Improvement Plan for the Chocolate Production Line of a Higher Education Institution

Plan de mejoras para la línea de chocolate de una Institución de Educación Superior

Valeria Esther Vera Vargas[1], Héctor Leodey Vinces Pacheco[1]
[1]Universidad Técnica de Manabí, Portoviejo,Manabí, Ecuador

How to cite
V. E. Vera Vargas, and H. L. Vinces Pacheco, "Improvement Plan for the Chocolate Production Line of a Higher Education Institution." Engineering: Science, Technology, and Innovation, vol. 12, 2025. https://doi.org/10.26495/3rjj9r05

Article information
Received: 15/01/2025
Accepted: 27/08/2025
Published: 01/12/2025

Corresponding author
Valeria Esther Vera Vargas
valeria.vera@utm.edu.ec

ABSTRACT: *The goal of higher education institutions is to integrate theory with practice, which is why it is essential to have spaces that provide the opportunity to learn about the real dynamics of companies on a scale. This is where theoretical knowledge is strengthened, becoming a space for experimentation and enabling the training of competitive professionals, positioning the university as a key player in technological, productive, and economic development. In this context, this research project had the objective of designing an improvement plan for the chocolate production line at the pilot plant of a higher education institution. The approach was mixed, combining techniques such as student surveys, lecturer interviews, and direct observation to collect and analyse relevant data on the current situation of chocolate production. The CAPDo methodology, based on the Deming cycle, was applied, which included the steps of Check, Act, Plan, and Do, to optimise an underutilised area. This approach allowed the identification of inefficiencies and areas of opportunity that could be addressed through an improvement plan. Among the results, 96% of respondents believed that an improvement plan is essential to revitalise the chocolate line. Furthermore, lecturers pointed out the need for plant improvements to enhance student learning. In conclusion, the implementation of the proposed plan will contribute to the continuous improvement of the institution, consolidating the scientific work of lecturers and students and developing highly competent professionals, who in turn will positively impact on the industrial development of the region..*

Keywords: *Organisational development, quality management, organisation, planning, industrial process.*

RESUMEN: *El fin de las instituciones de educación superior es integrar la teoría con la práctica; por ello, es esencial contar con espacios que brinden esa oportunidad de conocer a escala la dinámica real de las empresas. Es allí donde se fortalece el conocimiento teórico, convirtiéndose en un espacio de experimentación y permitiendo formar un profesional competitivo, lo que posiciona a la universidad como un actor clave en el desarrollo tecnológico, productivo y económico. En este contexto, este proyecto investigativo tuvo como objetivo diseñar un plan de mejoras para la línea de producción de chocolate en la Planta Piloto de una Institución de Educación Superior. El enfoque fue mixto, combinando técnicas como encuestas a estudiantes, entrevistas a docentes y observación directa para recopilar y analizar datos relevantes sobre la situación actual de la producción de chocolate. Se aplicó la metodología CAPDo, basada en el ciclo de Deming, que incluyó los pasos de Verificar, Actuar, Planificar y Hacer, para optimizar un área subutilizada. Este enfoque permitió identificar ineficiencias y áreas de oportunidad que podrían ser abordadas a través de un plan de mejora. Entre los resultados, el 96% de los encuestados opinó que un plan de mejora es esencial para revitalizar la línea de chocolate. Además, los docentes señalaron la necesidad de realizar adecuaciones en la planta para enriquecer el aprendizaje de los estudiantes. En conclusión, la implementación del plan propuesto contribuirá a la mejora continua de la institución, consolidando el trabajo científico de docentes y estudiantes y formando profesionales altamente competentes, que a su vez impactarán positivamente en el desarrollo industrial de la región.*

Palabras Claves: Desarrollo organizativo, gestión de la calidad, organización, planificación, proceso industrial.

DOI: https://doi.org/10.26495/3rjj9r05
Publishing Fund USS

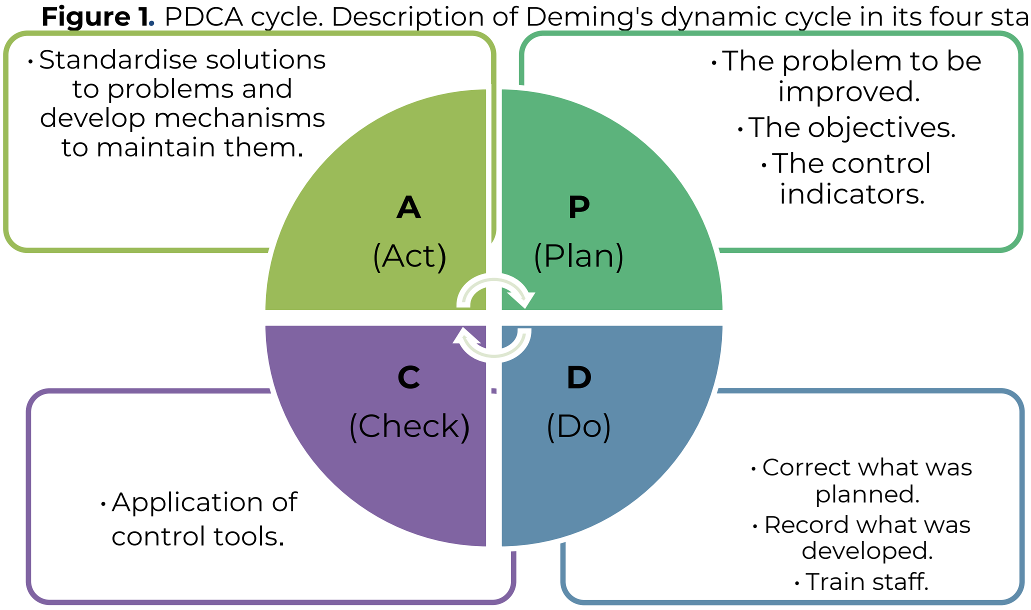
1. INTRODUCTION

In today's globalised world, constant market fluctuations have transformed project management practices, leading to the emergence of process management in companies. A project begins with a diagnosis to identify problems, with the aim of investigating causes and proposing solutions such as improvement plans. Improvement projects are designed to progressively achieve quality and overall excellence, emphasising the relationships between processes and people to encourage continuous improvement in organisations [1].

Continuous improvement is implemented in order to continuously enhance the operations of the company without making major changes, through the implementation of small changes rather than large-scale innovations [2]. Continuous improvement helps to identify areas that need to be improved, plan the implementation of these improvements, verify the findings obtained from the implementation, and correct any deviations that may occur. One of the main tools used in all companies is the Deming cycle created by William Edwards Deming, also known by its acronym PDCA, which consists of Plan, Do, Check, Act.

Edward Deming proposed a model for continuous improvement consisting of four stages, which becomes a cycle as it repeats in the same order at the end of the fourth stage [3]. The Plan-Do-Check-Act (PDCA) cycle (see Figure 1) is suitable for all companies worldwide and provides for the continuous improvement of operational processes based on the need to continually review operational problems, reduce opportunity costs, streamline and other factors that together enable optimisation [4].

