ACTIVE LEARNING PROJECT FOR TEACHING ELECTROMAGNETISM USING ELECTRONIC CIRCUITS

Projeto de aprendizagem ativa para o ensino de eletromagnetismo utilizando circuitos eletrônicos

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Abstract

Recent years have witnessed the prominence of active learning in pedagogy, shifting from teacher-centered to interactive student-focused education. Active learning fosters direct student engagement with study materials, enhancing teacher-student and peer interactions, yielding more immediate and personalized feedback. Methods like flipped classrooms, peer instruction, project-based learning, collaborative learning, gamification, and problem-based learning promote creativity and cognitive skills. These approaches have been extensively studied in North American and European higher education, demonstrating superior development of reasoning and knowledge construction compared to passive methods. In contrast, Latin American education suffers from traditional teaching methods. Some universities excel, employing Peer-Project Learning (PPL) in physics, yielding positive learning outcomes. This research highlights the benefits of project-based learning (PBL) for solving engineering problems with basic electronic circuits, linking practical-experimental PPL elements, encompassing theoretical circuit aspects and experimental segments with magnetic devices. The study showcases PBL-PPL's evolution within an engineering physics course, presenting results and interview-based perception analysis.

Keywords: PBL methodology, PPL methodology, collaborative and problem-based learning, educational methodology, active -learning.

Resumo

Os últimos anos testemunharam a proeminência da aprendizagem ativa na pedagogia, mudando de uma educação centrada no professor para uma educação interativa focada no aluno. A aprendizagem ativa promove o envolvimento direto do aluno com os materiais de estudo, aprimorando as interações entre professor-aluno e entre os próprios alunos, resultando em feedback mais imediato e personalizado. Métodos como salas de aula invertidas, instrução entre pares, aprendizagem baseada em projetos, aprendizagem colaborativa, gamificação e aprendizagem baseada em problemas promovem habilidades criativas e cognitivas. Essas abordagens foram extensivamente estudadas no ensino superior na América do Norte e na Europa, demonstrando desenvolvimento superior de raciocínio e construção de conhecimento em comparação com métodos passivos. Em contraste, a educação na América Latina sofre com métodos de ensino tradicionais. Algumas universidades se destacam, empregando a Aprendizagem entre Pares (PPL) na física, resultando em resultados positivos de aprendizagem. Esta pesquisa destaca os benefícios da aprendizagem baseada em projetos (PBL) para resolver problemas de engenharia com circuitos eletrônicos básicos, conectando elementos práticos e experimentais da PPL, abrangendo aspectos teóricos de circuitos e segmentos experimentais com dispositivos magnéticos. O estudo demonstra a evolução da PBL-PPL em um curso de física de engenharia, apresentando resultados e análise de percepção baseada em entrevistas.

Palavras-chave: Metodologia PBL, Metodologia PPL, aprendizagem colaborativa e baseada em problemas, metodologia educacional, aprendizado ativo.

Introduction

The teaching of physics is a topic that has been the subject of study and discussion in the educational field. In particular, the teaching of electromagnetism is a subject that can be complex for students due to its abstract and theoretical nature [1]. For this reason, various pedagogical strategies have been developed to facilitate the learning of this subject, among which active learning [2] stands out. Most definitions of active learning converge on the process in which students actively participate in the acquisition and construction of knowledge, rather than just passively receiving information [3]. In recent years, active learning has stood out in the pedagogical and educational field by allowing students to build their own knowledge, changing the paradigm of a traditional class focused on the teacher's knowledge towards an interactive class focused on the development of learning skills. the students [4]. Active learning allows students to participate directly with the study material, creating a more enriching and effective teacher-student and student-student interaction, obtaining more frequent, immediate, and personalized feedback [2]. Among the different methods based on active learning used to enhance students' creativity and develop their cognitive skills are flipped classroom [5], peer instruction [6], project-based learning [7], learning collaborative [8] and gamification [9]. These methodologies have been widely explored in universities and higher education centers in North America and Europe, demonstrating a substantial difference in the development of reasoning skills and knowledge construction in students [10], compared to the passive methodology of a traditional class [2]. However, in Latin American countries, the level of university and higher education is affected due to methodologies and classrooms based on traditional teaching as main sources for the transmission of knowledge. It is possible to highlight certain Latin American universities that have developed physics classes under the Peer Project Learning (PPL) methodology, obtaining positive results in the acquisition of knowledge by students [11].

