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Journal-Economic Development Technological Chance and Growth

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Presentation of Content

In a first article we present, *Applying electronical devices to save electrical* by MALDONADO-PESINA, Ericka, MARTÍNEZ-TOVAR, César, GALARZA-SOSA, Oscar and ELIZONDO-GUZMÁN, César, with adscription in the Tecnológico Nacional de México / Instituto Tecnológico de Linares, as a second article we present, *Methodological proposal for the transfer of industrial manufacturing processes in a transnational firm: A China-Mexico particular case* by MENDOZA-LEÓN, Jorge Guadalupe, GARCÍA-OCHOA, Juan José, VALENZUELA-EVARISTO, Aimée and SÁNCHEZ-ARENAS, Ricardo León, with adscription in the Instituto Tecnológico de Sonora, as the third article we present, *Utilizations of recycled glass* by FUENTES-CASTAÑEDA, Pilar, BETANZOS-CASTILLO, Francisco and CORTEZ-SOLIS, Reynaldo, with adscription in the Tecnológico Nacional de México/TES Valle de Bravo, as last article we present, *Study of lighting and noise levels in a higher education institution in the Lagunera region* by DE LA PEÑA- MARTINEZ, Ruth & RUIZ –AYALA, José Dolores, with adscription in the Instituto Tecnológico de la Laguna.

Content

Applying electronical devices to save electrical

Auditoria energética a un campus universitario

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Abstract

Saving energy and improving energy efficiency are important challenges that must be faced in the short term. Any company, industrial or service, must consider whether their facilities and processes respond to an optimized design from the energy point of view. Appropriate energy management leads to the efficient use of energy and, consequently, the reduction of energy costs. An energy audit should be part of the energy efficiency programs or plans of any company, as well as any educational institute that wishes to do so. These plans must include those actions aimed at achieving maximum efficiency in energy consumption, maximum savings and knowledge of the energy behavior of their facilities. The objective of this document is to carry out an energy audit in a Higher Education School located in the City of Linares, Nuevo León. Said audit can serve as a model for carrying out energy audits in other types of institutions.

Audit, Energy, Savings

Resumen

El ahorro de energía y la mejora de la eficiencia energética son desafíos importantes que se deben afrontar en corto plazo. Toda empresa, industrial o de servicios, deben plantearse si sus instalaciones y procesos responden a un diseño optimizado desde el punto de vista energético. Una gestión energética adecuada conlleva el uso eficiente de la energía y, por consiguiente, la reducción de los costes energéticos. Una auditoría energética debe formar parte de los programas o planes de eficiencia energética de cualquier empresa, así como también de todo instituto de educación que lo desee. Dichos planes deben comprender aquellas actuaciones encaminadas a lograr la máxima eficiencia en el consumo de energía, los máximos ahorros y el conocimiento del comportamiento energético de sus instalaciones. El objetivo de este documento es la realización de una auditoría energética en una Escuela de Educación Superior situado en la Ciudad de Linares Nuevo León. Dicha auditoría puede servir de modelo para la realización de auditorías energéticas en otros tipos de instituciones.

Auditoria, Energéticos, Ahorro

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Introduction

The context of energy saving, especially electricity, is currently a very important point for the development and comfort of mankind. It is therefore necessary for people to be more interested in the efficient use of energy, whatever it may be, to prevent a shortage that adversely impacts the daily work of any organization, private or service. In addition to the above, the implementation of energy audits provides an adequate parameter to diagnose energy consumption, which gives access to establish energy saving strategies of any kind through the efficient use of energy.

In addition, the care of energy is an area with great job growth, so it is necessary that people have knowledge about this area, based on practical theoretical teaching that provide a broad vision (Torres & Perez, 2019).

And based on the above, it is necessary to carry out integrative projects at the university level, where it is investigated how to solve scenarios that may present the inefficient use of energy of any type in an organization, always looking for energy savings, which represents probable decreases in expenses and conservation of energy resources.

And as Rojas & Contreras (2019) point out, in higher education it is important to use elements that allow a practical teaching, with the simple objective of preparing engineers in an effective way and bringing them closer to real work environments.

The application of energy audits, as described above, is precisely the point that can be carried out according to the characteristics of any organization, since there are different levels, depending on the resources required to invest, from basic to strenuous, with a simple methodology of implementation and monitoring as appropriate.

In the same way, it can be pointed out that the use of energy audits gives access to locate transforming and inexpensive solutions to existing problems in an organization, as is the case of saving electricity on a campus, allowing the development of a comprehensive process among those involved, simple and easy to develop.

Therefore, we propose the development of a study to eradicate the excessive consumption of electricity within the different areas of a university campus, which will be achieved by conducting an energy analysis of all equipment and systems that are part of it, to find areas of opportunity within them that allow us to carry out energy savings, and likewise propose solutions for improvement in the field, and the incorporation of new energy options that are technically and economically viable for an organization.

Rivera (2019), suggests that the Project Method orients to obtain in an established way, activities that allow not only to find and to be aware of new methods, but jointly to experience the taste of an evident result for the same one.

2. Objectives

2.1 General Objective

Through the use of the energy audit to establish a simple process of implementation, that allows to find areas of opportunity for the creation of strategies that allow the saving of electric energy inside a university campus, with the purpose of making more efficient the use of the same one.

2.1 Specific Objectives

a. To make a proposal for a plan of savings and
b. To make a proposal for a savings and performance plan for the campus, in order to reduce the environmental impact in our community.
c. To reduce the use of different appliances in order to reduce costs and have a better economy.
d. Make an improvement plan to encourage to turn off the equipment that is not being used in the different classrooms.
e. Analyze the possibility of integrating renewable or alternative energy installations in the facilities.

3. limitations

The campus does not have an efficient use of one of the causes of this is when the lighting and air conditioners are kept on all day or most of the day, even when not in use, in order to prevent these inappropriate uses.

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An energy audit is proposed, where the consumption will be reflected as well as the areas where the use of this electricity has to be optimized, which has an administrative cost.

To prevent these inappropriate uses, an energy audit is proposed, which will reflect the consumption as well as the areas where the use of this electrical energy, which has an administrative cost, must be optimized. These costs can be used in other ways, such as improving classrooms, improving the quality of buildings, and even promoting the use of renewable energies, which have a lower environmental impact.

Therefore, it must necessarily be taken into account that, although an energy audit can help improve energy efficiency, the lack of long-term vision of the staff of an organization, may mean a rejection in the early stages of the work proposal, coupled with the resistance of people, factors that must be considered in depth. Therefore, it is important to be aware that, when developing any proposal, it is necessary to implement teamwork among students and teachers of the campus.

4. Background

The energy audit is a procedure with which the energy flows in a system or process are examined, recorded and analyzed (Morales *et al*., 2016).

The importance of carrying it out in an organization lies mainly in finding areas of opportunity that help to optimize energy consumption, reducing energy consumption or finding viable alternatives, without affecting the output of an organization's system (Bellido, 2022).

In this context, in 2015, the United Nations (UN) approved the 2030 Agenda for Sustainable Development, in which 17 Sustainable Development Goals (SDGs) are established as an action plan in favor of people, planet and prosperity. Sustainable Development Goal 13 (SDG13) is precisely to "take urgent action to combat climate change and its impacts", while Goal 7 (SDG7) refers to "ensure access to affordable, secure, sustainable and modern energy".

Since then, the SDGs have been present in policies, both government and business, as it is part of environmental social responsibility (García & Quintana, 2012; González et al., 2020). In addition, the sustainable development goals constitute an area of research that has experienced exponential scientific growth (Sianes et al., 2022), factors that guide the efficient use of any available energy, naturally or alternatively.

Likewise, Higher Education Institutions have also declared their commitment to the SDGs (Lozano et al., 2013). For example, the Tecnológico Nacional de México (TecNM) includes sustainability as part of its mission.

Energy audits are conducted in seven stages: authorization management, review of previous diagnostics, billing analysis, survey, measurement of electrical parameters, energy indicators and approach of corrective measures (Morales et al., 2016).

For the realization of this work, only one of the seven stages mentioned above was performed, the "survey"; that is, a format was designed in which the electrical parameters (power, voltage and current) and usage (hours per day and days per week of use) of two categories were recorded: lighting and air conditioning. This is comparable to what (Morillón *et al.,* 2015) define as a "level one or basic" audit, which consists of a visual inspection of energy consuming equipment, without making measurements, so it has the advantage of identifying, in a general way, the possibility of energy savings at a low cost.

Only these two categories (lighting and air conditioning) were evaluated because they consume the highest percentage of energy (Morales *et al*., 2016).

5. Problem statement

The constant problem today is the inefficient use of currently is the inefficient use of energy (electricity, diesel, gas, water, etc.) that an organization uses for its processes or services, and at the same time, the lack of interest on the part of those involved and the lack of knowledge of practical diagnostic tools to know their status with respect to their energy flow, such as energy audits (Poveda, 2007).

Likewise, within the educational program of the Electromechanical Engineering career of the Tecnológico Nacional de México, the subject of Energy Saving is taught, which relates topics oriented to know, face and solve in detail the problems focused on the use of energy. In this subject, a practical development of an energy audit is designed, at the discretion of the teacher, not standardized.

Therefore, it is necessary, from a professional perspective, to promote among students and teachers, an appropriate work structure, depending on the situation, to correctly carry out an energy audit, and to understand its process, importance and impact on an organization based on results. correctly an energy audit, and that they understand its process, importance and impact on an organization based on results.

Therefore, in order to cover this need, an integral strategy of Energy Saving was formulated; which allows to optimally develop an energy audit of a company.

The proposal was mainly oriented to a professional environment within the electromechanical engineering career at the Instituto Tecnológico de Linares, where students used the proposed project structure to develop a work process to find areas of opportunity to improve the use of energy within the institution of study, focusing mainly on electricity consumption.

Based on the above, the objective was to establish whether the proposed work structure to carry out an energy audit in an organization, provides a tool that is sufficient to find points that optimize the use of energy, as is the case of electricity in an educational institution.

6. Methodology

The present study contemplated a approach to elaborate and implement in a practical way a work structure for an energy audit in an educational institution, as part of the didactic and professional process of the sixth semester students of the electromechanical engineering career in the Technological Institute of Linares, to promote its application and recognize its benefits.

In the same way, the following process was established to carry out the corresponding inquiries:

- For work process, the students of the energy saving subject of the electromechanical engineering career of the January - June 2023 semester were selected.
- The students were instructed on the proposal for the practical development of an energy audit.
- For convenience, they opted for electrical consumption devices, such as lighting and air conditioners.
- Working groups were established for the implementation of the energy audit.
- Selection of buildings within the Instituto Tecnológico de Linares to carry out the study.
- Analysis of results.

The following is the structure of practical work to perform the energy audit:

- Initial recognition of the organization, to establish its context with respect to energy and diagnosis.
- Elaboration of Project Charter, of the energy audit plan.
- Objectives (general and specific) of the energy audit project.
- Problem definition.
- Selection of specific work area.
- Create a work plan.
- General inventory of devices.
- Measurement of the consumption characteristics of the devices considering the way the organization works.
- Elaboration of a preliminary rational energy use program.
- Detect areas of opportunity based on points where energy gains and losses occur.
- Economic study of the energy consumption of the devices, including current consumption and historical data of the organization.
- Load factor, demand factor and power factor calculations (in the case of electrical systems).
- Analysis of collected data.
- Proposals and evaluation of their impact on the system or service.

– General results.
– Conclusions and recommendations.

7. Results

The initial diagnosis of the study organization included an analysis of the way of working in the process and service, in order to detect the areas of opportunities that could be presented to improve energy consumption, in this case, electricity.

The needs of the organization with respect to energy savings were correctly delimited in order to prepare the Project Charter, which set out the goals, responsibilities, work dates and commitments of those involved. It clarified the objectives, problems and risks of the energy management project.

The work areas were identified and the work plan was developed according to the space, inadequacies, the organization's way of working and the The work areas were identified and the work plan was developed in accordance with the spaces available, the organization's work methods and the project's restrictions.

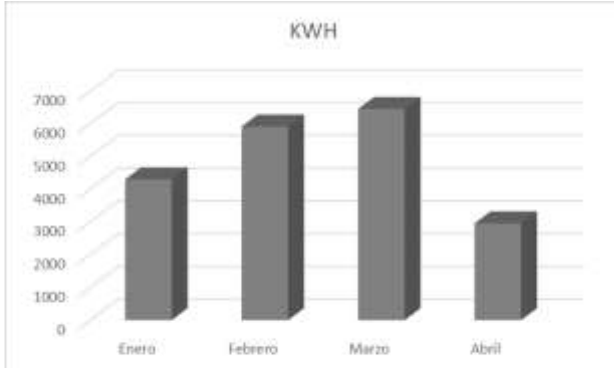
The equipment inventory took into account consumption characteristics, conditions, operating times and maintenance.

Table 1 shows the buildings selected for the energy audit, active power and effective power (considering working periods of a normal day).

Area	Active power (KW)	Effective power (KWH)
Building H	46.412	172.992
Cafeteria	8.888	35.124
Electromechanics laboratory	14.728	45.512
Computer Center	5.838	46.704
Address	21.799	126.275
Library	46.539	217.474
School building	62.540	205.120
Building G	13.350	41.650
Building C	21.320	84.080
Engineering Building Industrial	67.625	268.645

Table 1 Data of information collected

Table 2 shows the average consumption in January, February, March and April 2023.



Graph 1 Average consumption

As a parallel result of the monitoring of consumption during the four months, the way the organization works and the use of electrical devices (lighting and air conditioners) was known, which allowed the development of a preliminary rational energy use program, whose main feature is to propose short-term strategies to improve the use of energy, at low or no cost to the organization.

Problematic	Strategy
Doors open with air conditioners on	Create a regulation of use for users
Air conditioners on with no students or staff in work areas	Create a regulation of use for users
Laminarias always on where there are no students or staff	Create a usage regulation for users
Some doors do not close properly	Maintenance of pistons and door gaskets
Some windows are not tinted or without blinds	Schedule installation
Lack of maintenance on some air conditioners	Schedule maintenance
Inadequate gauges for air conditioners.	Change the wiring and place the appropriate one to avoid overheating.

Table 2 Rational energy use program

The preliminary simple energy analysis of the work areas determined that there are a large amount of electrical energy losses in the different devices, either due to misuse or lack of maintenance, based on a measurement of the temperature in the systems at peak working hours and the Joule effect in the conductors in general. With reference to the current economic study against the organization's history, there was no great difference with the four months of observation, which shows that the consumption monitoring was carried out correctly with the current tariffs.

The load factor and power factor calculations for the selected areas showed results ranging from 9.23% to 13.19% for the load factor. And from 0.92 to 0.99 for the power factor.

8. Conclusions

The development and application of an energy audit is in itself a useful instrument for the reduction of energy consumption, in this case electricity, since it provides in a solid way enough information to declare if the energy of an organization is being used in an efficient way, regardless of the type of energy used energy consumption of an organization, regardless of the line of work. Therefore, it can be stated that with a correct implementation of the same can create areas of opportunity for energy savings and therefore decrease direct and indirect costs. In addition, it allows the creation of a database for future savings strategies in an organization, since it already has a history of firm consumption.

In the same way, it can be observed in the results obtained before, with the established work technique, that the lack of awareness of the personnel with respect to energy saving is a point that must be addressed with the same way in which better use is made of the work equipment.

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References

Bellido Medic, D. (2022). *Aplicación de las metodologías de auditoría energética y sistemas de gestión energética a una instalación industrial*. Doctoral dissertation, ETSI_Energia).

García, A. y Quintana, L.F. (2012). *Responsabilidad social ambiental de las universidades colombianas*. Revista de Investigación Agraria y Ambiental, 3: 123. https://doi.org/10.22490/21456453.971

González, D.A., Díaz, A.A., Sotelo Zarate, M.J. y Martínez Marciales, Á. (2020). *Responsabilidad Social Ambiental y Educación Globalizada*. CITECSA, 12: 35-43.