Figure 1. PDCA cycle. Description of Deming's dynamic cycle in its four stages.



Source: [5].

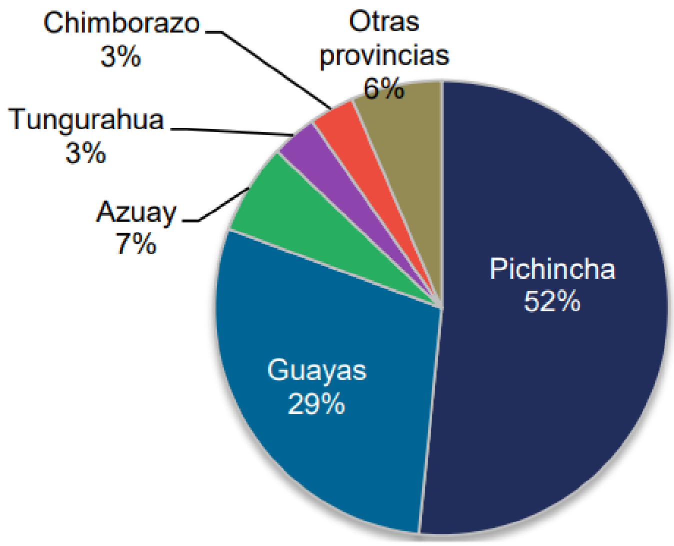
This model is cyclical and dynamic, allowing its application to any organisation seeking continuous improvement of operational processes, reduction of opportunity costs and overall optimisation, allowing customers to develop responses to the needs arising from the current environment in order to offer a better product or service [6].

The successful implementation of continuous improvement and process optimisation are ultimately determining factors for business sustainability, which is based on the sale of its products and services. This is the revenue base that all companies need to achieve high-quality production and sales; otherwise, they will not be able to sell, meaning the company would have no revenue [7]. Thus, the sustainability of a company is intrinsically dependent on the effectiveness of its production and marketing processes.

Based on this concept, each business activity helps the company achieve real success or failure in the various activities carried out in this business area, such as planning, product design, production processes, quality control, equipment layout and arrangement, among others. It is assumed that this will be possible, especially the management of the materials needed for production, the technical and human skills, and the tools needed to achieve business objectives [8].

Within this framework, the industrialisation of cocoa represents a significant opportunity for Ecuador, a country that accounts for more than 70% of global production and is a leading exporter of cocoa beans. The states with the highest production are Los Ríos, Guayas, Manabí and Sucumbíos [9]. Figure 2 shows the 2022 ranking of chocolate companies, where there were 31 companies engaged in the manufacture of chocolate and its derivatives, 81% of which were located in the provinces of Pichincha (52%) and Guayas (29%), with potential for development in other regions, driven by the growth of the sector [10].

Figure 2. Percentage distribution of the number of companies by province.



Source: [11].

In Ecuador, one of the existing pilot plants is located within the Comprehensive Cocoa and Coffee Quality Laboratory, located in the city of Mocache, Los Ríos. There, research is carried out on coffee and cocoa beans with the aim of developing new varieties and achieving greater production, as well as making the most of every part of these fruits. The University of Azuay has a cocoa and chocolate processing plant, which belongs to the Faculty of Science and Technology, whose purpose is to educate communities and students through the creation of these spaces, and because of the 4,017 hectares of cocoa that exist in Cañar [12].

In this context, universities play a fundamental role in connecting academic knowledge with industrial practice. In Ecuador, there are notable university initiatives, such as the Comprehensive Cacao and Coffee Quality Laboratory in Mocache and the cacao processing plant at the University of Azuay, which seek to educate and develop research on this valuable agricultural product [10].

In line with this vision, the higher education institution where our study is focused has a pilot plant equipped with a chocolate production line, founded in 2013. This infrastructure was initially conceived as a practical learning centre for students, a key space for training and skills development. However, external events such as an earthquake and the subsequent pandemic led to a gradual disconnection between this area and academic practices. This situation resulted in the underutilisation of existing machinery and tools, a lack of adequate maintenance and a consequent impact on production quality, which had a negative impact on the learning experience of students.

Given the importance of establishing this connection between education and practice in order to stimulate the motivation and interest of students, who seek learning environments that reflect the conditions of the world of work [13], there is a need to develop an improvement plan for the chocolate production line, which is justified by its potential to enrich the educational experience of students, facilitating the development of practical and research skills, and strengthening the link between theory and professional application.

The objective of this project is to propose an improvement plan for the chocolate production line of a higher education institution, with a view to reactivating and optimising its operations, enriching student experimentation and increasing opportunities for scientific research. By fostering a culture of knowledge generation and innovation, the development of this project is expected to significantly benefit the institution's educational and productive framework, encouraging the creation of new formulations and products that respond to local market needs and promote entrepreneurship. Ultimately, the reactivation and optimisation of this production line will bridge the gap between academia and practice, positioning this institution as a benchmark in the training of competent professionals who can contribute to the socio-economic development of the region [14], [15].

2. MATERIALS AND METHODS

This research used a mixed approach through an empirical method, combining a literature review with data collection techniques such as observation, surveys, and interviews. The four key steps that structure this study are detailed below:

2.1. Diagnosis and Data Collection Phase (CAPDo - "Check")

This first phase focused on gaining a thorough understanding of the current state of the chocolate production line and its challenges, using the following techniques and tools:

- **Literature review:** an exhaustive search of literature on process management, continuous improvement, business sustainability, and technologies in the chocolate industry to establish a solid theoretical framework.
- **Direct observation:** through on-site visits to the chocolate pilot plant, documenting the physical condition of the machinery, tools, and the general environment of the production line. A checklist was used, which was specifically designed to evaluate the functioning, maintenance status, and operability of each piece of equipment.
- **Photographic record:** Photographs were taken to visually document the problems detected, such as damaged equipment and disorganised areas, among others.
- **Interviews with lecturers:** In this part, semi-structured interviews were conducted with lecturers from the Food, Industrial, and Chemistry programmes who had prior knowledge or experience with the production line, in order to gather their perceptions of the current state, the problems identified, and the priority areas for improvement from a technical and academic perspective.
- **Student surveys:** Structured surveys were administered to active students in the seventh level of the Food, Industrial and Chemical Engineering programmes, who represent the segment directly related to the processing area, in order to determine

their level of knowledge and involvement in chocolate production activities at the plant, as well as their interest and perception of the line's potential.
- **Population and sample:** The target population was students legally enrolled in the corresponding subjects of the aforementioned degree programmes, resulting in a total of 386 students in this segment. A stratified probability sampling method was used to perform the calculation, whereby the population was divided into areas of study, and the samples were selected using a simple random procedure. The use of this type of sampling avoids bias, ensuring a representative distribution of the sample [16]. A confidence level of 95% and a margin of error of 5% were used.