In the field of electromagnetism and electronics, active learning has allowed us to change the common approach of passive transmission of information, which is generally abstract for this area, to a practical approach, aimed at exploring problem solving, critical thinking and construction skills. autonomous knowledge [12]. In this sense, the objective of this work is to show the advantages of combining the PPL methodology with Project Based Learning (PBL) through the resolution and implementation of basic electronic circuits for engineering applications. The practical and experimental components of the PPL methodology are used to develop the theoretical part of circuits, while the experimental part is complemented by the study and implementation of magnetic devices such as coils and solenoids. The development of the PPL - ABP methodology is presented with a group of engineering students in a Physics course, through the implementation of the magnetic-electronic device including the design stage, construction of the prototype, analysis of results and evolution of the student learning experience. In the next sections of this paper, the details of the practical implementation of the proposed methodology will be shown, presenting both the results and the qualitative analysis of the students' learning experiences through interviews.

Methodology

According to the PPL methodology, the practical-experimental component is made up of project planning, prototype design, project socialization, project monitoring, verification, and evaluation [11]. For the proposed experimental implementation in electronic circuits, the PPL methodology can be enhanced with the PBL attributes, which are characterized by having 6 fundamental steps [[13]]: (1) determination of the objectives, (2) definition of the topic, (3) development of the problem question, (4) establishment of an environment of continuous inquiry, (5) creation of the prototype, (6) definition of the student and the teacher. Next, the details of the PPL - ABP methodology for the design and implementation of electromagnetism with electrical circuits carried out with the students:

a) **Project proposal:** create a prototype for security applications or containment vault demonstration. The mechanism works from a metallic latch activated by the magnetic fields of the solenoids, which has opening, lock and security buttons, the latter when pressed closes the box safe and disables the operation of the opening button, thus preventing the safe from being opened during the time that the timer works, made with an RC circuit that delays the potential difference for 30 seconds.

b) **Learning objective:** Describe the concepts of electromagnetism, electric circuits and transient circuits through the design and implementation of an electromagnetic lock based on RC circuits and solenoids.

c) Prediction stage:

c.1.) Preparation of the Attraction Coil:

A specially designed coil will be developed to attract certain metals and function as a latch. The coil will allow us to demonstrate the use of the magnetic attraction force with the selected elements.

c.2.) Timed RC Circuit Design:

The team will design and build an RC (Resistance-Capacitance) circuit that met the requirement to activate the lock after an interval of 30 seconds. Precise implementation of the timer in the circuit will allow proper timing between magnetic pull and latch release, resulting in reliable and predictable operation.

c.3.) Application of Principles of Electromagnetism:

The concepts of electromagnetism learned during the course must be successfully applied in the creation of this prototype. Deep understanding of how magnetic force works and how to manipulate it to achieve a specific purpose was critical to the successful design and construction of the electromagnetic lock.

d) Prototyping:

According to the ABP methodology, we can enumerate the creation of the prototype in the following steps:

d.1.) Design of the safe structure: the structure of the safe is designed, considering the size and shape suitable for the prototype.
d.2.) Elaboration of the coil: a coil is made that can attract certain metals that function as a latch. For this, the concepts of electromagnetism seen in the course must be considered.
d.3.) Design of the timed RC circuit: a timed RC circuit is designed that can activate the lock in 30 seconds. This circuit must delay the potential difference for 30 seconds, as mentioned in the proposal.
d.4.) Construction of the electromagnetic lock: the electromagnetic lock is built using the elaborated coil and the designed timed RC circuit.
d.5.) Integration of the opening, lock and security buttons: the opening, lock and security buttons are integrated into the structure of the safe, so that the electromagnetic lock can be activated and deactivated.
d.6.) Tests and adjustments: Tests and adjustments are carried out on the prototype to ensure that it works correctly and meets the objectives of the project.

