Assessment Tools for Improving Hard Skills in a Virtual Laboratory (Electrical Machine Case Study)

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Abstract: - In 2023, the National University of Colombia (UNAL) in Bogotá developed a professional aptitude evaluation service utilizing their physical space and technological advancements to benefit the national industry. By integrating previously developed simulation projects, this service provides graduates with tools to enhance their knowledge and improve their employment prospects. Although initially tailored for electricians, these simulation tools and assessment methods are adaptable to other fields. This initiative not only assesses the professional aptitude of candidates but also identifies their weaknesses and recommends solutions, thereby helping them refine their skills and increase their job market competitiveness. Although these projects were developed by and for electricians, their field of action can include other careers.

Key-Words: - Employment, Electric machines, Experiential learning, Gamification, Hard skills, Aptitude test, Simulator, Simulation-based learning, Virtual reality, Virtual laboratory.

Received: August 24, 2023. Revised: April 10, 2024. Accepted: May 6, 2024. Published: June 25, 2024.

1 Introduction and State of Art

Since 2016, the Electric Machines Laboratory at UNAL has developed computer solutions that have allowed its students to approach the laboratory through simulators. Initially, these initiatives were focused on the transmission of knowledge to meet the needs of curricular projects. Originally, these projects were developed to recreate working conditions, similar to those found in laboratories and industries.

In the first four months of 2022, the National University of Colombia developed and offered a project based on a professional aptitude evaluation service. Examining the needs of graduates, this service not only includes an impartial quantification of the grades obtained but also includes an option to detect the weaknesses of those who did not pass and informs them about the existence of external providers who offer solutions to their problems.

The market offers goods and services that help its customers refine their hard and soft skills. In the face of increasing levels of unemployment, competition to obtain a job is much higher, so the added values are factors that can make a difference for an applicant.

This document describes the role of this project. Along with other previously developed projects, they integrate a system that goes beyond the classrooms and allows graduates (in their role as applicants) to improve their chances of obtaining a job.

2 Problem Depiction: Need of a Tool

The Electric Machines Laboratory is located on the first floor of the "Patios de Ingeniería " building at the UNAL (Figure 1). Its construction was completed in 1968, where A. Mejía describes this space as the habitat with which students, professors,

and workers from the Department of Electrical and Electronic Engineering have identified the most, [1]. Currently, the laboratory has a variety of electric machines equipped with industrial-level energization and protection systems.

During practical exercises, it is necessary to comply with safety rules and use protective equipment. Teacher supervision is essential in this space, as the hazards to which attendees are exposed range from minor injuries (such as cuts with the cable ends) to electrocutions (damage that can cause death), [2]. Therefore, the authors of this document have developed simulators and other virtual educational materials over the past six years that allow students to develop virtual practices that recreate the most relevant conditions that may be encountered in real exercises.

In 2016, the Monophasic Transformer Virtual Laboratory (LVTM) (machines used in the transmission and distribution of electricity), was developed as the graduation project, [3]. This first development allows its users to recreate tests, which are procedures for connecting and energizing machines to obtain data that will be used to evaluate the technical parameters of electric machines. The UNAL Electric Machines Laboratory already had other virtual materials, both self-created and third-party. The development of this graduation project allowed students to get closer to characteristics closer to those found in the Institution's facilities. The recreated conditions allow students to generate errors and simulate the steps they must follow in reality. In this way, they would not be exposed to risks and could repeat simulations at all times (Figure 2).

In 2017, the National Directorate of Academic Innovation of the UNAL (DNIA) sponsored the development of a new simulator, the Virtual Induction Machines Laboratory (LVMI), focused on induction machines (devices used in industry such as motors, (Figure 3)). This simulator shows step-by-step the activities to be carried out to energize and install the protection and measurement equipment during tests. Likewise, a module for evaluating the selection of the necessary protection equipment for use during the tests was included, [4].

In 2018, the UNAL's Vice-Deanery of Research and Extension sponsored the development of the synchronous machine simulator (used as electricity generators, (Figure 4)). As a novelty, a module for evaluating the handling of the equipment used during the tests was included, [5].

In 2021, as part of a joint development between the authors of this article, a game called "Electric motors shop" (Figure 5). It allows the user to recreate certain situations encountered daily in the marketing of Electric Motors. It is based on a fictional story, initiated in the year 2000, in which the user plays the role of Manager of an SME. Through missions, the player must manage the basic aspects of managing their company, in addition, to instilling the importance of innovation, which is represented as technology research, [6].