Lozano, R., Lukman, R., Lozano, F.J., Huisingh, D. y Lambrechts, W. (2013). *Declarations for sustainability in higher education: Becoming better leaders, through addressing the university system. Journal of Cleaner Production*, 48: 10 19. ttps://doi.org/10.1016/j.jclepro.2011.10.006

Morales, M., González, Ó., Sefoó, C.S. y Morillón, D. (2016). *Auditoría Energética a Edificaciones de la Universidad Nacional Autónoma de México: Instituto de Energías Renovables.* Acta de la XXXIX Reunión de Trabajo de la Asociación Argentina de Energías Renovables y Medio Ambiente, 4: 10.

Morillón, D., Escobedo, A., y García, I. (2015). *Retos y oportunidades para la sustentabilidad energética en edificios de México: Consumo y uso final de energía en edificios residenciales, comerciales y de servicio*. Universidad Nacional Autónoma de México. 123 pp.

Poveda, M. (2007). *Eficiencia energética: recurso no aprovechado.* OLADE. Quito. Rivera, B. (2019). *Método de proyecto y su influencia para desarrollar habilidades en instrumentación industrial de los estudiantes del tercer ciclo de electrónica industrial del instituto superior tecnológico público "Almirante Miguel Grau-Piura"* (Tesis de grado). Universidad Católica de los Ángeles Chibote, Piura, Perú.

Rojas, J. S. y Contreras, S. (2019). *Construcción de un prototipo para el mejoramiento de la enseñanza de la energía fotovoltaica* (Trabajo de grado). Universidad Santo Tomás, Bogotá D.C., Colombia. Sianes, A., Vega-Muñoz, A., Tirado-Valencia, P. y Ariza-Montes, A. (2022). *Impact of the Sustainable Development Goals on the academic research agenda. A scientometric analysis*. PLoS One, 17: 1-23. https://doi.org/10.1371/journal.pone.0265409

Torres, P. S. y Pérez, F. R. (2019). *Diseño y simulación de un módulo didáctico de un sistema de bombeo a presión constante para la capacitación de los alumnos de Ingeniería Electrónica de la UNPRG* (Tesis de grado). Universidad Nacional "Pedro Ruiz Gallo", Lambayeque, Perú.

Methodological proposal for the transfer of industrial manufacturing processes in a transnational firm: A China-Mexico particular case

Propuesta metodológica para la transferencia de procesos de manufactura industrial en una firma trasnacional: Un caso particular China-México

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Abstract

This paper addresses the problem of the transfer of international production processes in the manufacturing industry and proposes a methodology to identify the essential activities required for it. The bibliographical research reveals the problems associated with the lack of an objective methodology in the management of projects for the transfer of processes between countries. In order to solve this problem and in the absence of a specific methodology, a case study was developed, based on the transfer of the Zoned Amplified production line of the Carrier company, from China to Mexico. In order to obtain a solid and complete methodology, different authors and proposed approaches for manufacturing transfers were compared, collecting the relevant information. As a result, a methodology composed of seven steps is proposed, either: factors for implementation, initiation of transfer documentation, design of the transfer plan, design for manufacturing, technology transfer and installation requirements, validation process and, finally, launch. This contributes to the industry in general, a practical and effective guide to address international process transfer projects, associated with specific standards in some cases, thereby overcoming the associated challenges and guaranteeing success in their execution.

Manufacturing processes, International transfer, APQP, Methodology for process transfer

Resumen

El presente trabajo aborda el problema de la transferencia de procesos de producción internacionales en la industria manufacturera y propone una metodología para identificar las actividades esenciales requeridas para ello. La investigación bibliográfica revela las problemáticas asociadas a la falta de una metodología objetiva en la gestión de proyectos de transferencia de procesos entre países. Con el objetivo de resolver esta problemática y ante la ausencia de una metodología específica, se desarrolló un estudio de caso, basado en la transferencia de línea de producción Zoned Amplified de la compañía Carrier, desde China hacia México. Para obtener una metodología sólida y completa, se compararon distintos autores y enfoques propuestos para transferencias de manufactura, recopilando la información relevante. Como resultado, se propone una metodología compuesta por siete pasos, a bien: factores para la implementación, iniciación de documentación de transferencia, diseño del plan de transferencia, diseño para manufactura, transferencia de tecnología y requisitos de instalación, proceso de validación y, finalmente, lanzamiento. Con ello se contribuye para la industria en general, una guía práctica y efectiva para abordar proyectos de transferencia de procesos internacionales, asociados a normas específicas en algunos casos, superando con ello los desafíos asociados y garantizando el éxito en su ejecución.

Procesos de manufactura, Transferencia internacional, APQP, Metodología para transferencia de procesos

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1. Introduction

Technology transfer in industrial manufacturing has gained significant relevance in recent years. In particular, the international transfer of manufacturing processes has become a common strategy for companies seeking to diversify into new markets and optimize their operational efficiency. However, despite its importance, there is a lack of documentation and specific methodologies to guide this transfer process. This lack poses significant challenges in terms of product quality, process reliability and proper validation.

During 2018, United Technologies Corporation (UTC) announced its split into three independent companies, encompassing the aerospace, elevator and air conditioning divisions. This strategic decision materialized with the acquisition of Rockwell Collins, allowing the aerospace division to become an independent entity. Subsequently, on April 3, 2020, United Technologies formalized the separation of Carrier and Otis, while concluding the merger with Raytheon Company Cimate, Control & Security, a provider of heating, ventilation and air conditioning (HVAC), refrigeration and fire safety technologies, was renamed Carrier. As part of its strategy, the company has emphasized the importance of its independence, focusing on operational priorities, growth strategies and long-term profitability. These objectives include strengthening and growing its core businesses, expanding its product portfolio and geographic coverage, as well as developing digital services and offerings (Carrier Becomes Independent, Publicly Traded Company, Begins Trading on New York Stock Exchange, 2020).

In the context of diversification into new markets, Carrier has adopted international manufacturing process transfer as a key strategy. Although this practice is common in large companies, there is a paucity of specific information and documentation to guide the process of technology process transfer at the industrial level. The lack of a formal and registered methodology hinders the preservation of the quality of the final product, the reliability and reproducibility of the manufacturing process in the receiving unit, as well as the adequate validation of the process (Janodia et. al., 2008). Previous studies have shown several problems arising from the transfer of manufacturing processes in international companies.

A common problem is to determine whether the process should be transferred without modification (cloning) or whether it requires specific adaptations (Grant & Gregory, 1997).

In addition, it has been observed that the methodologies previously used for the transfer of manufacturing development lacked an analytical and systematic approach, resulting in a problematic process without clear direction, as well as being time consuming (Gerson et. al., 1998). It is clear that technology transfer requires proper documentation, a planned approach and trained personnel working within a quality system, covering all aspects of development, production and quality control (WHO, 2007).

In this context, the objective of this study is to develop a methodology for the international transfer of manufacturing processes. To achieve this, we will take as a case study the company Carrier, located in Navojoa, Sonora, which seeks to transfer the Zoned Amplified production line from China to Mexico. The purpose is to establish a systematic frame of reference to standardize, structure and organize the transfer process, providing a record that can be used in future related research.

The relevance of this research lies in its contribution to the industrial field by providing a methodology for the international transfer of manufacturing processes, based on the specific case of the transfer of Carrier's Zoned Amplified production line. The scarcity of systematic and structured information in this field highlights the importance of developing a methodology that facilitates the transfer process, allowing to reduce time, identify potential risks and provide tools and knowledge to the teams involved.

It is important to note that this study focuses on the process adaptation methodology, considering the current conditions of the case study, for which specific tools and approaches are proposed, according to the characteristics and needs of the manufacturing process to be transferred (Gaspar and Bustamante, 2019; Ruiz, 2015). However, it is clarified that the project will not cover the validation and launching stage of the new line, as another specific project will be required for that purpose.

This scientific article will be organized in the following sections: after this introduction, there is the literature review section, then the methodology, presentation of results and finally the conclusions.

2. Literature review

2.1 Manufacturing processes

Manufacturing processes are sequences of related activities that occur in an orderly and sequential manner, with the objective of adding value to inputs and generating a specific output or service for a customer or stakeholder or system. Manufacturing involves the making of goods and articles, either by hand or by machinery, with the division of labor. Manufacturing can be viewed as a transformation of materials and information into goods that satisfy human needs. Manufacturing processes comprise a wide range of disciplines and use various levels of automation, which are carried out through a succession of operations that bring the material closer to the desired final state (Maynard, 2006).

Also, manufacturing processes can be classified into two main types: process operations and assembly operations. Process operations add value by changing the geometry, properties or appearance of the material, while assembly operations put components together to create a new assembly. Product development can be simple, with a single operation, or more complex, with multiple operations, depending on the specifications of the final product (Maynard, 2006 and Groover, 2007).

2.2 Elements of Manufacturing Processes

Manufacturing processes require five main elements, known as the 5M's: Material, Method, Machinery, Labor and Environment. The first of these refers to any element or input that is generally obtained as raw material; the second implies that each product, part or material requires a specific method to transform the raw material into the desired product.

The third is related to the machinery and/or equipment to give shape, size and properties to the material and comply with the product specifications.

The fourth is the skilled labor to operate the machinery and apply the manufacturing methods; and the fifth refers to the environmental conditions present in the production environment, which are assumed to have an implication in the four previous elements to reach the desired result.

It is important to mention that other elements are also considered, such as measurement and factors related to the environment, which are equally important nowadays. Thus, the interaction of this set of elements and their correct management, guide the achievement of the expected results of the manufacturing process (Maynard, 2006).

2.3 Production lines

A production line is a set of operations in sequence that are carried out in a factory to assemble components and manufacture a finished product (Maynard, 2006; Corvo, 2019). It consists of the organization of a process through the sum of a series of sequential operations, therefore, it is valid to assume as a synonym of production process. In these production lines, there may be intermediate or final workstations for quality assurance, as well as packaging stations. Each workstation performs a part of the total work required to manufacture the product.

According to Maynard (2006) and Medina et. al. (2019), production lines are of utmost relevance in industry, since all the processes necessary for the creation of a product are carried out in them. The design of a production line involves knowing the operations to be carried out and capturing them in a block diagram. To ensure efficient production, it is necessary to avoid downtime, guarantee good manufacturing quality, optimize workplaces and have adequate storage for the products (Figure 1). They also describe three types of production lines:

a) Single model line: This production line focuses on the manufacture of a single product model. It is used when market demand is high for a single product or when the company specializes in the production of a specific item. The design and configuration of the production line is completely adapted to the needs of the single model, allowing for efficient and optimized production.

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b) Batch production line: In this type of production line, different products are manufactured in batches or groups. The products may be similar or have common characteristics that allow them to be produced together. For example, in automobile manufacturing, different models can be produced in batches, allowing resources to be shared and efficiency to be maximized. Each batch can pass through the production line following a sequential approach.

c) Mass production line: This type of production line is used when the company needs to manufacture large volumes of identical products on a continuous basis. The production line is designed to achieve high levels of efficiency and productivity, optimizing processes and minimizing changeover times between products. Mass production is applied in industries such as electronics, food or consumer goods manufacturing.

It is important to keep in mind that these are only examples of the three most common types of production lines, being the ones that apply to the case under study, in addition to the fact that organizations can adapt or combine them according to their specific needs.

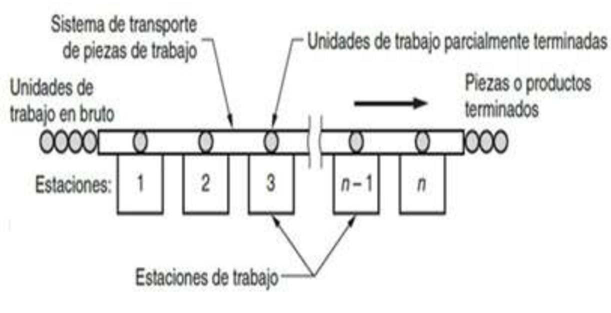

Figure 1 General configuration of a production line *(Adapted from Maynard. 2006 and Groover, 2007)*

2.4 Grant and Gregory's Methodology

According to Grant and Gregory (1997) and Janodia et. al. (2008), they mention that the demand for manufacturing process transfer occurs frequently in international companies; however, it should be taken into account that the study that supports this statement was published more than 20 years ago, so it is logical to think that nowadays this type of projects occur more frequently.

In the aforementioned research, the problem that companies have when deciding whether the transfer of manufacturing processes will be a cloning or an adaptation from the transferor to the receiver is mentioned, taking as a reference a set of factors divided into two dimensions, namely, 1) factors of adequacy and robustness and 2) transferability factors.

In the first group, 9 elements are assumed, ranging from the identification of the target market, through the analysis of organizational capabilities such as human resource skills, infrastructure, culture, supply chain; to the analysis of the environmental environment and the legal and regulatory requirements to be met. The second group of factors is based on the knowledge possessed and previous experience in this type of events, and also reviews the technological capacity and relevance, as well as the adaptability to change implied by the process to be transferred (Table 1).

Table 1 Factors influencing adaptation for a transfer setting
(Adapted from Grant and Gregory, 1997)

The fit of manufacturing processes can be systematically performed using the table as a checklist. Some dimensions of fit can be quantified and compared to a host capability profile, thus identifying areas of inadequacy that might otherwise go unnoticed until the start-up of the transferred facility.

As the authors mention to us, this table should be applied prior to transfer to verify whether the host is suitable for such a transfer, and whether retrofitting will be necessary.

2.5 APQP (Advanced Product Quality Planning) Methodology Quality Planning)

In addition, there are other methodologies and approaches used for the transfer of manufacturing processes, such as the Continuous Improvement model, the Knowledge Management model and the Project Management Based Approach. These methodologies focus on ensuring efficiency, quality and continuity of the process during the transfer, in addition to involving support in the incorporation of new technologies and sometimes even risk-sharing projects in the design and development of the production processes that are transferred (Mendoza and Valenzuela, 2014).

On the other hand, due to the high quality standards and new competitors in the automotive sector, and so organizations require different tools and techniques to help them improve their productivity, reduce costs, meet the requirements of their customers and maintain effective communication throughout the supply chain (Mora, 2021), a tool that has helped this sector, in the cases of product design and development, has emerged.

It is the APQP (Advanced Product Quality Planning) methodology, which is cited in this work due to its common application within the automotive manufacturing industry worldwide, as a base methodology for process transfers. The APQP tool is part of the Core Tools, which are a set of tools originally developed in the automotive industry to design, develop, measure, record, analyze and approve quality products and services that meet customer needs and expectations (Sillero et. al., 2019).

Within this set of tools there are 5 others, apart from the APQP tool, which are: PPAP (Production Part Approval Process), FMEA (Failure Mode and Effects Analysis), SPC (Statistical Process Control), MSA (Measurement System Analysis) and CP (Control Plan). All these tools are part of the IATF 16949:2016 standard (Quality Management Systems Standard specific to the automotive industry). Figure 2 illustrates the APQP model (AIAG, 2008; TDAE, 2021).

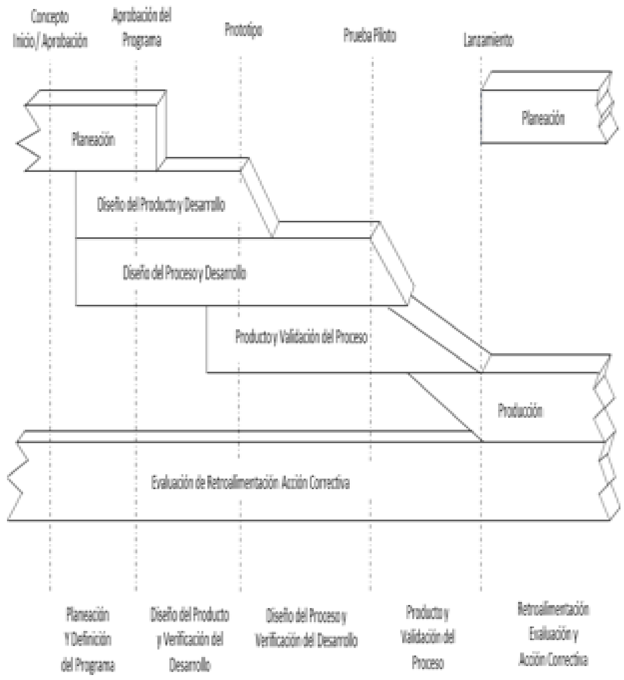

Figure 2 Time graph of a product quality planning (AIAG- APQP Manual, 2008)

The following is a brief description of each of the APQP stages (AIAG, 2008; Gutiérrez, 2014; Mora, 2021; TDAE, 2021):

1. Program planning. This phase has as inputs the legal and negotiation requirements established by the companies. These include the business plan, product characteristics and customer requirements.

