Natural Resources for Human Health

eISSN: 2583-1194

Original Research

Received 10 April 2026
Revised 18 May 2026
Accepted 20 June 2026

Natural Resources for Human Health 2026, Vol. 6 (3s): 310–350

KEYWORDS:
Bosch KTS 590 scanner, teaching performance, continuous training.

Application of the Bosch KTS 590 Scanner and its Influence on the Teaching Performance in Electromechanics at Public University

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ABSTRACT: The research called Application of the Bosch KTS 590 scanner in the teaching performance of Electromechanics at UNE Enrique Guzmán y Valle, 2026, aimed to evaluate the effects of the application of the Bosch KTS 590 scanner in the teaching performance of Motive Power at UNE Enrique Guzmán y Valle, 2026. The approach used was quantitative, adopting a pre-experimental design, with a sample of 11 Teachers from the Motive Power study program. In this research, the degree of reliability of the instrument for measuring the teaching performance variable was determined using a Kuder-Richardson (KR-20) for the calculation of internal consistency, confirming the reliability of the instrument for the dependent variable with a value of 0.930. The result revealed that there are positive, relevant and significant effects of the application of the Bosch KTS 590 scanner on the teaching performance of the Motive Power of the UNE Enrique Guzmán y Valle, 2026.

INTRODUCTION

Nowadays, we live in situations characterized by uncertainty, where the activities occurring in the world are volatile, uncertain, complex, and ambiguous. These conditions demand that both our personal paradigms and institutional paradigms be rethought in order to gain new momentum and adapt to these new realities, thus remaining relevant in the activities carried out by individuals and organizations. [1]

Adapting to the current context is a challenge for institutions regardless of the sector in which they operate. Professional Education is not exempt from this situation, and one of its major challenges is to train professionals capable of responding to the demands of the labor market. However, reality in many cases is far from meeting this need, especially when it comes to training in technical careers, since it requires investment in the implementation of laboratories or workshop classrooms equipped with modern tools and technologies. Furthermore, instructors or teachers must be properly trained and capable of mastering the technology, particularly the application of workshop equipment and instruments during practical training. [2]

The study by Christian et al. found that, in contrast to the advantages of technology in the classroom, a number of studies also indicate that the use of online technology or digitalization in education affects stress levels. Numerous studies have looked at stress in the teaching profession. [3]

Additionally, Christian et al. suggested that the overwhelming amount of work needed to accomplish online teaching goals and the uncertainty around its utilization could result in technostress, which then affects teaching effectiveness. They explain that technocomplexity and techno-insecurity have a detrimental influence on teachers' performance, whereas techno-overload has a favorable effect. Job performance is impacted by an individual's level of technostress, which is created by task overload and technical mastery. But the usage of inefficient ICTs, which leads to boredom and exhaustion, will eventually lower productivity. [3]

The automotive field provides a clear example of this situation. Current technology requires that during Professional Education, competencies be developed in electronic vehicle diagnostics with a comprehensive perspective rather than focusing solely on mechanical processes. Unfortunately, the latter approach still predominates today. [4]

The problems mentioned above are evident. Due to my professional activities, I have had the opportunity to visit many Professional Education institutions at the national level across different levels (technical high schools, CETPROs, higher institutes, and universities). The pattern observed in the vast majority of these institutions is consistent in three main aspects: lack of implementation of workshops with proper equipment and instructional modules, teachers or instructors without continuous training or professional updating, and academic content that does not respond to the needs of the labor market. [5]

One of these institutions is public university, where the Professional School of Electromechanics offers the study program Fuerza Motriz (Motive Power). This program has been equipped with modern tools and equipment; however, it has been observed that teachers are unfamiliar with the proper use of these tools, and when they do use them, they do so in a limited manner, failing to take full advantage of all their functionalities. One of these tools is the Bosch KTS 590 automotive diagnostic scanner, whose use should be transversal across all specialized courses within the curriculum. [6]

As a consequence of the above, all stakeholders in Professional Education will be affected: students, who will encounter difficulties when entering the labor market; teachers, who will not fully develop their competencies despite their willingness and effort; and finally the Fuerza Motriz study program itself, which may not achieve accreditation and therefore may be unable to open admission calls, risking a reduction in student enrollment and potentially leading to the closure of the program.[7]

This research seeks to determine the effects of the application of the Bosch KTS 590 scanner on the teaching performance within the Fuerza Motriz study program and to serve as a possible solution to the problems identified. Therefore, it is necessary to consider the theoretical foundations presented in the following categories. [8]

At the global level, in the coming years, "the field of action of the automotive sector will be defined by four mega trends: connected mobility, autonomous mobility, electromobility, and digitalization" [9]. At the same time, the electronics implemented in vehicles will continue to bring significant innovation and development in terms of performance, environmental impact, and safety. This means that diagnostic equipment such as the Bosch KTS 590 automotive scanner will also continue to evolve in order to respond to these emerging needs.

On the other hand, it is important to note that there is no automotive equipment specifically manufactured for pedagogical purposes, unlike instructional modules, which are didactic materials designed to facilitate the teaching–learning process under real or near-real conditions. The challenge lies in providing a pedagogical and didactic meaning to technology in order to address teaching and learning demands according to labor market needs.[10]

From the above, it can be deduced that this situation affects teaching performance to the extent that teachers are unable to meet the expectations of students, who are the central focus of the learning process. Therefore, it is important to clearly understand what teaching performance entails, since it is a concept that is very complex to define due to the many aspects it encompasses. However, it can be described as a process in which teachers put into practice their professional experience, individual aptitude, and social commitment in order to effectively articulate the necessary components of the educational process, while also participating in educational management to achieve meaningful learning, competencies, and life skills [11].

Likewise, it is important to consider that technological development in industry across all sectors is constant and continuous, and its processes are also affected by these new realities. However, these sectors also seek new opportunities in response to such challenges. The automotive sector provides a clear example of this situation, as it seeks new alternatives for sustainable transportation over time. In this regard, Aldaz et al. state that professional training institutions must implement their laboratories with updated equipment so that students can be trained under real conditions and thus respond to new demands related to diagnostic, maintenance, and repair services, which are also requirements for professional automotive workshops [12].

Teacher training is not unrelated to the automotive sector, since it must respond to these needs in accordance with the new technologies implemented in vehicles. [13]

In this sense, universities must assume that one of their priorities should be to invest in continuous teacher training in order to continue developing competencies aimed at improving professional performance and, consequently, the results of educational work. Training enables professional updating, learning management, and integration through improvements in new professional profiles and occupations [11]. Another possible strategy to address this need is through the management of interinstitutional relationships with private companies.

In Peru, the vehicle fleet increased due to the progressive recovery of the economy despite the health and political context. For example, during 2021, 157,100 units were sold, representing a 40% increase compared to 2020. Regarding heavy vehicles, 17,651 units were sold, which represents a 36.7% increase compared to 2020 (according to the 2021 annual report of the Peruvian Automotive Association). These vehicles must comply with Euro 4 regulations onwards, which require professionals in the sector to acquire new knowledge, competencies, and skills in diagnostic and automotive maintenance processes using equipment that has technical support and constant updates, such as the Bosch KTS 590 diagnostic scanner. Universities are not exempt from these changes; however, defining their role in isolation is complex, as it depends on many factors, such as whether the institution is private or public. [14]–[16]

At the local level, public university is the only institution that provides university-level academic training in the Fuerza Motriz study program. Graduates of this program, in addition to their pedagogical competencies, must possess disciplinary competencies that enable them to diagnose vehicle faults using modern equipment and instruments, as well as perform predictive, preventive, and corrective maintenance according to procedures established by manufacturers. However, it is appropriate to cite what is stated in its Institutional Quality Management Plan 2019–2022, which on page 4 expresses its commitment to "train professionals with a humanistic, scientific, intercultural, and technological perspective, as well as social responsibility, oriented toward competitiveness and innovation" (Annex of Resolution No. 3497-2019-R-UNE). The training of competitive professionals also requires competitive teachers with strong pedagogical performance and practical experience in the area in which they operate. Both aspects are closely related, especially in technical education.

In 2019, after obtaining institutional licensing from SUNEDU, the Fuerza Motriz study program at the National University of Education was equipped with state-of-the-art equipment. During the technical handover carried out by the supplier, teachers received training and updating on the operation and application of this equipment. However, the health crisis that began in 2020 affected face-to-face academic activities. This situation, together with other factors such as teacher turnover, lack of hiring of new teachers, and the transition to virtual classes, resulted in the training and updating received not achieving the desired objectives.

As a consequence, several aspects were affected:

- First, teachers' cognitive, procedural, and attitudinal performance in relation to pedagogical methodologies and strategies, as well as their disciplinary competencies regarding the diagnostic process and the use and application of diagnostic equipment.[17]
- Second, the processes of continuous training and professional updating for teachers. [18]
- Finally, the acquisition of practical skills by students in the use and application of diagnostic equipment. [2]

These conditions affect not only teachers but mainly students, who after graduation must work in professional training institutions educating the new generation of professionals in the automotive sector.

The issues mentioned above provide the foundation for the present research, which aims to develop a training program for the use of the Bosch KTS 590 scanner (independent variable) and to determine its effects or influence on teaching performance (dependent variable).

These new challenges must become new opportunities for public university and for the Fuerza Motriz study program to strengthen their connection with the productive sector and to analyze and evaluate possibilities for:

- Improving the automotive diagnostic process considering three fundamental pillars: reading control units, handling technical information, and performing additional measurements.

eISSN: 2583-1194

- Improving the specialization profile in order to provide continuous automotive training according to market needs.
- Developing and implementing virtual courses aimed at the productive sector.
- Establishing strategic alliances with industry for the continuous training of teachers, as well as for professional internships.

FORMULATION OF THE PROBLEM: GENERAL AND SPECIFIC

General Problem

What are the effects of the application of the Bosch KTS 590 scanner on the teaching performance of the Fuerza Motriz program at public university (UNE) in 2026?

Specific Problems

SP1. What are the effects of the application of the Bosch KTS 590 scanner on the basic competencies of the teachers of the Fuerza Motriz program at public university, 2026?

SP2. What are the effects of the application of the Bosch KTS 590 scanner on the specific competencies of the teachers of the Fuerza Motriz program at public university, 2026?

SP3. What are the effects of the application of the Bosch KTS 590 scanner on the transversal competencies of the teachers of the Fuerza Motriz program at public university, 2026?

OBJECTIVES: GENERAL AND SPECIFIC

General Objective

To evaluate the effects of the application of the Bosch KTS 590 scanner on the teaching performance of the Fuerza Motriz program at public university, 2026.

Specific Objectives

SO1. To determine the effects of the application of the Bosch KTS 590 scanner on the basic competencies of the teachers of the Fuerza Motriz program at public university, 2026.

SO2. To determine the effects of the application of the Bosch KTS 590 scanner on the specific competencies of the teachers of the Fuerza Motriz program at public university, 2026.

SO3. To determine the effects of the application of the Bosch KTS 590 scanner on the transversal competencies of the teachers of the Fuerza Motriz program at public university, 2026.

IMPORTANCE AND SCOPE OF THE RESEARCH

Importance

Today we live in situations characterized by uncertainty that require our personal and institutional paradigms to be reconsidered in order to gain new momentum and adapt to new realities while remaining relevant.

On the other hand, technological development in all industrial sectors is constant and continuous, and the automotive sector is a clear example of this. New technologies require professionals in this sector to remain permanently updated in order to respond to these new demands.

Universities should not remain isolated from this reality, as they must also keep their training programs updated in order to educate new professionals capable of performing efficiently when entering the labor market.

In this sense, this research project is justified because it seeks to respond to this problem considering the following aspects.

Theoretical justification

The research sought to objectively analyze the current situation regarding teachers' management of the Bosch KTS 590 scanner and how it influences their basic, specific, and transversal competencies in relation to students' expectations. Surveys, interviews, checklists, and teacher evaluations served as the basis for the analysis.

Practical justification

The research is based on the premise that there is no automotive equipment specifically designed for pedagogical purposes. Therefore, it proposes the implementation of a training program for the use of the Bosch KTS 590 scanner to strengthen teachers' basic, specific, and transversal competencies regarding professional updating, pedagogical methodologies and strategies, and the creation of an optimal learning environment in the use and application of diagnostic equipment.

Methodological justification

The research aimed to update teachers in automotive diagnostic techniques, who will later have the responsibility of multiplying this knowledge among students and within the industry. This represents a challenge aimed at strengthening teachers' professional competencies.

In addition, a support guide for the use of the Bosch KTS 590 scanner was developed, which will serve as a reference in the future for the preparation of additional supporting materials by teachers and students.

These new challenges must become new opportunities for public university and the Fuerza Motriz study program to strengthen their relationship with the productive sector and evaluate possibilities such as:

- Improving the curriculum in order to strengthen links with the productive sector through continuous automotive training according to market needs.
- Developing and implementing virtual courses for the productive sector.
- Establishing strategic alliances with industry for continuous teacher training and professional internships.

Scope of the Research

The research is framed within the quantitative approach, supported by the positivist and post-positivist paradigms.

Type of research

This is applied research at the pre-experimental level, focused on the application of the Bosch KTS 590 scanner in teachers' performance.

Social group

The research directly and immediately benefited:

- Teaching staff of the Fuerza Motriz study program (10 teachers).
- Workshop assistant (1 assistant).

In the medium term, it will have a positive impact on:

- Professional training institutions that teach automotive programs such as technical schools, CETPROs, higher education institutes, and universities.
- The institutional image of the Fuerza Motriz study program as well as that of public university.

Spatial delimitation

The research was conducted in the Fuerza Motriz study program at public university.

Temporal delimitation

The research was conducted from September 2025 to May 2026.

Conceptual delimitation

From an academic perspective, the research is situated within the automotive field and the training of future teachers in this specialty.

Knowledge from the following areas was applied:

- Research methodology

- University didactics
- Automotive sector trend analysis
- Applied statistics in research
- Among others

Limitations of the Research

During the development of the research thesis, the following limitations were identified.

Curriculum limitations

- Use of a curriculum focused more on repair rather than electronic diagnostics, where the use of the Bosch KTS 590 scanner should be transversal in specialized courses.
- Use of an automotive vehicle as a didactic module limited to a single brand and its technology.

Teacher-related limitations

- Limited mastery of automotive electronic diagnostic techniques using the Bosch KTS 590 scanner.
- Limited use of updated information from the ESI[tronic] 2.0 software in the courses they teach.
- Limited knowledge of new automotive technologies and their diagnostic processes.
- Limited use of ICT tools related to updating the ESI[tronic] 2.0 software.

Researcher-related limitations

- Limited knowledge of statistical techniques to analyze information according to the research type; therefore, support from a statistics expert was required.

