Vol. 15, Año. 2026
ISSN-e: 2310-3637|RNPS-e: 2324-3647|RNSW: A-0872

Research instruments

1. Instrument 1: Structured Interview with Students

1.1 General Description

Name of the instrument: Structured interview on the perception of theory–practice integration and professional skills development in the Electrical Circuits course.

Objective of the instrument: To analyze students' opinions on the usefulness of the didactic activities and the virtual laboratory practice mediated by the application developed in Scilab, in relation to:

- The linkage between theory and practice
- The development of professional skills
- The exchange of knowledge and skills among peers

1.2 Population, Sample, and Context

Target population: Students enrolled in the Electrical Circuits course within the Electrical Engineering program at the Technological University of Havana (CUJAE), across three consecutive academic years.

Sample and coverage: Students from the 2022, 2023, and 2024 cohorts were included, with sample sizes of 50, 70, and 70 respectively (Ntotal = 190), representing 83%, 100%, and 100% of the students who took the course in each year.

Moment of application: At the end of the implementation of the didactic design and the virtual laboratory practice with the Scilab application, upon completion of each academic year.

Application modality: Structured interview guided by a questionnaire, with standardized recording of responses for subsequent statistical processing by cohorts.

1.3 Questionnaire Structure

The questionnaire guiding the structured interview was organized into the following questions:

1. *In your opinion, did the development of the activities help reinforce and link theoretical and practical content?*
2. *In your opinion, did the development of the virtual laboratory through the proposed application and case study help develop professional skills?*
3. *In your opinion, did the proposed didactic design for the study of energy efficiency help exchange knowledge and skills with your classmates?*

Vol. 15, Año. 2026
ISSN-e: 2310-3637|RNPS-e: 2324-3647|RNSW: A-0872

1.4 Normative Scale and Coding

Type of scale: For the main analysis reported in the manuscript, the questions operate as closed nominal dichotomous responses (Yes/No), since the processing is reported through absolute and relative frequencies.

Recommended coding (for reproducibility):

- Yes = 1
- No = 0

1.5 Categories of Analysis

Considering the structure of the instrument and its direct correspondence with the evaluated dimensions, deductive categories were established per question:

- **C1. Theory–practice linkage (associated with Question 1):** Assessment of the integration of theoretical content with practices and contextualized problems in electrical/industrial systems.
- **C2. Development of professional skills (associated with Question 2):** Assessment of the contribution of the virtual laboratory and case study to technical analysis and decision-making skills in electrical engineering contexts.
- **C3. Peer exchange and collaborative learning (associated with Question 3):** Assessment of group work, information exchange, and cooperative learning during activities and the virtual laboratory.

1.6 Validity Considerations

Content validity of the instrument was ensured through expert review, based on the judgment of Electrical Circuits instructors who participated in the methodological meetings for the design and implementation of the proposal. This review evaluated the relevance and clarity of the items, as well as their coherence with the study’s objectives and the dimensions intended to be explored (theory–practice linkage, professional skills development, and collaborative learning). Necessary wording adjustments were made to guarantee unambiguous comprehension and alignment with the educational context.

2. Instrument 2: Scilab Application

2.1 Resource Description

Name of the resource: Application *“Load Arrangement in Industrial Systems”*, developed in Scilab.

Methodological role: Technological instrument for didactic intervention that operationalizes simulation as an empirical method to study load arrangement and elements associated with energy efficiency, supporting the professionalized teaching–learning process in Electrical Circuits.

2.2 Input and Output Data

Vol. 15, Año. 2026
ISSN-e: 2310-3637|RNPS-e: 2324-3647|RNSW: A-0872

Main inputs:

- Hourly record of active power P (kW) of the industrial system (meter or network analyzer)
- Power factor by hourly measurement (pf)

Main outputs:

- Calculation of load factor and determination of the need for arrangement
- Daily load curve before and after arrangement
- Possibility of analysis with/without photovoltaic incorporation
- Support for technical–economic analysis (including estimation of savings and suggestions related to contracted demand, as reported)

2.3 Case Study Used

The didactic design was implemented with a case study of an industrial system (*UEB Pinturas Vitral*), based on data obtained through a network analyzer and technical parameters reported in the manuscript.

2.4 Simulation Variants for the Virtual Laboratory

In the virtual laboratory, four load arrangement variants were proposed:

- Peak hours 11:00–13:00
- Peak hours 18:00–22:00
- 24 hours
- 24 hours with photovoltaic generation incorporated

4. Ethical Considerations

Prior to the application of the instrument, students were informed of the purpose of the interview, aimed at understanding their assessment of the activities and the virtual laboratory. It was emphasized that participation was voluntary. They were also informed that responses would be treated confidentially, would not affect their grades or academic standing, and that results would be analyzed and reported in aggregate form by cohorts (2022, 2023, and 2024), ensuring participant anonymity.