Figure 1: Schematic diagram of the lock circuit

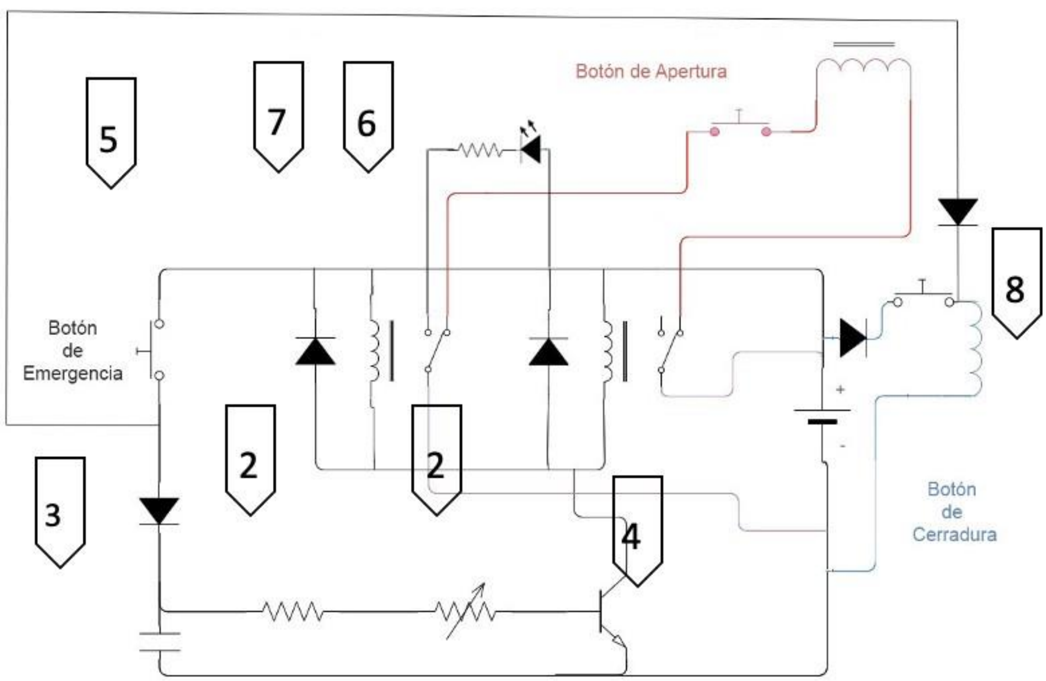

Table 1: elements of the schematic diagram of figure 1

ITEM	NAME	VALUE	PHYSICAL UNIT	QUANTITY
1	Resistance	200	Ohms	1
2	Variable Resistor	1000	Ohms	1
3	Capacitor	3300	mf	1
4	Transistor	12	V	1
5	Button	-	-	3

6	Relay	12	V	2
7	Diode	12	V	2
8	Solenoid	4	mT	2
9	LED diode	3v	-	1

a) Validation of results:

In the next section the experimental results are validated.

Figure 2: Photos of the implemented prototype

Results

Table No. 2: Comparison of theoretical data versus experimental data

	Theoretical values	Experimental values	Error (%)
Resistance: used in the circuit necessary to meet the target time (resistors only)	1477.2 Ω	1760Ω	19.14
Opening current	1.35A	1.14A	15.55
Lock current intensity	1.35A	1.04A	22.96
Magnetic field	0.039T	It was not possible to measure before submitting the report, it will be put on the printed poster	
Solenoid resistance	9.23 Ω	10 Ω	8.34

Conclusion

This research endeavors to shed light on the merits of implementing project-based learning (PBL), specifically in solving engineering challenges using basic electronic circuits. By combining practical-experimental components with theoretical knowledge, as seen in the PPL methodology, a holistic learning experience is facilitated. The application of PBL-PPL to an engineering student group within a physics course exemplifies the evolution of their learning journey. The outcomes and insights gained from this study, including interview-based perception analysis, contribute to the broader discourse on effective pedagogical methods in higher education.

Throughout the implementation of the PBL-PPL methodology within the engineering student cohort enrolled in a physics course, discernible shifts in their learning trajectory were observed. The confluence of theoretical knowledge with practical application in the context of engineering problem-solving provided a multifaceted educational experience. This synthesis is indicative of a pedagogical approach that transcends traditional didactic methods, fostering a more nuanced understanding of the subject matter. A pivotal facet of this inquiry involved an examination of the students' learning outcomes, elucidated through an interview-based perception analysis. The qualitative insights gleaned from these interviews serve as a valuable repository of data, offering a nuanced perspective on the students' experiential learning journey. The triangulation of experiential data with academic performance metrics affords a comprehensive assessment of the impact of the PBL-PPL methodology on student cognition.

In essence, the adoption of project-based learning methodologies marks a significant stride towards fostering proactive student engagement, practical problem-solving skills, and a deeper understanding of complex subjects. As education continues to adapt and innovate, embracing these methodologies holds the potential to bridge educational gaps and cultivate a more dynamic and enriching learning environment for students worldwide.

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