2. THEORETICAL FRAMEWORK

Although there are not enough studies that directly relate the two variables of the present research, this has not been a limitation in obtaining information about each variable independently. In fact, it represents a challenge to demonstrate that the use of the Bosch KTS 590 scanner does affect teaching performance with respect to the application of pedagogical competencies, with particular emphasis on disciplinary competencies.

2.1 International Background

It indicated the reasons that have driven the continuous development of KTS diagnostic scanners for more than 30 years, highlighting that Bosch as a brand is highly competitive in development, technical quality, and reliability. Modern diagnostic equipment and software aim to improve efficiency and effectiveness in the daily work carried out in automotive service workshops. Procedure-based diagnostic solutions are aligned with the future needs of automotive workshops. Furthermore, he emphasized that development will continue in order to provide safer diagnostics of control units through current scanner generations such as the KTS 590, which offer hardware solutions oriented toward future technological requirements [19].

In their study on the implementation of a printed circuit board printer designed to improve teaching and learning processes in practical laboratory activities at the Faculty of Technical Sciences of UNESUM in Ecuador, highlighted that the implementation of such technology in a technical program through specialized software such as SolidWorks generated significant changes in the teaching and learning process. Their results concluded that the implementation of this technology within the laboratory had a positive impact on the teaching and learning process [20].

Similarly, it conducted a study on the implementation of computer numerical control (CNC) technology in electrical circuits to support academic teaching activities in practical sessions within the robotics laboratory at the Faculty of Technical Sciences of UNESUM in Ecuador. The implementation of this CNC technology through specialized software significantly improved the teaching and learning processes. The study concluded that the incorporation of this technology within the laboratory positively impacted the level of teaching and learning, allowing educators to better manage and control their teaching processes [21].

Recital (51) of Regulation (EU) 2018/858 of the European Parliament and of the Council, which went into effect in September 2020, states that the goal of guaranteeing independent operators access to repair and maintenance information should not be compromised by technological advancements introducing new methods or techniques for vehicle diagnostics and repair, such as remote access to vehicle information and software [22].

Therefore, it is important to mention that the operational procedures of the Bosch KTS 590 scanner are aligned with this regulatory framework, and it is essential that users master the comprehensive operation of the scanner. This requirement implies continuous updating in order to respond efficiently to these new technological demands. [23]

Likewise, Regulation (EU) 2018/858 of the European Parliament and of the Council indicates in Appendix 2, "Information on the vehicle OBD system," section 3 "Information required for the manufacture of diagnostic tools," that in order to facilitate the supply of generic diagnostic tools for multi-brand repairers, vehicle manufacturers must provide the necessary information through their repair information websites. any diagnostic tool features as well as any links to repair details and troubleshooting guidelines must be included. Access to such information may be subject to the payment of a fair fee [24].

Additionally, it is important to consider that innovations in electronics applied to vehicles not only provide greater comfort and safety but also introduce risks such as manipulation and cyberattacks. Automotive workshops are already facing challenges imposed by the different security systems implemented by various vehicle manufacturers. These new diagnostic paradigms represent a valuable opportunity to update automotive vocational training curricula and a major challenge for instructors to improve and update their disciplinary competencies. The Bosch KTS 590 scanner and the ESI[tronic] 2.0 software will be key tools to ensure success in this process. [25]

To provide context, in our country, and even across the region, the concept of automotive diagnostics has evolved since the implementation of the standard OBD II connector in 1988. Both technical personnel in multi-brand workshops and vocational training institutions traditionally performed automotive diagnostics using scanners that provided access to most of the active data stored in the vehicle's electronic management systems, meaning that there were practically no restrictions on data access. [26]

However, since September 2020, the concept of diagnostics has changed significantly. In order to perform active diagnostics and access vehicle data, the vehicle must now be unlocked through authorized procedures [21]. As a result, it is now necessary to have scanners approved by vehicle manufacturers to perform complete vehicle diagnostics, including clearing fault memory, coding functions, performing actuator tests, executing special functions, and calibrating ADAS (Advanced Driver Assistance Systems), among other operations.

Another important aspect in understanding the trend of automotive diagnostics is its economic projection in the market. Omeñaca states that the automotive diagnostic market is expected to reach US$22 billion by 2031, according to a report by Transparency Market Research [4]. This economic projection encompasses the following market aspects:

- Automotive scanners, including mobile devices, PC-based scanners, and manual scanners.
- Internal combustion engines, electric automobiles, and hybrid vehicles are examples of vehicle propulsion systems.
- Vehicle types include trucks, buses, coaches, motorbikes, passenger cars, and light commercial vehicles.
- Applications: driving behavior monitoring, emission analysis, supplemental instrumentation, consumer telematics, usage-based insurance, fleet management, automobile sharing, among others.
- Diagnostic types: remote diagnostics and cloud-based diagnostics.

These five aspects provide a broad overview that should be considered when improving the curriculum of the Fuerza Motriz study program in order to address technological challenges effectively.

Likewise, complementing the above, it is necessary to understand the expected behavior of the automotive industry in the coming years. For vocational training institutions, such information is relevant for strategic planning in professional training.

The report states that the automotive industry will generate greater added value and is expected to increase by approximately 30% by 2030, while vehicle production is projected to reach 123 million units. Therefore, original equipment (OE) manufacturers, suppliers, and aftermarket services must be prepared to work with disruptive technologies and new digital customers. Some of these disruptive technologies are already part of our current reality; however, the following challenges will become more pronounced in the coming years: vehicle connectivity, autonomous vehicles, electromobility, digitalization, e-commerce and electronic payments, new customer segmentation, and improved human–machine interfaces. [27]

All these disruptive trends framed within Industry 4.0, supported by technologies such as artificial intelligence, 3D printing, the Internet of Things, and robotics, are significantly impacting areas related to the industrial sector [28]. Universities are not exempt from this context and must reflect and prepare for this new challenge known as Professional Education 4.0. In my view, this new paradigm will be characterized by training in more flexible environments, the use of virtual tools applied to education, and the implementation of workshop-laboratories equipped with modern technology.

This innovative scenario also requires innovative and flexible teaching staff whose challenge is to internalize the moment, transform information into knowledge, adapt it, and transmit it to future professionals who will join the industry, often within very short time frames and requiring immediate responses. [29]

It focused on identifying the perceptions of students, teachers, and administrators regarding teaching performance. The methodological design considered the following aspects: interpretative paradigm, qualitative approach, case study method, and semi-structured interview technique. As a conclusion, the author highlighted the importance of strengthening an evaluation culture in order to promote spaces for reflection and dialogue aimed at the professional development of teachers and, consequently, improve the quality of higher education [30].

It considers that one of the main factors for improving teaching performance is to first evaluate whether the specialty or academic area has its own institutional culture, and whether each professional identifies with it. Once this aspect has been addressed, it becomes the first step toward assuming a strong commitment to students.

On the other hand, it is important to consider students' opinions regarding their level of satisfaction with the educational offer of the institution and the performance of teachers.

In this research, it has been confirmed that both the design of objectives and the content of the different undergraduate and master's courses have obtained low scores. Interestingly, both objectives and content, apart from being key elements in academic training, are those that generate the greatest expectations among students. Therefore, teachers responsible for these subjects must carefully analyze the reasons behind these scores. The research also indicates that there must be a bidirectional relationship between course content and intended objectives in order to avoid false expectations and student dissatisfaction. [31]

Another strategic aspect is the low score assigned to teachers who deliver the courses, which is related to their teaching performance. Mastery of the subject matter, planning, and the ability to resolve students' doubts significantly influence students' interest in the subject. From a management perspective, one factor influencing this dimension is the teacher's basic competence related to experience in the subject area, as well as the availability of time for preparation. In addition to deficiencies in the selection of teaching staff, there is also a lack of adequate induction processes for the position and, in some cases, excessive academic workload. [32]

This research is important because it collects the opinions (information) of the actors involved in the educational process, which will serve as input for the continuous improvement of the services offered by the university. On the one hand, it considers the opinions of students (clients), whose expectations are to receive high-quality education that allows them to develop as individuals and professionals. On the other hand, teachers must assume their commitment to self-training and to achieving meaningful learning outcomes for students. This practice should be promoted within the university according to its current regulatory framework. Finally, it must be considered that students are the central axis of educational institutions; without them, the institution would cease to exist, just as a company would fail if it did not care for its customers.

It was carried out at the University of Sancti Spíritus with the goal of figuring out how the factors under study related to one another. Using the Teacher Self-Efficacy Questionnaire for university professors, structured interviews, and observational methods, the researchers employed a quantitative approach with a non-experimental cross-sectional design. Planning the teaching-learning process, student participation in that process, interaction and the development of a positive classroom climate, assessment of student learning, and self-evaluation of teaching performance are the most representative areas of university teaching, according to the research, which also confirmed that the great majority of teachers use a variety of teaching strategies. The study found that there are various levels in the relationship between university instructors' self-efficacy views and their instructional effectiveness [33].

The concept of self-efficacy is related to our personal capacity to believe how capable we are of facing diverse situations in order to overcome challenges and achieve success in a given context. In this case, it refers to teaching performance at the university level when facing new challenges related to technological innovations within the subjects being taught. [34]

2.2 National Background

The goal of its defense at the public university's Graduate School was to determine whether the two research variables were related. The study used a non-experimental design, descriptive-correlational level, applied research type, and quantitative methodology. A census sample was taken from the 55 instructors that made up the population. Twenty questions with a five-category response scale pertaining to both variables were used in the survey. With a value of 0.806, the instrument demonstrated good reliability. According to a study of the survey data, 86.6% of respondents thought favorably of the dimensions and indicators included in the tool. In the teaching performance variable, four variables were considered: personal, pedagogical, institutional, and societal. The study found that there is, in fact, a direct correlation between instructors' job satisfaction and their effectiveness as teachers [35].

Job satisfaction reflects the degree of agreement or disagreement regarding the work performed by a person and for which they have been trained. This depends on many factors such as the work environment, organizational culture, job functions, professional development and growth, and economic aspects, among others. These conditions decisively influence job performance (teaching performance) either positively or with limitations. Therefore, it is the responsibility of the company or educational institution to ensure that these working conditions are fulfilled in order to maintain the satisfaction of both external and internal clients. [36]

It stated in his study that the use of new technologies is a necessary means for improving teaching performance. The study was conducted at the Amazonian Polytechnic University located in Bagua Grande, where 21 teachers were surveyed. The findings showed that the implementation of new technologies produced significant changes, leading to the conclusion that such technologies directly influence teachers' performance [37].

It conducted at the Graduate School of the Peruvian Cayetano Heredia University, evaluated the compliance with specific learning plans (practical learning tasks that must be completed in companies) in the modules Diesel Engine Tuning, Gasoline Engines, and the Electronic Fuel Injection Laboratory for Gasoline Engines. The results showed that only 57% of the activities were completed, leaving 43% pending. The study applied the following methodology: quantitative research approach, descriptive level, non-experimental cross-sectional design, and questionnaire-type instruments. The study concluded that it is necessary for teachers to complete the tasks not fulfilled in each module so that the competencies required by the program can be achieved [38].

Every institution must comply with the educational offer established in its curriculum in order to achieve meaningful learning outcomes in students so that they can apply them in their future professional activities. Automotive engineering, in order to comply with current regulations, has implemented significant innovations in the electronic management systems of vehicles. Therefore, for diagnostic purposes it is necessary to use automotive scanners such as the Bosch KTS 590. Teachers must clearly understand the pedagogical logic behind the use of this scanner during teaching–learning sessions, since performing a diagnostic procedure on a vehicle requires prior knowledge of the technological prerequisites involved. Only in this way can meaningful learning be achieved, which will be verified through the results demonstrated by students at the end of the teaching session. [39]

It conducted at the Faculty of Education and Languages of César Vallejo University, aimed to describe the level of scanner use in automotive diagnostics by students and the extent to which they understand and apply it in their training. The methodology used was a non-experimental, cross-sectional descriptive design with a quantitative level, applied to a sample of 40 students using a checklist instrument. The results showed that 30% were at a low level, 50% at a medium level, and 20% at a high level. The study concluded that in order to improve this situation, it is necessary to conduct training programs to refine teaching strategies and respond to the real needs of the labor market. It also recommends that the government equip polytechnic schools with modern equipment. [40]

The experience of the present study, transferred to university teacher training, must adopt a comprehensive approach to the use of diagnostic equipment, since the use of scanners goes beyond simply knowing how to operate them. These devices serve as support tools that allow technicians to solve problems within the electronic management systems of vehicles. Therefore, teachers must have experience with the new technologies implemented in modern vehicles. If the teacher is responsible for training future teachers, such experience becomes indispensable. [41]

It conducted at the Faculty of Engineering of the Autonomous San Francisco University, aimed to determine the level of knowledge regarding the use of scanners and whether workers correctly apply them during diagnostic activities. The methodology was non-experimental with explanatory and descriptive characteristics, using a census sample of 10 workers. Interviews and questionnaires with closed questions were used as instruments. The study concluded that 60% of the sample did not know how to properly operate the scanner, which caused the diagnostic process to take longer. [42]

My experience in the sector allows me to affirm that, as field workers in independent workshops, the level of demand regarding automotive diagnostics is higher. However, two major limitations arise for these professionals. The first is their level of professional training; in most cases they are operational-level technicians whose main limitation is the inability to analyze a problem and determine its root cause. The second limitation is the lack of motivation toward training and technological updating, which ultimately affects their job performance.

It defended at the Graduate School of the José Carlos Mariátegui University, assumed that the current approach to supervision is traditional and focused more on control rather than support for the educational process. The objective was to determine whether there was an influence between the variables studied. The research followed a quasi-experimental design, with a population sample of 29 instructors divided into two groups: an experimental group of 15 and a control group of 14. The study concluded that creative supervision positively influences the technical–pedagogical performance of instructors and therefore recommended its implementation [43].

It agrees that pedagogical supervision or auditing verifies whether the teacher fulfills the functions or responsibilities of the job position, which is tacitly assumed to be the case without the need for constant control, since the individual initially received a job induction process. However, reality often shows that this is not always the case. Therefore, the individual themselves directly influences their professional performance, which in the context of this research project refers specifically to pedagogical performance.

The purpose of its defense at the National University of San Marcos was to ascertain whether the two study variables were related. Applied research, correlational level, non-experimental cross-sectional design, hypothetical-deductive method, and quantitative approach were all part of the methodology. According to the study's findings, inclusive practices and teaching effectiveness are significantly correlated from the viewpoint of the students [44].