2.2 Data analysis and causality phase (CAPDo - "Analyse")

In this second phase, the collected data was processed for systematic analysis, which included the following:

- **Processing of survey and interview data:** Quantitative survey data was tabulated and analysed to identify trends and patterns in student perceptions. Lecturer interviews were transcribed and content analysis was performed to extract recurring opinions and issues.
- **Identification of problems and root causes:** Using information from observations, checklists, surveys, and interviews, a list of the main problems affecting the production line was compiled. For each problem identified, a cause-and-effect diagram (Ishikawa diagram or fishbone diagram) was applied. This tool allowed for the systematic breakdown of possible causes (labour, machinery, method, materials, environment, measurement) contributing to the negative effects observed in production and plant functionality. The objective was to understand the interrelationships between causes and their effects.

2.3 Improvement proposal phase (CAPDo - "Plan")

This phase was based on the results of the techniques applied and the root cause analysis, developing the following steps:

- **Definition of improvement objectives:** based on the results, areas for improvement were identified, establishing clear and measurable objectives for each area identified as deficient.
- **Design of the improvement plan:** specific strategies and actions were formulated to address the root cause, based on the principles of continuous improvement and the PDCA cycle. This plan detailed specific actions, the human, material and financial resources required, those responsible for its implementation and the indicators of success. This proposal includes improvements in infrastructure, equipment, staff training, and process and management standardisation.

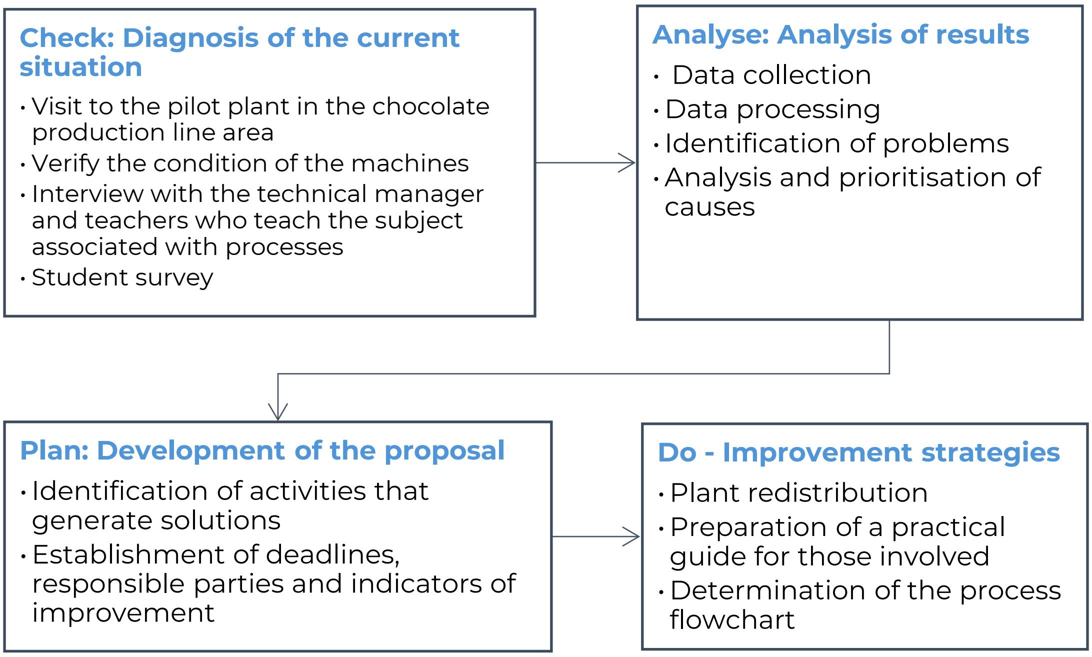
2.4 Implementation and verification phase (CAPDo - "Do" and "Act")

This research culminates in the proposal of the plan, laying the foundations for the subsequent phases of the CAPDo cycle. It is therefore important to detail the following in order to complete the cycle:

- "Do": This involves the controlled execution of the proposed improvement actions, such as corrective and preventive maintenance, training for the personnel involved (students and teachers), the implementation of new operating and cleaning protocols, and any other action detailed in the plan.
- "Act": This phase involves constant monitoring of results, standardisation of successful practices, and identification of new opportunities to start a new cycle of improvement.

Figure 3 presents a schematic representation of the methodological procedure of applied research, outlining the workflow from the diagnostic and data collection phase, through information analysis, to the formulation of the proposal and implementation of improvement strategies.

Figure 3. Research procedure. Research methodology



Source: [17], [18].

Sample calculation

Using a non-experimental field design, techniques such as student surveys, lecturer interviews, and observation were used to collect data (*in situ*) where the events took place. A stratified probability analysis was performed to select the sample. This means that the population from which a sample is chosen is divided into area strata, for which the sampling areas are selected using a simple random procedure. This type of random sampling reduced the possibility of areas without samples or areas with a high concentration of samples [16]. In this context, a segment directly related to the area of processes from the seventh level onwards in the Food, Industrial and Chemical Engineering programmes was analysed (see Table 1), with a total of 386 students legally enrolled in the corresponding subjects, establishing a confidence level of 95% with a margin of error of 5%. This facilitated the understanding and projection of the results obtained from primary sources.

Table 1. Study population.

PROGRAMMES	SUBJECTS	LEVEL	CREDITS	NUMBER OF STUDENTS
FOOD	Chocolate, Coffee and Confectionery Technology	SEVENTH	2	32
INDUSTRIAL	Industrial Processes I	SEVENTH	3	34
INDUSTRIAL	Industrial Processes II	EIGHTH	3	89
INDUSTRIAL	Production Engineering I	EIGHTH	3	86
INDUSTRIAL	Production Engineering I	NINTH	3	121
CHEMISTRY	Food Processing	NINTH	3	24
TOTAL				**386**

Source: own elaboration.

The formula for obtaining the sample is shown in equation (1).

$$n = \frac{Z^2(NPQ)}{Z^2PQ + (N-1)E^2} \qquad \textbf{(1)}$$

Where:

Population size (N) = 386
95% confidence level (Z) = 1.96
Expected proportion (P) = 0.5
Complement of P (Q) = 0.5
Precision or margin of error (E) = 0.05
Sample size (n) = ?

$$n = \frac{(1.96)^2(386 * 0.5 * 0.5)}{(1.96)^2(0.5 * 0.5) + (386-1)(0.05)^2}$$

$$n = \frac{(3.8416)(96.5)}{(0.9604) + (0.9625)}$$

$$n = \frac{(370.71)}{(1.9229)} \Longrightarrow n = \boldsymbol{193\ estudiantes}$$

After performing the calculation for the sample, a total of 193 students were selected for the survey. To distribute them by strata, the relative frequency for each subject was calculated by dividing the number of students by the total population, obtaining the values shown in Table 2. Once the relative frequency values had been calculated, each one was multiplied by the corresponding number for the sample, thus obtaining the number of students to be surveyed by subject.

Table 2. Sampling calculation.

Subjects	No. of students	Relative frequency	(n) per subject
Chocolate, coffee and confectionery technology	32	0.083	16
Industrial processes I	34	0.088	17
Industrial processes II	89	0.231	45
Production engineering I	86	0.223	43
Production engineering I	121	0.313	61
Food Processing	24	0.062	12
POPULATION	386	1.000	193
SAMPLE (n)	193		

Source: Faculty General Secretariat.

3. RESULTS

To develop this section, a diagnosis was made of the current situation of the area used for chocolate production procedure, through an on-site visit, where a checklist was used to verify the condition of the machines in order to collect data. Likewise, instruments were used to gather relevant information from those involved, both lecturers (interviews) and students (surveys).

Table 3 shows the balance of the condition of machinery and tools, where it was found that the industrial kitchen requires repairs to grills and knobs, although the three burners are working properly and the LPG tank is in good condition. The semi-industrial extractor needs maintenance due to dust accumulation, and the rods that support it must be protected, as must the axial fan.

The cocoa bean receiver needs maintenance due to its bearing system, although its structure is adequate. The roaster and shelling machine require complete repairs due to vibrations, cracks, and the need for lubrication in their bearings. The electric mill also needs repair due to wear on the grinding discs.

Table 3. Balance sheet of machinery and tools.

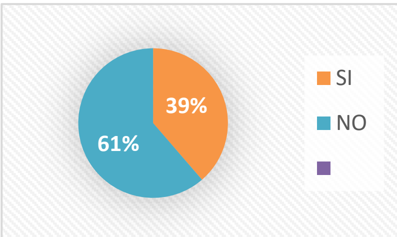
Equipment to be retired	Equipment to be repaired	Equipment in good condition
Plastic moulds	Industrial kitchen	LPG tank, hose and reservoir
Infrared thermometer	Semi-industrial extractor	-
-	Grain receiver	-
-	Grain roaster	-
-	Descaler	-
-	Electric mill	-
-	Press	-

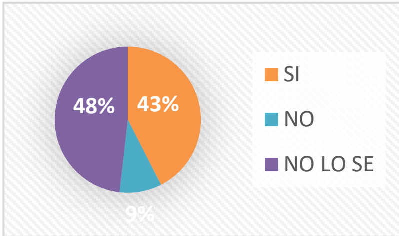
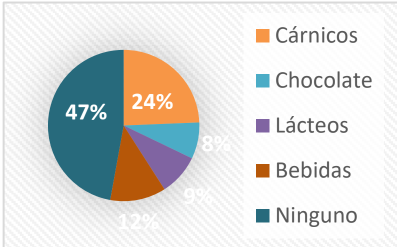
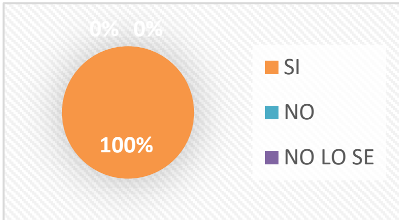
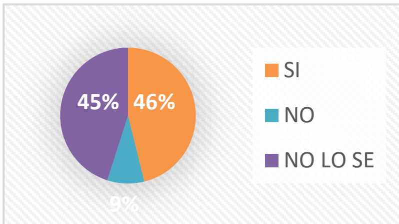
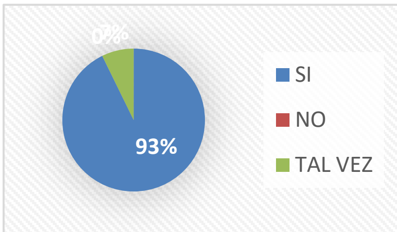
Source: own elaboration.

The press requires cleaning and corrective maintenance, and it is suggested that it be replaced with a more efficient system. The moulds must be retired due to their deterioration and age (since 2014), and it is recommended that they be replaced with silicone moulds. Finally, an infrared thermometer is necessary for temperature control, as the current one is defective and must be replaced. The information is summarised in Table 4 to facilitate the visualisation of the results.

A survey was conducted to assess students' engagement with academic practices in the chocolate production line at a higher education institution. The summarised results are presented below:

Table 4. Areas for improvement with regard to the academic services offered by the Pilot Plant.

QUESTION	RESULTS AND FINDINGS	FIGURE
Did you know that a higher education institution has a production line for making chocolate?	The vast majority are unaware that there is a line dedicated to chocolate production, and therefore consider it to be an underutilised area. However, with the right adjustments, it could be put to better use, allowing students to apply the knowledge they have acquired in the classroom by putting it into practice and transforming raw materials into final products.	

Does the chocolate production line at a higher education institution have adequate areas for academic internships?	Forty-three percent of the student sample knows that the higher education institution does have areas for academic internships, 48% say they do not know, and 9% consider them inadequate. These results indicate that the vast majority of students are not involved with these spaces, which are the link between theory and practice.	
In which production line of the higher education institution have you carried out practical training during your studies?	The results of this question indicate that the vast majority of students have not completed internships during their studies, making it crucial to offer a higher quality practical experience, consolidating its role as a fundamental pillar of practical training.	
Do you think it is important to have spaces where students can carry out their academic internships?	All the students surveyed recognise the importance of these spaces, which validates the need for infrastructure such as the chocolate production line. This leads to the conclusion that there is an unmet demand for practical opportunities, and that optimising the chocolate production line would not only respond to an institutional need, but also to a fundamental educational expectation and requirement for future professionals.	
Do you believe that the chocolate production line at a higher education institution complies with food production standards?	There is a divided perception regarding compliance with quality standards. A considerable percentage of students do not believe that standards are being met, or are simply unsure. It is crucial to address this perception through improvements that ensure compliance with all food safety and quality regulations, which is essential for any university and commercial production.	
Do you consider proposing improvements to be an alternative solution for the chocolate line to be operational?	A large majority sees the need for improvements in the chocolate line. This is a compelling finding that demonstrates strong support from the student body for the initiative to propose and implement improvements to the chocolate line. The vast majority who perceive this as a viable and necessary solution directly validate the objectives of the research. The implication is that there is a favourable climate and receptiveness among direct users (students) towards the optimisation proposals. This facilitates the justification of the project and underlines the need for concrete actions to reactivate and improve the line's operability.	

Source: survey conducted among students.

Interview results

After the survey was conducted, an interview was held with each lecturer who teaches subjects related to the processes, with the aim of evaluating the academic services offered by the Pilot Plant, for which the criteria established in Table 4 were developed. Based on this, it was observed that the machines are not in order and the area is completely inoperative, so the regulations required by ARCSA must be complied with in order for this line of processes to meet the quality required for food products, seeking to technify the operations in the process of transforming raw materials into final products.

On the other hand, the survey indicated that 89% of students demand the implementation of practices that can direct this knowledge towards scientific research. The survey confirms that university students are unaware that there are areas dedicated to chocolate production, so it is suggested that the products made there be promoted. Based on these suggestions, the criteria were divided into three groups, as shown in Table 5, and then broken down into fundamental aspects and areas of interest for this research project in order to prioritise their implementation.

Table 5. Aspects to be improved with regard to the academic services offered by the Pilot Plant.

OPTIONS	QUANTITY	PERCENTAGE	PRIORITY
1. Adaptations and standardisations of the physical plant	**80**	**41%**	**A**
• Technological upgrading of equipment and tools	28		
• Having a changing room and disinfection area to prevent cross-contamination	26		
• Do you consider that the chocolate production line complies with the entire process for obtaining quality chocolate	26		
2. Spaces designated for scientific research	**63**	**33%**	**B**
• Work on extension and research processes	23		
• The area should promote the generation of business ideas	23		
• Training of technical teachers through programmes and/or agreements with the university	17		
3. Dissemination of manufactured products	**51**	**26%**	**C**
• Processed products must pass laboratory tests before being sold to the community.	26		
• Dissemination of practical processes in production lines.	25		
GRAND TOTAL	194	100%	

Source: own elaboration.

Priority A: Physical plant upgrades and standardisation (41%)

This category emerges as the top priority, with 41% of responses, underscoring respondents' perception of critical deficiencies in the line's physical infrastructure. The high priority given to physical adaptations validates the need for direct intervention in the infrastructure and equipment. It is essential to address these issues to ensure the safety, hygiene and efficiency of the production process, which is a prerequisite for any academic or commercial activity. Failure to address these basic improvements will limit any other initiatives, reinforcing the justification for investing in the modernisation and certification of the plant.

Priority B: Spaces dedicated to scientific research (33%)

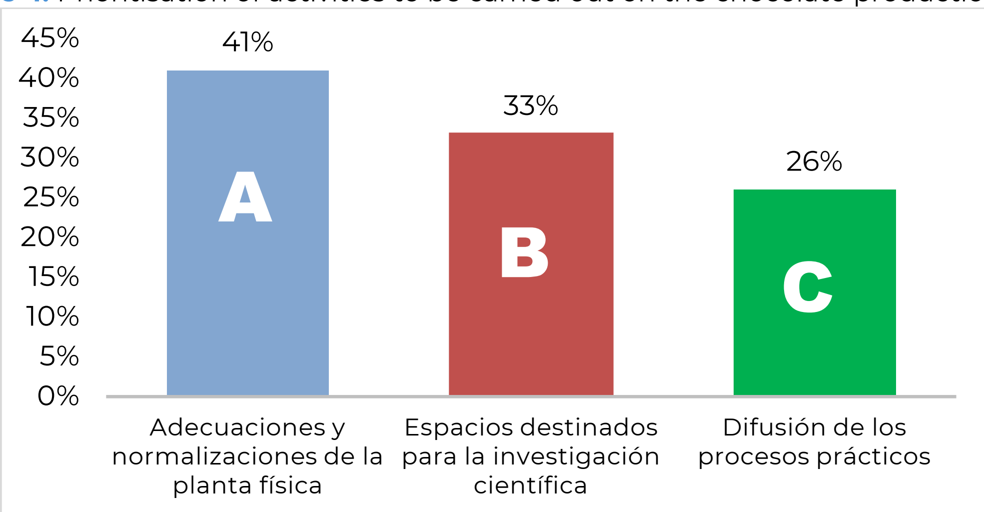
This category, with 33% of responses, highlights the respondents' vision of the line's potential beyond production. This finding is powerfully complemented by survey information indicating that 100% of students demand the implementation of practical training, allowing them to direct this knowledge towards scientific research. These results demonstrate that there is a latent and significant demand to convert the chocolate line into a dynamic space for applied research and business development. Therefore, these improvements must consider the line's capacity to facilitate research projects, the development of new products/prototypes, and the incubation of student ventures. Hence, the preparation of technical lecturers emerges as a critical factor in enabling this vision, which implies specific training programmes.

Priority C: Dissemination of manufactured products (26%)

Although it is the third priority with 26%, the 'dissemination of manufactured products' remains a relevant issue, as concerns about the quality and safety of the final product remain latent. Once the physical plant is adequate and the process standardised, dissemination becomes a logical and necessary step. This involves not only marketing and commercialisation, but also the validation of product quality and safety through laboratory testing, which is essential to gain consumer confidence and comply with health regulations. The subsequent dissemination of practical processes becomes a key element in demonstrating the academic value and impact of the line.

Figure 4 graphically shows the results of the interview conducted with the teachers who teach the subjects related to the processes and the laboratory assistant, who are directly involved in the processing activities with the students.

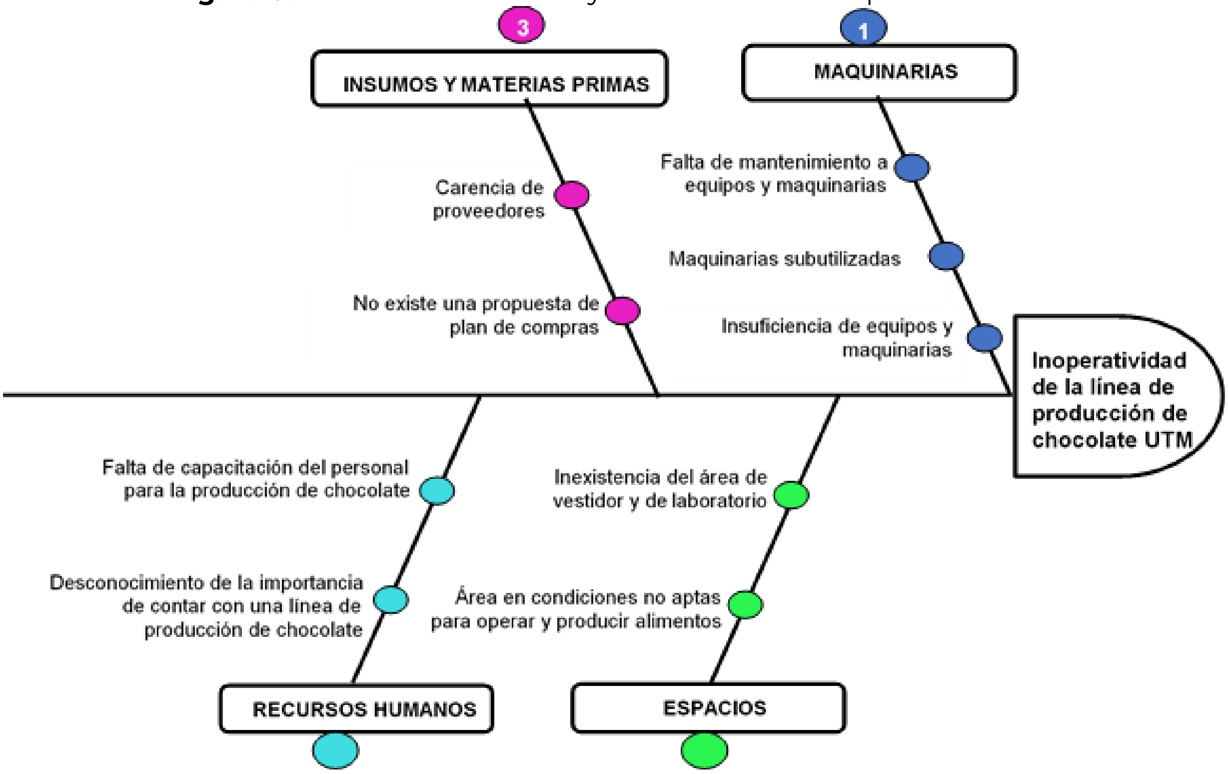
Figure 4. Prioritisation of activities to be carried out on the chocolate production line.



Source: own elaboration.

With the application of the techniques, the cause-effect diagram was outlined (see Figure 5), which identified the causes for which the chocolate line is inoperative. These causes were identified according to four areas: machinery, spaces, supplies and raw materials, and finally human resources, which are part of the production process of the chocolate production line.

Figure 5. Cause and effect analysis of the chocolate production line.



Source: own elaboration.

Machinery:

Identified causes: "Lack of maintenance of equipment and machinery", "Underutilised machinery", and "Insufficient equipment and machinery".
These causes are directly correlated with priority A. The students' perception of doubts about the adequacy of the facilities finds a technical explanation here: lack of maintenance and insufficient or underutilised machinery prevent optimal and modern operation.

Spaces:

Identified causes: "Lack of changing rooms and laboratory facilities" and "Area unfit for food production and handling".
The identification of "areas in unsuitable conditions" validates the community's perceptions about "doubts regarding the suitability of the facilities for the practices" and the "divided perception regarding compliance with quality standards", directly alluding to failures in infrastructure and biosafety, which are critical for any food production process.

Inputs and Raw Materials:

Identified causes: "Lack of suppliers" and "No purchasing plan proposal exists".
Connection to previous findings: The lack of inputs and poor purchasing management are fundamental operational barriers. These causes impact the line's ability to produce consistently and with quality, which in turn would affect the "Distribution of manufactured products" (Priority C), as there would be no sustained production to distribute.

Human Resources:

Identified causes: "Lack of staff training in chocolate production" and "Lack of awareness of the importance of having a chocolate production line".

The “lack of training” is a critical link that is linked to the suggestion of “Preparation of technical teachers through programmes and/or agreements by the University”. For the line to be a space for research and idea generation, the staff (teachers, technicians) must be highly qualified.

Development of the proposal

After addressing the comprehensive situational diagnosis, opportunities for improvement were analysed, leading to the development of this proposal, taking into account the technical standards for the distribution of machines and the requirements suggested by ARCSA. This proposal was entitled:
“Rehabilitation of the chocolate production line as an area for the development of academic practices and research”.
To carry this out, the following objectives were established:
· To develop an improvement plan for the refurbishment of the chocolate production line, ensuring an organised and safe space that complies with food product regulations.
· To redistribute the machines in the area.
Table 6 details the improvement plan with regard to the academic services offered by the Pilot Plant.

Table 6. Areas for improvement with regard to the academic services offered by the Pilot Plant.

PARAMETERS	IMPROVEMENT ACTIONS	TASKS	BUDGET	RESPONSIBLE
MACHINERY **Maintenance of equipment and machinery** **Underutilised machinery** **Adaptation of equipment and machinery**	Submit a request for the Institution to allocate resources to repair the machines and purchase those that are missing. **Sustainability:** Involve teachers and students of industrial maintenance and metalworking subjects in practical exercises applying prevention	1.1 Repair and cleaning of equipment and machinery 1.2 Relocation of equipment and machinery that does not belong in the area and cleaning 1.3 Purchase of 2 tables 1.4 Purchase of a shelling machine (see Annex P) 1.5 Purchase of an infrared thermometer (see Annex Q) 1.6 Purchase of moulds in various designs 1.7 Implementation of signage 1.8 Fire extinguisher 1.9 Smoke detector #2 1.10 Epoxy paint for floors and walls #4	USD 1670.00 USD 0.00 USD 80.00 USD 1500.00 USD 60.00 USD 80.00 USD 120.00 USD 80.00 USD 40.00 USD 550.00	Laboratory Assistant (pilot plant) Vice Dean of the School of Industrial Engineering Inventory Department Institution cleaning staff

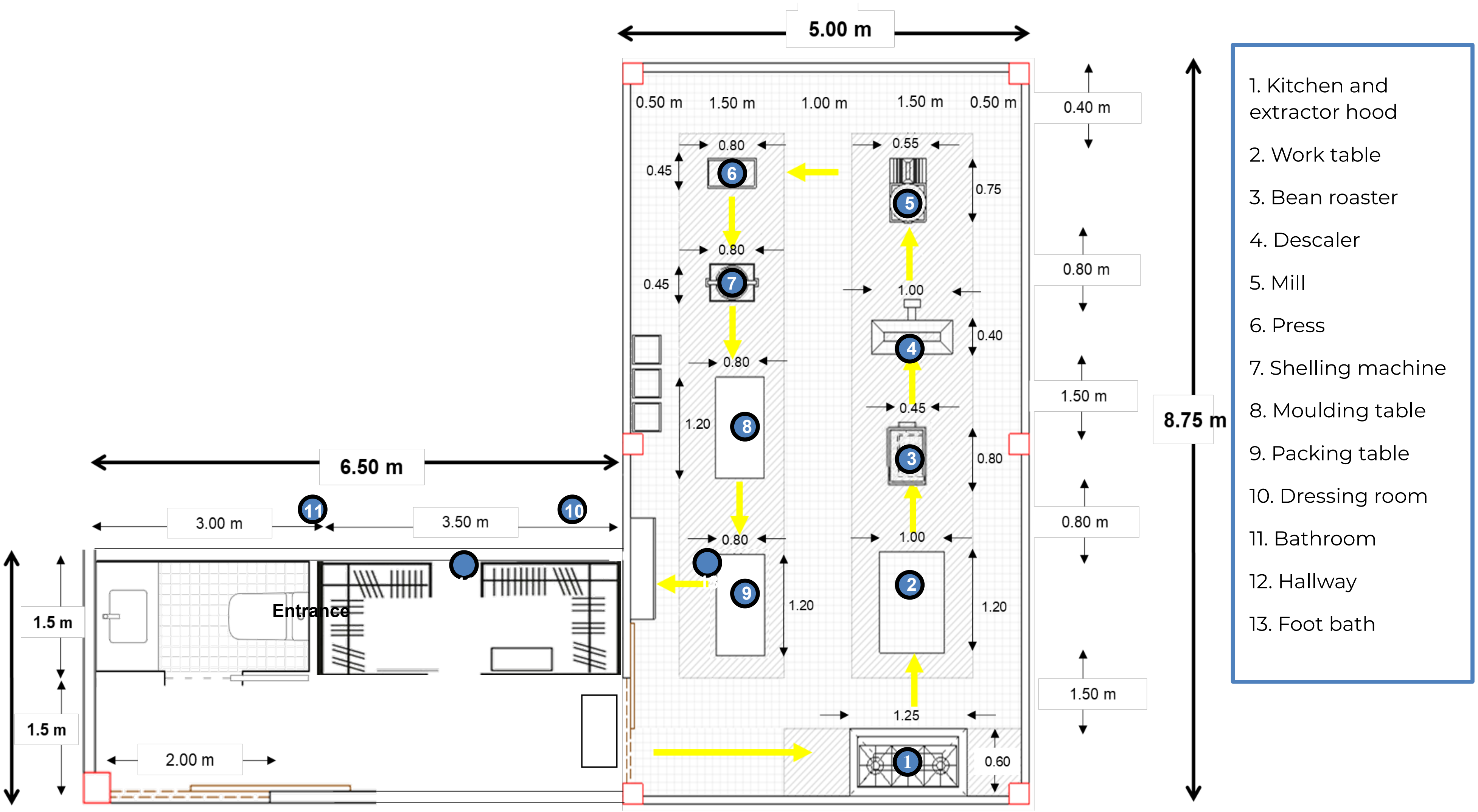
SUPPLIES AND RAW MATERIALS				
Budget allocation Search for suppliers Purchasing plan	Creation of a proposal to allocate petty cash for the purchase of supplies and materials for students to carry out their practical work. **Sustainability:** That by resolution of the University Council, an annual budget be allocated for the implementation of the process. It is suggested that the products made in the chocolate line be distributed to the institution's bars and that this resource be used to implement the instrumentation, raw materials, and supplies necessary to give the plan greater sustainability.	2.1 Development of a plan for the purchase of supplies and tools 2.2 Presentation of the proposal to the vice-dean's office with a copy to the rector's office	USD 0.00 USD 0.00	Vice-Dean of the School of Industrial Engineering Rector of the institution Finance department
HUMAN RESOURCES				
External training for lecturers	Enter into agreements with institutions for lecturers to attend courses and workshops.	Select lecturers for the relevant subjects for production.	USD 0.00	Vice-Dean of the Degree Programme
SPACES				
Changing room and laboratories area. **Encourage student participation.**	Submit a proposal for the expansion of a lobby in the area (lockers, bathroom, changing room, footbath). Application of building regulations **Sustainability:** With an adequate floor plan, it is expected that the process will be standardised in compliance with safety regulations.	4.1 Presentation of the project 4.2 Socialisation 4.3 Preparation of budget	USD 3500.00	Vice Dean of the School of Industrial Engineering Lecturers
	TOTAL INVESTMENT (∑S1+S2+S3+S4)		**USD 7680.00**	

Source: [19].

Distribution of machines in the area

Currently, the area where chocolate was produced before the earthquake is not suitable for operation, as there are machines, equipment, tools, and other utensils that do not belong in the area. Given the current context of the pilot plant, it is subject to low production volume and low variety, therefore, the layout of the machines must be fixed. In this context, Figure 6 proposes a redistribution of the plant, complying with current worker safety regulations. The physical space comprises a total of 43.75 square metres of production area and 19.5 square metres of lobby space.

Figure 6. Proposed layout.



4. DISCUSSION

The implementation of the improvement plan for the chocolate production line at the Higher Education Institution is a crucial step towards revitalising both the production process and the academic and practical training of students [12].

The initial diagnosis revealed that 96% of respondents consider an improvement plan to be essential, highlighting the positive perception of the need to optimise the chocolate line. This response is in line with the literature that highlights the importance of having these spaces that can link this synergy between education and practice, suggesting that a learning environment that reflects the conditions of the world of work and business is essential to maintain student interest and motivation and to train competitive professionals [13],[15].

The CAPDo methodology, based on the Deming cycle, was used to structure the improvement process, allowing the continuous review of operational problems and the implementation of effective solutions, which is essential for continuous improvement in any organisation [3]. This coincides with other research suggesting that the application of this cycle seeks to foster a culture of innovation and knowledge generation among students and lecturers [1].

The proposal for adjustments and standardisation in the physical plant, including equipment repairs and the creation of suitable spaces for research, is essential to ensure a safe and efficient learning environment. It also allows safety regulations to be met and enforced in order to comply with the standards required by regulatory bodies such as ARCSA [7], [17].

Furthermore, it is important to highlight the need to train teachers and students in the use of new technologies and processes, as continuous training is key to maintaining competitiveness and quality in production [8]. Therefore, it is important to take into account the collaboration between the university and the productive sector, as this can facilitate access to resources and knowledge that benefit both students and the community in general [14].

The differential value of this research lies in the adaptation of the CAPDo cycle to the educational-productive context, representing a pioneering application that goes beyond typical industrial implementation, creating a replicable model for other higher education institutions. This research proposes a comprehensive framework that simultaneously considers technical, educational, and organisational factors, laying the foundations for long-term sustainable development with the potential for scalability to other academic programmes.

Among its practical implications is that it strengthens the creation of a learning environment that simulates real working conditions and university-business links, which, by complying with production standards, generates additional income for the university through efficient production, contributing to economic development through the training of qualified professionals.

Empirical evidence, reflected in 96% support for the improvement plan, underscores the validity and relevance of this initiative. However, the true transformative impact lies in its ability to create a learning ecosystem that transcends the traditional classroom, establishing a new paradigm in technical higher education with the integration of industrial production, which offers a replicable model that could transform the way universities approach practical training and resource generation. The implications of this study provide a roadmap for other institutions seeking to modernise their production facilities while improving the quality of their education.

5. CONCLUSIONS

The current condition of the machinery and equipment necessitates comprehensive repairs and the acquisition of new machinery/equipment to complete the process. It is also necessary to increase the space available to create a changing room area in order to improve academic services and mobility within the processing area.

This proposal contributes to the organisation and continuous improvement of the pilot plant, creating areas that comply with the regulations required by government agencies and consolidate the scientific work carried out by teachers and students.

The proposal is suitable for implementation, with the Faculty of Engineering and Applied Sciences and the Vice-Deans of the relevant degree programmes, such as Industrial Engineering, Chemical Engineering and Food Engineering, being responsible for the start-up of the plant.

The implementation of this improvement plan will enrich the educational experience of students, bridge the gap between theory and practice, and contribute to the socio-economic development of the region. The combination of a solid methodological approach, the adaptation of spaces and continuous training are key elements for the success of this initiative.

ACKNOWLEDGEMENTS AND FUNDING

The authors would like to thank the higher education institution under study for its invaluable contribution to the research. In particular, we acknowledge the support of the academic staff of the Industrial Engineering programme for facilitating access to the chocolate production line facilities and providing the necessary technical documentation.

This research was funded with the authors' own resources and logistical support from the higher education institution under study. No external funding was received from public or private entities for the completion of this study.

CONFLICTS OF INTEREST

The authors declare that there are no personal, academic, financial, or institutional conflicts of interest that have influenced the results presented in this article.

STATEMENT OF AUTHORSHIP

Valeria Esther Vera Vargas and Héctor Leodey Vinces Pacheco participated equally in the design of the study, the collection and analysis of data, the writing of the manuscript, and the final review of the document. Both authors approve the final version and are responsible for the content of the article.

REFERENCES

[1] K. Alvarado Ramírez, and V. Pumisacho Álvaro, “Prácticas de mejora continua, con enfoque Kaizen, en empresas del distrito metropolitano de Quito: Un estudio exploratorio,” *Intang. Cap.*, vol. 13, no. 2, p. 479, 2017. https://doi.org/10.3926/ic.901

[2] R. N. Lay-De-León, A. J. Acevedo-Urquiaga, and J. A. Acevedo-Suárez, “Guía para la aplicación de una estrategia de mejora continua,” *Ing. Ind.*, vol. 43, no. 3, pp. 30–48, Nov. 2022. http://scielo.sld.cu/scielo.php?pid=S1815-59362022000300030&script=sci_arttext

[3] S. Montesinos-Gonzalez, C. Vázquez-Cid de León, I. Maya-Espinoza, and E. B. Gracida-Gracida, “Mejora Continua en una empresa en México: estudio desde el ciclo Deming,” *Rev. Venez. Gerenc.*, vol. 25, no. 92, pp. 1863-1883, Oct. 2020. https://doi.org/10.37960/rvg.v25i92.34301

[4] M. E. Llumiguano Poma, C. V. Gavilánez Cárdenas, and G. W. Chávez Chimbo, “Importancia de la auditoría de gestión como herramienta de mejora continua en las empresas,” *Dilemas contemp.: educ. política valores*, Jun. 2021. https://doi.org/10.46377/dilemas.v8i.2723

[5] M. García, C. Quispe, and L. Ráez, “Mejora continua de la calidad en los procesos,” *Ind. Data*, vol. 6, no 1, pp. 88-94, Aug. 2003. https://www.redalyc.org/pdf/816/81606112.pdf

[6] S. O. Pazmiño-Cáceres, “Diseño de un plan de mejora continua de producción de chocolates y caramelos para una empresa de alimentos,” Tesis de grado, Facultad de Ciencias Naturales y Matemáticas, Escuela Superior Politécnica del Litoral, Guayaquil, Ecuador, 2015. https://www.dspace.espol.edu.ec/xmlui/handle/123456789/37746

[7] A. E. Bueno-Tacuri, and M. J. Jácome-Ortega, “Gestión de operaciones para la mejora continua en Organizaciones,” *Rev. Arbitr. Interdiscip. Koin.*, vol. 6, no. 12, p. 334, Jul. 2021. https://doi.org/10.35381/r.k.v6i12.1292

[8] J. N. Cañar-Tinitana, and A. A. Hidalgo-Avila, “Modelos de gestión empresarial centrados en la innovación como ventaja competitiva. Una mirada a las PYMES de Manta,” *Polo del Conocimiento*, vol. 6, no. 3, pp. 2165–2189, Aug. 2021. https://polodelconocimiento.com/ojs/index.php/es/article/view/2498

[9] A. Abad, C. Acuña, and E. Naranjo, “El cacao en la Costa ecuatoriana: estudio de su dimensión cultural y económica,” *Estud. Gest. Rev. Int. Adm.*, vol. 7, no. 3, pp. 59–83, Jun. 2020. https://revistas.uasb.edu.ec/index.php/eg/article/view/1442

[10] H. P. Cabrera, J. E. Álvarez, M. J. Jácome, and M. M. Matovelle, “Los rankings mundiales y el posicionamiento de las universidades de la provincia del Azuay - Ecuador,” *Rev. Univ. Soc.*, vol. 14, no. 5, pp. 668–677, Oct. 2022. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2218-36202022000500668

[11] Corporación Financiera Nacional, “Noticias,” cfn.fin.ec, 2023. Accessed: Sep. 28, 2023. [Online]. Available: https://www.cfn.fin.ec/noticias/

[12] E. Vera, “Planta procesadora de cacao y chocolate en la UDA,” Corresponsal Universidad el Azuay (UDA), Nov. 14, 2021. [Online]. Available: https://www.uazuay.edu.ec/corresponsales-noticias/planta-procesadora-de-cacao-y-chocolate-en-la-uda

[13] D. Acuña, and W. Torres-Bruges, “Mecanismo de vinculación de la universidad con el sector productivo, un paradigma para el desarrollo tecnológico en

Colombia," *Omnia*, vol. 22, no. 1, pp. 106–120, Oct. 2016. https://produccioncientificaluz.org/index.php/omnia/article/view/21437

[14] D. Rivas-Ramírez, and É. H. Fuentes-Contreras, "Transconstitucionalismo: ¿teoría sin práctica? Análisis crítico de una de las teorías actuales sobre las relaciones entre órdenes jurídicos," *Díkaion*, vol. 31, no. 2, p. e3124, Aug. 2022. https://dikaion.unisabana.edu.co/index.php/dikaion/article/view/17853

[15] L. Cano, D. Montes-Bermúdez, and V. Díaz-Arango, "Experiencias STEM+H en instituciones educativas de Medellín: factores que prevalecen en su implementación," *Sociología y tecnociencia: Revista digital de sociología del sistema tecnocientífico*, vol. 11, no. Extra_1, pp. 1-22, Dec. 2021. https://dialnet.unirioja.es/servlet/articulo?codigo=7845273

[16] A. Porras Velázquez, "Tipos de muestreo," Centro de Investigación en Geografía y Geomática, Consejo Nacional de Humanidades, Ciencias y Tecnologías, CDMX, México, 2017. [Online]. Available: https://centrogeo.repositorioinstitucional.mx/jspui/bitstream/1012/163/1/19-Tipos%20de%20Muestreo%20-%20%20Diplomado%20en%20An%C3%A1lisis%20de%20Informaci%C3%B3n%20Geoespacial.pdf

[17] D. P. Jiménez-Giraldo, "Plan de mejoramiento para las plantas piloto de alimentos de la Universidad del Quindío," Tesis de Maestría, Facultad de Ciencias Económicas y Administrativas, Universidad del Quindío, Armenia, Quindío, Colombia, 2018. https://hdl.handle.net/20.500.14550/5586

[18] R. A. Miñano-Cabrera, and R. A. Cosavalente-Robles, "Propuesta de mejora en la gestión de producción y calidad, de una fábrica de chocolate, para incrementar su rentabilidad. Trujillo 2022," Tesis de grado, Universidad Privada del Norte, Trujillo, Perú, 2023. https://repositorioslatinoamericanos.uchile.cl/handle/2250/9281787

[19] Aneca, *Guía para la elaboración de un Plan de Mejoras,* Universidad de La Rioja, España, V.1.0, 2021. Accessed: Sep. 28, 2023. [Online]. Available: https://www.unirioja.es/servicios/opp/acr/doc/GPlanMejoraD-v1.0-2021-02.pdf