In 2022, thanks to the Bogotá Campus Extension Division of the UNAL, the Professional Aptitude Evaluation Service (SECAP) project was developed. It was built as a service in which the UNAL acts as an arbitrator between industry and the general public, offering an ideal and impartial physical and technological environment for the development of aptitude tests.

Fig. 1: Facade of the “Patios de Ingeniería” building
Source: The authors

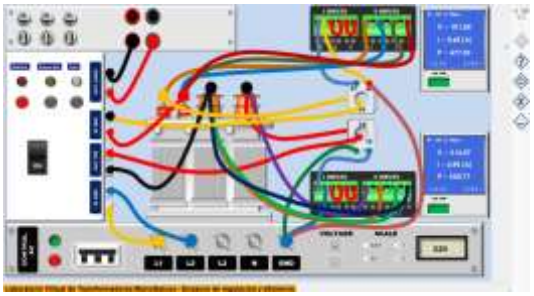

Fig. 2: Example of a test setup for a single-phase transformer included in the LVTM
Source: UNAL DNIA, [3]

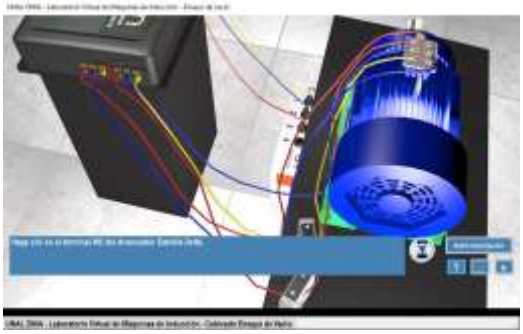

Fig. 3: Connection of an induction machine in the LVMI
Source: UNAL National Directorate of Academic Innovation, [4]

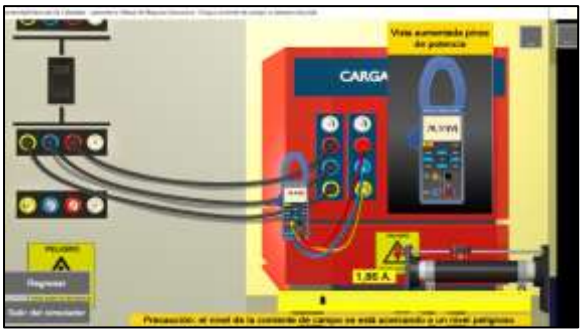

Fig. 4: Example of power measurement in a load during a test on a synchronous machine
Source: UNAL Vice Dean for Research and Extension, [5]

Fig. 5: Promotional graphic of the game "Electric motors shop"
Source: the authors

Fig. 6: SECAP screenshot - Multiple choice question with only true answer
Source: UNAL – Bogotá Headquarters Extension Division

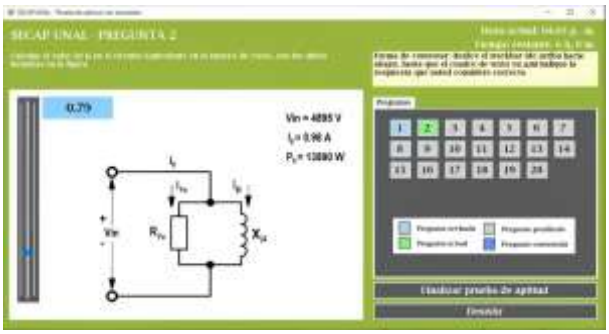

Fig. 7: SECAP Screenshot - Rough estimation question
Source: UNAL - Extension Division Bogotá Headquarters

3 Proposed Approach: Professional Aptitude Evaluation through SECAP

The SECAP working team includes the authors of this article (directed by Engineer Rivera and developed by Engineer Ramírez) and Electrical Engineers Pedro Julián García Guarín and Carlos Mauricio Bula Oyuela. The software developed for this project allows the development of Aptitude Tests that contain the question types described in Table 1.

The SECAP Aptitude Tests are not exclusively focused on electricity-related tests; they can also be focused on other professions.

UNAL and the industry can generate joint Aptitude Tests, in which the candidate can obtain a certificate (with a limited validity period) that can be attached to their resume (Figure 8).

Once the Aptitude Tests are developed, candidates who were not selected can receive feedback on the possible errors they made (Figure 9), the corrective measures they can take (Figure 10), and suggested providers of goods and services that will help them refine their skills (Figure 11).