Additionally, in order to provide theoretical support for the teaching performance variable, the author cited Stronge, who identifies the following dimensions: educational planning, knowledge delivery, learning assessment, learning environment, and professionalism. This research invites reflection on the importance of inclusive practice within teaching activities. Therefore, the challenge is to ensure that all students, without distinction, achieve meaningful learning that facilitates their insertion into the labor market. This implies that teachers must facilitate learning conditions within the educational process similar to those found in the industry. [45]

2.3 Theoretical Foundations

Bosch KTS 590 Scanner

In 1988, Bosch introduced the KTS 300, the first diagnostic device that provided independent workshops with the possibility of accessing the electronic management systems of engines. At that time, Bosch named it KTS, which stands for "Klein-Tester-Serie" in German (Small Tester Series). Throughout its development, several previous versions were released with the objective of increasing efficiency and effectiveness in the daily activities of workshops while adapting to future technological needs. [46]

A scanner is a diagnostic instrument used in the automotive sector. According to the KTS 560 / 590 Instruction Manual (KTS 5th Series):

- The Bosch KTS 590 scanner is described as a module that communicates with vehicle electronic control units to perform advanced diagnostics, including control unit diagnostics, multimeter measurements, and signal analysis through a two-channel oscilloscope, when operated together with the ESI[tronic] 2.0 software. [47]
- In addition to all communication interfaces currently implemented in vehicles within the Peruvian automotive fleet, the KTS 590 is the first multi-brand scanner that includes Ethernet-based vehicle interfaces (DoIP – Diagnostic over Internet Protocol). [48]
- Its communication with electronic management systems is based on the Bosch ESI[tronic] 2.0 diagnostic software. [49]

Another complementary definition of an automotive scanner is provided by Muñoz, who states that a scanner is a device capable of communicating with electronic control units in order to read stored faults in their memory, whether permanent or temporary. Scanners may be original equipment scanners, multi-brand scanners, or simple fault-code readers [50].

Finally, regardless of the type or brand of scanner used, it is important that the person operating the equipment is properly trained to take full advantage of its capabilities during diagnostics. Otherwise, errors may occur that could even damage control units, leaving the vehicle and its systems inoperative.

Functions of the Bosch KTS 590 Scanner

During its operation with ESI[tronic] 2.0, the KTS 590 scanner performs the following main functions:

Electronic control unit diagnostics

- Reading fault codes stored in different ECMs.
- Displaying real-time values during diagnostics.
- Actuator activation for adjustment or recalibration processes.
- Specific functions of control units enabled by vehicle manufacturers.

Multimeter measurements

- Voltage measurement: range from 20 mV to 200 V DC and AC.
- Resistance measurement: range from 100 Ω to 1 MΩ.
- Current measurement: only with special accessories such as 100 A and 600 A current clamps.
- Diode testing: diode voltage measurement.
- Graphical display (time section): measurement values can be displayed graphically.
- URI: return to voltage (U), current (I), or resistance (R) measurements.

Two-channel oscilloscope

- Recording measurement values in the range of 100 mV to 200 V DC and AC.
- Time range (X deviation): 50 μS to 1000 ms.
- Analysis of diagnostic interfaces of control units.
- Switching to diagnostic mode (pin selection).
- Displaying signals in separate diagrams.

Visualization of protocols and maintenance records

- Saved diagnostic reports or maintenance plans can be viewed, saved as PDF, printed, or deleted.

ESIticket generation (technical query)

- ESIticket allows direct communication with Bosch technical support (ESI[tronic] service team). Through this system users can submit suggestions, describe faults, or propose solutions.

Abbreviations

- Provides explanations of various technical abbreviations used in diagnostic or repair processes.

DEMO function

- Particularly useful in vocational training as an induction phase for scanner operation. Allows demonstration of diagnostic procedures without connecting the scanner to the vehicle ECM. For real diagnostic conditions, this function must be disabled.

eISSN: 2583-1194

- Before using the KTS 590 module in diagnostic tasks, teachers must first become familiar with the instruction manual and encourage students to use it during training activities.

3. AUTOMOTIVE COMMUNICATION PROTOCOL

Communication protocols are sets of formats and rules that contain digital messages used to exchange information between computer systems. Every protocol must include authentication, fault detection and correction, and signaling processes, and they are implemented within computer networks.

In the automotive field, where vehicles incorporate electronic management systems, it is essential to understand the basic principles of communication protocols in order to comprehend the operational logic of scanners when communicating with electronic control units (ECU, ECM, BCM, etc.) during onboard diagnostic processes.

Thanks to the OBD II standard, automotive scanners use a standardized trapezoidal 16-pin connector. Each pin number corresponds to specific communication protocols, although some pins remain available for manufacturers to use according to their particular requirements.

Protocols are defined by organizations such as ISO or SAE, and the same applies to diagnostic connectors. However, some manufacturers implement proprietary protocols that are not standardized across the industry and can only be used within their own vehicles. This is particularly common in commercial vehicles such as buses, trucks, or off-road vehicles, which often use round connectors with 9 or 14 pins.

The Bosch KTS 590 scanner, according to ISO 15031, supports the following protocols for diagnosing control units:

- ISO 22900 – Ensures diagnostic and reprogramming applications for ECMs through standardized hardware and software interfaces. European legislation considers Euro V standards for light vehicles and Euro VI standards for commercial vehicles.
- SAE J2534-1 and J2534-2 (PassThru) – Used for ECM programming. Requires a VCI interface (approved scanner) connecting the OEM manufacturer portal and the vehicle.
- ISO 13400 (Diagnostic over IP – DoIP) – Enables vehicle diagnostics via Ethernet, providing data transmission speeds 100 times faster than CAN technology, which is particularly useful for ECM programming.
- ISO 9141-2 (K and L communication lines) – K-line provides bidirectional communication, while L-line is used to initialize communication.
- SAE J1850 VPW and SAE J1850 PWM – Pulse-width variable and pulse-width modulation protocols used for data exchange between ECMs and diagnostic tools.
- BUS+ and BUS- communication cables – Standard CAN network connections used to transmit communication data between modules.
- CAN ISO 11898 / ISO 15765-4 (OBD) – Bidirectional communication protocols using CAN-H and CAN-L.
- CAN Single Wire – Single-wire CAN interface communicating at speeds up to 33.3 kbit/s, used in comfort systems such as seat and mirror adjustments.
- CAN Low Speed – Two-wire network communicating up to 125 kbit/s, used in comfort and safety systems such as interior lights and brake lights.
- Other vehicle-specific protocols, particularly in commercial vehicles, such as J1708 and J1939.

Additionally, the KTS 590 scanners can be used with vehicles compatible with Euro 5 standards through the PassThru Standard interface, which enables programming of control units via manufacturer portals. However, this feature has not yet been fully implemented in the Latin American region.

Application of the Bosch KTS 590 Scanner

The Bosch KTS 590 scanner is widely used in the automotive sector, particularly in multi-brand workshops and authorized dealership service centers.

Due to its versatility, it is also used in the educational sector, especially in programs that offer automotive mechanic training at different educational levels, including technical training, professional technical training, and auxiliary technician training.

Likewise, it is applied at the university level in programs such as Mechanical Engineering and Automotive Engineering, as well as in public university, specifically within the Fuerza Motriz study program.

The device is highly didactic and can also be used in simulation mode as an introductory phase for learning how to operate the scanner. This feature is useful in classroom environments for demonstrating diagnostic procedures without connecting the KTS 590 scanner to the vehicle's ECM. However, for real diagnostic conditions, this function must be disabled.

Procedure and Technical Information – ESI[tronic] 2.0 Software

ESI[tronic] is a modular technical information software system developed by Bosch, which also includes technical data provided by vehicle manufacturers for workshops according to their specialization (hence the term information modules). These data are used together with the KTS 590 scanner during the diagnosis of vehicle electronic management systems.

Through this system, multi-brand workshops can improve both efficiency and quality in maintenance and diagnostic operations across various vehicle brands and models. The software provides access to technical information for more than 90,000 vehicles from approximately 150 brands.

Since 2019, the software information has begun migrating to the ESI[tronic] 2.0 Online version, meaning that the technical information is continuously updated. When installing the ESI[tronic] 2.0 software, the DDM software (Bosch Diagnostics Download Manager) is automatically installed. This tool is necessary whenever updates must be downloaded and installed to obtain the latest Bosch diagnostic information.

From 2022 onward, the download and installation link for ESI[tronic] 2.0 Online stored on the hard drive contains only control unit diagnostics (information types SD and Truck). The system downloads the calibration values of diesel injection pumps (Module W) separately and installs them locally, making them available through additional software used for testing values.

Once the vehicle has been identified, the ESI[tronic] 2.0 Online diagnostic software provides the following communication tabs in the main menu:

Vehicle Information

Provides detailed information about the vehicle and its equipment systems installed in the vehicle.

Diagnostics

Contains all functions related to communication with the vehicle's control units through the interface between ESI[tronic] 2.0 and the KTS scanner. The following functions are activated: System overview, Repair, Service tasks, Global OBD II, Total trip and Components

Additionally, in the lower-left section there are two important functions: Diagnostic Port and Adaptation. In the Diagnostic Port, the user can view the silhouette of the vehicle indicating the location of the OBD II diagnostic connector or another connector type, including information about pin location, communication protocols, and pin assignment tables.

Search

Allows the user to locate information based on specific diagnostic needs or the vehicle being diagnosed.

Maintenance

Contains clear and systematic information about the mechanics of the selected vehicle type. For example, for diesel vehicles it includes: Maintenance plans, Service illustrations, Maintenance interval display, Diesel exhaust after-treatment systems, Vehicle model identification plate, Tire pressure information, Technical data, Timing system, Auxiliary drive belts, Wheel alignment, and Key programming

Manuals

Includes documentation such as SIS / CAS guided troubleshooting instructions (Service Information System with computer assistance). This system provides structured procedures to use manufacturer technical information during diagnostics and allows comparisons between actual operating values and nominal values specified by the manufacturer. Users can select information based on functional group and information type.

Wiring Diagrams

These are electrical diagrams of the vehicle's electronic management systems, which every user must consult during diagnostics. They can be selected by functional group and manufacturing year.

Known Faults

Contains Experience-Based Repair (EBR) information, which provides quick and simple solutions to known faults reported by other workshops and compiled by Bosch experts. When selecting a known fault, the software displays detailed information regarding: Affected systems, Causes, Possible solutions.

Equipment

Provides complete information about Bosch spare parts equipment applicable to the vehicle being diagnosed or repaired.

Another important feature of the ESI[tronic] 2.0 software is SDA (Secure Diagnostic Access) used together with the KTS scanner to access protected vehicle data. According to ESI[tronic] 2.0 Online – News 2021/3:

many manufacturers already implement individual protection solutions with different access requirements for the electronic systems of new vehicles, which poses a significant technical and administrative challenge for independent multi-brand workshops; the Secure Diagnostic Access (SDA) function was therefore developed to offer users a centralized, integrated, and standardized way to access protected vehicle data from current and future manufacturers [36].

For the end user, accessing SDA through the KTS 590 represents a competitive advantage because it improves service to customers whose vehicles are protected by electronic security systems, as indicated by EU Regulation 2018/858.

For vocational training centers, this represents an opportunity to update teaching content regarding the concept of automotive diagnostics. For teaching staff, it implies the need to change traditional paradigms related to automotive diagnostic processes.

4. INSTRUCTION MANUAL

Instruction manuals provide guidance on the main procedures for operating a specific machine or equipment. An initial review is essential to properly convey information to users and enable them to operate effectively within a specific context. The success of equipment operation largely depends on the user's understanding of the manual. Additionally, manufacturers assume that the end user already possesses basic knowledge about the equipment.

The instruction manual for the KTS 590 module includes the following information:

- Symbols used
- User instructions
- Product description
- Initial commissioning
- Maintenance
- Decommissioning
- Technical specifications

The instruction manual is a document prepared by the manufacturer that presents the equipment's contents in an organized manner, adapting its use for pedagogical purposes where learning becomes the central element. Therefore, at the beginning of each procedure, the manual must specify the prior knowledge required from the end user.

Teaching Performance

Teaching performance is a widely shared concept; therefore, it is necessary to first understand the meaning of the term performance. When defined as a verb (to perform), it refers to an action carried out concretely. When expressed as a noun (performance), it refers to the execution of an activity of a professional or other nature, without initially judging whether the action was performed well, poorly, or moderately.

If performance is associated with activities that involve completing scheduled tasks that must lead to a concrete result benefiting oneself, others, or an organization, the concept becomes broader. In this sense, performance refers to an activity within a specific occupation and is therefore more precisely understood as job performance.

It indicated that job performance is related to all activities performed by individuals that are observable and relevant to the objectives of the organization or institution [51]. Thus, two main actors enable job performance: individuals and institutions.

Individuals contribute their professional profile while performing tasks required by their job position within the organization. Depending on their performance, their professional permanence within the institution may be shorter or longer, allowing them to develop a professional career.

When considering the activities performed by teachers or instructors within educational institutions, it is important to understand the multiple characteristics they must demonstrate. Ausubel emphasized that teachers are a key variable in the learning process and identified three main aspects [52]:

- Cognitive factor: extensive experience and knowledge in the subject taught.
- Instructional competence: the ability to organize and explain content clearly, promoting dialogue that supports learning.
- Communication with students: the ability to adapt knowledge according to students' cognitive maturity and prior knowledge.

These characteristics should be present in teachers to varying degrees depending on educational levels and form part of all pedagogical training curricula. However, the key issue lies in how much knowledge teachers have acquired and how much they apply in practice to succeed in their teaching careers.

The cognitive mastery of the subject taught in the classroom provides the foundation for organizing and applying content effectively. It also builds confidence when communicating and interacting with students. These competencies are strengthened through daily pedagogical practice.

From a sociocultural perspective, concepts cannot be transmitted directly without proper foundation. As Vygotsky warned:

- A teacher who attempts to transmit concepts without an adequate experiential foundation risk producing little more than empty expressions that students repeat mechanically rather than internalize [53].
- In technical education, this could lead to mechanized processes and memorization-based learning, practices that have been widely criticized but are still present in many educational contexts. Instead, concepts should be supported by technological foundations and real-world applications.
- Teaching performance can be defined as a construct formed by multiple aspects involved in the educational process and associated with all activities related to the teaching function [54].

Similarly, It states that teaching performance is synonymous with pedagogical practice, as it encompasses all professional activities within the classroom, including planning, student support, application of teaching strategies, evaluation, collaboration, institutional management, and continuous professional development [46].

Education is and will continue to be a complex process, particularly when teaching performance is evaluated at the university level, where future professionals are being trained.

Zabalza emphasized that good teaching requires both personal qualities and professional competencies, referring to the dual competence required of effective teachers: disciplinary competence and pedagogical competence [38].

