from a perspective of instrumental genesis [11] shows the ability of students to describe the physical phenomenon mathematically, by analyzing graphs of voltage and current measurements in different configurations of electrical circuits, even the use of various lines and mathematical curves to make the corresponding adjustment of experimental data through EXCEL, in order to arrive at the mathematical formula that describes the electrical physical phenomenon.

References

[1] L. C. McDermott, Resource Letter: PER-1: Physics Education Research, *Am. J. Phys*. **67**, (1999)755.

[2] M. A.Alvarenga, M. de Moura, H. A.Acciari,E. N. Codaro,Determinação da concentração de ácidoacético no vinagrepormedidas de tensão superficial: umaatividadedidáticainterdisciplinar com vistas à mediaçãosemiótica,*Cad. Bras. Ens.Fís.***32**(2015)253-262.

[3] P. S. de Camargo, Dificuldadessemióticasnaconstrução de gráficoscartesianosemcinemática, *Cad. Bras. Ens. Fís*.**28**(2011) 546-563.

[4] CCADET. Centro de CienciasAplicadas y DesarrolloTecnológico, UNAM, http://ihm.ccadet.unam.mx/ideasprevias

[5] L. Radford, De la teoría de la objetivación. *RevistaLatinoamericana de Etnomatemática: PerspectivasSocioculturales de la EducaciónMatemática***7**(2014) 132-150.

[6] B. Waldrip, V.Prain,*Learning From and Through Representations in Science*. In B. J. Fraser, K. Tobin y C. J. McRobbie (Eds.), Second International Handbook of Science Education,Springer, New York, 2012.

[7] R. Duval,The cognitive analysis of problems of comprehension in the learning of mathematics, *Paper presented to the Discussion Group on Semiotics and Mathematics Education at de 25th PME International Conference*, The Netherlands, University of Utrecht, 2001.

[8] G. Touma, Une étude sémiotique sur l'activité cognitive d'interprétation,*Annales de Didactique et de Sciences Cognitives*, **14**(2009) 79–101.

[9] R. Chabay, B. Sherwood, Brief Electricity and Magnetism Assessment, *Physical Review Special Topics - Physics Education Research***2** (2006) 7-13.

[10] D. R. Sokoloff, R. K. Thornton,*Interactive Lecture Demonstrations: Active Learning in Introductory Physics*, John Wiley & Sons, Hoboken, N.J, 2004.

[11] P. Verillon, P. Rabardel, Cognition and Artifacts: A contribution to the study of thought in relation to instrumented activity, *European Journal of Psychology of Education***10**(1995)77-103.