Aptitude tests should fulfill their role as filters where only candidates with the best skills will remain. Evaluations must be developed to recreate conditions that candidates will encounter in their daily work, so it is not possible to evaluate practical conditions using written tests or verbal interviews. Therefore, SECAP is a tool that allows the evaluation of candidates by making impartial scores.

The service design also includes an internal regulation that covers the developers of the tests, the candidates, and the evaluators. The rules seek to ensure that the company and/or candidates contact SECAP to request the availability of physical space for the development of evaluations.

Fig. 8: SECAP Screenshot – Certification of approval of the aptitude test
Source: UNAL – Bogotá Headquarters Extension Division

In general, a room that is not being used in the institution is sought to serve as a quiet space where candidates take tests using a computer, where the necessary software for the operation of the evaluation software will be installed.

Fig. 9: SECAP Screenshot - Rough estimation question
Source: UNAL - Extension Division Bogotá Headquarters

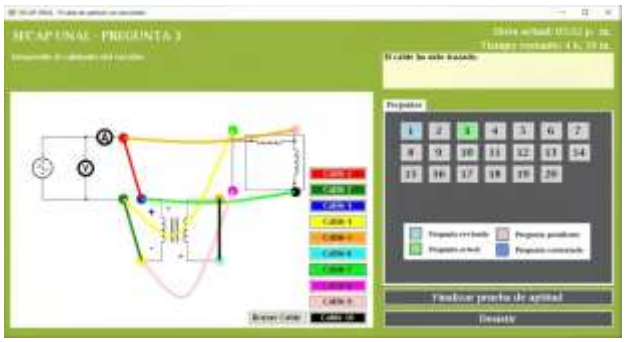

Fig. 10: SECAP screenshot - Wiring type question
Source: UNAL – Bogotá Headquarters Extension Division

Fig. 11: SECAP Screenshot – Example of a list of opportunities for improvement and offering of goods and services from sponsors
Source: UNAL – Bogotá Headquarters Extension Division

Some aspects can only be considered if service delivery recreations are developed, which can help make the development more enjoyable.

For example, the UNAL area is very extensive, and it is effortless for a candidate to take a long time to find the place where they will take the test (especially those who have never entered the campus).

This situation is common during undergraduate entrance exams. Therefore, it is necessary to use current digital tools to help users use the system without problems.

Table 1. Types of SECAP questions

Question type	Description
Multiple Choice	Question with four options and only one valid answer. See Figure 6. An image can be included to complement the question asked of the Applicant.
Estimation approximate	The applicant selects a value that they consider to be within the correct range. It is ideal for evaluating valid responses within a range. See Figure 7. This type of question is restricted to numerical values.
Positions indication	The user clicks on an image, indicating, among one and four coordinates, which they consider as the location of the correct answers. See Figure 8.
Cabling	The user connects terminals through cables. Ideal for evaluating wiring before the operation of a machine. See Figure 9.

Source: self-made

4 Problem Solution: The Point of View of the Working World and the Path of Job Applicants

In general, Human Resources Departments speak of two types of skills: hard skills, which integrate the knowledge and abilities that an applicant for a job should have, and soft skills, related to their attitudes, behaviors, and values at work, [7]. The services offered by the national industry within the life cycle of electric machines require skills that are acquired through theoretical-practical training. The use of induction machines has focused on their role as a driving force, extending to industrial applications since they do not generate harmful vapors (unlike gasoline engines) and are not restricted to use in certain places (as it happened in the Industrial Revolution, where the driving force obliged the installation of engines on the banks of rivers). Two examples can be found in the cement and mining industries. In both cases, it is necessary to increase the efficiency of the processes whose objective is to

apply digitization in drive systems to obtain competitive advantages. Throughout the life cycle of induction machines, the services required by the industry focus on consulting and support services, preventive and corrective maintenance, spare parts, personnel training, modernization and updating, digital services, and service agreements, [8].

Figure 12 shows a generalization of the process of obtaining hard skills by a professional, including the tools they have available. The acquisition of theoretical knowledge officially begins in the classroom. Currently, most higher education institutions have didactic material that includes books, photographs, videos, and animations, among others. These are suggested in the bibliography recommended by the teachers. Likewise, there is more audiovisual content that has been created and made publicly available.