Practical experience (disciplinary competence) is essential and should be a verified requirement during the selection of teaching staff if high-quality educational outcomes are desired. This action will have a significant social impact because it promotes the training of competent professionals and encourages greater participation of new students in academic programs. [24]

It conducted research in two campuses of a private university in Chile and proposed a Teaching Competency Profile that synthesizes the competencies required in contemporary higher education within three dimensions: basic, specific, and transversal competencies. Their study concluded that, from the students' perspective, the most expected competency is teacher accessibility, meaning that teachers should be approachable, empathetic, flexible, humble, and available to students, in addition to maintaining updated knowledge. [7]

Finally, It proposed evaluating teaching performance through cardinal competencies and concluded that certain behaviors need to be strengthened through training strategies to improve teaching performance and institutional educational quality. It considers that a key factor in improving teaching performance is first evaluating whether the academic specialization or department possesses its own institutional culture, and whether each professional identifies with it. Once this aspect is addressed, it becomes the first step toward strengthening teachers' commitment to their students. [6]

Basic Competencies of Teachers

These competencies are the result of professional experience acquired in the workplace within the industry and that, in the new teaching role, the instructor must demonstrate. Teachers possess skills, knowledge, and attitudes that must be complemented by mastery of the subjects or topics they teach and, above all, by how up to date they are with the topics addressed. These conditions provide confidence when expressing ideas and transmitting experiences, stories, and concepts to students, allowing them to refine their teaching strategies whenever necessary. [2]

Additionally, teachers must have the ability to work collaboratively with their peers, which demonstrates responsibility, commitment to their teaching work, and professional ethics. Therefore, these competencies involve cognitive, social, communicative, technological, and personal competencies [55].

It stated that these are competencies that every teacher must possess in order to perform educational tasks effectively. They include general skills applicable to different areas of professional and personal life. These include communication competence, which refers to the ability to express and communicate ideas clearly both orally and in writing; digital competence, which involves the use of information and communication technologies (ICT) in the classroom as a pedagogical tool; and problem-solving competence, defined as the ability to address and resolve challenges arising within the educational context [56].

Specific Competencies of Teachers

Specific competencies represent the core of the teaching process, prioritizing learning rather than focusing exclusively on content. Instead, emphasis should be placed on the learner's process of knowledge appropriation and its usefulness in the context in which it is needed [57].

Through this process, teachers identify the most effective methodological and didactic strategies to achieve the expected results in their teaching planning. These competencies involve planning and organizational competencies, didactic competencies, and competencies related to the design and implementation of evaluation methodologies [58].

It stated that these competencies are directly related to mastery of a specific discipline or field of knowledge and to the ability to design, implement, and evaluate learning situations. These include:

- Pedagogical competence, referring to the ability to plan, implement, and evaluate the teaching–learning process according to students' needs.
- Disciplinary competence, referring to a deep mastery of the subject matter and the methodological approaches within the field taught.
- Evaluation competence, defined as the ability to apply tools and methods that measure student learning and progress.

Transversal Competencies of Teachers

Transversal competencies represent the additional commitment that teachers contribute to the teaching–learning process and that distinguishes them from their peers. Teachers assume the role of mentors to interact with students and bring out their best potential in order to achieve the expected learning outcomes. [59]

Teachers assume responsibility for the learning process by being self-critical and reflective regarding their professional practice. To achieve this, they must demonstrate empathy toward students, promote teamwork, and maintain strong professional commitment in order to achieve both student satisfaction and professional fulfillment. [60]

It stated that transversal competencies are those that cut across all areas and stages of the educational process and must be applied by teachers regardless of their teaching specialization. These include ethical competence, referring to commitment to ethical values and justice in education; emotional competence, defined as the ability to manage both personal and students' emotions to promote a positive learning environment; and collaborative competence, which refers to the ability to work as part of a team with other teachers and the educational community [61].

Continuous Training

The growing demand for professionals to be better prepared to face ongoing technological innovations encourages many individuals to participate in continuous training programs, often outside the formal education system.

Similarly, companies in the private sector require highly qualified personnel to meet new customer demands, typically through an Annual Training Plan. Therefore, training programs should be considered investments rather than expenses. Educational institutions also develop annual training plans depending on their level of education. At the university level, training plans focus on the specific needs of academic programs to strengthen teachers' competencies. For example, the 2026 Annual Training and Professional Development Plan for Teachers of public university states that training programs aim to promote academic development among teaching staff through organized activities designed to provide knowledge, skills, and competencies aligned with current educational demands. [62]

Additionally, several institutional guidelines contribute to institutional development:

- Ensure quality in the educational services provided.
- Strengthen teachers' capabilities within the university.
- Maintain and promote the physical and mental well-being of teachers.
- Continuously update teachers in scientific advances and new technologies to improve teaching and research processes.

These guidelines must later be evaluated to ensure continuous improvement. Campi, Saa, and Dicado indicated that training programs should be evaluated by measuring their impact in the following aspects [63]:

- Level of employee satisfaction.
- Level of knowledge assimilation.
- Applicability of learned knowledge in the workplace.
- Improvement in job performance and its influence on the organization.
- Economic benefits derived from training.

Multiplier Effect

Although the multiplier effect is traditionally associated with numerical values, it can also be applied to education by quantifying the impact and benefits generated by educational activities. [64]

One of the main advantages of the multiplier effect in education is the sustainability of learning over time. Individuals who acquire new knowledge can subsequently disseminate it to others, creating new multipliers who continue transmitting knowledge to additional learners. [65]

Another advantage is that individuals who assume the role of multipliers become leaders in the dissemination of knowledge, allowing them to move beyond routine work and recognize the value of new activities and skills they acquire. [66]

By applying the multiplier effect to knowledge transfer, individuals may discover new talents related to research and learning (intellectual capital). Consequently, their professional updating becomes continuous. These individuals become capable of learning, unlearning, and relearning, which allows them to adapt more effectively to ongoing changes. This process allows educational institutions to respond appropriately to technological developments within their academic programs. As a result, investment in teacher training improves intellectual capital. These new experiences enable teachers to design innovative educational products (courses) and services aligned with market needs [67]. Consequently, the organization also improves its institutional image.

Disciplinary Competence

In addition to pedagogical competence and personal-social competencies, disciplinary competence is highly valued by students. Guzmán-Cedillo, Moreno, and Lima-Villeda defined disciplinary competence as the set of capacities that teachers demonstrate in relation to their professional performance or mastery of a specialized field [22].

Although every profession begins with initial training, competence improves as professionals practice their occupation and apply their knowledge. Experience strengthens disciplinary competence, which is further reinforced through additional training or updates that ultimately contribute to improved teaching performance.

Institutional Culture

Organizational culture refers to the set of values, languages, beliefs, rituals, social norms, mental models, metaphors, and ideologies shared by some or all members of an organization. These elements define the style and manner in which activities are carried out within an organization and generate commitment and identification with the organization's objectives.

Within a culture, there may also exist subcultures. Universities have their own culture, which encompasses the subcultures of each faculty or specialization. Therefore, it is essential that each member understands this concept due to its institutional significance. Robbins and Judge state that organizational culture fulfills several important roles within organization [7]: It defines boundaries between organizations. It creates a sense of identity among members. It promotes commitment to the organization beyond personal interests. It contributes to internal social stability. Therefore, culture acts as the social glue that maintains cohesion within an organization.

Organizations and their members develop their own cultural frameworks in order to design strategies and achieve objectives aligned with their institutional vision. Based on the theoretical foundations presented and as a response to the identified problem, this research proposes the implementation of a training program on the use of the Bosch KTS 590 scanner to strengthen teachers' basic, specific, and transversal competencies, improve their pedagogical methodologies and strategies, and create an optimal learning environment for the use and application of diagnostic equipment. The training program consisted of eight learning sessions, each lasting four pedagogical hours. At the beginning of the program, dichotomous questionnaires were applied to measure the research variables. During the process, checklists were applied in sessions 1 through 7, followed by a final evaluation in session 8. Finally, the dichotomous questionnaires were applied again to measure the final results of the research variables. [68]

Definition of Basic Terms

Automotive scanner. A scanner is a device used in automotive diagnostic procedures that allows communication with the vehicle's control units. Automotive diagnosis. Automotive diagnosis is a process that helps technicians identify and determine the root cause of vehicle faults. Electronic control unit (ECU). An ECU is an electronic device that receives input signals from sensors, compares them with programmed operational data stored in its memory, and sends output signals to actuators to adjust system performance.

Student (customer). A university student is an individual committed to academic training in order to become a professional capable of entering the labor market. This process originates from a personal need that must be satisfied. Education can also be understood as a service offered by educational institutions, which leads to the paradigm that students may be considered clients seeking to satisfy academic needs in order to achieve professional development and economic satisfaction [16].

Prior knowledge. Prior knowledge refers to the cognitive, affective, and psychomotor experiences that students have previously acquired, enabling them to respond to new learning situations. When initiating a new learning process, it is important to identify this prior knowledge in order to promote meaningful learning that generates cognitive conflict and brings students closer to real learning situations [14].

In technical or engineering education, when using equipment such as the Bosch KTS 590 scanner, teachers must consider two essential conditions: understanding how the equipment functions and demonstrating the application of all its designed functions. These conditions constitute the prior knowledge required from teachers. To continue using the equipment effectively, teachers must also master the operating principles of the systems being diagnosed and understand the technological innovations incorporated into these systems. Meeting these requirements ensures that teachers achieve excellent disciplinary performance in the operation and application of the Bosch KTS 590 scanner. [11]

5. HYPOTHESES AND VARIABLES

Hypotheses: General and Specific

General Hypothesis

The application of the Bosch KTS 590 scanner significantly influences the teaching performance of the Fuerza Motriz program at public university, 2026.

Specific Hypotheses

SH1. The application of the Bosch KTS 590 scanner influences the basic competencies of the teachers of the Fuerza Motriz program at public university, 2026.

SH2. The application of the Bosch KTS 590 scanner influences the specific competencies of the teachers of the Fuerza Motriz program at public university, 2026.

SH3. The application of the Bosch KTS 590 scanner influences the transversal competencies of the teachers of the Fuerza Motriz program at public university, 2026.

Variables

Independent Variable

Bosch KTS 590 Scanner

The scanner is a diagnostic instrument used in the automotive sector. According to the KTS 560 / 590 Instruction Manual (KTS 5a Series): The Bosch KTS 590 scanner is a module that communicates with vehicle electronic control units to provide advanced diagnostics, including control unit diagnostics, multimeter measurements, and signal analysis through a two-channel oscilloscope when operated with ESI[tronic] 2.0. [13]

Dependent Variable

Teaching Performance

Teaching performance is a widely shared concept; therefore, it is necessary to understand the meaning of both terms. It defines teaching performance as synonymous with pedagogical practice, since it includes all activities related to the profession within the classroom such as planning, student guidance, application of teaching strategies, assessment, collaboration, and management activities inside and outside the institution, as well as continuous professional development through training programs [15].

Education is and will remain a complex process, particularly when teaching performance is evaluated at the university level, where future professionals are being trained. Good teaching has always been complex. To be a good teacher, it is necessary to combine personal conditions, professional competencies, and practical experience. Therefore, the concept of dual competence is currently emphasized: disciplinary competence, referring to mastery of the subject matter taught, and pedagogical competence, referring to commitment to students' learning and professional development [69].

Operationalization of Variables

In order to operationalize variables, it is necessary to define their concepts with the objective of developing measurement instruments related to dimensions and indicators.

It indicates that operationalizing variables produces a sequence of methodological outcomes. First, measurement instruments are developed, which later become indicators for observation. At the same time, this process helps organize the thematic content of the research index and allows feedback and integration of information across dimensions [14].

In this research thesis, the operationalization of variables begins with the conceptualization of each variable, from which the corresponding dimensions and indicators are derived. In this study, a training program on the use of the Bosch KTS 590 scanner (independent variable) was implemented to determine its effects on teaching performance (dependent variable). The training program was divided into eight learning sessions, each lasting four chronological hours.

Table 1. Operationalization of the Independent Variable: Bosch KTS 590 Scanner

Variable	Operational Definition	Dimensions	Indicators	Items	Instrument	Training Program
Independent Variable: Bosch KTS 590 Scanner	The three dimensions are operationalized through a training program related to the independent variable and its influence on the dependent variable.	**D1: Scanner Functions**	I1: Control unit diagnosticsI2: Multimeter measurementsI3: Two-channel oscilloscope signals	8 sessions of 4 chronological hours	Content analysis of messagesTraining stimulusKTS 590 scanner checklist	Week 1: Automotive diagnosisWeek 2: Functions of the KTS scannerWeek 3: KTS hardware configurationWeek 4: ECM management diagnosticsWeek 5: ECM management diagnosticsWeek 6: Diagnostics using the multimeter functionWeek 7: Diagnostics using the oscilloscope functionWeek 8: Technological innovations in the automotive sector
		D2: Application	I1: Educational contextI2: Automotive sector			
		D3: Procedures and Technical Information	I1: Interprets and analyzes faultsI2: Relates information with technical dataI3: Performs additional measurements			

Table 1 describes the operationalization of the independent variable considering three dimensions and their indicators, as well as the measurement process.

Table 2. Operationalization of the Dependent Variable: Teaching Performance

Variable	Operational Definition	Dimensions	Indicators	Items	Measurement Scale	Instrument
Dependent Variable: Teaching Performance	The three dimensions are operationalized through the training program of the independent variable and its influence on the dependent variable.	**D1: Basic Competencies**	I1: Training in new automotive technologiesI2: Mastery of automotive technologiesI3: Mastery of the KTS 590 scannerI4: ICT managementI5: TeamworkI6: Social responsibility	1–10	Dichotomous scaleNo (0)Yes (1)	Content analysis of messagesDichotomous survey questionnaire (Pretest and Posttest)Training stimulusData matrix for recording and analyzing pretest/posttest scoresKTS 590 checklist

		D2: Specific Competencies	I1: Plans, designs, and conducts continuous training coursesI2: Links theory and practiceI3: Applies knowledge in real situationsI4: Comprehensive evaluation	11–16		
		D3: Transversal Competencies	I1: EmpathyI2: Maintains a positive classroom and workshop environmentI3: Continuous improvement in teaching practice	17–21		

Table 2 describes the operationalization of the dependent variable considering three dimensions, their indicators, and measurement procedures.

6.SYSTEM IMPLEMENTATION

Beyond the pedagogical intervention described above, the training program was supported by a lightweight software component designed to digitize the Bosch KTS 590 checklist, automate the scoring of the pretest/posttest dichotomous instrument, and provide teachers with immediate feedback on their progress across the eight training sessions. This component, referred to here as the Diagnostic Training Support System (DTSS), was developed as a complement to the experimental design and is described in this section in terms of its architecture, control logic, and computational behavior, following the implementation pattern commonly used in applied educational-technology research [70].

6.1 System Architecture

The DTSS follows a three-layer architecture, consistent with approaches used in IoT-enabled diagnostic and monitoring systems for technical training [5], [6]:

- **Acquisition layer:** a tablet-based digital checklist that mirrors the printed Bosch KTS 590 checklist used during Weeks 1–8, capturing the instructor's observed performance per item (control unit diagnostics, multimeter measurements, two-channel oscilloscope use) at the moment each task is demonstrated.