2. Product design and development. It has to define the key characteristics of the product, the expected production processes and the potential suppliers needed in order to assess the feasibility of design manufacturing from the documentation submitted.

3. Design and process development. A production readiness review is performed to ensure that the process produces products consistently and compliantly according to customer and supplier requirements.

4. Product/process validation. At this stage, the product is produced according to the planned production using defined equipment and processes.

5. Feedback, evaluations and corrective actions. Define activities that include defect and price reduction, as well as time and product improvement.

According to the Advanced Planning for Product Quality and Control Plans manual (AIAG, 2008), at the project closure and entry stage of the project, the following activities are required (AIAG, 2008), at the stage of project closure and entry into production, the relevant aspects of the operation of the final product are evaluated and subjected to improvement processes in terms of quality, time and delivery and cost indicators. The participants in the project evaluate the positive aspects, as well as those that could be improved in the execution of the plan. Records are made of lessons learned and good practices applicable to future projects. This stage is assumed as the principle of Continuous Improvement.

It is important to highlight that the transfer of manufacturing processes can present significant challenges, such as the loss of tacit knowledge, adapting to new conditions and ensuring operational continuity. Therefore, it is critical to have a systematic approach and appropriate methodologies to ensure the success of production line transfer (Grant and Gregory, 1997; Borrero and Maya, 2018; Garcia- Sabater, 2020).

In addition to the steps mentioned above, there are other key considerations in the manufacturing process transfer process, such as risk management, which consists of managing the risks associated with the process transfer, is essential to minimize negative impacts; effective communication, which is critical throughout the transfer process, including keeping all stakeholders informed, from personnel directly involved in the transfer to customers and suppliers; another consideration is the measurement of indicators and follow-up, which involves monitoring process performance, analyzing the results and taking corrective action when necessary.

Therefore, the transfer of manufacturing processes is, in itself, a complex process that requires proper planning, documentation, evaluation, implementation and follow-up.

3. Methodology

This section describes the activities that were necessary to achieve the were necessary to achieve the proposed objective, that is, to develop a methodology for the international transfer of manufacturing processes, by means of the case of the company under study. Thus, based on the pertinent information of the technical and design aspects involved in a transfer, the proposed methodology is constructed, integrating and structuring the corresponding elements. It is important to mention that the actions described in each phase can be carried out in order or not, likewise, they are considered highly iterative.

Phase I. Project initiation.

Objective: Define the project for the transfer of the corresponding manufacturing process in general terms for approval.

Actions:

1. Identify the vision and objectives based on the results we want to obtain at the end of the project. It is important to determine whether the objectives will be measurable or quantifiable; they must have the characteristics of being realistic, achievable and precise, along with the importance of time constraints. In this way, we can have a general project direction.

2. Assign teams. Team assignment is one of the most important points for the success of a project, so it should involve, if possible, all interested and/or affected parties. After determining the participants, the project leader (who will be responsible for achieving the expected results in a timely manner) should be assigned.

3. List the main functions involved, along with their responsibilities, and assign them to the appropriate party. This should be done in a structured manner together with a communication plan.

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4. Initiate documentation for the transfer. All necessary documentation for the transfer of the manufacturing process shall be provided. The requirements that may be involved shall be documented together with the general plan. Likewise, the risks that may arise before, during and after the execution of the project should be identified and documented along with their possible solutions.

Phase II. Preparation of the transfer

Objective: Prepare all the necessary aspects to carry out the transfer of the manufacturing process effectively.

Actions:

1. Identify the resources and equipment required for the process transfer. This includes specialized personnel, machinery, facilities and any other resources needed to carry out the manufacturing process.

2. Establish a detailed schedule that includes all the activities required for the process transfer.

This will allow for proper management of time and resources throughout the project.

3. Designate a project team in charge of coordinating and executing the process transfer. This team should include representatives from different areas involved in the manufacturing process, such as production, engineering, quality and logistics. iv) Clearly define the roles and responsibilities of each member of the project team. This will ensure proper distribution of work and effective communication among all involved.

4. Conduct a detailed analysis of the existing manufacturing process, identifying critical points, constraints and areas for improvement. This analysis will serve as the basis for the design of the manufacturing process at the target location.

5. Establish the acceptance criteria for the transfer of the process, defining the quality, performance and efficiency standards to be met at the target location.

Phase III. Design of the manufacturing process at the target location.

Objective: Adapt the existing manufacturing process to the target location, taking into account local specifications and requirements.

Actions:

1. Analyze the differences and similarities between the source location and the target location, considering factors such as local regulations, supply of materials, availability of labor and any other relevant aspects.

2. Design the manufacturing process adapted to the destination location, taking into account the constraints and resources available at that location. This may involve modifications to equipment, changes in procedures or any other measures necessary to adapt to the any other measures necessary to adapt to the local environment.

3. Establish the validation criteria for the newly designed manufacturing process, defining the necessary tests and verifications to ensure its functionality and compliance with the established standards.

4. Develop the necessary documentation to support the new manufacturing process, such as procedure manuals, work instructions, specification sheets and any other relevant document.

Phase IV. Implementation of the new manufacturing process.

Objective: Implement the new manufacturing process at the target location in an effective and efficient manner.

Actions:

1. Conduct testing and validation of the new manufacturing process to ensure proper operation and compliance with established standards.

2. Provide training and coaching to personnel involved in the operation of the new manufacturing process. This includes both existing personnel as well as new personnel hired specifically for the target location.

3. Make adjustments and optimizations to the new manufacturing process, based on test results and feedback from the personnel involved.

4. Establish monitoring and control systems to ensure the quality and efficiency of the new manufacturing process.

5. Gradually transfer production of the manufacturing process from the source location to the destination location, ensuring a smooth transition and minimal disruption in the supply chain.

Phase V. Validation and optimization of the new manufacturing process.

Objective: Validate and optimize the new manufacturing process at the destination location to ensure its efficiency and compliance with established standards.

Actions:

1. Conduct a thorough validation of the new manufacturing process to ensure its compliance with previously established criteria and standards.

2. Identify opportunities for improvement in the manufacturing process and make adjustments to optimize its performance, quality and efficiency. iii) Monitor and analyze the key performance indicators of the new manufacturing process in order to identify possible areas for improvement and take the corresponding corrective actions.

3. Collect and document the lessons learned during the implementation of the new manufacturing process, with the objective of applying them in future transfer projects.

Phase VI. Closure and evaluation of the transfer project.

Objective:

To conduct a formal closure of the project, including documentation of results, delivery of final reports, and completion of administrative and logistical aspects related to the transfer of the manufacturing process.

Conduct an evaluation meeting with the project team and other stakeholders to review project results, identify lessons learned and discuss possible improvements for future manufacturing process transfers.

Conduct appropriate internal and external communication to report on the success of the manufacturing process transfer project and highlight the benefits achieved. Expected results: A successfully closed manufacturing process transfer project, with a full evaluation of the results and lessons learned documented.

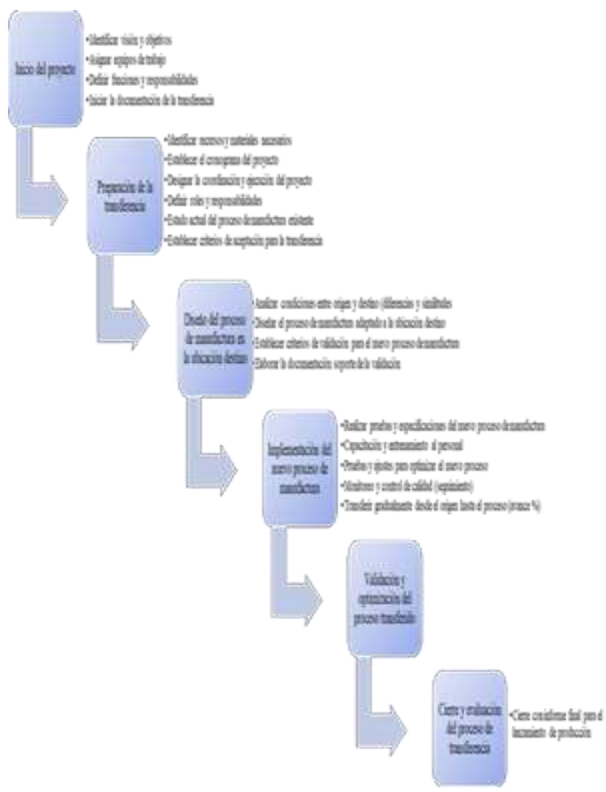

Figure 2 Phases of the proposed methodology
Own elaboration based on Grant and Gregory, 1997; Groover, 2007)

4. Results

The results obtained after applying the methodology

The results obtained after applying the methodology developed for the transfer of manufacturing processes in the case study are presented below:

4.1 Start of the project

The transfer project, called "Rebranding" and led by the New Product Introduction (NPI) area, started prior to the completion of this work, so detailed information on the initial decisions made to determine the type of transfer to be implemented is not available. However, it is known that a transfer adaptation was carried out. The vision and objective of the project were established, assigning activities to the teams involved according to their profiles and roles. These activities included the development of a communication plan in collaboration with the parent plant's project manager, the designation of a project leader and the initiation of the documentation of the process to be transferred.

4.2 Design of the transfer plan

Once the initial transfer requirements were approved, the responsibilities to be executed were delineated. The scope of the project was determined and the initial master plan was prepared, considering the critical elements that could affect the project. These activities were led by the project team, managers and the project manager of the parent plant. The detailed documentation of these activities is kept confidential and will not be discussed in this work for reasons of industrial secrecy.

The plant layout was defined by the NPI area together with the plant engineer. This decision was fundamental to determine the type of transfer to be carried out, opting for an adaptation due to the existence of a previous line of the same client with similar activities. It was decided to extend this existing line to incorporate the new process to be transferred.

Likewise, a review of materials was carried out, identifying the need to change suppliers to comply with the new brand requirements (from UTC to Carrier). This transition was mainly reflected in the documentation and packaging labels.

4.3 Design for manufacturing

The manufacturing team evaluated the technical specifications of the product to be manufactured. Although it was decided to change suppliers, the raw material remained the same. Since a similar procedure existed at the receiving plant, this activity was less complex and faster than estimated. In addition, the new suppliers were selected and approved, the documentation related to the engineering change was generated, and the labels for the final packaging of the transferred product were designed.

The tooling required for the operators was created from scratch, using SolidWorks CAD software to generate printed prototypes with the company's in-house 3D printer. The designs were developed by the manufacturing team and approved by the quality team, the project leader and management. Subsequently, the tooling was manufactured in larger quantities and with high-quality specialized suppliers.

4.4 Technology transfer and installation requirements

The transfer of machinery and technological elements necessary to ensure the successful operation of the transfer process was carried out. Specific details on the acquisition of materials and their validation are not provided due to confidentiality, but they were clearly defined in accordance with the design specifications.

4.5 Validation process

Finally, a comprehensive review was conducted for product launch, which included process validation testing, personnel training, establishment of quality inspection plans and definition of operational requirements, as well as the operational design of the production line or manufacturing process.

These results show that the implementation of the manufacturing process transfer methodology was successful in the case study. The existing process was adapted to incorporate the new product and the necessary changes were made in terms of suppliers, tooling and technology. The discussion of these results could focus on the effectiveness of the applied methodology, challenges encountered during implementation and lessons learned.

In addition, aspects such as the impact on product quality, process efficiency and customer satisfaction could be addressed. One of the highlights is the collaboration between the different teams involved in the project, as well as the assignment of clear roles and responsibilities, as well as the assignment of clear roles and responsibilities, as well as effective communication, which allowed the workflow to be coordinated and efficient. This facilitated the execution of the planned activities and contributed to the overall success of the transfer.

The decision to carry out a transfer adaptation, taking advantage of an existing line with similar activities, proved to be a wise one. This strategy minimized the impact on existing infrastructure and resources, while incorporating the new process in an efficient manner. In addition, by keeping the same raw material, the changes and complexities associated with the acquisition of new materials were reduced.

The design of specific tooling for the operators, using CAD technology and additive manufacturing, was another highlight of the implementation, since it allowed for greater precision and efficiency in the manufacture of the components required for the process. In addition, involving the quality team in the approval of the designs ensured that they met the required standards. The transfer of machinery and technological elements was fundamental to guarantee the successful operation of the process. Procurement of materials through the purchasing team and validation by the manufacturing team ensured that quality standards were met and that the necessary resources were available at the right time.

The final validation process, which included extensive testing, training of personnel and establishment of quality inspection plans, was crucial to ensure that the transferred product met the established requirements and specifications. This stage enabled potential problems to be identified and adjustments to be made before the product was launched on the market.

5. Conclusions

The present work on manufacturing process transfer has demonstrated the importance of having a detailed and orderly procedure to achieve success in the development of this type of project has demonstrated the importance of having a detailed and orderly procedure to achieve success in the development of projects of this type. Throughout the implementation of the methodology, expected results have been obtained and several problems have been overcome, which has allowed the achievement of the established objectives. Despite the challenges and limitations encountered, such as the Covid-19 pandemic situation that generated delays with suppliers, the systematic approach and rigorous planning have been fundamental to overcome the obstacles and keep the project on track.

Effective communication has been a key aspect of this process. Constant interaction between the teams involved, both internally and with foreign operations, has maintained a smooth flow of information and ensured alignment of all project participants, and has been particularly relevant in addressing the challenges arising from the international transfer and ensuring successful integration of processes.

Thus, based on the results obtained and lessons learned, it is technically recommended to maintain this methodological approach in future process transfers. Alternatively, having a well-structured and time-bound procedure has proven to be an effective strategy to achieve efficient and quality results.

The successful implementation of the manufacturing process transfer methodology has confirmed the importance of planning, communication and rigorous follow-up in this type of project.

Through team collaboration, problem solving and adaptation to changing circumstances, the objectives have been achieved.

The APQP methodology can be of significant help in taking into account all factors related to product design and development, as it offers both inputs and outputs, and suggested tools for the creation of quality products, within the context that is commonly used (automotive industry).

However, the methodology proposed in this work, offers all this having a unique approach to manufacturing process transfers, making the course of the project more manageable and in shorter times with quick decision making.

Finally, this work lays the groundwork for future process transfers, providing valuable guidance for obtaining optimal results and promoting success in similar projects, particularly for the productive context of the company under study.

Acknowledgements

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References

Automotive Industry Action Group. (2008). Planeación Avanzada para la Calidad de Productos y Planes de Control: APQP. *AIAG*, Segunda Edición.

Borrero, L. y Maya, L. (2018). Transferencia de conocimiento de las prácticas exitosas de Ideaxión entre plantas de producción de cemento y concreto Argos, ubicadas en CCA y Colombia [Tesis de maestría, Universidad EAFIT, Medellín, Colombia]. Repositorio institucional https://repository.eafit.edu.co/bitstream/handle/10784/12766/Lina_MayaCardona_Lucas_BorrerodeCastro_2018.pdf

Carrier. (2020, April 3). *Carrier Becomes Independent, Publicly Traded Company, Begins Trading on New York Stock Exchange*. Retrieved from Carrier Global Corporation: https://www.corporate.carrier.com/news/n ews-articles/carrier_becomes_independent_publicly_traded_company__begins_trading_on_new_york_stock_exchange.html

Corvo, H. S. (2019, julio 24). Línea de producción: caracteristicas, organización, balance, ejemplo. Retrieved from lifeder: https://www.lifeder.com/linea-de- produccion/

García-Sabater, J. P. (2020). Líneas de producción. Nota técnica. Retrieved from RIUNET Repositorio UPV: http://hdl.handle.net/10251/138801

Gaspar, J.E. y Bustamante, R. (2019). Implementación de una metodología basada en manufactura esbelta para el arranque de operaciones de una planta automotriz. Revista Nthe, No. 25, abril- julio de 2019: pp.1-10, ISSN: 2007-9079.

Gerson, D. F., Himes, V., Hopfer, R., Khandke, L., Kohn, F., Komotar, A., Sciotto- Brown, S. (1998). Transfer of process from development to manufacturing. Drug Information Journal, 19-26. Grant, E. B., & Gregory, M. J. (1997). Adapting manufacturing process for international transfer. International Journal of Operations & Production Managment, 994-1005.

Groover, M. P. (2007). Fundamentos de manufactura moderna. México, D.F.: McGraw-Hill Interamericana.

Gutiérrez Restrepo, S. (2014). Método de aplicación de la Planeación Avanzada de la Calidad del Producto (APQP) en las ensambladoras y proveedores del programa de gestión del sector motocicletas en los proyectos de desarrollo de nuevos productos. Universidad EAFIT, 4-10.

Janodia, M. D., Sreedha, D., Virendra, S., & Ajay, P. (2008). Technology Transfer: A perspective of Pharmaceutical Industry. Journal Pharmaceuticals, 13-34.

Maynard, H. (2006). Manual del Ingeniero industrial. Vol. I, 5ª Ed. McGraw-Hill/Interamericana de México.

Medina, A., Nogueira, D., Hernández, A. y Comas, R. (2019) Procedimiento para la gestión por procesos: métodos y herramientas de apoyo. Ingeniare. Revista chilena de ingeniería, vol. 27 Nº 2, 2019, pp. 328-342.

Mendoza León, J. G., & Valenzuela Valenzuela, A. (2014). Aprendizaje, innovación y gestión tecnológica en la pequeña empresa. Un estudio de las industrias metalmecánica y de tecnologías de información en Sonora. Contaduría y Administración, 59(4), 253-284

Mora Serrano, J. L. (2021). El APQP COMO UNA HERRAMIENTA DE MEJORA PARA LAS EMPRESAS DEL SECTOR AUTOMOTRIZ. Fundación Universidad de América. Facultad de Ingeniería.

Ruiz, J.M. (2015). Gestión y arranque de línea de producción “mixed model manufacturing – 3P” [Tesis de maestría, Centro de Investigación y Asistencia Técnica, Aguascalientes]. Repositorio institucional https://ciateq.repositorioinstitucional.mx/jspui/bitstream/1020/55/1/RuizLopezJonathanM%20MMANAV%202015%20AUT ORIZADA.pdf

Sillero Pérez, J. A., Roaro García, L. O., Villalón Guzmán, M. T., & Vázquez Rojas, S. (2019). Herramientas de Core Tools para implementar mejoras en la línea de producción. Pistas Educativas.

WHO. (2007). Quality assurance of pharmaceuticals: A compendium of guidelines and related materiales. Good manufacturing practices and inspection, Volume 2.

Utilizations of recycled glass

Usos del vidrio reciclado

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Abstract

Glass recycling in Mexico accounts for only 12%, making it one of the materials with the lowest percentage in this area. The different applications where recycled glass can be used range from the construction industry, concrete production replacing fine aggregate or cementitious material, ceramic materials, architecture (mortar), glass blocks, road paving and dentistry. Among the sources of discarded glass to be recycled are primarily beverage bottles and window glass; however, there are a wider variety of glass items to be investigated for use as recycled material, as well as their use in these and other applications. From the review carried out in the research work presented here, a different panorama was obtained with respect to other sources of waste glass that can be recycled, without losing sight of the fact that this will contribute to reducing the environmental impact, in a first stage of the area surrounding the Educational Institution in which the work is carried out.

Recycled glass, Concrete, Cement

Resumen

El reciclado de vidrio en México cuenta con solo el 12%, siendo uno de los materiales con menor porcentaje en este rubro. Las diferentes aplicaciones donde el vidrio reciclado puede ser utilizado, van desde la industria de la construcción, elaboración de concretos remplazando al agregado fino o material cementante, en materiales cerámicos, arquitectura (mortero), bloques de vidrio, pavimentación de carreteras y la odontología. Entre las fuentes de vidrio desechado para ser reciclado se encuentran principalmente las botellas de bebida y vidrio de ventanas; sin embargo, existen una variedad más amplia de artículos de vidrio para ser investigados y poder ser utilizados como material reciclado, así como su uso en estas y otras aplicaciones. De la revisión realizada en los trabajos de investigación aquí presentados, se obtuvo un panorama diferente respecto de otras fuentes de vidrio de desecho que pueden ser reciclados, sin perder de vista que con ello se contribuirá a reducir el impacto ambiental, en una primera etapa, de la zona circundante a la Institución Educativa en la que se trabaja.

Vidrio reciclado, Concreto, Cemento

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Introduction

The increase in municipal solid waste (MSW) production is directly related to population growth and current lifestyles, which generally define a higher consumption of goods and services. This trend makes it necessary to put attention to issues related to the collection, management, and final disposal of waste (SEMARNAT, 2016).

In Mexico, 102,895 tons of MSW are generated daily, of which only 83.93% is collected and 78.54% is disposed of in final disposal sites, with only 9.63% of the MSW generated being recycled. According to estimates of the National Association of Plastics Industries (ANIPAC), the national recycling market is worth more than 3 billion dollars; also, in 2019 it is estimated that the production of about 14.9 million tons of solid waste that can be reused, of which 39% corresponds to paper, cardboard and similar products; 30.7% to plastics and 16.6% to glass; and the level of recycling was of the order of 56% of paper and cardboard discarded, 50% in plastics, but only 12% of glass (Sandoval, Ramos & Correa, 2023).

According to the figures mentioned, in Mexico the least recycled solid waste is glass, which makes it a topic of interest to address and propose a possible solution to the problem of confinement in waste landfills of this type of material. This paper presents the generalities of glass, how it is disposed of once the use of this material is fulfilled, where glass waste has been used and a proposal for the recycling of this material.

1. Generalities of Glass

Quartz melts at approximately 1600°C and forms a sticky liquid. If the liquid is cooled rapidly, the silicon-oxygen bonds re-form before the atoms have been able to arrange themselves in a regular fashion. The result is an amorphous solid, known as quartz glass or silica glass (Brown, LeMay, Bursten & Burdge, 2004).

Ordinary glass used in windows and bottles is known as soda-lime glass, and contains CaO and Na_2O, in addition to SiO_2 from sand. CaO and Na_2O are produced by heating two inexpensive chemicals: limestone and sodium carbonate (ídem).

The addition of CoO to soda-lime glass produces the deep blue color of "cobalt glass". The substitution of Na_2O for K_2O results in a harder, higher melting point glass. The use of PbO instead of CaO results in "lead crystal" glass, which is used to make decorative glassware. With the addition of non-metallic oxides, such as B_2O_3, a glass with a higher melting point and greater ability to withstand temperature changes is obtained, which are used where resistance to thermal shock is important, for example, in laboratory glassware or coffee pots (ídem).

A "natural glass" is obsidian, which is a natural combination of oxides melted by intense volcanic heat and vitrified (turned to glass) by rapid cooling in contact with air. Its black and opaque color is due to the relatively high content of iron oxides. Its chemical resistance and hardness compare favorably with those of many commercial glasses (apud Paneque, Díaz & López, 2023).

Today glass is an essential element in key sectors, such as energy, biomedicine, agriculture, electronics, information and communications, optics and optoelectronics or aerospace (Paneque *et al*, 2023).

2. Disposition of glass

Glass is among the most abundant materials on earth, obtained mainly from silicon. With the development of science, technology, and society, it has become one of the most important inorganic materials. Combining transparency, durability, chemical resistance, and compressive strength greater than that of concrete and even steel, it is widely used in house construction and in everyday life (Quirino, Agrawal, Alves, de Figueiredo & Rodrigues, 2023).

Bottles, jars for the pharmaceutical industry, cosmetics, perfumery, household items (Tittarelli, Giosue & Mobili, 2018), in cathode ray tube, containers, light bulbs (Rahim, Che, Mohamad, & Salehuddin, 2015), microwave dishes, television screens, monitors, are some of the shapes and applications of glass that can be seen daily.

After use, the waste glass can be filtered, cleaned, and re-melted for the manufacture of new glass products.

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However, impurities, multiple shapes, color, lack of detection facilities constitute a barrier to the reuse of this material (Hamada, Alattar, Tayeh, Yahaya & Thomas, 2022).

Due to the high cost of cleaning and color sorting, the recycling rate for glass bottles is around 25% and a large amount of waste glass is sent to landfills as waste; since glass is not biodegradable, landfills do not provide an environmentally friendly solution (Tittarelli *et al*, 2018). Waste glass treatment and recycling is a pressing problem that is currently unresolved (Bristogianni & Oikonomopoulou, 2022).

The recycling process is complex, and the cost is relatively high, which leads to a lack of motivation for glass recycling in companies (Quirino *et al*, 2023). Recycling companies realize that they earn little or even have a loss of revenue from processing glass (Rahim *et al*, 2015).

In Mexico, only 12% of the material is recycled and this is mainly due to supply and demand situations (Sandoval *et al*, 2023).

However, in the study by Barfod, Freestone, Jackson, Lichtenberger & Raja (2022), it has been shown that from the first century to the middle of the eighth century A.D. the supply of glass and the recycling of this material played an important role in the economy of ancient cities. his was due to the high demand for glass in urban environments coupled with the higher cost of overland transportation compared to the coastal trade at the time.

This shows the importance of recycling this type of material both in terms of environmental protection and economically, since past times.

3. Use of waste glass

Due to the environmental problems associated with the production of portland cement, some alternatives arise to try to obtain sustainable development, for example, through the development of new, more eco-efficient cementitious materials (Torres, Rodríguez, Alonso & Puertas, 2015).

The construction industry is an attractive option for the utilization of waste glass, as the physical properties and chemical compositions of glass resemble those of concrete raw materials such as cement and river sand (Quirino *et al*, 2023).

On the other hand, the quantities of sand and gravel extracted as aggregates for the preparation of mortar and concrete are 130 million cubic meters each year and represent 59% of the materials excavated in Italy. Therefore, the use of by-products to replace these natural aggregates, as is waste glass, seems an interesting approach to create environmentally friendly composites (Tittarelli *et al*, 2018).

In addition, the process of obtaining aggregates and producing cement has created significant environmental hazards, such as high energy production and excessive CO_2 emission (Hamada et al, 2022). This has motivated the implementation of strategies to reduce environmental pollution, concrete production costs and carbon footprint by partially replacing cement with other low-cost components and more environmentally friendly materials (Redondo, Sánchez, R. Pérez, Gómez & Abellán, 2023).

The waste glass has been used as fine aggregate (partial replacement of sand of 20%, 40% or 60%) (Hamada *et al*, 2022); or as a cementitious material (partial replacement of cement of approximately 50% with silica fume) (Redondo et al, 2023). In the first case a particle size between 2 and 0.15 mm is considered, which is identified as waste glass powder. For the second case the particle size is of the order of microns (2.5, 45, 275 µm). When performing different tests of the concretes made with waste, according to the results obtained for compressive strength at 28 days, Rahim *et al* (2015), identifies as a maximum value 10% to replace the fine aggregate with waste, differing from those presented by Hamada *et al* (2022), from 20% to 30%.

A study was carried out on concrete mixtures (concrete), where sand and cement are replaced by ground glass, in dosages of 25%, 50% and 100% for the former and 10%, 20% and 30% for the latter, maintaining the properties of the mixtures within the parameters of traditional concrete.

The recycled ground glass was obtained from the Empresa de Recuperación de Materias Primas de Villa Clara. The tests were carried out on fresh concrete, slump, in which it was found that the percentage of cement substitution should not exceed 20%. In hardened concrete, compressive strength tests were carried out, where it was determined that up to 25% of the sand can be replaced by ground glass (Columbié, Crespo, Rodríguez & González, 2020).

Frometa, Vidaud, Font & Negret (2020), conducted a study with glass obtained from bottles from the Empresa Provincial de Recuperación de Materias Primas (EPRM), in Santiago de Cuba; however, it mentions that there is no defined producer, and neither are they of national production. The bottles are imported from different countries, which raises several questions regarding their main properties and subsequent performance in concrete. The analysis of properties: chemical composition, granulometry, fineness modulus, absorption, specific weight, among others, determined that the product is suitable to be used as an addition to concrete as a partial replacement of fine aggregate. Based on national and ASTM standards.

Tittarelli *et al* (2018), mentions that the use of waste glass instead of aggregates/natural sand in the composition of mortars is feasible, and the replacement cost represents an advantage. Additional benefits include: (1) less use of natural aggregates, decreasing the cost of exploitation, less invasion of quarry extraction, extension of quarry life, less use of non-renewable natural resources. (2) Recycle that part of glass that would end up in a landfill and thus a greater eco-sustainability in the entire production cycle. (3) Increased architectural value of mortars/concretes, as the visible colored glass particles will produce a pleasing visual effect on the surfaces where the mortar is applied. Since construction requirements such as functional, aesthetic, economic and insulating criteria must be met, the use of different colored glass cullet in cementitious materials is a good alternative. The glass samples used come directly from an as-is hollow waste glass management system to test a mixture of different glass wastes without costly additional treatment. The calcareous sand was replaced by recycled glass in proportions of 0-33-66-100%.

The samples were tested for slump, compressive and flexural strength of mortars, and drying shrinkage, to mention a few. From the results obtained they conclude that it is possible to replace in its totality the calcareous gravel with recycled waste glass of mixed color, to produce architectural mortars without any addition or mixture.

Ultra high performance concrete (UHPC) contains a large amount of cement. This situation places this type of concrete in the "environmentally unfriendly manufacturing product" category. On the other hand, the amount of water in the mix is very low, which leads to early hydration and consequently to a higher shrinkage value compared to conventional concrete (apud Mosaberpanah, Eren & Tarassoly, 2019).

Ultra-high performance vitreous concrete is an environmentally friendly version, which gives technical, economic, and environmental advantages due to the replacement of glass powder by cement. Generally, the particle size of glass powder plays an important role in the effects on the mechanical properties of concrete, especially on the compressive strength (Mosaberpanah *et al*, 2019). In their study models mechanical, rheological and drying shrinkage properties of a UHPC under normal curing conditions, by the addition of nano-silica and replacement of cement with waste glass powder.

The amber glass powder was prepared from glass bottles dumped in the wild, after washing and removing the paper labels, they were crushed and ground to a particle size of 63 µm. The samples were prepared with the following percentages of nano-silica and glass powder, respectively: 0%-0%, 2.5%-10% and 5%-20%.

The addition of nano-silica increased the compressive strength and drying shrinkage at 28 days of age, while it decreased the flowability of fresh UHPC concrete. The addition of glass powder increased the compressive strength, drying shrinkage and flowability of fresh UHPC at 28 days of age.

Glass has favorable properties for construction because it is a material that is tenacious to compression, as well as fan shells, which are made of calcium carbonate shells, becoming materials that are not harmful to concrete and with similar characteristics to conventional aggregate, considering them as alternative components for making concrete (Milla, 2023). He collected glass samples in the city of Huaraz, Peru, and fan shells from the Huarmey dump, Peru. The glass was crushed in a mortar and the fan shells were calcined in a furnace and then ground. Pattern samples and specimens with glass powder and calcined fan shells were made, both materials were added 2% each in the concrete, the design compressive strength was 210 kg/cm2. Simple compression tests were performed at 7, 14 and 28 days.

For both types of specimens, the compressive strength increased as the days of testing increased, being more notable the value at 28 days, because in the pattern samples the compressive strength was 295.4 kg/cm2, while the concrete with the addition of powdered glass and calcined fan shells showed as a result a strength of 306.1 kg/cm2. They conclude that the materials used provide 45.7% to the compressive strength of the concrete.

Arjona, Guzman, Torres, Cedeño & Acosta (2015), perform their work with respect to porcelain stoneware, which is a ceramic product characterized by low water absorption ≤0.5% and mechanical flexural strength >35MPa in accordance with ISO 13006. Porcelain stoneware tile has experienced growth in production and sales, compared to other building ceramics; this is attributed to its high technological properties, especially regarding water absorption, chemical resistance and frost resistance, and mechanical properties such as flexural and abrasion resistance.

It is currently working on the implementation of alternative raw materials to conventional ones, which will reduce production costs and maintain or improve both physical and mechanical properties. The glass used is window glass, as a possibility of using glass powder as a replacement for the traditional flux material used in the production of porcelain stoneware, based on the firing behavior of the green product and the physical-mechanical properties of the sintered material.

The average particle diameters of the ground glass are 35.69 µm. In the fired pieces, the degree of vitrification and flexural strength were evaluated, considering the requirements established in several ASTM standards. From their study they concluded that the incorporation of glass powder as a replacement for feldspar in porcelain stoneware mixtures contributes to a decrease in the maximum densification temperature of samples fired at 150°C, with respect to a standard composition. In addition, although glass powder was shown to be a strong flux, fired specimens with feldspar substitution by glass powder at 25% and 50% by total weight, do not allow to have Bla porcelain stoneware (flexural strength >35MPa and water absorption ≤0.5%).

The raw material normally used for the formulation of porcelain is divided into three main groups of minerals with respect to their function: cay materials improve the plasticity of the body, while non-plastic supplementary materials improve the melting characteristics (flux) and impart structure (filler). Decorative ceramic objects are manufactured using clay, quartz, and feldspar, but nowadays waste materials such as glass powder are being used to make these objects. This waste glass can replace traditional fluxing agents, such as feldspar, without changing the process and quality of the final product.

The influence of waste glass (borosilicate glass and soda-lime) on the physico-mechanical behavior of soft porcelain ceramics was investigated. Technical parameters such as water absorption, porosity, shrinkage, bending stress, wear, bulk density, and microstructural evaluation were determined. The glass was crushed and then ground to a particle size of less than 150 µm for each of the materials used. Samples were prepared for porcelain with soda-lime glass waste and samples with borosilicate glass, in both cases in percentages of 30%, 45% and 55% of the soft porcelain composition.

From the results, it was concluded that porcelain containing soda-lime glass presented better results, indicating that this glass improves mullite growth and increases the formation of the glassy phase, which decreases the presence of pores, resulting in decreased water absorption, increased bulk density and decreased wear (Owoeye, Sayo, Isinkaye & Kingsley, 2019).

There are different methods of glass production, including blowing, drawing, floating, and melting (Quirino *et al*, 2023). In the work, they propose a practical and versatile alternative to the recycling of waste glass to produce hollow blocks, using the furnace melting process. The process includes the design of blocks and characterization tests of the blocks obtained. The material used in this study was sodium calcium silicate glass, post-consumer beverage bottles.

The glass bottles were separated by color, washed, crushed, and sieved on different meshes. The mesh sizes were 4.76, 2.38- and 0.71-mm. Chemical composition, microstructural characterization of the glass and compression tests were obtained. From their results they conclude that higher temperatures and exposure times lead to better adhesion of glass particles and higher crystallinity, leading to an increase in compressive strength.

The study by Perera, Saberian, Zhu, Roychand & Li (2022), concerns the subgrade layer, which often consists of natural/native soil; however, some natural soils, such as expansive or reactive clays, have undesirable attributes, which include high expansion and contraction potential, low bearing capacity, high compressibility, among others.

These characteristics jeopardize the longevity and performance of the entire pavement system. Stabilization of expansive clays could be achieved through two main approaches, i.e., chemical, and mechanical stabilizations. Mechanical stabilization involves the introduction of foreign aggregates, such as glass, rubber, plastic, fibers, to name a few, with desirable physical properties into the reactive clay, thus alleviating its problematic behavior.

Crushed glass has favorable construction properties, such as lower water absorption potential, good mechanical strength, relatively light weight (low specific gravity), durability, workability, etc., making it an ideal material for use in civil engineering applications. Mechanical and microstructural investigations on expansive clay and crushed glass composites for pavement subgrade applications were performed in the research mentioned.

The crushed glass was collected from a 15-location recycling company, where crushed glass is produced by crushing waste glass to a mixture with a particle size no larger than 5 mm. Compaction tests, unlimited compressive strength, repeated triaxial loading, to name a few, were carried out to evaluate the 5%-10%-15%-20% glass content mixes. Among the results are improved flexibility of the clay subgrade, reduction in subgrade thickness and savings in construction cost and time, improved expansion-shrinkage behavior (ibídem, 5).

When building roads, the objective is always to reduce construction costs, and carry dirt are expensive, so when deciding to stabilize the subgrade of a road, a physical-mechanical study must be carried out to make the best decision on whether to treat the subgrade or to improve or replace it. Always avoid additional soil treatment. This is mentioned by Culquichicon & Vasquez (2022), in their thesis work; in which they sought to determine the influence of ground glass for the stabilization of a road.

In their research, they considered the soils of the Simbal-Caserío Simbal Mucha road, Peru, from which they extracted 9 pits, with one kilometer from each other and excavated to a depth of 1.5 meters, according to the country's regulations, from which they obtained the samples to carry out tests with the stabilizing agent, ground glass, in different percentages 6%, 8% and 10%. Ground glass was collected from bottles, broken glass that usually goes to the landfill. It was then washed, crushed, and ground to be sieved in a N°200 mesh (75 microns).

From the evaluation of the results of physical and mechanical properties (humidity, density, CBR index, among others), it was determined that they were improved with the use of ground glass. The amount of glass influenced the compaction properties, the maximum compaction moisture decreased. The CBR index in the standard sample was 7.52%, while for the sample with 8% ground glass it was 38.38%, which when compared with the 100% standard of the MDS has a better value.

The development of glass in medical applications is acceptable worldwide, especially in dentistry and orthopedics. Glass used in biology is known as bio-glass.

Calcium aluminosilicate glass is considered a material slightly like bone and tooth structure and of potential use for dental restorative material. Glass ionomer cement (GIC) is produced from the acid-base reaction between different types of alkali glass powder and polymeric acid. GIC has been used clinically as a restorative material for more than 40 years and researchers have shown increased interest in the development of GIC, such as its physical, structural, and mechanical properties.

In the study of Matori, Ahmad, Mohd, Che, Zainuddin, Wan, Abdul, A. Rahman, Kul, A. Wahab & Effendy (2020), calcium fluoroaluminosilicate glass (CFAS), they generate it from waste materials such as soda-lime-silica glass, raw material to obtain silicon, and clam shell, to obtain calcium oxide. By mixing CFAS powder with polyacrylic acid and water, GIC is formed. The GIC samples are immersed in distilled water for 7, 14, 21 and 28 days of aging; the samples were analyzed to study the structural and mechanical physical properties. As the aging time increases, the density also increases, the compressive strength of 42.23-50.28 MPa, ISO 9917 establishes a minimum value of 50MPa to be used as a material in dental application. From these results, mainly, it is considered that the GIC obtained from CFAS is a material with properties suitable for use in dentistry, especially in luting, base, and liner applications.

From what has been described in this section, it can be observed that the area where most studies have been carried out for the use of recycled glass is in the construction industry, since its properties to react with the elements of gravel, sand and cement are considered. However, there is research that explores different uses for this waste material. It is important to mention that according to bibliographic sources that were taken as reference for this work, they show that there are countless research works focused on physical, chemical, and mechanical properties to improve and increase the amount of waste glass material used in the applications mentioned here.

Results

As part of the review of the articles described in the corresponding section 3, it is worth highlighting the importance that is being given to recycling glass.

To reduce the disposal of this material in landfills that cause damage to the environment, since this is a non-biodegradable material, which generates the permanence of this waste material in a confined area for an indeterminate period. Among the benefits mentioned for recycling glass are (Arjona *et al*, 2015; Hamada *et al*, 2022):

- Economic benefit.
- Reduced impact on the environment.
- Reduction of the cost related to the disposal of glass waste in landfills.
- Reduction of CO_2 emissions and energy consumption.
- Reduction of air pollution because of cement production.
- Public awareness of waste issues and the advantages of reuse.
- Protection of the environment by keeping a large quantity of the main raw materials on earth.

However, it is important to mention that some research considers that there is an additional cost for the preparation and elimination of contaminants in the glass to be recycled; it is also mentioned that glass cannot be recycled continuously, but this depends on the impurities and manufacturing process of the material.

In addition, most of the authors in their research suggest studying other properties different from those presented, varying the percentage of ground glass they use, as well as using different particle sizes, depending on the application in which the incorporation of recycled glass is to be investigated.

They also consider adding other waste materials, mostly organic, to investigate the effect of combining them in the physical and mechanical properties of the "new" material. Under this premise, and due to the low percentage of this recycled material in Mexico, there is a potential field of research to contribute to the reduction of this type of waste, in the first instance, and because the crushed or ground glass is required, is to have equipment that allows carrying out this task and that does not represent a high cost, to obtain the raw material in particle sizes according to those described in the researches presented in this document.

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Conclusions

The recycling of waste glass is an area that is little researched in Mexico, which makes it a potential field for research and proposals for the recycling of this material, in a first stage in the area surrounding the Academic Institution mentioned above, helping to reduce the damage to the environment by reducing the amount of material disposed of in landfills.

It is also concluded that there are other sources of glass that can be recycled that are not usually mentioned, the most common are beverage bottles or window glass, but there are also microwave dishes, evacuated tubes, television and computer monitors, kitchen utensils, among others, so that research in this field can take different aspects and a greater number of applications.

One element that should not be overlooked is that the works described in previous sections were tested based on the regulations of the country where the research was carried out, as well as on international regulations, to validate their results and to ensure that the material they propose can be considered for possible application.

References

Arjona, S., Guzmán, A., Torres, J., Cedeño, M. & Acosta, D. (2015). Feasibility of using glass powder as flux in porcelain stoneware tile manufacturing. *Tecnura*, 19, 59-70. http://www.redalyc.org/articulo.oa?id=257036222005 Consultado el 23 de agosto de 2023.

Barfod, G., Freestone, I., Jackson-Tal, R. & Lichtenberger, A. (2022). Exotic glass types and the intensity of recycling in the northwest Quarter of Gerasa (Jerash, Jordan). *Journal of Archeological Science*, 140, 1-18. https://doi.org/10.1016/j.jas.2022.105546 https://www.sciencedirect.com/science/article/pii/S0305440322000048?via%3Dihub

Bristogianni, T. & Oikonomopoulou, F. (2022). Glas up-casting: a review on the current challenges in glass recycling and a novel approach for recycling “as-is” glass waste into volumetric glass components. *Glass Struct. Eng.* https://doi.org/10.1007/s40940-022-00206-9 https://link.springer.com/article/10.1007/s40940-022-00206-9

Brown, T., LeMay, H., Bursten, B. & Burdge, J. (2004). *Química. La ciencia central*. Pearson Educación. México. 908-909.

Columbié, L., Crespo, R., Rodríguez, L. & González, Y. (2020). Evaluación del uso de vidrio reciclado en la producción de hormigones cubanos. *Minería y Geología*, 36, 217-231. http://www.redalyc.org/articulo.oa?id=223563028007 Consultado el 23 de agosto de 2023

Culquichicon, J. & Vasquez, B. (2022). Influencia del vidrio molido para la estabilización del camino Simbal- Caserío Simbal Mucha del km 0+000 al 9+000, La Libertad, 2022. [Tesis de Ingeniero Civil, Universidad Privada del Norte]. Repositorio Institucional UPN. https://repositorio.upn.edu.pe/handle/11537/33293 Consultado el 23 de agosto de 2023.

Frometá, Z., Vidaud, I., Font, E. & Negret, D. (2020). Empleo del vidrio reciclado triturado en sustitución parcial del árido fino para elaborar hormigón con fines de sostenibilidad. *Ciencia en su PC*. 1, 64-78. https://www.redalyc.org/articulo.oa?id=181366194006 Consultado el 23 de agosto de 2023.

Hamada, H., Alattar, A., Tayeh, B., Yahaya, F. & Thomas, B. (2022). Effect of recycled waste glass on the properties of high-performance concrete: A critical review. *Case Studies in Construction Materials*, 17, 1-18. https://doi.org/10.1016/j.cscm.2022.e01149 https://www.sciencedirect.com/science/article/pii/S2214509522002819?via%3Dihub

Matori, K., Ahmad, M., Mohd, M., Che, A., Zainuddin, N., Wan, W., Abdul, R., A. Rahman, N., Kul, E., A. Wahab, S. & Effendy, N. (2020). Soda lime silicate glass and clam shell act as precursor in synthesize calcium fluoroaluminosilicate glass to fabricate glass ionomer cement with different ageing time. *Journal of Materials Research and Technology*. 9(3), 6125-6134. https://doi.org/10.1016/j.jmrt.2020.04.015 https://www.sciencedirect.com/science/article/pii/S2238785420311807?via%3Dihub

Milla, E. (2023). Incorporación de vidrio pulverizado y conchas de abanico calcinadas en el concreto. *EPISTEMUS. Ciencia, Tecnología y Salud*. 17(34), 1-19. https://doi.org/10.36790/epistemus.v17i34.253 https://epistemus.unison.mx/index.php/epistemus/article/view/253

Mosaberpanah, M., Eren, O. & Tarassoly, A. (2019). The effect of nano-silica and waste glass powder on mechanical, rheological, and shrinkage properties of UHPC using response surface methodology. *Journal of Materials Research and Technology*. 8(1), 804-811. https://doi.org/10.1016/j.jmrt.2018.06.011 https://www.sciencedirect.com/science/article/pii/S2238785418302266?via%3Dihub

Owoeye, S., Sayo, T., Isinkaye, O. & Kingsley, U. (2019). Influence of waste glasses on the physico-mechanical behavior of porcelain ceramics. *Boletín de la Sociedad Española de Cerámica y Vidrio*. 58, 77-84. https://doi.org/10.1016/j.bsecv.2018.07.002 https://www.sciencedirect.com/science/article/pii/S0366317518300529?via%3Dihub

Paneque, A., Díaz, A. & López, N. (2023). Chemical nature of glass and its impacto n society. Revista Cubana de Química. 35, 105-124. https://cubanaquimica.uo.edu.cu/index.php/cq/article/view/5305/4734

Perera, S., Saberian, M., Zhu, J., Roychand, R. & Li, J. (2022). Effect of crushed glas son the mechanical and microstructural behavior of highly expansive clay subgrade. *Case Studies in Construction Materials*, 17, 2-19. https://doi.org/10.1016/j.cscm.2022.e01244

Quirino, L., Agrawal, P., Alvés, T., de Frigueiredo, G. & da Silva, C. (2023). Recycling of waste glass for the production of hollow blocks using the kiln-casting process. *Cleaner Waste Systems*, 4, 1-12. https://doi.org/10.1016/j.clwas.2023.100079 https://www.sciencedirect.com/science/article/pii/S2772912523000052?via%3Dihub

Rahim, N., Che, R., Mohamad, N., Salehuddin, S., Afiza, S. & Abdul, M. (2015). Utilization of recycled glass waste as partial replacement of fine aggregate in concrete production. *Materials Science Forum*, 803, 16-20. doi:10.4028/www.scientific.net/MSF.803.16 https://www.scientific.net/MSF.803.16

Redondo, J., Sánchez, D., Redondo, M., Gómez, J. & Abellán, J. (2023). Development of high-volume recycled glass ultra-high-performance concrete with high C_3A cement. *Case Studies in Construction Materials*, 18, 2-19. https://doi.org/10.1016/j.cscm.2023.e01906 https://www.sciencedirect.com/science/article/pii/S2214509523000852?via%3Dihub

SERMANAT, 2016. Informe del medio ambiente.https://apps1.semarnat.gob.mx:8443/dgeia/informe15/tema/pdf/Cap7_Residuos.pdf Consultado el 20 de abril del 2023.

Sandoval, G.E, Ramos, R.G. & Correa T.A (2023). Midiendo la economía circular en México. *Realidad, datos y espacio Revista Internacional de Estadística y Geografía*, 14, 38-53. https://rde.inegi.org.mx/wp-content/uploads/2023/PDF/RDE39/RDE39.pdf Consultado el 20 de abril del 2023.

Tittarelli, F., Giosué, C. & Mobili, A. (2018). Recycled glass as aggregate for architectural mortars. *International Journal of Concrete Structures and Materials*, 12-57. https://doi.org/10.1186/s40069-018-0290-3 https://link.springer.com/article/10.1186/s40069-018-0290-3

Torres, C.M., Rodríguez, P.C., Alonso, M. & Puertas, F. (2015). Alkali activated slag cements using waste glass as alternative activators. Rheological behavior. *Boletín de la Sociedad Española de Cerámica y Vidrio*, 54, 45-57. http://dx.doi.org/10.1016/j.bsecv.2015.03.004 https://www.sciencedirect.com/science/article/pii/S0366317515000254?via%3Dihub

Study of lighting and noise levels in a higher education institution in the Lagunera region

Estudio de iluminación y ruido en institución de educación superior de la comarca Lagunera

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Abstract

The study of lighting and noise determines whether the educational institution complies with an accreditation criterion and how they influence the work and school environment, taking into account the physical surroundings for the development of activities within the institution.The research type is descriptive, utilizing a qualitative-quantitative methodology. Data collection tools are based on document review, creating mappings, and measurement points in the environments. Regarding noise, it emphasizes its importance to health, taking into account the environmental regulations of the Mexican Ministry of Labor and Social Welfare. Therefore, the results should ensure compliance and make recommendations for the university community in order to maintain the quality of infrastructure within the standards set by accrediting bodies for noise and lighting, thus avoiding disturbances and health issues.

Lighting, Noise Level, Accreditation, Work Environment

Resumen

El estudio de iluminación y ruido determina si se cumple con un criterio de acreditación en la institución educativa y como influyen en el ambiente laboral y escolar teniendo en cuenta el entorno físico, para el desarrollo de las actividades en la institución. El tipo de investigación es descriptivo, la metodología cualitativa – cuantitativa, las herramientas de recolección de datos se basan en la revisión documental, elaborando los mapeos y los puntos de medición en los entornos, en el aspecto de ruido se resalta la importancia sobre la salud, contando con las legislaciones ambientales de la Secretaria de Trabajo y Previsión Social Mexicanas, por lo tanto los resultados deben dar cumplimiento y realizar las recomendaciones para la comunidad universitaria, con el fin de mantener dentro de los estándares la calidad de la infraestructura como marcan los organismos acreditadores de ruido e iluminación evitando perturbaciones y daños a la salud.

Iluminación, Ruido, Acreditación, Ambiente laboral

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Introduction

In Mexico, Higher Education Institutions offer various training options to Mexicans based on their interests and professional objectives. Consequently, the country hosts a range of higher education institutions, both public and private. According to the OECD, the statistics are as follows: In the year 2000, 28.4% of the total population of university-age individuals were enrolled in Higher Education Institutions. By 2005, this figure had risen to 32.1%, reaching 35.8% in 2010, 40.3% in 2015, and 45.5% by 2020 (OCDE, 2015).

Therefore, the provision of quality service is of paramount importance for the effective execution of activities within these institutions. This entails two significant aspects in this study: ensuring the safety of activities and fostering an environment conducive to creativity and motivation for those involved. This research encompasses two dimensions: the first pertains to the safety during activity execution, and the second dimension revolves around the development of the environment where creativity and motivation of the participants occur.

The Higher Education Institution named the National Technological Institute of Mexico, Instituto Tecnológico de la Laguna, boasts a 57-year history with a focus on engineering education. It occupies a sprawling area of 178,816 square meters, comprising 43 buildings, extensive courtyards illuminated by natural light, sports fields, and a swimming pool.

Initially known as Instituto Tecnológico Regional de La Laguna, it was established to fulfill the need for specialized technicians and professionals capable of fostering, planning, directing, and organizing existing and emerging industries.

Its inception was the result of the initiative by a group of graduates from the National Polytechnic Institute, combined with the collaborative efforts of then-President of the Republic, Lic. Gustavo Díaz Ordaz, and the mayor of Torreón, Ing. Heriberto Ramos González.

Until 1987, the institution provided education at both upper secondary and higher levels.

Subsequently, it exclusively focused on Higher Education and postgraduate programs, spanning various engineering fields such as Computer Systems Engineering, Electrical Engineering, Electronics, Renewable Energies, Industrial Engineering, Mechanical Engineering, Mechatronics, Chemical Engineering, Business Management, and Business Administration. At the postgraduate level, it offers Master's and Doctorate degrees in Electrical Engineering, with a reputation extending locally, nationally, and internationally.

The study analyzes the risks arising from noise and lighting exposure faced by personnel and students engaged in activities within the institution, specifically within the buildings designated for the Computer Systems Engineering program. This includes Building 19, housing a student population of 600, and the Computer Lab in Building 28, with a daily population of 1,150 students and 46 teachers. These are distributed as follows: Building 19 comprises 9 classrooms on the ground floor, each accommodating 30 students, and 4 classrooms on the upper floor, of which three are actively utilized. In the Computer Lab in Building 28, which serves the entire community of 5,000 university students, there are 1,428 daily students distributed across 46 classes with 30 students each, a common area with a capacity of 28 students, and a CISCO workshop with space for 20 students.

Exposure to noise-generating sources not only correlates with health issues but also leads to disruptions in physical, social, and psychological well-being, manifesting in various ways and intensities for humans. A study conducted on populations of similar age groups in rural and urban areas revealed that the rural population, exposed to lower noise levels, had lower auditory thresholds than their urban counterparts. This underscores the subjectivity of noise assessment, dependent on individual factors and location (Abatte, Concetto, Forfunato, Brecciaroli, & Tringali, 2018).

Noise and lighting play pivotal roles in accreditation bodies, influencing the comprehensive development of male and female students, as well as the degree to which educational institutions meet quality standards.

Failure to regulate these factors according to official norms can negatively impact the well-being of teachers, students, and administrative staff, giving rise to physiological and psychological health issues. Adverse effects of inadequate noise and lighting encompass vision loss, auditory impairments, and disruptions in brain, respiratory, and cardiac functions. These issues can affect focus, mental concentration, sleep, rest, and communication. Moreover, they can lead to irritability and aggression in individuals exposed to unfavorable noise and lighting conditions.

Literature Review

Noise. Specifically, the unit for measuring noise is the decibel (dB), and according to the World Health Organization (WHO), it establishes that a suitable environment for education should not exceed 65 dB. For instance, for an educational or cultural space, a maximum of 40 dB creates a relaxed atmosphere, while a reading room is recommended to be at 35 dB. Noise substantially affects reading, concentration, attention, and memory, consequently directly impacting academic performance. The issue can become particularly serious for schools located near sources of noise that surpass the aforementioned recommendations, such as industries, airports, and heavily trafficked roads. In such cases, effects can include delayed reading skills, aggressive states, fatigue, anxiety, and even cases of isolation.

In classrooms exposed to noise, there is a risk for teachers if they have to raise their voice to 70 dB, for example. This jeopardizes the normal functioning of the vocal cords, which in the long run can lead to aphonia (loss of voice) or dysphonia (loss of the normal voice tone), in addition to mental fatigue, irritability, and a decrease in attention and concentration (Noismart, 2023).

Ecophon (2023) emphasizes the risks faced by both students and teachers when exposed to an environment that does not meet noise standards. They break down the issue into external noise and internal noise, with the latter being the responsibility of the teacher to maintain at appropriate levels. They recommend designing (or remodeling) classrooms to isolate them based on the sources of external noise they are exposed to.

In the case of internal noise, they mention a Reverberation Time (RT) that should not exceed half a second, as this distorts the noise itself and hampers verbal communication. This implies that to achieve a comfortable classroom environment in terms of noise, one must take into account both decibels (dB) and echo or reverberation time (RT). They add that an aspect of inclusion is to consider that students who are most at risk from noise exposure are those with special education needs such as hearing loss, cognitive problems, and additionally: "students with (a) permanent sensorineural/conductive hearing problems, (b) fluctuating conductive hearing problems (caused by colds, ear infections, etc.), (c) attention deficit hyperactivity disorder (ADHD), (d) auditory processing disorder (APD) (Ecophon, 2023, pág. 34).

It is important to clarify that all matters related to noise exposure are regulated by the Ministry of Labor and Social Welfare (STPS), with the purpose of preventing health issues due to noise exposure. This involves classification based on activities conducted, setting noise levels, and establishing maximum exposure times. It's worth noting that this regulation solely considers the preservation of auditory health and does not include aspects of comfort and performance (DOF, 2022). Lighting. Inadequate lighting, besides hindering our ability to carry out activities efficiently, can impact our vision and overall mood. Therefore, it's crucial to consider the risks that workers and students are exposed to due to insufficient lighting; their performance, and more importantly, the gradual and permanent long-term damage it can cause to their visual capabilities (Segurmanía, 2023).

Since 2008, the Mexican Official Standard NOM-025-STPS-2008 has regulated lighting in workplaces, establishing conditions to provide a safe and healthy environment for work with appropriate lighting for carrying out relevant activities in workspaces, offices, and educational spaces (STPS, 2008). From the perspective of educational program accreditation, the Accreditation Council for Engineering Education, A.C., in their Criterion 5 Infrastructure and Equipment, indicator 5.1 Classrooms, laboratories, cubicles, and support offices, emphasizes that these spaces should have adequate lighting, among other aspects such as sufficient and ergonomic space (Cacei, 2018).

The company Simón Electric (2021) specifies appropriate lighting levels for each location and activity. As known, lighting intensity can be measured with a lux meter, and the units are lux (lx). For example, lighting for a desk or reading area is 500 lx, and generally, for an educational center, it ranges from 300 to 1,000 lx.

In the European Union, there is a specific directive for lighting in educational institutions, the UNE-EN 12464.1 standard. It considers that spaces for students and teachers should be illuminated in a way that represents pleasant and stimulating environments, minimizing visual effort and avoiding fatigue, which can lead to headaches. The standard details relevant aspects for good lighting, such as Glare Control, Color Rendering, Uniformity, Illuminance, and Luminaire Types for Educational Classrooms (Sinelec, 2023).

In 2021, a significant experiment was conducted on dynamic lighting. It measured the main photometric variables (color temperature and illuminance) and the continuous and selective attention of students. This was done using a Gesell chamber, Emotiv Epoc EEG 14-channel headphones that measure brain activity, and eye-tracking glasses. It was determined that selective and continuous attention increases substantially with dynamic lighting (Nieto-Vallejo, Camacho, Cuervo-Pulido, & Hernández-Mihajlovic, 2021).

It's worth mentioning that dynamic lighting refers to lighting that changes its brightness, color, or angle for specific periods of time to provide a tailored experience for individuals. This not only personalizes people's experiences but can also lead to energy and cost savings (Secom, 2022).

Furthermore, it has been established that the biological clock (also known as the circadian rhythm) influences (a) attention, (b) behavior, (c) hormonal production, (d) body temperature, (e) metabolism, and (f) sleep. Ambient light is a significant stimulus for synchronizing the circadian rhythm. Consequently, due to individuals' varying sensitivity to light exposure, there are important variations in the production of melatonin and cortisol—substances that directly affect mood (Tonello, 2015).

Studies conducted at a clinic in Hamburg determined that appropriate classroom lighting, considering intensity, color temperature, and dynamics, increased reading speed by up to 35%, reduced comprehension errors by up to 45%, and decreased hyperactivity incidents by 76%. In general, they have found that good lighting leads to effects that enhance the educational experience. This is because lighting affects not only visual clarity but also mood, with color temperature being a significant factor, all in favor of academic performance.

The company Lamp Worktitud for Light recommends creating spaces with dynamic lighting, incorporating variations in color temperature and light flux. They achieve this with LED Wellbeing technology, which illuminates with a spectrum similar to natural sunlight. Temperature variations can range from relaxing warm light (2700 K) to gradually transitioning to cooler illumination (4000 – 5000 K) at higher intensity (Lamp, 2012). To provide further clarity, the color temperature scale ranges from warm (1000 K) to cool light (10000 K); warm light has an orange hue, transitioning to white around 6000K and gradually taking on a slight blue hue up to 10000K (Luxiform, 2023).

A specialized lighting company based in Barcelona, Spain, defines the objectives of educational space lighting as follows: (a) Improved light quality, (b) Enhanced visual comfort for users, (c) Increased concentration leading to improved activity performance, (d) Energy consumption efficiency, (e) Optimized installation costs, and (f) Reduced maintenance. The company emphasizes the interaction between natural sunlight and artificial lighting, utilizing architectural designs that leverage natural light, sensor-based management of both light sources, and energy-efficient practices, enabling light regulation by zones and even its elimination in specific areas when not needed (Eld Design light studio, 2010).

When designing an educational space, it's imperative to consider the role of light in visual stimulation for developing minds. A study by the Heschong Mahone Group in 1999 found that students in areas with more sunlight achieved grades 26% higher than those exposed only to artificial light.

The study demonstrated that natural light regulates individuals' biological or circadian rhythms and cortisol levels, which in turn enhances intellectual performance (Zaire, 2023).

In the realm of architecture and lighting, there's a modern lighting management system that incorporates what is referred to as "Lighting Reform," an essential aspect for contemporary classrooms. This system, known as Livelink, employs sensors and an intelligent network to manage the lighting in specific areas, such as a classroom. It involves architectural features like windows and skylights to harness natural sunlight, combines them with LED lamps, and utilizes digitization and connectivity to create an intelligent system that automates and customizes lighting management (Trilux, 2023).

In Austria, they have established Smart Teaching Centers, where the central focus is on adapting spaces to people's needs, prioritizing the use of natural light, ensuring uniform lighting, and illuminating specific points only when necessary. For instance, lighting in a classroom is activated only if the room is in use or if the teacher is giving a presentation. All of this is achieved through sensors for automatic operation, while still allowing for teacher intervention to achieve greater precision. The entire system is integrated wirelessly for aesthetic purposes. Additionally, the application provides statistics on usage and energy performance, enabling the planning of visualization system enhancements and gradual adaptations and improvements (XAL, 2023).

Furthermore, as observed in Colombian education, particularly at the Universidad Militar Nueva Granada, the need to adapt to Information and Communication Technologies (ICT), new Learning and Knowledge Technologies (LKT), as well as Empowerment and Participation Technologies, arose due to the COVID-19 contingency. In this context, it became necessary to identify risks related to teacher safety and comfort, taking care of factors such as lighting and noise (Díaz Melgarejo & Mantilla Bautista, 2023).

Overall, the well-being and comfort of teachers, in the pursuit of enhancing the educational practice of the teaching and learning process, are highly sensitive to the conditions within educational institutions. In this regard, administrative management of education holds great importance.

To address this, an evaluation tool was developed at the Technological Institute of Sonora in Mexico, covering aspects such as (a) planning, (b) execution, (c) collaborative work, (d) leadership, (e) responsible social participation, and (f) monitoring and control. This tool serves to identify areas of opportunity for improving the administration and operation of educational centers (Méndez Rodriguez, Arellano González, & Carballo Mendívil, 2023.).