In the case of theoretical-practical hard skills, laboratories are essential to recreate the conditions found in the industry. The handling of electrical machinery involves risks, so the use of simulators is necessary. There are circumstances where it is necessary to recreate adverse conditions to instill diagnostic criteria for faults in students. For safety reasons, it is better to perform this task in a simulator than in a real device. This task, when developed in a tangible environment, can be risky for both students and teachers. Simulators are capable of showing phenomena visually and showing the measurements obtained from the instruments, [9].

Before laboratory practices, the teacher can use simulators so that students can recreate the conditions existing in a real environment. It does not necessarily have to be restricted to the devices found in the institution; the behavior of current and past machinery (examining the efficiency of a current device compared to the old) or future machinery (usually idealizations, where there are devices that reach the highest degree of efficiency, which cannot be achieved with current technology but could be achieved with future technology, can also be recreated).

Once the students become graduates, for industrial purposes, they will be the Applicants who will be in their selection processes, at some point, they will send job applications and may need to present aptitude tests. Currently, both oral and written tests are used to establish a written record of the evaluations carried out. Tests can also be done with de-energized machines, making connections or operating instructions to the evaluators. It should be noted that just entering a workplace implies many risks to the physical integrity of the Applicants.

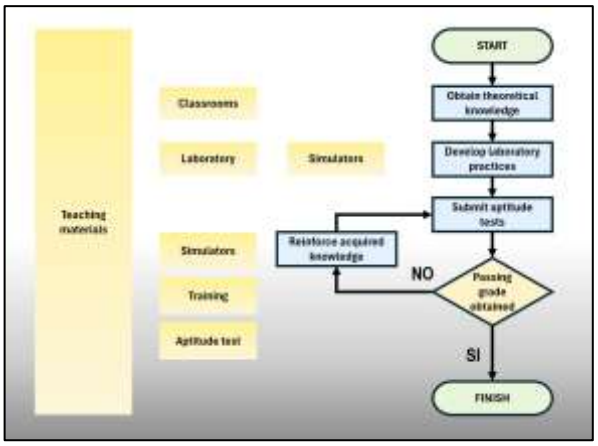

Fig. 12: Description of the tools available to applicants for vacancies in the aptitude test approval process
Source: The authors

Before taking an evaluation, applicants can complement the use of simulators with didactic material used in the classroom, training offered by educational institutions (that usually offer certifications), and the experience gained in the presentation of other aptitude tests. These are the moments when they need to have classrooms or laboratories at their disposal again. According to the policies of their Alma mater, graduates can continue to use simulators to review the necessary knowledge, [10], [11].

Examining the context of the Applicants who graduate from Electrical Engineering and related programs, the following difficulties are listed:

- In comparison to software development or electronics laboratories (for example, software development or development of circuits controlled by Development Boards laboratories, where it is possible to perform a practice space in a room and the investment in equipment is not very high), students can't recreate an Electrical Machines laboratory in their homes since the physical space, electrical connections, and machines require a very high investment to ensure the proper functioning and a safe environment. Likewise, the electrical and mechanical risks to which they are exposed are considerably high.
- Graduates cannot provide feedback on the knowledge acquired in the UNAL Electrical Machines Laboratory unless they are developed within processes related to the fulfillment of the institution's mission purposes.
- There are no conditioned spaces in the market for the development of industrial practices in electrical machines that can be used by the general public to polish the hard skills of

Applicants. If they were to exist, very high investment and much stricter regulation would be necessary, obliging attendees to accredit their affiliation with Occupational Risk Management systems.

5 Conclusion

The SECAP is a service that allows UNAL to make use of its physical and technological space through a service that enables candidates to quantify their current level, identify their weaknesses, and learn about goods and services that are available on the market to improve their scores in future evaluations.

Day by day, some services and solutions allow bringing the Laboratory Home through simulators. Candidates must keep in mind that market conditions change, and although there are topics that are valid since the time they were studying for their undergraduate and graduate degrees, it is necessary to know the state of the art and learn to apply the rules that have been recently issued. Omitting this principle will put them at a disadvantage compared to other competitors in the selection process.

In personnel selection processes related to the electrical field, it is very important to impartially evaluate the candidates. A selection error can lead to an accident that can cause economic losses and workplace accidents. It is also not advisable to favor a candidate or induce other candidates to make mistakes. The SECAP can only operate efficiently if it is used within clean selection processes.

Human Resources Departments must continually update themselves to examine the solutions available in the market related to the virtual recreation of work conditions.

Higher Education Institutions must continue to provide simulation tools to their students so that they can recreate the laboratories developed during their stay when preparing to take an aptitude test.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare.