

Scientific
Journal of
**Applied
Social and
Clinical
Science**

**CONTINUOUS
IMPROVEMENT
TOOLS USED IN
MANUFACTURING
COMPANIES AND
THEIR IMPACT ON
SUSTAINABILITY**

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Abstract: Due to the growing need to generate actions that lead to care for the environment and promote the development of sustainable processes in manufacturing companies, recently, the use of continuous improvement tools and techniques has been increasing with a focus on sustainability, this with the objective of achieving the continuous improvement of the processes considering at the same time the care of the environment. In this sense, this research presents the findings found when conducting a search for applications of continuous improvement tools implemented with sustainable objectives in recent publications, this, with the intention of showing the upward trend in their applications, their relationship with the sustainability and the benefits found, the results obtained will provide a visual aid to facilitate understanding in relation to the tools used and their applications.

Keywords: Manufacturing companies, Continuous improvement, Sustainability, Industrial processes

INTRODUCTION

Recently and with the boom of Lean systems and the need to create awareness about the environment, there has been a boom in the use of continuous improvement tools and techniques with the aim of achieving sustainable benefits, recent literature has been showing the Increase in the applications of these tools related to sustainability, derived from the above, in the present investigation the main findings found are shown, as well as the conceptualization of some terms, such as: continuous improvement, continuous improvement tools, sustainability, among others. Likewise, the method and criteria developed for the search and selection of scientific articles that have a significant contribution to the investigation will be described.

CONTINUOUS IMPROVEMENT

Continuous improvement is a method by which companies carry out small-scale optimizations continuously, with the purpose of improving the quality of products, processes and services, in this sense it is important to mention that currently there are various tools that They are used to improve companies constantly, these tools allow organizations to propose solutions and that favorable results can be repeated and maintained over time.

Some continuous improvement tools are described below, in relation to what is reported in the reviewed literature.

DEMING CYCLE (PDCA)

According to Silva, Madeiros & Vieira (2017), this methodology induces change step by step, taking into account the following phases: Plan, Do, Verify and Act.

5'S

For Ribeiro, et al. (2019), with the implementation of this tool it is ensured that the environment remains clean, safe and efficient, the 5's come from five practices to adopt in the workplace, which are: Separate, Organize, Clean, Standardize and keep.

VISUAL ADMINISTRATION

It is the content management accessible and easy to read for everyone, including strangers to the system or who are not part of the organization, it shows relevant information from all departments of the company, (Ribeiro, et al., 2019).

VALUE STREAM MAP

Gunduz & Fahmi Naser (2017), define this technique as a graphic presentation of the production processes starting with using a raw material as input to deliver the client's product as output.

SIX SIGMA

For Baptista, Silva, Campilho, Ferreira & Pinto (2020), six sigma is a statistical methodology used worldwide that allows recognizing if processes produce components with only 3.4 defects per million and eliminating waste and excess inventories.

In addition to those mentioned above, within the continuous improvement tools are: Poka Yoke, Just in time, Kaizen, Kanban, Benchmarking, DMAIC, Lean manufacturing, Line balancing and clean production, to mention a few, (Saurin, Ribeiro & Vidor, 2012), (Shijin & Benyan, 2018), (Salazar Lopez, 2019), (Gilibets, 2020), (Espinosa, 2017), (Mast & Lokkerbol, 2012), (Estrada-González, Taboada-González, Guerrero-García-Rojas, & Márquez-Benavides, 2020), (Klochkov, Gazizulina, & Muralidharan, 2019).

SUSTAINABILITY

The term sustainability refers to meeting the needs of the present without compromising the needs of future generations, it integrates three dimensions: economic, social, and environmental, and its performance is reflected in profits, personnel, and planet, respectively. The term of sustainability in manufacturing aims to produce completely recyclable products, friendly to the environment, with production processes and that at the end of their life cycle have an adequate final disposal, (Mostafa & Dumrak, 2015).

IMPORTANCE OF SUSTAINABILITY

According to Meppem & Gill (1998), as time passes, the number of voices that call for policies and strategies that promote the development of ecological, agricultural, and urban industrial processes, as well as new patterns of production and consumption, is greater. that reduce the flow of materials and energy. On the other hand, sustainability is

related to the quality of life of a community, to the extent that the economic, social and environmental systems that constitute it also contribute to maintaining a significant level of health and productive capacity for the inhabitants both present as futures, (Hart, 1998).

THE IMPACT OF SUSTAINABILITY, IN RELATION TO ITS THREE PILLARS

ENVIRONMENTAL PERSPECTIVE

According to Coutiño (2015), environmental disturbances are the object of interest, especially the state of complexity and the units and factors that promote it.

SOCIAL PERSPECTIVE

For Sen and Dreze (1995), the configuration of the sociocultural scenario of sustainability is understood as a process of dialogue that implies “learning and collective construction of ideas and proposals” trying to cement democracy and build bridges to include the entire population and move towards social equity.

ECONOMIC PERSPECTIVE

The economic scenario is nourished by the identity criteria of the community to stimulate productive changes, pretending that these are governed with a vision of the ecological limits in their relationship with local economies, Coutiño (2015).

Derived from the foregoing, it is considered that the existing relationship between the tools and methodologies of continuous improvement is a topic of special relevance to deepen the research that allows, with foundation and evidence, to validate the existence of the existing relationship and the increase in use. of these techniques for sustainable purposes.

In this sense, the method developed for the literature search and the main findings found are presented.

DESCRIPTION OF THE METHOD

To search for scientific articles, a detailed search was carried out in the following databases: Elsevier, Emerald Insight, EBSCO, SCOPUS, among others, taking into consideration articles that mentioned case studies in which results will be presented. related to applications of continuous improvement tools where favorable results have been achieved on the subject of sustainability, for the selection of the articles the following criteria were taken into account: that they contained any of the keywords considered for this research (“continuous improvement”, “sustainable”, “sustainability”, “JIT”, “5S”, “Poka yoke”, “six sigma”, “lean-green”, “PDCA”, “DMAIC”) and year of publication (2015 to 2022), mostly.

Taking into account the criteria established for the selection of the articles, Figure 1 shows the summary of the years of publication, where it can be seen that the topic of sustainability has been advancing through the years in an increasing way. As previously stated, the issue of sustainability is a necessity for every company, so knowledge about the relationship between continuous improvement tools and the sustainable issue has become a priority for researchers and businessmen.

In relation to the databases taken into account to do the literature search, Figure 2 shows a summary of the findings found in each of them, highlighting that the ELSEVIER database is the one in which it was possible to identify a greater number of publications that met the criteria established prior to the search and selection of scientific articles.

As part of the search carried out, various application sectors were identified, of which the following are mentioned: electronics,

health care, automotive industry, mail processing service, fashion industry, food industry, construction industry, brewing industry, services, sustainable energy, supply chain, metal-mechanic industry, ceramic industry, textile industry, finance, government, hospital industry, agriculture, Figure 3 presents a summary of the industrial sectors that are using improvement tools continue with sustainable objectives.

Figure 4 shows the tools identified in the literature review, standing out in the first 5 places: Six Sigma, SMED, Lean, PDCA and DMAIC. It is important to highlight that sustainable benefits were identified with the use of these tools.

As it can be seen in the reviewed literature, the interest in validating the relationship between continuous improvement methodologies and the sustainable benefits that can be obtained with their applications presents a growth that allows strengthening a favorable panorama for businessmen interested in preserving the environment and manage to match its organizational objectives with sustainable objectives, in the same way it represents an encouraging panorama for caregivers of the environment.

RESULTS

From the literature review carried out, several findings were identified, mainly the existence of the relationship of continuous improvement tools with sustainable benefits, in this sense, Table 1 shows the main tools and the way in which they allow obtaining of sustainable benefits.

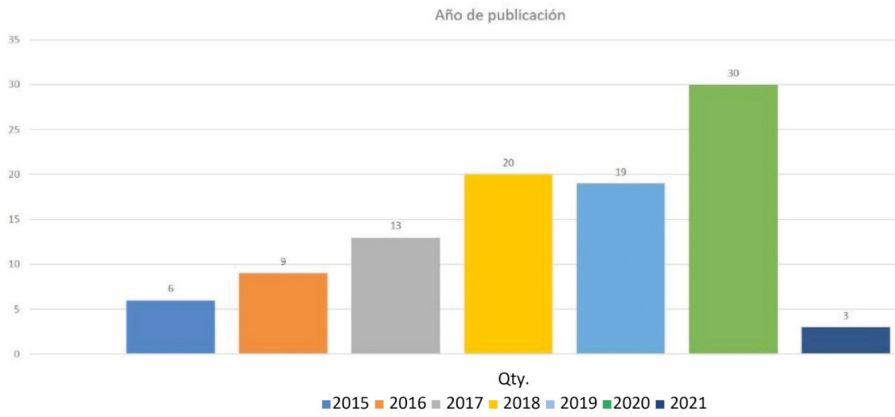


Figure 1. Year of publication related to sustainability

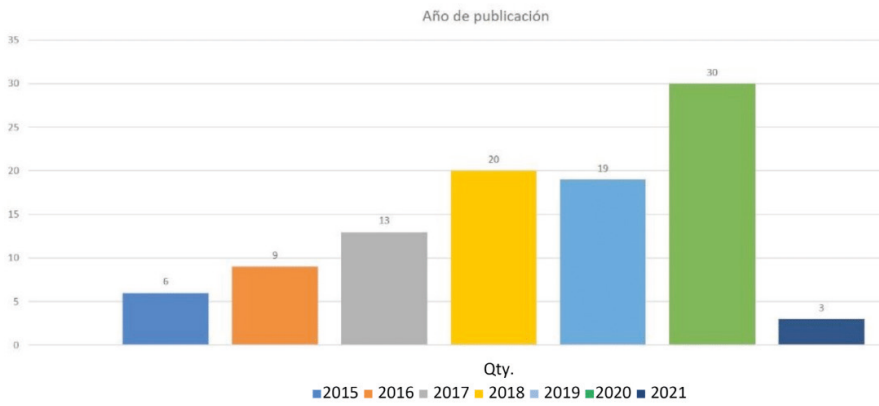


Figure 2. Databases

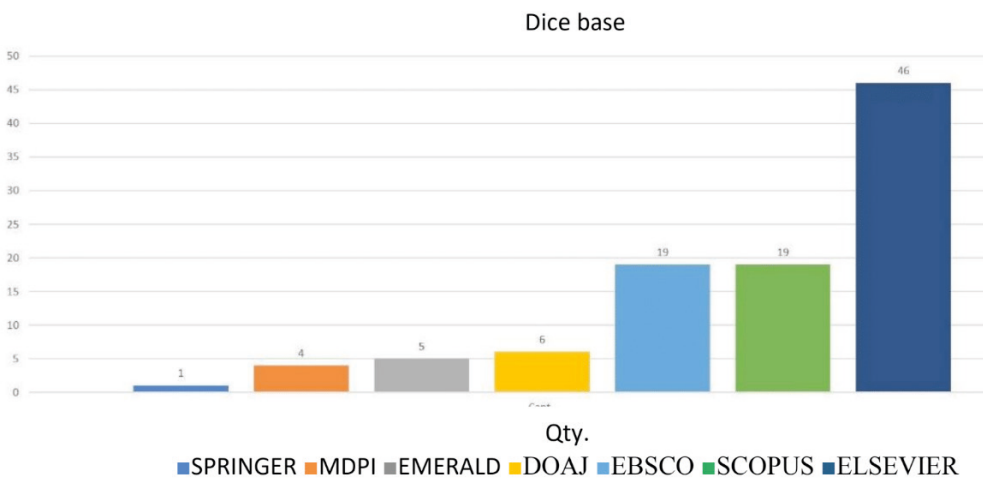


Figura 3. Sector industrial con aplicaciones enfocadas a la sustentabilidad

Industry sector

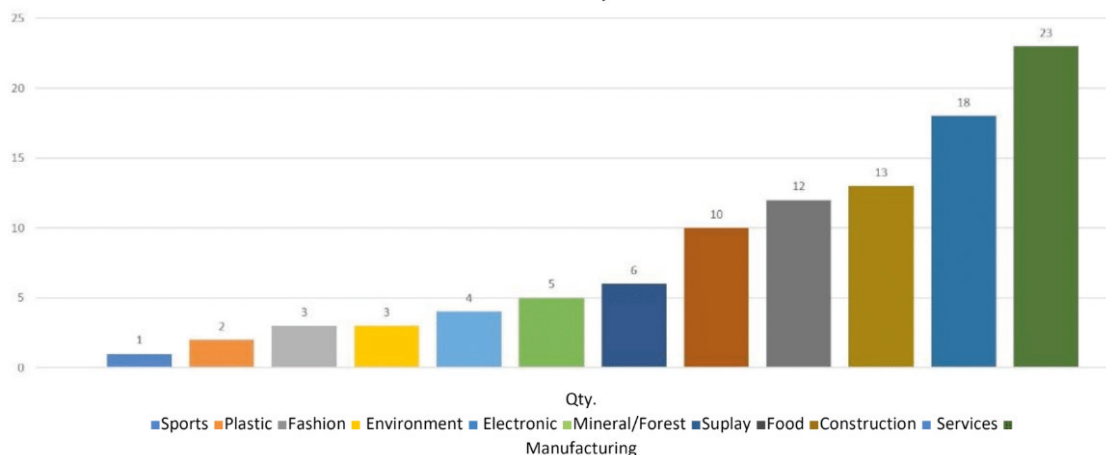


Figure 4. Continuous improvement tools used for sustainable purposes

Continuous improvement tool	Sustainable benefits
Lean Six Sigma	It allows analyzing the feasibility and environmental impact caused by the implementation of sustainable measures that seek to reduce the volume of waste and an economic benefit for the company.
Six Sigma	It allows developing frameworks that focus on the dimensions of sustainability, improving profits and savings (economy), reducing pollution from emissions (environment) and safeguarding the company's workers.
PDCA	It helps in the integration of sustainable programs that promote the use of environmentally friendly materials and integrates other continuous improvement tools for the detection and reduction of defects and their causes.
VSM	When used as a sustainable tool, it allows reducing the number of activities that do not add value and the misuse of time at each stage of a process (economic dimension). It also makes it easier to measure the consumption of resources and quantify the sources of pollution (environmental dimension). In addition, it is responsible for facilitating the workflow (social dimension).
KAIZEN	It allows reducing the generation of waste (environmental), which in turn reduces process cycle times (economic).
5S	It allows the creation of best practices that result in the improvement of the work environment, which will be clean of impurities, organized and will make processes more efficient. In other words, it helps to eliminate work stress, expand the work space and improve inventory storage.
KANBAN	With the implementation of this system it is possible to balance times and the efficiency of operations, promoting economic sustainability in the company. In addition to this, there is an efficient flow of materials and it can be applied in caring for the environment.
POKA-YOKE	It contributes to the environment by reducing the consumption of resources and helping to control the emission of pollutants. It has an economic impact by improving factors such as quality, costs and production times. Lastly, it contributes to society by protecting employees from occupational hazards.
VISUAL MANAGEMENT	Reduces the generation of errors in the work area by workers and, consequently, waste, producing environmental and economic benefits.
LEAN MANUFACTURING	Its main benefits are observed with the reduction of waste and pollution, as well as the implementation of proactive practices in favor of caring for the environment.
DMAIC	Helps in the identification and implementation of waste elimination plans that result in long-term economic benefits.

Table 1. Continuous improvement tool, the sustainable benefits that can be obtained with its implementation
Therefore, it can be seen that the identified relationship has a tendency to continue increasing, due to the growing need to continue improving industrial processes along with caring for the environment.

CONCLUSIONS AND RECOMMENDATIONS

Derived from the literature review, two main findings are reached, the first one oriented to the need of organizations to continue applying continuous improvement tools in order to be competitive and improve their manufacturing processes, at the same time as generating strategies that allows them to develop sustainable processes and minimize damage to the environment, the second is in relation to the development of sustainable practices that favor environmental care, in this sense the literature shows the

interest of researchers towards empirical research that allows to verify with greater accuracy of the relationships between the statistical techniques used for the continuous improvement of processes and the sustainable benefits that can be obtained with their correct deployment.

Therefore, it is recommended that organizations continue using continuous improvement tools, not only with the aim of improving their manufacturing processes, but also, from the beginning, they can integrate sustainable objectives and those related to caring for the environment.

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