In a similar vein, at the Instituto Tecnológico Superior de Guasave, an organizational climate measurement tool was developed, alongside assessing physical and environmental conditions such as (a) lighting, (b) noise, (c) equipment, and (d) workspaces. The study was conducted in a commercial construction materials company and was later adapted for application in a higher education institution under Mexico's National Technological System, incorporating aspects like identity, regulations, customer satisfaction, and social well-being, which involves balancing personal and work life. The resulting evaluation serves as a foundation for designing and implementing strategies that contribute to an improved organizational climate. This is achieved through monitoring behaviors, making modifications, or redirecting them as objectives are achieved (Osuna Armenta, Lopez Rodríguez, Gálvez Rodríguez, & Reyes Zúñiga, 2022).

The assessment tool developed at the Universidad César Vallejo in Lima, Peru, to measure self-regulated learning in higher education students is also of great interest. Among the 60 criteria it evaluates, one criterion involves characterizing educational spaces, considering factors such as noise levels, lighting, and other elements like access to information sources (Ángeles Sanchez, 2023).

Speaking specifically about lighting, there's a study conducted at the Instituto Universitario Vida Nueva in Quito, Ecuador, that demonstrated a significant increase in selective attention and concentration. This was done by applying a d2-R attention test, which measures selective attention and concentration, to two groups of students—one with low lighting (60 lux) and another with proper lighting (700 lux). This underscores the importance of appropriate lighting, especially in educational spaces with nocturnal activities (Tituaña Diaz , Guamán Freire, & Basantes Paredes, 2022).

Methodology

An analysis of the existing literature on lighting and noise was carried out, along with field observations, considering both qualitative aspects in the collection of related information from readings, and quantitative aspects involving the creation of various tables for the interpretation of different data such as lux measurements, shifts, and characteristics of the work area. This research was conducted in several stages:

A bibliographic review was conducted regarding the international, national, and local lighting sector, following the standards established by the Ministry of Labor and Social Welfare. Based on the bibliographic review, the national and local context during the specified period was established.

Evaluations were performed at the specific workstations including computers, work tables, desks, and workbenches.

Comparisons were made between the obtained lighting levels and the recommended levels based on the type of activity, as outlined in the Official Mexican Standard (Norma Oficial Mexicana).

The reflection percentages on work surfaces that affect lighting conditions were determined, following the guidelines of the Official Mexican Standard NOM-025-STPS-2008.

Areas of risk or non-compliance were identified in relation to appropriate noise levels, as established by the Official Mexican Standard NOM-011-STPS-2001.

A detailed recommendation was developed to enhance the lighting and noise conditions in classrooms and laboratories of the Computer Systems Engineering program.

The lighting and noise study was conducted by a specialized company called North Zone Microanalysis, accredited by the Mexican Accreditation Entity (EMA) and approved by the Ministry of Labor and Social Welfare (STPS). Regarding the lighting study, the selection of measurements in each classroom was determined based on the arrangement of the chalkboard and desks, as each classroom has a unique layout.

The aim was to gather information on whether the classrooms were adequately illuminated. Measurements were taken for each workspace in offices, positioning the lux meter as close as possible to the work surface and taking precautions to avoid casting shadows or reflecting additional light onto the lux meter. The measurements were taken using a lux meter, which is an instrument for measuring lighting levels. The Extech Instruments Light Meter was utilized. To ascertain whether the lighting levels complied with established standards, the Official Mexican Standard NOM-025-STPS-2008 for lighting conditions in workplaces was consulted. The minimum lighting level for classrooms and offices is set at 300 lux, and for corridors, it's 50 lux.

In order to conduct the noise study within the parameters of the Official Mexican Standard NOM-011-STPS-1999, a survey was conducted. In the work areas, noise levels exceeding the specified limit of 70 decibels were not identified. This is because the human ear can tolerate and assimilate such noise levels without causing temporary or permanent damage. The permissible maximum exposure limits for noise are outlined in the following Table 1.

NER	TMPE
90 db(A)	8 hours.
93 db(A)	4 hours.
96 db(A)	2 hours.
99 db(A)	1 hour
102 db(A)	30 minutes
105 db(A)	15 minutes

Table 1 Permissible Noise Levels

When the noise exposure level (NER) is between 90 and 105 dB(A), the maximum allowable time should be calculated using the following equation:

$$MPE = \frac{8}{2(\frac{NER-90}{3})}$$

The research is based on environmental noise quality standards that should not be exceeded in order to protect human health, considering application areas and schedules. The measurement is conducted using the equivalent continuous sound level (LAeqT), which is an indicator used to describe acoustic pollution at a particular location. It represents the accumulated noise level over a period of time (T), standardized with respect to that interval.

The measuring time interval will be between 5 to 10 minutes, during which operational activities should be consistently present. The installation of the sound level meter follows the national monitoring protocol. The sound level meter is positioned on a tripod at a height of 150 centimeters above the ground in the ambient environment. Calibration is performed both before and after each measurement. Refer to Figure 1.

Figure 1 Location of Noise Study Points

Both the lighting and noise studies were conducted during a time frame ranging from 7:00 AM to 9:00 PM. The monitoring shifts were as follows: Morning shift from 8:30 AM to 11:00 AM, and evening shift from 7:00 PM to 9:30 PM.

Field Materials:

Field notebook: Used for written and illustrated notes, serving as a record of each work area.

Pencil: Graphite writing instrument made from a slender wooden cylinder, utilized for writing or drawing.

Equipment:

Lux meters: Measure light while considering prior conditions, defining the distance and angle between the lux meter and the object being measured.

Brand: EXTECH Model: EASY VIEW 30, Serial Number: 070100338, with cosine-corrected +/- 5% photopic spectral response and +/- 5% accuracy. The lux meter should be verified before and after each assessment as specified by the manufacturer, and illumination should not be blocked during evaluations. It possesses a calibration certificate in accordance with the Federal Law on Metrology and Standardization.

Sound level meter: Electronic tool that measures noise levels in a specific area, compliant with prevailing norms for audible sound measurement and acoustic calibrators.

Computer: Used for spreadsheet calculations, relevant measurements for each activity, and results in word processing software. Also, image and photography editing tools are utilized.

Cameras: Capture evidence for research documentation.

Tape measure (Flexometer): Measurement instrument consisting of a thin, flexible metal tape that self-winds into a casing, which can be made of metal or plastic, equipped with a brake or locking system to keep measurements steady. It's used to determine measurement spaces in the work area.

Tripod: A three-legged frame, usually articulated and foldable, designed to support specific instruments or devices.

Gathered Information:

Data collection. To achieve research objectives, including records, direct observations, and report presentations.

Desk Materials:

Tools used by researchers to perform tasks optimally within the indicated timeframe.

Figures 2 and 3 depict the trained personnel and dimensions of a randomly selected classroom.

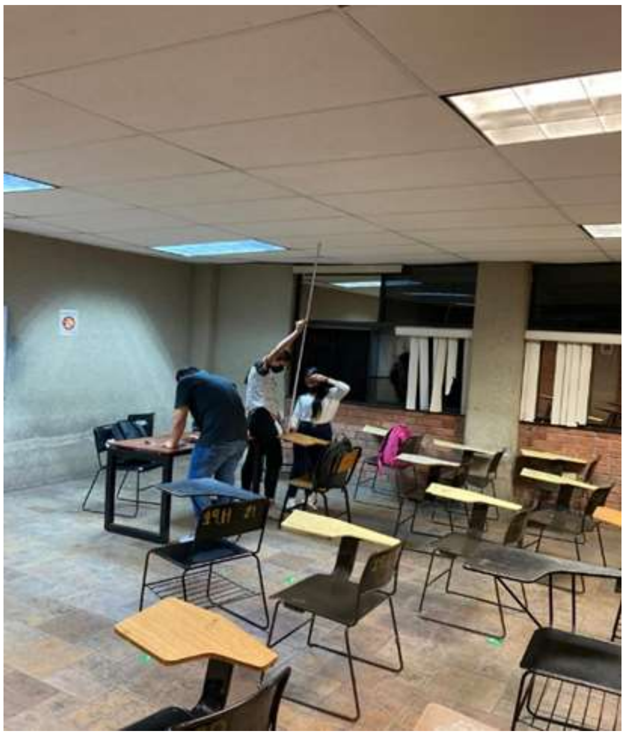


Figure 2 Materials

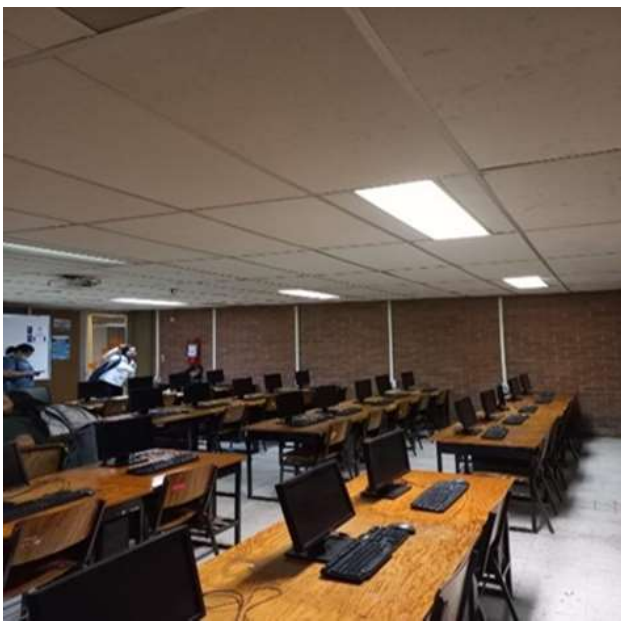


Figure 3 Classroom Evidence

Results and Discussion

In the lighting study, the selection of measurement points yielded 18 measurement points in Building 19 and 10 measurement points in Building 28. The measurements vary based on the dimensions of the work area, as shown in Table 1. The work areas should be divided into zones of the same size, according to the guidelines in Column A (minimum number of zones to evaluate). Measurements should be taken in areas with the highest concentration of workers or at the geometric center of each of these zones.

If the measurement points coincide with the focal points of the luminaires, the number of evaluation zones should be determined based on Column B (minimum number of zones to consider due to limitations) as specified in Table 2. If the geometric center of each evaluation zone coincides with the location of the luminaire's focal point, the previously defined number of zones should be maintained.

The value of the area index, which determines the number of zones to evaluate, is calculated using the following equation:

$$IC = \frac{(X)(Y)}{h(X+Y)}$$

Area Index	Minimum Number of Zones to Evaluate	Number of Zones to Consider Due to Limitation
IC < 1	4	6
1 < IC < 2	9	12
2 < IC < 3	16	20
3 < IC	25	30

Table 2 Relationship between the Area Index and the Number of Measurement Zones

Where:
IC = area index.
X, Y = dimensions of the area (length and width), in meters.
h = height of the luminaire above the work plane, in meters.

Here, x represents the value of the area index (IC) of the location, rounded up to the nearest integer, except for values equal to or greater than 3, where x is set to 4. The equation provides the minimum number of measurement points. Refer to Figure 4.

In corridors or staircases, the work plane to be evaluated should be a horizontal plane at 75 cm ± 10 cm above floor level. Measurements should be taken at midpoints between adjacent luminaires.

For workstations, at least one measurement should be taken on each work plane, placing the lux meter as close as possible to the work surface and taking precautions to avoid casting shadows or reflecting additional light onto the lux meter.

h = 1.65 meters.

$$IC = \frac{8.17*9.00}{1.68(8.17+9.00)} = \frac{73.53}{1.68(17.17)} = \frac{73.53}{28.845} =$$
$$IC = 2.5$$

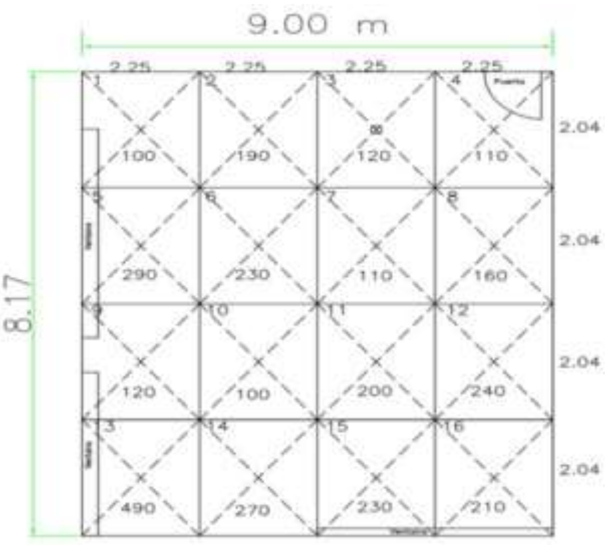


Figure 4 Work Area

Once the evaluation areas are defined, the process involves assessing the average illumination level using the following formula:

$$Ep = \frac{1}{N}(\sum Ei)$$

Where:
Ep = Average illumination level in lux.
Ei = Illumination level at the center of each point in lux.
N = Number of evaluated points.

Evaluation Method on the Work Plane: Applied to specific tasks, especially those requiring higher illumination levels due to factors such as size, contrast, time, and task complexity, Figure 5.

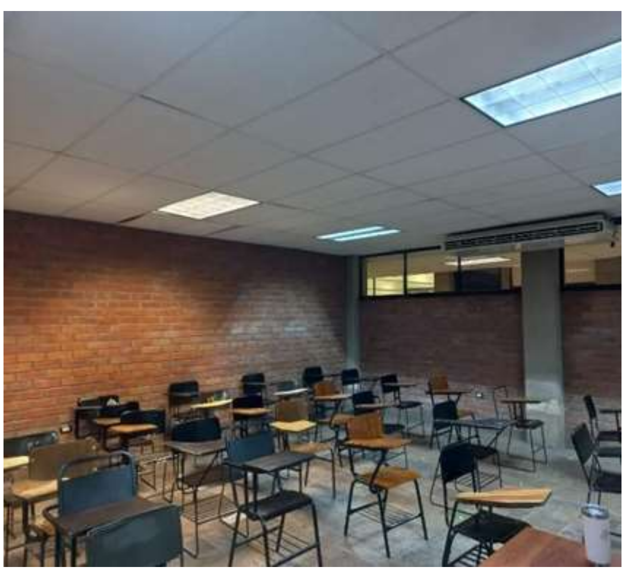
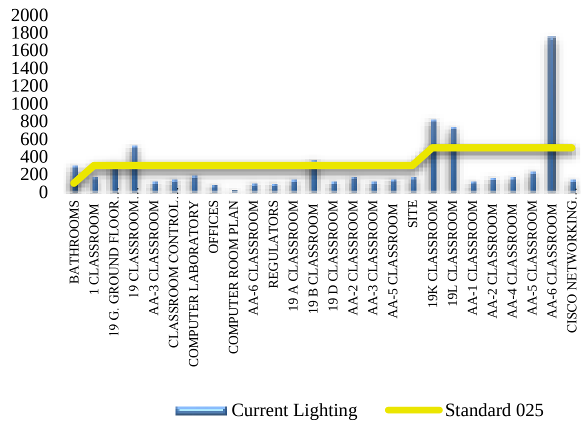


Figure 5 Work Area Example

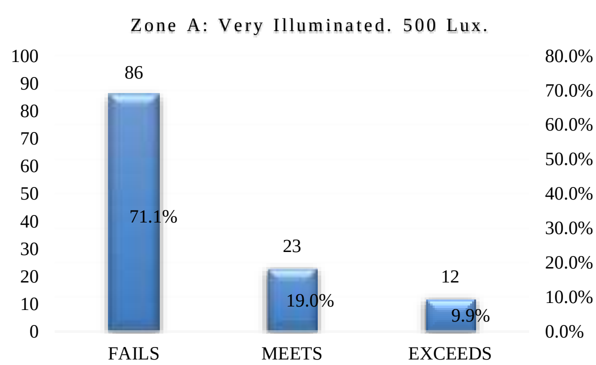
Preliminary Results

According to Standard 025, there are environments that need to be brightly illuminated with 500 lux, known as Zone A; other areas should be illuminated with 300 lux, referred to as Zone B, and there are areas that require 100 lux, identified as Zone C. This graph provides an overview of the entire study, compared to the limits set by Standard 025, represented as a yellow line. The blue bars that fall below the yellow line represent environments that do not meet the standard. Graph 1.

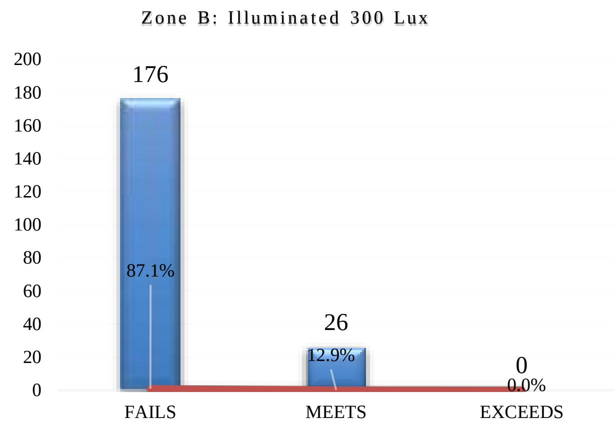


Graph 1 General Results

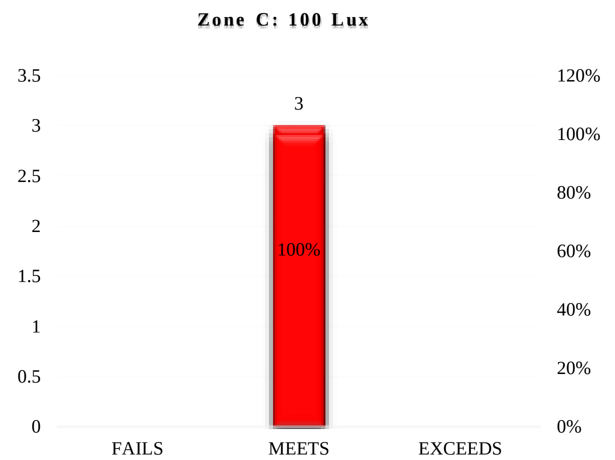
These graphs show the number of environments in Zone A that comply and do not comply with the mentioned standard, along with their percentage measurements. As a result, it is evident that more than 70% of the facilities in Zone A do not meet the Official Standard of the Ministry of Labor and Social Welfare. Graph 2 represents Zone B, indicating compliance and non-compliance with Standard 025 at an illumination level of 300 lux. In this case, 87.1% do not comply, while 12.9% comply, as shown in Graph 3. This contrasts with Graph 4, which represents Zone C, demonstrating 100% compliance.



Graph 2 Zone A



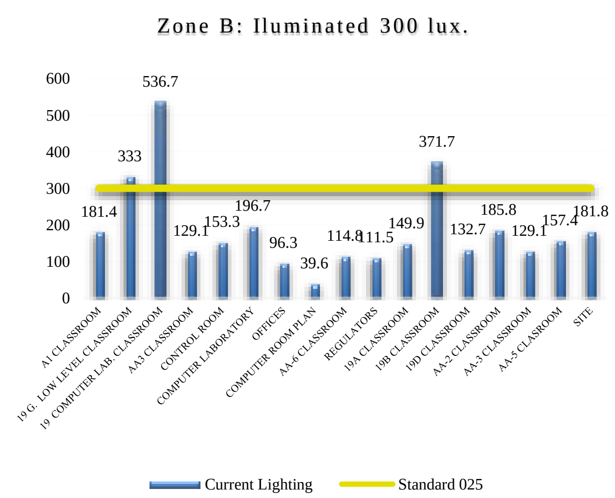
Graph 3 Zone B



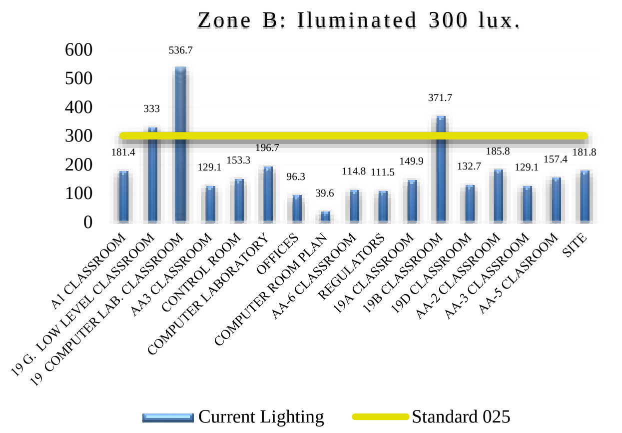
Graph 4 Zone C

Second Results

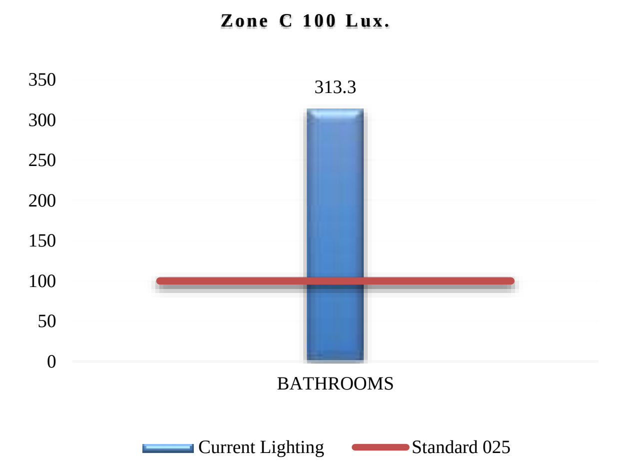
According to the findings presented in the study, the breakdown of the three zones A, B, and C is as follows, as shown in Graphs 5, 6, and 7**.**



Graph 5 Zone A (500 Lux)



Graph 6 Zone B (300 Lux)

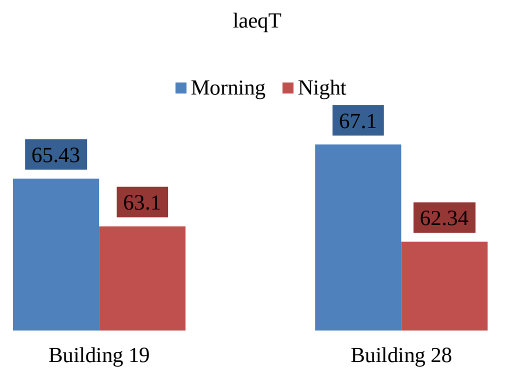


Graph 7 Zone C (100 Lux)

Noise originates from an initial disturbance, occurs periodically, and is perceived by the ear, especially in a work environment such as a higher education institution. This noise comes from various emitting sources and is considered both annoying and unwanted. For this reason, the Official Mexican Standard 011 of the Ministry of Labor and Social Welfare establishes safety and hygiene conditions in workplaces where noise is generated, based on its characteristics, levels, and duration of exposure, capable of impacting the health of all users of these workplaces during the workday.

Considering that preserving health is a universal right for every individual, it's essential to note that noise can lead to adverse health conditions. The most well-known and concerning effect of noise exposure is hearing loss. This effect primarily depends on the level of acoustic pressure and the duration of exposure. It's important to remember that noise-induced hearing loss can be of two types: conductive and sensorineural. Conductive loss can result from eardrum rupture or dislocation of the middle ear bones.

In the measurements and surveys conducted, sound levels exceeding those specified in Standard 011-STPS-2001 were not identified. Graph 8.



Graph 8 Average Noise by Shift and Building

Future Work

Based on the study's results, merely complying with legislation and accreditation requirements will necessitate a significant investment. The lighting system in general exhibited deficiencies, and simply replacing similar lamps won't suffice. Lamps of higher capacity will be needed, which in itself will be costly, mainly due to the quantity of lamps involved. The noise study showed no alterations to the work environment, preventing noise-induced illnesses like hearing loss, cataracts, otopathies, and sleep disorders.

Subsequently, an investigation is undertaken to prevent occupational hazards related to lighting. It's suggested to appoint a safety officer in accordance with Standard 025 and 11 of the Ministry of Labor and Social Welfare. This officer would identify the potential consequences for each stakeholder in the university through methods such as questionnaires, interviews, checklists, mapping, and evaluation matrices.

Conclusions

To enhance the quality of life for students, employees, and the university community, competent authorities should implement action plans to meet the established environmental lighting and noise standards set by the Ministry of Labor and Social Welfare.

By complying with legislation, undergoing reaccreditation processes, creating better work environments, and developing activities to mitigate health-related consequences.

Competent institutions should conduct awareness campaigns against noise and highlight the importance of proper lighting within the university community. This is crucial for environmental awareness and industrial safety protection. The infrastructure of classrooms, buildings, laboratories, offices, and bathrooms should be examined and adjusted for both lighting and acoustic isolation.

Having trained and professional staff in place to address infrastructure needs, plan and execute the institution's plans, is crucial. In the short term, it's pertinent to conduct a cost-benefit analysis for changing luminaires and providing suitable spaces, resulting in well-being for the entire university community.

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References

Abatte, Concetto, C., Forfunato, M., Brecciaroli, R., & Tringali, M. (2018). *Influence of environmental factors on the evolution of industrial noiseinduced heraring loss.* Vol 107 pp. 351 361.: Springer . https://doi.org/10.1007/s10661-005-3107-1. doi:https://doi.org/10.1007/s10661-005-3107-1

Ángeles Sanchez, A. S. (2023). *Uso de tic y la autorregulación del aprendizaje en estudiantes de Educación Superior, Lima, Perú.* Recuperado el 27 de agosto de 2023, de https://repositorio.ucv.edu.pe/bitstream/handle/20.500.12692/111966/Angeles_SAS-SD.pdf?sequence=1&isAllowed=y

Cacei. (2018). *Marco de Referencia 2018 para la acreditación de programas de Ingeniería: Criterios e Indicadores.* Obtenido de http://cacei.org.mx/docs/marco_ing_2018.pdf

Díaz Melgarejo, A. M., & Mantilla Bautista, S. I. (2023). Seguridad y confort: percepción del trabajo en casa de profesores universitarios en tiempos de pandemia COVID-19. *Revista Logos Ciencia y Tecnología, 15*(2 https://doi.org/10.22335/rlct.v15i2.1779), 130-145.

DOF. (2022). *Norma Oficial Mexicana NOM-011-STPS-2001.* Obtenido de https://bibliotecavirtual.stps.gob.mx/Doctos/Nom-011.pdf

Ecophon. (2023). *Impacto del ruido en la educación.* Obtenido de https://www.ecophon.com/globalassets/media/pdf-and-documents/es/education-launch-2022/es_-ecophonresearch-summary-education.pdf/

Eld Design light studio. (2010). *Iluminación de espacios para la educación.* Obtenido de https://e1d.eu/iluminacion-de-espacios-para-la-educacion/

Lamp. (2012). *La importancia de una buena iluminación en espacios educativos.* Obtenido de https://www.lamp.es/es/news/la-importancia-de-una-buena-iluminacion-en-espacios-educativos_500258#:~:text=La%20iluminaci%C3%B3n%20es%20un%20elemento,y%20emocional%20de%20los%20alumnos.

Luxiform. (2023). *¿Qué son los grados Kelvin en Iluminación?* Obtenido de https://www.luxiform.com/que-son-grados-kelvin/

Méndez Rodriguez, R. D., Arellano González, A., & Carballo Mendívil, B. (2023.). Gestión educativa estratégica: estructuración y validación de una encuesta para las instituciones de educación superior. *Revista Electrónica Gestión de las Personas y Tecnología, 16*(46), 21 . Recuperado de https://www.revistas.usach.cl/ojs/index.php/revistagpt/article/view/6040 . DOI:10.35588/gpt.v16i46.6040.

Nieto-Vallejo, A., Camacho, J., Cuervo-Pulido, R., & Hernández-Mihajlovic, E. (22 de enero de 2021). *Sistema de iluminación dinámica para incrementar la atención de los estudiantes de diseño en las aulas.* doi:https://doi.org/10.19053/01211129.v30.n55.2021.12233

Noismart. (2023). *Ruido en educación: Consecuencias.* Obtenido de https://www.noismart.com/consecuencias-ruido-alumnado/#:~:text=Un%20nivel%20de%20ruido%20normal%20en%20el%20aula,de%20disminuir%20el%20nivel%20de%20atenci%C3%B3n%20y%20concentraci%C3%B3n.

OCDE. (2015). *Censo General de Poblacion y Vivienda. Encuesta Intercensal.* Mexico: Economicos., Organizacion para la Cooperacion y el Desarrollo.

Osuna Armenta, M. O., Lopez Rodríguez, M. D., Gálvez Rodríguez, A., & Reyes Zúñiga, F. M. (2022 . Recuperado de https://itsta.edu.mx/wp-content/uploads/2023/02/18-2022.pdf). Análisis de la Cultura y del Clima Organizacional en una Empresa Constructora del Municipio de Guasave. *Revista Interdisciplinaria de Ingeniería Sustentable y Desarrollo Social, 8*(2), 200-214.

Secom. (09 de mayo de 2022). *¿Qué es la Iluminación arquitectónica dinámica y cómo utilizarla?* Obtenido de https://blog.secom.es/iluminacion-arquitectonica-dinamica/

Segurmanía. (2023). *La importancia de una buena iluminación en tu puesto de trabajo.* Obtenido de https://www.segurmaniazurekin.eus/lecciones-seguridad/la-importancia-de-una-buena-iluminacion-en-tu-puesto-de-trabajo/

Sinelec. (2023). *25 SEP Iluminación en las aulas.* Obtenido de https://blog.gruposinelec.com/actualidad/iluminacion-en-las-aulas/

STPS. (2008). *NORMA Oficial Mexicana NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo.* Obtenido de https://sidofqa.segob.gob.mx/notas/docFuente/5076393

Tituaña Diaz , D. V., Guamán Freire, M. R., & Basantes Paredes, A. C. (2022 . https://media.proquest.com/media/hms/PFT/1/VAYIS?_s=r6bPILE%2BH6RpUGm7aAsrK%2Ff%2BVQY%3D). Niveles de iluminación nocturna: Atención selectiva en estudiantes de educación superior. *Revista Ibérica de Sistemas y Tecnologías de Información, 56*(2), 142-154.

Tonello, G. (13 de abril de 2015). *Los efectos de la luz en el comportamiento humano.* Obtenido de https://www.conicet.gov.ar/los-efectos-de-la-luz-en-el-comportamiento-humano/

Trilux. (2023). *Una luz con las mejores notas, Una luz ideal para las escuelas.* Obtenido de https://www.trilux.com/es/aplicacion/education/sectores-de-la-educacion/

XAL. (2023). *Centros de enseñanza inteligentes.* Obtenido de https://www.xal.com/es/iluminacion-inteligente-para-centros-educativos

Zaire, R. (09 de enero de 2023). *¿Qué importancia tiene el diseño de iluminación en el aula de clases?* Obtenido de https://iluminet.com/diseno-de-iluminacion-en-el-aula-de-clases/

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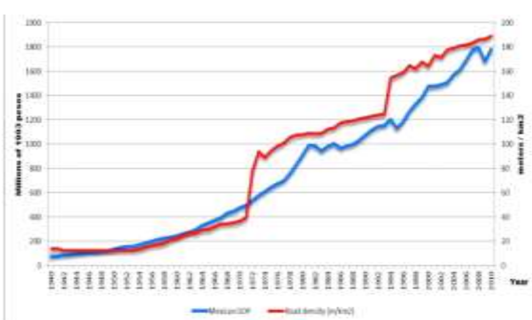

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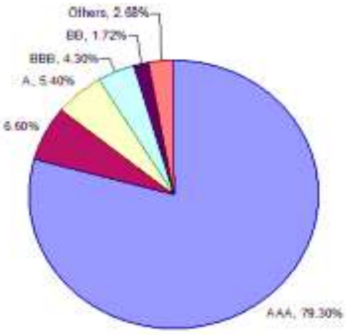

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