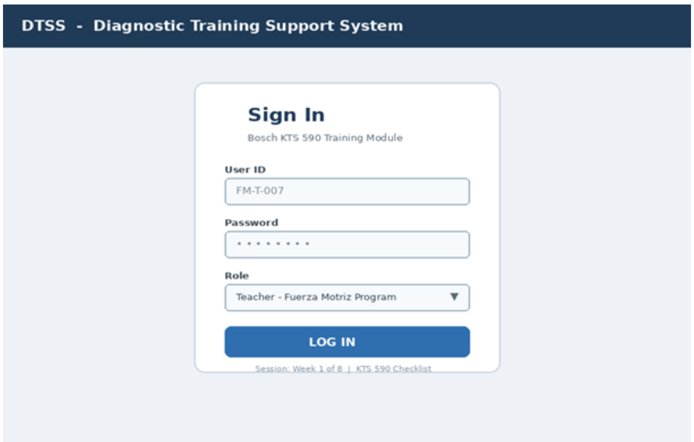

Fig. 1. Sign-in screen of the DTSS acquisition layer, used by teachers to access the digital checklist for each training session.

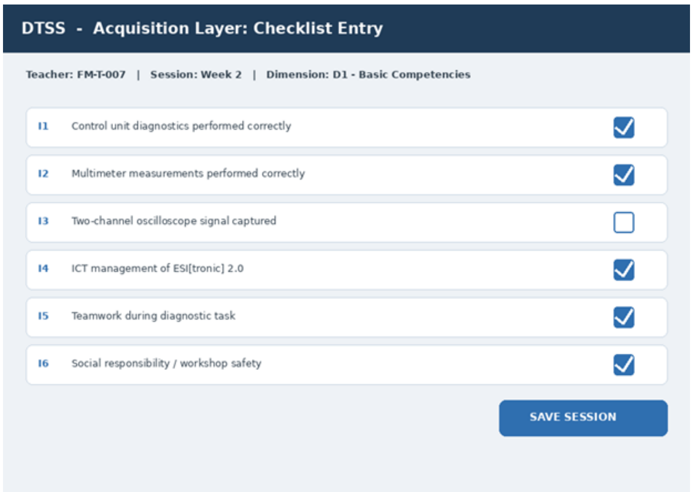

Fig. 2. Checklist-entry screen, where the instructor records dichotomous observations (Yes/No) for each Bosch KTS 590 item during a weekly session.

- **Processing layer:** a local scoring module that aggregates dichotomous item responses (0 = No, 1 = Yes) into the three dimensions of the dependent variable (basic, specific, and transversal competencies) and computes per-dimension and overall scores for both the pretest and the posttest.

Teacher	D1 Basic	D2 Specific	D3 Transversal	Total	Level
FM-T-001	9/10	6/6	5/5	20/21	High
FM-T-002	8/10	5/6	5/5	18/21	High
FM-T-003	6/10	4/6	4/5	14/21	Average
FM-T-004	9/10	6/6	4/5	19/21	High
FM-T-005	10/10	5/6	5/5	20/21	High
FM-T-006	5/10	3/6	3/5	11/21	Low
FM-T-007	9/10	6/6	5/5	20/21	High

Fig. 3. Teacher progress dashboard generated by the DTSS reporting layer, showing average pretest/posttest scores per dimension and the posttest performance level reached by each teacher.

eISSN: 2583-1194

- **Reporting layer:** a dashboard that exports the consolidated data matrix in a format compatible with SPSS and R Studio, the same statistical packages used for the inferential analysis reported in the Results section, and that generates per-teacher progress charts for the eight weekly sessions.

Fig. 4. Data matrix export screen, consolidating per-teacher dimension scores and overall performance level prior to export to SPSS / R Studio.

Table 3 summarizes the correspondence between each architectural layer, its main function, and the research instrument it supports.

Table 3. Correspondence between the DTSS architectural layers, their function, and the research instruments.

Layer	Main Function	Related Instrument
Acquisition	Digital capture of checklist items per training session	KTS 590 checklist
Processing	Aggregation and scoring of dichotomous items by dimension	Pretest/posttest questionnaire
Reporting	Export of the data matrix and progress visualization	SPSS / R Studio data matrix

6.2 Scoring Algorithm

The core of the processing layer is a deterministic scoring procedure executed after each session and again at the close of the training program. Algorithm 1 describes its logic in pseudocode.

```
Algorithm 1: DTSS_Score(responses, dimension_map)

Input:  responses[1..21]        // dichotomous answers, 0 or 1
        dimension_map           // maps item index to {D1, D2, D3}
Output: scores{D1, D2, D3, Total}, level{Low, Average, High}

for each dimension d in {D1, D2, D3}:
    items_d ← items in responses where dimension_map[i] = d
    scores[d] ← sum(items_d)
    max_d ← count(items_d)
```

```
5.      pct_d ← scores[d] / max_d
6.      level[d] ← Classify(pct_d)
7.  Total ← sum(scores[D1], scores[D2], scores[D3])
8.  level[Total] ← Classify(Total / 21)
9.  return scores, level

Function Classify(pct):
10. if pct < 0.50:  return Low
11. if pct < 0.75:  return Average
12. else:           return High
```

Algorithm 1. Dichotomous scoring and three-level classification procedure applied to the Teaching Performance instrument.

The classification thresholds in lines 10–12 reproduce the low/average/high cut points already used for the descriptive analysis of the dependent variable, so that the system's automated output is directly comparable with the manually computed frequencies reported in the Results section. Because the algorithm performs a single linear pass over a fixed number of 21 items, partitioned into three dimensions, its time complexity is O(n), where n is the number of checklist items, and its space complexity is O(1) beyond the storage of the input vector, which makes it suitable for execution on the tablet used during each training session without noticeable latency.

6.3 Reference Implementation

A minimal reference implementation of Algorithm 1 was coded in Python to validate the scoring logic before the checklist items were administered, as shown below.

Algorithm 2. Python reference implementation used to validate the dichotomous scoring logic prior to data collection.

```
def classify(pct: float) -> str:
    if pct < 0.50:
        return "Low"
    elif pct < 0.75:
        return "Average"
    return "High"

def dtss_score(responses: list[int], dimension_map: dict[int, str]) -> dict:
    dims = {"D1": [], "D2": [], "D3": []}
    for idx, value in enumerate(responses, start=1):
        dims[dimension_map[idx]].append(value)

    scores, levels = {}, {}
    for d, items in dims.items():
        scores[d] = sum(items)
        levels[d] = classify(scores[d] / len(items))

    total = sum(scores.values())
    levels["Total"] = classify(total / len(responses))
    return {"scores": scores, "levels": levels, "total": total}
```

6.4 Implementation Limitations

The DTSS was conceived as a support tool for data collection and consistency checking rather than as a substitute for the statistical analysis reported in the Results section, which was carried out independently in SPSS version 27 and R Studio. The system does not perform inferential statistics, and its classification thresholds are descriptive rather than diagnostic; consequently, all hypothesis testing in this study continued to rely on the Shapiro–Wilk normality test and the Wilcoxon signed-rank test, as reported above. Future iterations of the DTSS could incorporate connectivity with the KTS 590 scanner itself, following IoT-based vehicle diagnostic architectures already documented in the literature [12], [71], in order to log equipment usage data automatically rather than through manual checklist entry.

7.METHODOLOGY

7.1 Research Approach

The research follows a quantitative approach. The term quantitative etymologically derives from the Latin quantitas, which refers to the numerical counting of real data using mathematical calculations. This type of research aims to provide explanations for its research questions based on the epistemology of the exact sciences and following an orderly sequence of procedures.

Science is expected to be grounded in observation, verification, and first-hand experience, with knowledge relying on the analysis of factual evidence so that descriptions can be as neutral, objective, and complete as possible [72].

Having real and verifiable data allows the researcher to obtain more accurate results in order to test the hypotheses and determine whether their application is feasible. This process contributes to building knowledge and answering the research questions posed in the study, ultimately proposing possible solutions to the identified problem.

Quantitative research is grounded in previous studies. Literature plays a key role because it guides the entire research process. Through this information, the researcher formulates the problem statement, constructs the theoretical framework, develops hypotheses, and defines the research design.

The quantitative approach is sequential and confirmatory, meaning that all stages complement each other and no steps should be skipped; the order must be respected, although certain stages may be redefined if necessary [72].

Furthermore, quantitative research employs deductive reasoning, moving from general laws and theories to specific data or facts. However, conclusions derived from deductive reasoning must be tested against reality in order to be accepted or rejected within the research context.

Likewise, it is important to consider that the quantitative approach is supported by the positivist and post-positivist paradigms. Positivism, developed by Auguste Comte (1798–1857) and Émile Durkheim (1858–1917), holds that social phenomena must be studied using the scientific method and that all phenomena analyzed by science must be measurable to ensure their validity [73].

According to this paradigm, statements that cannot be directly or indirectly verified through empirical evidence are not considered valid. Only those statements confirmed through observation are accepted, and the researcher must maintain an objective position. Finally, the post-positivist perspective introduces certain corrections to positivism. Positivists argue that there must be independence between the researcher and the research object. However, post-positivists acknowledge that the researcher is a social being with beliefs, experiences, philosophical positions, and even religious perspectives that may influence observations and potentially introduce bias into the research. This situation does not invalidate research findings but rather reflects the complexity of social inquiry. Consequently, post-positivists recognize that both quantitative and qualitative methods are valid research approaches because they develop within social practice. [74]

7.2 Type of Research

The research is applied and explanatory in nature. Applied research seeks to solve practical problems. It is a process that transforms knowledge generated by basic research into new concepts, products, solutions, and further research developments. These innovations result from the interaction between researchers and end users in order to respond to the evolving needs of society.

In this case, the researcher intervened in a specific context involving teachers from the Fuerza Motriz study program of the Faculty of Technology at public university (2026), with the aim of addressing and overcoming the lack of knowledge among teachers regarding the operation of the Bosch KTS 590 automotive diagnostic scanner.

7.3 Research Design

The study employed a pre-experimental design, since it involved a single group composed of 10 teachers and 1 workshop assistant from the Fuerza Motriz study program at public university.

A research design refers to the plan developed to obtain the information required to answer the research problem. A set of methods and techniques is used to control the research process.

In this study, a pretest–posttest design with a single group was applied.

In this design, a group is first subjected to a pretest prior to the experimental stimulus or treatment. Then the treatment is administered, followed by a posttest.

This design offers an advantage over a single measurement because it provides an initial reference point to determine the group's baseline level in the dependent variables before the stimulus is applied.

However, the design has limitations for establishing causality because there are no control group and no manipulation of variables. Other events occurring between the pretest and posttest may influence the results, potentially generating internal validity threats.

The experimental group consisted of 11 participants. The use of the Bosch KTS 590 scanner served as the stimulus applied to the experimental group in order to determine its influence on the dependent variable (teaching performance). Additionally, a pretest and posttest were applied during the training process, and supporting materials were provided.

The research design can be represented as follows:

G — O1 — X — O2

Where:

- G: Group of participants (teachers)
- O1: Pretest evaluation applied to the experimental group
- X: Training in the use of the Bosch KTS 590 scanner (experimental stimulus)
- O2: Posttest evaluation applied to the experimental group

7.4 Method

The research employed the hypothetical-deductive method. Based on inferential statistical analysis, the study seeks to determine whether the application of the Bosch KTS 590 scanner significantly influences teaching performance (basic, specific, and transversal competencies) among teachers of the Fuerza Motriz program at public university.

This method begins with hypotheses derived from principles or theoretical laws and is tested through empirical data. Through inferential reasoning, predictions are generated and subsequently verified through observation and practice. If the predictions derived from the hypothesis are consistent with the empirical data, the hypothesis is accepted. If contradictions arise, the hypothesis must be reformulated.

One of the main advantages of this method is its flexibility, which allows modifications during the research process. This flexibility enables adjustments to the theoretical framework, conceptual definitions, and methodological procedures when necessary.

7.5 Population and Sample

Population

The population consisted of 30 teachers from the Electromechanical Professional School of the Faculty of Technology at public university (2026).

Table 4. Distribution of Teachers in the Electromechanical Professional School

Electromechanical Professional School	Number of People
Fuerza Motriz Study Program	10
Electricity Study Program	10
Industrial Automation Study Program	10
Total	**30**

Table 4 shows the total population distributed according to the study programs and the number of teachers in each.

Sample

The sample was determined through non-probabilistic intentional sampling and consisted of 10 teachers and 1 workshop assistant from the Fuerza Motriz study program.

Table 5. Sample

Fuerza Motriz Study Program	Number of People
Teachers	10
Workshop Assistant	1
Total	**11**

Table 5 presents the sample size used in the research.

7.6 Data Collection Techniques and Instruments

Techniques are the procedures used by researchers to establish relationships with research objects or participants, while instruments are the mechanisms or documents used to collect and record information.

These techniques and instruments are not exclusive to a specific discipline. Researchers must select those most appropriate to their research objectives in order to ensure the validity of the collected data.

The following techniques were used:

Document Analysis Technique

Information related to the research topic was reviewed from theses, books, journal articles, conferences, and websites. A content analysis instrument was used to extract relevant information that supports the study.

Survey Technique

A dichotomous survey questionnaire was applied to measure both variables. The instrument was administered in person to the experimental group and online to a pilot group.

Observation Technique

Observation allowed the researcher to record real and immediate information about events occurring during the research process, facilitating continuous improvement of the training process.

Inspection Technique

This technique was used to ensure preventive control of the independent variable (Bosch KTS 590 scanner) and the surrounding environment in order to guarantee its correct operation during the training process. This procedure also ensured compliance with occupational safety and health standards.

When applying the checklist instrument, it was necessary to do so carefully and objectively while implementing corrective actions when required.

All data collection instruments were required to meet three criteria:

- Reliability
- Validity
- Objectivity

Statistical Analysis

The population consisted of 30 teachers, while the sample included 10 teachers and 1 workshop assistant.

The research was conducted in the Electromechanical Professional School – Fuerza Motriz Study Program at the Faculty of Technology of public university.

Data processing involved collecting information using the previously described techniques and verifying the consistency of the collected data.

The analysis was conducted using two types of statistics:

Descriptive Statistics

Descriptive statistics allow the analysis of a complete dataset from which conclusions can be drawn that apply specifically to that dataset.

The following analysis tools were used:

- Bar charts

Inferential Statistics

Inferential statistics aim to obtain general conclusions about a population by analyzing a representative sample [18].

The following analyses were performed:

- Reliability analysis: Kuder-Richardson Formula (KR-20)
- Normality test: Shapiro-Wilk test ($n < 50$)
- Hypothesis testing: Wilcoxon signed-rank test for related samples (since data did not follow a normal distribution)

Data were processed using:

- Microsoft Excel
- SPSS version 27
- R Studio

7.7 Technical Sheet of the Instrument

Name: Questionnaire 2 to measure the dependent variable Teaching Performance

Year: 2025

Objective: Determine the effects of the application of the Bosch KTS 590 scanner on the basic, specific, and transversal competencies of teachers in the Fuerza Motriz program.

Population: 10 teachers and 1 workshop assistant

Number of questions: 21 questions distributed as follows:

- 10 questions: Basic competencies
- 6 questions: Specific competencies
- 5 questions: Transversal competencies

Administration: Individual / group

Duration: 20–25 minutes

Item type: Closed – Dichotomous

Validity

- Content validity: expert judgment
- Construct validity: exploratory factor analysis (EFA)

Reliability

- Internal consistency calculated using Kuder-Richardson Formula 20 (KR-20).

7.8 Ethical Considerations

This research is based on the premise that it contributes to the benefit of teachers and the student community of the Fuerza Motriz study program.

From an ethical perspective, the study respects institutional regulations, the rights and responsibilities of participants, and the professional ethics of the researcher in order to safeguard the results derived from the research for the benefit of the common good.

The main ethical objective of the research is to protect and respect the participants involved in the study, ensuring their well-being and professional development.

The research also follows ethical principles such as:

- Justice
- Beneficence
- Non-maleficence
- Autonomy in selecting the research topic
- Commitment to truth
- Avoidance of plagiarism
- Respect for intellectual property
- Protection of participants, resources, and materials used in the research

These ethical principles are established in Resolution No. 3314-2019-R-UNE, which corresponds to the Code of Ethics for University Research of public university.

The research process began with a request for institutional authorization from the Faculty of Electromechanics and the Fuerza Motriz study program in order to obtain permission to conduct the research.

8.RESULTS

8.1 Validity and Reliability of the Instruments

Instrument Validation

Validity is broadly defined as the degree to which an instrument actually measures the variable it is intended to measure.

In this regard, the validation of the research instruments was submitted for expert judgment for review. The experts were able to make observations or recommendations for improvement if necessary and subsequently issue a value judgment.

The procedure was as follows: three experts from the university were contacted and provided with the following documents:

- the consistency matrix,
- the operationalization of variables, and
- the research instrument (questionnaire) for the dependent variable.

They were then asked to conduct the corresponding evaluation. Finally, they issued a favorable judgment, indicating that the research instrument was applicable. The results are shown in Table 6.

Table 6 presents the names of the experts who evaluated the instrument.

Table 6. Content Validity by Expert Judgment of the Teaching Performance Instrument

No.	Experts	Institution	Opinion	Score
1	Dr. César Contreras Salazar	Undergraduate Professor – UNE	Applicable	80.00
2	Mg. Rósulo Ordaya Casas	Undergraduate Professor – UNE	Applicable	85.00
3	Dr. Juan A. Romero Silva	Undergraduate Professor – UTP	Applicable	81.00
			Average	**82.00**

The content validity results obtained through expert judgment indicate that, for the questionnaire measuring the dependent variable Teaching Performance, the average value was 82.00%.

Therefore, it can be inferred that the validation level is classified as Excellent according to the validation scale. Consequently, it is concluded that the instrument is applicable for the research process.

Instrument Reliability

Defining the reliability of an instrument refers to the fact that it can be applied multiple times to the same individual and will produce similar results [20].

Different techniques may be used depending on the type of measurement instrument applied. Generally, the reliability value ranges between 0 and 1. A value of 0 indicates no reliability, while values closer to 1 indicate higher reliability.

In this research, to determine the reliability of the measurement instruments for the variables, the Kuder–Richardson Formula 20 (KR-20) was used to calculate internal consistency, since the evaluation was based on dichotomous scales.

The reliability index obtained for the variable is shown in Table 7.

Table 7. Reliability Index of the Dependent Variable

Instrument	Kuder-Richardson (KR-20)	Number of Items
Teaching performance	0.930	22

Table 7 shows a reliability index of 0.930, indicating that the instrument has high reliability and can therefore be applied to the sample.

8.2 Presentation and Analysis of Results

Descriptive Analysis

Descriptive Analysis of the Teaching Performance Variable

Table 8. Distribution of Levels of the Teaching Performance Variable (Pretest and Posttest)

	Low		Average		High		Total	
	F	%	F	%	F	%	F	%
Teaching performance pretest	1	9%	5	45.5%	5	45.5%	11	100%
Teaching performance posttest	1	9%	2	18.2%	8	72.8%	11	100%

The analysis of the pretest results for the teaching performance variable shows an equal distribution between average and high levels, each representing 45.5% of the respondents. This indicates that before the training, nearly half of the teachers were at an intermediate level of performance, while the other half demonstrated a high level of performance.

Additionally, 9% of teachers were at a low performance level prior to the intervention. Although this percentage represents a minority, it indicates the presence of difficulties related to the use of technological tools or the teaching of complex technical content.

After the intervention, which consisted of training using the Bosch KTS 590 scanner, a significant improvement in teaching performance levels can be observed.

In the posttest, 72.8% of teachers reached a high level of performance, representing a substantial increase compared to the 45.5% observed in the pretest. At the same time, the percentage of teachers at the average level decreased to 18.2%, suggesting that many teachers improved their competencies after the training.

However, the 9% of teachers at the low level remained unchanged, indicating that additional training or reinforcement strategies could be beneficial for this group.

Descriptive Analysis of the Basic Competencies Dimension

Table 9. Distribution of Levels of the Basic Competencies Dimension

	Low		Average		High		Total	
	F	%	F	%	F	%	F	%
Basic competencies pretest	2	18.2%	4	36.4%	5	45.4%	11	100%
Basic competencies posttest	1	9.1%	3	27.3%	7	63.6%	11	100%

The pretest results show that 45.4% of teachers were at a high level of basic competencies, indicating that nearly half of the participants already demonstrated an adequate mastery of essential teaching competencies prior to the training.

Additionally, 36.4% were at a medium level, suggesting that although these teachers possessed some competencies, there were still areas requiring improvement, particularly related to the use of advanced technological tools.

Furthermore, 18.2% of teachers were at a low level, indicating more significant difficulties in the evaluated competencies, especially in the management of tools and planning of technical activities.

After the intervention, the high competency level increased to 63.6%, representing an improvement of 18.2% compared to the pretest. This suggests that the training with the Bosch scanner positively influenced teachers' basic competencies.

Meanwhile, 27.3% of teachers remained at the average level, indicating that some teachers still require additional training to reach a high level.

Finally, 9.1% remained at the low level, which implies that a small proportion of teachers did not significantly improve and could benefit from additional or personalized training strategies.

Descriptive Analysis of the Specific Competencies Dimension

Table 10. Distribution of Levels of the Specific Competencies Dimension

	Low		Average		High		Total	
	F	%	F	%	F	%	F	%
Specific competencies pretest	3	27.3%	3	27.3%	5	45.4%	11	100%
Specific competencies posttest	1	9%	1	9%	9	82%	11	100%

The increase in the high level from 45.4% to 82% demonstrates that training using the Bosch scanner was effective in improving teachers' specific competencies, enabling them to apply technical knowledge more efficiently in their daily teaching practice.

The decrease in the average level from 27.3% to 9% suggests that most teachers advanced in their skills after the training.

Similarly, the reduction in the low level from 27.3% to 9% indicates that many teachers improved their competencies. However, the remaining 9% could benefit from reinforcement programs or personalized strategies to overcome existing limitations.

Descriptive Analysis of the Transversal Competencies Dimension

Table 11. Distribution of Levels of the Transversal Competencies Dimension

	Low		Average		High		Total	
	F	%	F	%	F	%	F	%
Specific competencies pretest	3	27.3%	3	27.3%	5	45.4%	11	100%
Specific competencies posttest	1	9%	1	9%	9	82%	11	100%

The increase in the high level from 63.6% to 82% clearly indicates that the training program was successful in improving teachers' transversal competencies.

This result demonstrates that most participants were able to develop important skills to enhance their educational performance.

The reduction in the average level from 18.2% to 9% shows that the intervention helped several teachers move from an intermediate level to a higher level of competency.

Finally, the reduction of the low level from 18.2% to 9% is also a positive result, although the remaining 9% of teachers could benefit from additional interventions aimed at strengthening their transversal competencies.

Inferential Analysis

Normality Test

The normality test was performed using SPSS software version 27.

Table 12. Normality test of the dependent variable Teaching Performance

Variable	Kolmogorov-Smirnov	gl	Sig.	Shapiro-Wilk	gl	Sig.
PRE_TEST_TEACHING_PERFORMANCE	0.314	11	0.003	0.782	11	0.005
POST_TEST_TEACHING_PERFORMANCE	0.329	11	0.002	0.617	11	0.000

In Table 12, it can be observed that the number of observations is 11, and since this value is less than 50, the Shapiro–Wilk test was applied. Additionally, the p-values obtained in all analyzed cases are ≤ 0.05, specifically 0.005 in the pretest and 0.000 in the posttest. From this analysis, it is concluded that the data do not follow a normal distribution. Therefore, the non-parametric Wilcoxon test was applied.

General Hypothesis Test

Null Hypothesis (H0):

The application of the Bosch KTS 590 scanner does not significantly influence the teaching performance of the Fuerza Motriz program at public university, 2026.

Alternative Hypothesis (H1):

The application of the Bosch KTS 590 scanner significantly influences the teaching performance of the Fuerza Motriz program at public university, 2026.

Hypothesis acceptance criterion:

If the Wilcoxon test yields a significance value lower than 0.05, H1 will be accepted; otherwise, the null hypothesis will be accepted.

Table 13. General hypothesis test

Teaching Performance Pretest – Posttest[a]	
Z	-2.952[b]
Asymptotic Sig. (two-tailed)	0.003

a. Wilcoxon signed-rank test

b. Based on negative ranks

According to the hypothesis acceptance criterion, and since the significance value is lower than the established parameter (0.05), it is determined that the application of the Bosch KTS 590 scanner has a relevant and significant influence on the teaching performance of the Fuerza Motriz program at public university, 2026.

Specific Hypothesis Test 1

Null Hypothesis (H0):

The application of the Bosch KTS 590 scanner does not significantly influence the basic competencies of teaching performance in the Fuerza Motriz program at public university, 2026.

Alternative Hypothesis (H1):

The application of the Bosch KTS 590 scanner significantly influences the basic competencies of teaching performance in the Fuerza Motriz program at public university, 2026.

Hypothesis acceptance criterion:

If the Wilcoxon test produces a significance value lower than 0.05, H1 will be accepted.

Table 14. Specific hypothesis test 1

Basic Competencies Pretest – Posttest[a]	
Z	-2.944[b]
Asymptotic Sig. (two-tailed)	0.003

a. Wilcoxon signed-rank test

b. Based on negative ranks

Based on the acceptance criterion, the significance value is lower than 0.05, confirming that the application of the Bosch KTS 590 scanner significantly influences the basic competencies of teaching performance.

Specific Hypothesis Test 2

Null Hypothesis (H0):

The application of the Bosch KTS 590 scanner does not significantly influence the specific competencies of teaching performance.

Alternative Hypothesis (H1):

The application of the Bosch KTS 590 scanner significantly influences the specific competencies of teaching performance.

Hypothesis acceptance criterion:

If the Wilcoxon test produces a significance value lower than 0.05, H1 will be accepted.

Table 15. Specific hypothesis test 2

Specific Competencies Pretest – Posttest[a]	
Z	-2.697^{b}
Asymptotic Sig. (two-tailed)	0.007

a. Wilcoxon signed-rank test

b. Based on negative ranks

The significance obtained (0.007) is lower than 0.05, indicating that the application of the Bosch KTS 590 scanner significantly influences the specific competencies of teaching performance.

Specific Hypothesis Test 3

Null Hypothesis (H0):

The application of the Bosch KTS 590 scanner does not significantly influence the transversal competencies of teaching performance.

Alternative Hypothesis (H1):

The application of the Bosch KTS 590 scanner significantly influences the transversal competencies of teaching performance.

Hypothesis acceptance criterion:

If the Wilcoxon test produces a significance value lower than 0.05, H1 will be accepted.

Table 16. Specific hypothesis test 3

Transversal Competencies Pretest – Posttest[a]	
Z	-2.588^{b}
Asymptotic Sig. (two-tailed)	0.010

a. Wilcoxon signed-rank test

b. Based on negative ranks

Since the obtained significance value (0.010) is lower than 0.05, it is concluded that the application of the Bosch KTS 590 scanner significantly influences the transversal competencies of teaching performance.

8.3 Appendix I: Training Program for the Use of the Bosch KTS 590 Scanner

The content and development of the training sessions were carried out as follows:

Week 1 (September 15, 2025)

Technology: Bosch KTS 590 scanner. ESI[tronic] 2.0 software. Electronic automotive diagnostics. Diagnostic pillars. Communication protocols. Electrical energy management in the vehicle. Initial screens of the KTS 590 scanner.

Applied Technology: Perform an inventory/check of the scanner. Locate the diagnostic connector in the vehicle. Identify the pins of the diagnostic connector. Check the battery.

Week 2 (September 15, 2025)

Technology: Functions of the Bosch KTS 590 scanner. Structure of the ESI[tronic] 2.0 software.

Applied Technology: Navigate through the control unit diagnostic function. Perform measurements using the multimeter function. Capture signals using the two-channel oscilloscope function. Navigate through the description of the icons in the main menu toolbar.

Week 3 (April 5, 2026)

Technology: KTS 590 hardware configuration. Vehicle selection.

Applied Technology: Navigate through the main menu functions. Navigate through the functions used to select a vehicle.

Week 4 (April 5, 2026)

Technology: Diagnosis of vehicle electronic management systems. Fundamentals. Prior knowledge. Engine management diagnosis. ABS management diagnosis. Service tasks.

Applied Technology: Diagnose the electronic engine management system. Diagnose the electronic ABS management system. Perform service tasks.

Week 5 (May 3, 2026)

Technology: Diagnosis of vehicle electronic management systems. Fundamentals. Prior knowledge. Engine management diagnosis. ABS management diagnosis. Service tasks.

Applied Technology: Diagnose the electronic engine management system. Diagnose the electronic ABS management system. Perform service tasks.

Week 6 (May 3, 2026)

Technology: Multimeter function.

Applied Technology: Perform diagnostics using the multimeter function.

Week 7 (May 10, 2026)

Technology: Two-channel oscilloscope function.

Applied Technology: Perform diagnostics using the two-channel oscilloscope function.

Week 8 (May 10, 2026)

Technological Innovations for the Automotive Sector: Market trends. Aftermarket sector. Hybrid propulsion. Safety and efficiency in motorcycles. Common rail technology. Gasoline direct injection system – MED. Driving assistance and steering systems. Automated driving. New generation ESP. Mobility solutions. Security Gateway / Cybersecurity.

9.DISCUSSION

The results obtained in this research indicate that training in the use of the Bosch KTS 590 scanner had a significant impact on teaching performance in the electromecánica area.

Before the intervention, teachers showed limited knowledge regarding the use of the equipment, reflected in the low scores obtained in the Bosch KTS 590 scanner checklist, which was used to evaluate the practical handling of the device during training sessions. This instrument was essential to understand how teachers acquired specific technical skills.

After the training process, however, most teachers successfully understood and effectively handled the equipment, which is reflected in the notable improvement observed in the qualitative evaluation conducted through the Bosch KTS 590 checklist.

Previous studies have shown that the integration of new technologies into technical education significantly improves teaching performance and technological skill development. Evaluating the technological competencies of teachers in higher education institutions has a direct impact on the development of their technological skills [75]. In several of these studies, teachers demonstrated significant levels of technological integration in their pedagogical practices as a result of continuous training and the strengthening of technological infrastructure.

Similarly, Kakhorov and Rasulova support this perspective, stating that improving the professional activity of technology teachers through the incorporation of modern pedagogical technologies significantly increases learning efficiency and the development of creative skills [13]. This highlights the need to adapt pedagogical methods to current technological demands in order to improve teachers' professional performance.

Furthermore, the inferential analysis performed using the Wilcoxon test demonstrates that the improvements observed were not due to chance but to the effectiveness of the training program. The significant difference in teaching performance before and after the intervention supports the hypothesis that the use and application of the Bosch KTS 590 scanner improves teachers' technical skills.

However, an important aspect that must be considered is the long-term sustainability of this type of training. Although the improvement is evident in the short term, it is necessary to implement continuous follow-up programs to ensure that teachers continue improving their technical skills. Literature also suggests that a single intervention may not be sufficient to guarantee sustained changes in teaching performance [55].

Overall, this study provides evidence of the importance of technical training in improving teaching performance at public university. The implementation of similar training interventions could be replicated in other institutions in order to improve the quality of professional education.

Regarding the general objective, which aimed to evaluate the effects of the application of the Bosch KTS 590 scanner on teaching performance, the results confirmed that the application of the scanner positively influences teaching performance.

These findings are consistent with the study by Marcillo and Orellana, who demonstrated that the implementation of printed circuit design technology using SolidWorks in technical education significantly improved teaching and learning processes in the electronics laboratory at UNESUM in Ecuador [76].

For Specific Objective 1, the results indicated that the application of the scanner positively influenced basic competencies. These results are consistent with Salcedo, who found that the implementation of new technologies significantly improved teaching performance among educators at the Amazon Polytechnic University in Bagua Grande [14].

For Specific Objective 2, the findings showed that the scanner positively influenced specific competencies. These results align with the study by Marcillo and Tumbaco, who reported that the implementation of CNC technology significantly improved teaching and learning processes in robotics laboratories [15].

Finally, regarding Specific Objective 3, the results showed that the scanner positively influenced transversal competencies. These findings are also consistent [16], reinforcing the theoretical and practical consistency between studies regarding the integration of technological tools in technical education.

10.CONCLUSIONS

First: There are positive, relevant, and significant effects of the application of the Bosch KTS 590 scanner on the teaching performance of the Fuerza Motriz program at public university, 2026.

Second: There are positive, relevant, and significant effects of the application of the Bosch KTS 590 scanner on the basic competencies of teachers.

Third: There are positive, relevant, and significant effects of the application of the Bosch KTS 590 scanner on the specific competencies of teachers.

Fourth: There are positive, relevant, and significant effects of the application of the Bosch KTS 590 scanner on the transversal competencies of teachers.

11.RECOMMENDATIONS

The current curriculum focuses mainly on repair topics. Based on current market needs, the Fuerza Motriz study program curriculum should incorporate automotive diagnostics using the Bosch KTS 590 scanner across all specialization courses.

During the teaching of specialization courses, teachers should use updated information from the ESI[tronic] 2.0 software relevant to the subjects they teach.

Teachers in the Fuerza Motriz program should participate annually in continuous training programs focused on specialization courses in order to remain updated and improve their teaching performance.

It is recommended to conduct similar studies with a larger sample of teachers in order to generalize the results and obtain a more robust understanding of the impact of the Bosch KTS 590 scanner on teaching performance.

Future studies should also explore the use of complementary technologies to the Bosch KTS 590 scanner, such as simulation software or online platforms, to expand opportunities for learning and continuous training.

AUTHOR CONTRIBUTIONS

Rolando Hinostroza-Ibarra: Conceptualization, Investigation.

Darwin Gutierrez-Alamo: Methodology, Laboratory Analysis.

Nerio Enriquez-Gavilan: Data Curation, Formal Analysis.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required for this study.

REFERENCES

[1] J. Liao, M. Wang, X. Wu, Y. Wang, and X. Wei, "IAEAgent: LLM-Based Educational Agent for Instructional Alignment Evaluation in University Courses," *IEEE Trans. Learn. Technol.*, vol. 19, p. Article 19, 2026, doi: 10.1109/TLT.2026.3695576.

[2] S. Rosales-Anzola, D. Baptista, and C. Guillen-Drija, "A Decision Support System for Faculty Performance Management: A Case Report using Statistical Analysis, Text Mining, and Artificial Intelligence," *J. Ind. Eng. Manag.*, vol. 19, no. 2, p. Article 19(2), Apr. 2026, doi: 10.3926/jiem.9019.

[3] L. Li and X. Wang, "Technostress inhibitors and creators and their impacts on university teachers' work performance in higher education," *Cogn. Technol. Work*, vol. 23, no. 2, pp. 315–330, May 2021, doi: 10.1007/s10111-020-00625-0.

[4] I. D. Mamaev, "Towards the Issue of Creating Linguistic Pedagogical Profiles," *NLPIR 2024 - 2024 8th Int. Conf. Nat. Lang. Process. Inf. Retr.*, vol. Nlpir, p. Article Retrieval, Apr. 2025, doi: 10.1145/3711542.3711584.

[5] C. Aldana, J. Adauto, Y. Saavedra, and V. Mestanza, "Teaching management based on student outcomes for continuous improvement in an engineering program, 'ICACIT,'" *Proc. - 7th Int. Symp. Accredit. Eng. Comput. Educ. ICACIT 2021*, vol. Proceedings, p. Article 2021, 2021, doi: 10.1109/ICACIT53544.2021.9612474.

[6] C. Aldana, Y. Saavedra, F. Saavedra, C. Lecarnaque, and Y. Aguirre, "Continuous improvement in the faculty of an engineering program, ICACIT-V.3.2.," *Proc. - 8th Int. Symp. Accredit. Eng. Comput. Educ. ICACIT 2022*, vol. Proceedings, p. Article 2022, 2022, doi: 10.1109/ICACIT56139.2022.10041503.

[7] H. L. S. Chen, H. Jou, S. P. Lin, and I. A. J. Sianturi, "Developing Teacher Performance Indicators for 21st Century Competency-Oriented Teaching and Learning: Implications From IB Philosophy and Practices," *Bull. Educ. Res.*, vol. 70, no. 4, p. Article 70(4), Dec. 2024, doi: 10.6910/BER.202412_70(4).0003.

[8] J. Wu, "Modeling Personalized Smart Teaching for Learner Needs," *Appl. Math. Nonlinear Sci.*, vol. 9, no. 1, p. Article 9(1), Jan. 2024, doi: 10.2478/amns-2024-1384.

[9] G. PANGA, S. ZAMFIR, T. BĂLAN, and O. POPA, "IOT DIAGNOSTICS FOR CONNECTED CARS," *Sci. Res. Educ. AIR FORCE*, vol. 18, no. 1, pp. 287–294, Jun. 2016, doi: 10.19062/2247-3173.2016.18.1.39.

[10] M. Gopalan, K. Rosinger, and J. Bin Ahn, "Use of Quasi-Experimental Research Designs in Education Research: Growth, Promise, and Challenges," *Rev. Res. Educ.*, vol. 44, no. 1, pp. 218–243, Mar. 2020, doi: 10.3102/0091732X20903302.

[11] C. Antonietti, A. Cattaneo, and F. Amenduni, "Can teachers' digital competence influence technology acceptance in vocational education?," *Comput. Human Behav.*, vol. 132, p. 107266, Jul. 2022, doi: 10.1016/j.chb.2022.107266.

[12] M. R. B. Mandlik, "IOT System for Monitoring and Diagnostics of Engine," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 7, no. 4, pp. 487–492, Apr. 2019, doi: 10.22214/ijraset.2019.4089.

[13] L. Tu, Z. Rao, H. Jiang, and L. Dai, "Technostress, Burnout, and Job Satisfaction: An Empirical Study of STEM Teachers' Well-Being and Performance," *Behav. Sci. (Basel).*, vol. 15, no. 7, p. 992, Jul. 2025, doi: 10.3390/bs15070992.

[14] J. Sánchez-Prieto, J. M. Trujillo-Torres, M. Gómez-García, and G. Gómez-García, "Incident Factors in the Sustainable Development of Digital Teaching Competence in Dual Vocational Education and Training Teachers," *Eur. J. Investig. Heal. Psychol. Educ.*, vol. 11, no. 3, pp. 758–769, Jul. 2021, doi: 10.3390/ejihpe11030054.

[15] F. Pettersson, "On the issues of digital competence in educational contexts – a review of literature," *Educ. Inf. Technol.*, vol. 23, no. 3, pp. 1005–1021, May 2018, doi: 10.1007/s10639-017-9649-3.
[16] V. A. Villarroel and D. V Bruna, "Competencias Pedagógicas que Caracterizan a un Docente Universitario de Excelencia: Un Estudio de Caso que Incorpora la Perspectiva de Docentes y Estudiantes," *Form. Univ.*, vol. 10, no. 4, pp. 75–96, 2017, doi: 10.4067/S0718-50062017000400008.
[17] Januri, A. Maksum, I. Muda, and R. B. Bukit, "Teaching performance at private universities in Medan City: Analysis of factors affecting university governance," *Int. J. Innov. Res. Sci. Stud.*, vol. 6, no. 2, p. Article 6(2), 2023, doi: 10.53894/ijirss.v6i2.1339.
[18] C. Tutyandari, C. L. Anandari, and P. Ardi, "THE IMPLEMENTATION OF VIRTUAL PEER MENTORING IN MICRO TEACHING CLASSES," *Llt J. J. Lang. Lang. Teach.*, vol. 25, no. 2, p. Article 25(2), Oct. 2022, doi: 10.24071/llt.v25i2.4213.
[19] F. Gao and X. Xiao, "Application Scenarios and Framework Construction of Artificial Intelligence Technology in Higher Vocational Education," *Appl. Math. Nonlinear Sci.*, vol. 9, no. 1, p. Article 20243405, Jan. 2024, doi: 10.2478/amns-2024-3405.
[20] R. Sánchez-Cabrero, M. Sandoval-Mena, G. P. Saez-Suanes, and E. López-De-Arana Prado, "Design and validation of the classroom climate for an inclusive education questionnaire (CCIEQ)," *Environ. Soc. Psychol.*, vol. 9, no. 5, p. Article 1754, 2024, doi: 10.54517/esp.v9i5.1754.
[21] O. Chamorro-Atalaya *et al.*, "Collaborative learning through virtual tools: Analysis of the perception of student satisfaction of teaching performance," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 26, no. 2, p. Article 26(2), May 2022, doi: 10.11591/ijeecs.v26.i2.pp1082-1090.
[22] N. H. Diep, V. T. T. Hoai, P. N. Son, P. T. Nga, H. T. P. Thuy, and N. M. Duc, "Developing competencies of natural science teachers for designing and organizing STEM education activities in Vietnam," *Int. J. Educ. Pract.*, vol. 11, no. 3, p. Article 11(3), Apr. 2023, doi: 10.18488/61.v11i3.3430.
[23] R. Murnak, "The importance of teaching performance artistry," *J. Pop. Music Educ.*, vol. 8, no. 2, p. Article 8(2), Jun. 2024, doi: 10.1386/jpme_00110_1.
[24] L. F. Vargas-Madriz and N. Nocente, "Exploring students' willingness to provide feedback: A mixed methods research on end-of-term student evaluations of teaching," *Soc. Sci. Humanit. Open*, vol. 8, no. 1, p. Article 100525, Jan. 2023, doi: 10.1016/j.ssaho.2023.100525.
[25] L. Fernández-Olaskoaga, M. Guitert Catasús, T. Romeu Fontanillas, and J. P. Cerro Martínez, "Learning Analytics: A View on the Design and Assessment of Asynchronous Online Discussions for Better Teaching Performance," *Educ. Sci.*, vol. 13, no. 10, p. Article 1064, Oct. 2023, doi: 10.3390/educsci13101064.
[26] M. R. Farangi, H. Nejadghanbar, and M. Bahraman, "A mixed-methods investigation of critical friend groups as a tool for honing teachers' practice," *Cogent Educ.*, vol. 13, no. 1, p. Article 2610564, 2026, doi: 10.1080/2331186X.2025.2610564.
[27] D. Zhang *et al.*, "Enhancing peer teaching and psychological outcomes in medical education through structured formative assessment: a quasi-experimental study," *Front. Psychol.*, vol. 16, p. Article 1710203, 2025, doi: 10.3389/fpsyg.2025.1710203.
[28] J. G. Villegas, C. P. Carolina, and E. C. Gómez, "Planning and performance measurement in higher education: three case studies of operational research application | Planeación y medición del desempeño en educación superior: tres casos de aplicación de investigación de operaciones," *Rev. Fac. Ing.*, no. 100, p. Article (100), Jul. 2021, doi: 10.17533/udea.redin.20210526.
[29] K. L. D. Llaro, J. C. C. Guzman, M. A. S. Tipian, and A. A. T. Arana, "Digital competencies and teacher performance in the Unidad de Gestión Educativa Local Pachitea, Huánuco, 2020 | Competencias digitales y desempeño docente en la Unidad de Gestión Educativa Local Pachitea, Huánuco, 2020," *RISTI - Rev. Iber. Sist. e Tecnol. Inf.*, vol. 2021, no. E44, p. Article 2021(E44), Aug. 2021.
[30] A. H. Sam, C. Y. Fung, J. Barth, and T. Raupach, "A weighted evaluation study of clinical teacher performance at five hospitals in the UK," *Adv. Med. Educ. Pract.*, vol. 12, p. Article 12, 2021, doi: 10.2147/AMEP.S322105.
[31] M. E. Carrillo Ortega, B. A. De La Hoz Suárez, P. E. Guim Bustos, and D. Ayala Rada, "Teacher performance evaluation in higher education: Normative analysis with a focus on continuous improvement | Evaluación del desempeño docente en la educación superior: Análisis normativo con enfoque en la mejora continua," *Rev. Ciencias Soc.*, vol. 31, no. 12, p. Article 31(12), 2025.
[32] R. Brandenburg *et al.*, "'More than Marking and Moderation': A Self-Study of Teacher Educator Learning through

Engaging with Graduate Teaching Performance Assessment," *Stud. Teach. Educ.*, vol. 19, no. 3, p. Article 19(3), 2023, doi: 10.1080/17425964.2022.2164761.

[33] C. A. H. Carreón *et al.*, "Cognitive fatigue in older adult university educators during psychoadaptation to digital environments | Fatiga cognitiva en educadores universitarios adultos mayores durante la psicoadaptación a entornos digitales," *Rev. Habanera Ciencias Medicas*, vol. 22, no. 6, p. Article 22(6), 2023.

[34] E. F. Q. Alarcón, H. C. Huachaca, L. M. S. Justiniano, Y. M. A. Arias, M. L. M. Hidalgo, and D. M. M. Fernández, "Sentiment Analysis and NeutroAlgebra to Evaluate Organizational Strategies and Performance Levels of Basic Education Teachers," *Neutrosophic Sets Syst.*, vol. 74, p. Article 74, Sep. 2024.

[35] D. Ginting *et al.*, "Students' perception on TPACK practices on online language classes in the midst of pandemic," *Int. J. Eval. Res. Educ.*, vol. 11, no. 4, p. Article 11(4), Dec. 2022, doi: 10.11591/ijere.v11i4.23014.

[36] R. Damewood, F. Michelassi, A. Mansour, M. Shabahang, K. Sharp, and D. Farmer, "Blue Ribbon Committee II Faculty Development: Report of the Subcommittee on Faculty Development and Educational Support," *Ann. Surg.*, vol. 281, no. 1, p. Article 281(1), Jan. 2025, doi: 10.1097/SLA.0000000000006435.

[37] B. Babu and M. A. A. Charles, "Impact of life skill development program to improve teaching skills of teacher trainees," *Edelweiss Appl. Sci. Technol.*, vol. 8, no. 6, p. Article 8(6), 2024, doi: 10.55214/25768484.v8i6.3229.

[38] Z. He, X. Zhang, Z. Zhang, Y. Lin, and B. Yu, "Assessment of influencing factors of college and universities' teaching effects using fuzzy and deep learning techniques," *Sci. Rep.*, vol. 16, no. 1, p. Article 5168, Jan. 2026, doi: 10.1038/s41598-026-35940-5.

[39] A. B. De La Cruz, J. Herrera, F. Barturén, and L. Montaño, "Educational organizational climate as a determinant of educational success | cLIMA ORGANIZAcIONAL EDUcATIVO cOMO DETERMINANTE DEL éXITO PEDAGÓGIcO," *Encuentros Maracaibo*, vol. 17, p. Article 17, 2023, doi: 10.5281/zenodo.7527554.

[40] L. Mohebi and A. Elsayary, "EVALUATING PRESERVICE TEACHERS' PERFORMANCE IN A BLENDED FIELD EXPERIENCE COURSE DURING THE QUARANTINE OF COVID-19," *J. Educ. Online*, vol. 19, no. 3, p. Article 19(3), Sep. 2022, doi: 10.9743/JEO.2022.19.3.11.

[41] L. C. Piñón, A. L. Sapién, M. del C. Gutiérrez, and J. L. Bordas, "Use of information and communication technologies: university teaching performance on virtual mode during times of pandemic | Uso de tecnologías de información y comunicación: desempeño docente universitario en la virtualidad durante tiempos de pandemia," *Form. Univ.*, vol. 15, no. 5, p. Article 15(5), Oct. 2022, doi: 10.4067/S0718-50062022000500015.

[42] S. G. Saleh and R. M. Alali, "Teaching Performance of Students of the Faculty of Education, Sohag University: 'An Evaluative Study in Light of Teacher Preparation Standards,'" *J. Ecohumanism*, vol. 3, no. 7, p. Article 3(7), Sep. 2024, doi: 10.62754/joe.v3i7.4423.

[43] R. L. Cerveza, "The Strategies Behind the PhD in Mathematics Education Graduates' Professional Growth: Insights from a Graduate Tracer Study (2016–2023)," *Math. Teach. Res. J.*, vol. 18, no. 2, p. Article 18(2), Mar. 2026.

[44] C. Juan-Llamas, "Flipped Learning and technological tools in Statistics for Biology | Flipped Learning y herramientas tecnológicas en Estadística del grado de Biología," *Rev. Complut. Educ.*, vol. 34, no. 2, p. Article 34(2), Apr. 2023, doi: 10.5209/rced.77352.

[45] O. Chamorro-Atalaya *et al.*, "Text mining and sentiment analysis of teacher performance satisfaction in the virtual learning environment," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 28, no. 1, p. Article 28(1), Oct. 2022, doi: 10.11591/ijeecs.v28.i1.pp525-535.

[46] C. A. Huertas-Abril, M. E. Gómez-Parra, and F. J. Palacios-Hidalgo, "Peer assessment as a tool to enhance pre-service primary bilingual teachers' training | La evaluación entre iguales para mejorar la formación inicial de maestros bilingües de educación primaria," *Ried Rev. Iberoam. Educ. A Distancia*, vol. 24, no. 2, p. Article 24(2), Dec. 2021, doi: 10.5944/ried.24.2.28788.

[47] R. L. Yong, W. Cheung, R. K. Shrivastava, and J. B. Bederson, "Teaching quality in neurosurgery: quantitating outcomes over time," *J. Neurosurg.*, vol. 136, no. 4, p. Article 136(4), Apr. 2022, doi: 10.3171/2021.2.JNS203900.

[48] M. E. T. Luiz, S. E. Martins, and A. Marinho, "Teaching performance in higher education: facilities, difficulties, and perspectives in face of covid-19 | ATUAÇÃO DOCENTE NO ENSINO SUPERIOR: FACILIDADES, DIFICULDADES E PERSPECTIVAS FRENTE À COVID-19," *Rev. Bras. Educ.*, vol. 28, p. Article e280056, 2023, doi: 10.1590/S1413-24782023280057.

[49] H. Madani, A. Adhikari, and C. Hodgdon, "Understanding faculty acceptance of online teaching during the COVID-19 pandemic: a Saudi Arabian case study," *J. Int. Educ. Bus.*, vol. 16, no. 2, p. Article 16(2), Apr. 2023, doi: 10.1108/JIEB-12-2021-0109.

[50] M. G. Ayaneh, A. A. Dessie, and D. M. Fetene, "Psychometric Properties of Student Evaluation of Teachers' Performance Scale: Evidence from Debre Markos University Students' Evaluation Dataset," *Educ. Res. Int.*, vol. 2021, p. Article 5543317, 2021, doi: 10.1155/2021/5543317.

[51] A. M. Ibrahim, A. A. Teleb, and A. S. Abdelmagid, "Evaluation of teaching performance in the light of life and professional skills among faculty members at the college of education, king khalid university," *Inf. Sci. Lett.*, vol. 12, no. 5, p. Article 12(5), May 2023, doi: 10.18576/isl/120502.

[52] T. Nielsen *et al.*, "Teacher and Teaching-related Practices Student Teachers May Have Difficulty Believing They Can Enact/Engage in While in Field Practice: Perspectives from Student Teachers and Teachers in Field-practice Schools," *Nord. Stud. Educ.*, vol. 44, no. 2, p. Article 44(2), 2024, doi: 10.23865/nse.v44.6190.

[53] M. B. Freeh and M. S. Hussein, "The Level of Teaching Performance of Islamic Education Teachers in The Intermediate Stage in The State of Iraq in The Light of Quality Assurance Standards from The Point of View of Teachers (The Assistant Teacher)," *Rev. Int. Geogr. Educ. Online*, vol. 11, no. 5, p. Article 11(5), 2021, doi: 10.48047/rigeo.11.05.280.

[54] O. Chamorro-Atalaya *et al.*, "Sentiment analysis through twitter as a mechanism for assessing university satisfaction," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 28, no. 1, p. Article 28(1), Oct. 2022, doi: 10.11591/ijeecs.v28.i1.pp430-440.

[55] M. Tarafdar, E. B. Pullins, and T. S. Ragu-Nathan, "Technostress: negative effect on performance and possible mitigations," *Inf. Syst. J.*, vol. 25, no. 2, pp. 103–132, Mar. 2015, doi: 10.1111/isj.12042.

[56] R. Truzoli, V. Pirola, and S. Conte, "The impact of risk and protective factors on online teaching experience in high school Italian teachers during the COVID-19 pandemic," *J. Comput. Assist. Learn.*, vol. 37, no. 4, pp. 940–952, Aug. 2021, doi: 10.1111/jcal.12533.

[57] E. Mondragon-Estrada, I. Kirschning, J. A. Nolazco-Flores, and C. Camacho-Zuñiga, "Fostering digital transformation in education: technology enhanced learning from professors' experiences in emergency remote teaching," *Front. Educ.*, vol. 8, p. Article 1250461, 2023, doi: 10.3389/feduc.2023.1250461.

[58] J. Godoy-Pozo *et al.*, "Remote simulation with simulated patient: Initial clinical learning experience in medical students | Simulación a distancia con paciente simulado: Experiencia inicial de aprendizaje clínico en estudiantes de medicina," *Rev. Med. Chil.*, vol. 151, no. 11, p. Article 151(11), Nov. 2023, doi: 10.4067/s0034-98872023001101446.

[59] N. R.E., F. J.A., C. T., P. S.R., and R. D.N., "The Optimizing Whiteboard Lectures (OWL) Checklist: Validation of a Novel 'Chalk Talk' Assessment Tool," *J. Gen. Intern. Med.*, p. Article undefined, 2026.

[60] A. A. Joshi, P. Mukundan, V. J. Dave, R. A. Bradoo, and N. R. Dhorje, "Prevalence of Voice Disorders in Indian Female Secondary School Teacher Population-A Cross Sectional Study," *Indian J. Otolaryngol. Head Neck Surg.*, vol. 74, p. Article 74, Oct. 2022, doi: 10.1007/s12070-020-02160-w.

[61] I. Estévez, A. Souto-Seijo, and I. Jorrín-Abellán, "Beliefs and Integration of Digital Resources: a Study with Professors of Health Sciences | Creencias e integración de recursos digitales: un estudio con docentes universitarios de Ciencias de la Salud," *Ried Rev. Iberoam. Educ. A Distancia*, vol. 26, no. 1, p. Article 26(1), 2023, doi: 10.5944/ried.26.1.34035.

[62] F. Quispe-Victoria *et al.*, "Assess the effectiveness of digital platforms in facilitating content delivery and pedagogical strategies," *J. Phys. Educ. Sport*, vol. 24, no. 9, p. Article 24(9), Sep. 2024, doi: 10.7752/jpes.2024.09254.

[63] Z. Luo and L. Jiang, "Analysis and construction of evaluation index system for tourism management classroom teaching based on regression model," *J. Intell. Fuzzy Syst.*, vol. 46, no. 4, p. Article 235844, Apr. 2024, doi: 10.3233/JIFS-235844.

[64] A. M. I. Omar, A. A. M. M. Ali El Deen, A. S. A. Mohamed, and A. A. Teleb, "Evaluating Teaching Performance in View of Learning and Innovation Skills among Saudi University Instructors," *Inf. Sci. Lett.*, vol. 12, no. 7, p. Article 12(7), Jul. 2023, doi: 10.18576/isl/120701.

[65] L. Kong, "Performance evaluation model for operation research teaching based on IoT and Bayesian network technology," *Soft Comput.*, vol. 28, no. 4, p. Article 28(4), Feb. 2024, doi: 10.1007/s00500-024-09632-z.

[66] S. Berlanga-Fernández *et al.*, "Perceived training needs by tutors of family and community medicine and nursing of specialized health training: a qualitative descriptive study," *Front. Med.*, vol. 11, p. Article 1329671, 2024, doi: 10.3389/fmed.2024.1329671.

[67] C. B. Fontao, M. L. Santos, and A. Lozano, "ChatGPT's Role in the Education System: Insights from the Future Secondary Teachers," *Int. J. Inf. Educ. Technol.*, vol. 14, no. 8, p. Article 2131, 2024, doi: 10.18178/ijiet.2024.14.8.2131.

[68] Y. Wu, K. Lian, P. Hong, S. Liu, R.-M. Lin, and R. Lian, "Teachers' Emotional Intelligence and Self-efficacy: Mediating Role Of Teaching Performance," *Soc. Behav. Personal. an Int. J.*, vol. 47, no. 3, pp. 1–10, Mar. 2019, doi: 10.2224/sbp.7869.

[69] H. Wang, N. C. Hall, and S. Rahimi, "Self-efficacy and causal attributions in teachers: Effects on burnout, job satisfaction, illness, and quitting intentions," *Teach. Teach. Educ.*, vol. 47, pp. 120–130, Apr. 2015, doi: 10.1016/j.tate.2014.12.005.
[70] M. Kuzmanovic, G. Savic, M. Popovic, and M. Martic, "A new approach to evaluation of university teaching considering heterogeneity of students' preferences," *High. Educ.*, vol. 66, no. 2, pp. 153–171, Aug. 2013, doi: 10.1007/s10734-012-9596-2.
[71] J. Osmanović Zajić and J. Maksimović, "Quasi-Experimental Research as An Epistemological-Methodological Approach in Education Research," *Int. J. Cogn. Res. Sci. Eng. Educ.*, vol. 10, no. 3, pp. 177–183, Dec. 2022, doi: 10.23947/2334-8496-2022-10-3-177-183.
[72] R. Hernández Sampieri, C. Fernández Collado, and M. Baptista Lucio, *Metodología de la Investigación*, 6ta edición., vol. 1. Ciudad de México-México: McGRAW-HILL / INTERAMERICANA EDITORES, 2014. Accessed: Dec. 23, 2021. [Online]. Available: http://observatorio.epacartagena.gov.co/wp-content/uploads/2017/08/metodologia-de-la-investigacion-sexta-edicion.compressed.pdf
[73] J. Pérez Villamar, "os El Positivismo y la Investigacion Cientifica," *Rev. Empres. ICE-FEE-UCSG*, vol. 9, no. 3, pp. 29–34, 2015, [Online]. Available: http://editorial.ucsg.edu.ec/ojs-empresarial/index.php/empresarial-ucsg/article/view/20/16
[74] C. Fernández and P. Baptista, *Metodología de la Investigación*, 6ta edición., vol. 1. México: Mc Graw Hill Education/Interamericana, 2014. Accessed: Nov. 04, 2020. [Online]. Available: http://observatorio.epacartagena.gov.co/wp-content/uploads/2017/08/metodologia-de-la-investigacion-sexta-edicion.compressed.pdf
[75] R. M. Klassen and V. M. C. Tze, "Teachers' self-efficacy, personality, and teaching effectiveness: A meta-analysis," *Educ. Res. Rev.*, vol. 12, pp. 59–76, Jun. 2014, doi: 10.1016/j.edurev.2014.06.001.
[76] H. Mautong *et al.*, "Assessment of depression, anxiety and stress levels in the Ecuadorian general population during social isolation due to the COVID-19 outbreak: a cross-sectional study," *BMC Psychiatry*, vol. 21, no. 1, pp. 1–15, 2021, doi: 10.1186/s12888-021-03214-1.