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5S methodology implementation in the laboratories of an industrial engineering university school

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ABSTRACT

This article examines the experience in 5S methodology implementation in order to optimize the work and safety of the university engineering laboratories, in such a way that the results obtained can be extended to other, similar centers. The research project developed has created an organization culture of all resources in the practice laboratories. A working model was defined to create a 5S structure and an implementation process has been established. With the 5S methodology implementation, the school laboratories have become industrial laboratories; they have been adapted to the conditions of security and organization that are usually found in the metalworking industry. Learning, control and maintenance of the resources and activities involved are performed in less time and with a considerable reduction of cost. There is also an increase in available space available for the location of the resources.

1. Introduction

'Some of our most essential skills in engineering arise out of engagements not only with formal representations, but also with tools, materials and other people' (Johri and Olds, 2011). The continuously improving component parts are, somehow, a way to improve the performance of the entire process.

5S is a work space management method which emerged in Japan as a consequence of the application of the *kaizen* culture (continuous improvement in the personal, family, social and professional life). The original concept of the 5S has socio-historical and philosophical roots (Kobayashi, 2005). Many of the usual practices in Japan are characterized by having a part of philosophy and another part of technique, e.g. *kendo*, or Japanese fencing (that has its origin in *kenjutsu*) or *judo* (*jujutsu*), the Japanese 'art of gentle, soft, supple, flexible, pliable or yielding', which is used to coach the body and mind through the discipline (Sugiura and Gillespiere, 2002). This approach also applies in Japanese administration, which encompasses both the management philosophy and management techniques (Gapp et al., 2008).

In the beginning, 5S methodology was used to develop an integrated management system which developed in the total production maintenance (TPM) (Bamber et al., 2000). On the other hand, in the West 5S has a minimal use and is associated with an activity of maintenance (Becker, 2001).

The 5S Practice is a technique used to establish and maintain a quality environment in an organization (Khamis et al., 2009). The application of the 5S methodology in a business as a *kaizen* process was first implemented in 1980 by Takashi Osada (1989, 1991). Osada raised the need for the continuous improvement philosophy of professional behavior through the integration of *seiri*, *seiton*, *seiso*, *seiketsu* and *shitsuke* in the workplace. The Toyota production system (TPS) is a clear example of the application of the 5S principles (Monden, 2012).

At this time, the improvement requirement in different organizations may be affected by different complexity of systems. Furthermore, it is really important to know which method can help us begin the process of continuous improvement in order to achieve increased productivity and safety of the workplace through participation and knowledge of the involved staff. It is why such university methodologies are considered as essential tools for the development of future professionals, especially engineers (Sheppard et al., 2008), and there is no doubt that one of the best ways to assimilate a methodology is through routine use.

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In many organizations, the ultimate goal is the implementation of a quality management system – QMS (Dulhai, 2008), which requires that the organization adequately responds to proposals for quality through commitment, initiative and motivation of the staff, which allows the organization to achieve greater competitiveness.

The 5S methodology is not seen in the same way in all countries. For example, as you can see in Kobayashi et al. (2008), Japan emphasizes 5S as a strategy for business excellence, requiring participation both at work and in the home; in the other hand, 5S in the UK and US is viewed as a system or tool for the workplace only. In some countries, the implementation of 5S methodology is a simple way to comply with the minimum requirements for health and safety in the workplace. This relationship has led to the possibility of extending the scope of the 5S through the incorporation of a new S, 'safety and health' (Zelinski, 2005).

Lixia and Bo (2011) point out the main misunderstandings and errors of Chinese enterprises in implementing 5S via investigations in manufacturing enterprises. This resulted from the failure of 5S management and proposed steps to carry out 5S programmes successfully, namely how to make 5S a culture.

The present research project, developed in an university environment, responds to the continuous improvement process implementation and the need to optimize available resources used in different laboratories for trials and practice. During the project deployment we have released two initial obstacles which, in addition, have marked the development of the project:

1. How should the improvement be approached, controlling costs and trying to simplify the implementation process?
2. How can the use of resources be increased during the laboratory practice (productivity), with safety and the minimization of risk?

For an improvement, it was decided that the basis should be to organize, sort and maintain in perfect condition all the involved resources. On the other hand, the productivity increase in the resources used, and the improvement of the workplace should come through the definition of a systematic management plan that maintains and improves that process.

To overcome these barriers, it is proposed that 5S is the ideal method for properly learning the knowledge related to quality, through the identification and commitment of all staff with the work equipment and facilities. This awareness generates an attitude and behavior change, which guarantees the start-up process of the Total Quality Management.

There are several 5S implementation studies in Chinese Universities from its involvement in the international ISO 9000 quality certification (Osada, 1989; Pheng, 2001), as well as previous experiences of local 5S implementation in educational centers (Zhang, 2005). In terms of the 5S application in university laboratories, which use teaching resources similar to the employees in industry, a detailed study of the implementation process is required; participants have special characteristics that force reconsideration of the usual stages of the standard implementation methodology (Maharjan, 2011; Borrego et al., 2009).

The selected laboratories for this project meet certain characteristics which help the students to understand and develop the 5S methodology. The first characteristic which makes these laboratories suitable for 5S implantation and practice, is that they are teaching spaces where there is a real interaction with the student, i.e. the student is the protagonist, handling different resources with total independence. He has to take his environment into account and know how to develop his work so his activity is productive. The second characteristic that makes them suitable is that they are an example of small-scale industry, where students will have the opportunity to apply this methodology once they finish their studies and join a company (Chi, 2011).

The research project has focused on the detailed analysis of the 5S methodology implementation model in the Sheet Metal Forming and Cutting, Integrated Manufacturing Systems, Welding and Metrology laboratories in order to achieve risks reduction and profitability. This environment is characterized by the variety of available teaching resources and its use by those with particular requirements.

In the laboratories, technical resources have functional characteristics similar to the resources employed in the industry, as machine-tools, fastening and cutting tools, metal materials, engineering hardware and software, etc. These resources require a use methodology based on the order and forecast that will guarantee a high level of safety (Fig. 1).

2. Development and methodology

The 5S methodology has been used in all kind of laboratories (mechanical, biological, pharmaceutical, etc.) in different parts of the world (Altamirano, 2013; Ananthanarayanan, 2006; Chitre, 2010; Mallick et al., 2013; Pentti, 2014; Purdy et al., 2013).

The methodology used for the 5S implementation involves two phases and several stages for each element of the 5S, so it is especially important that all the organization levels have been integrated in the process. As we said above, the 5S′ are the initials of five Japanese words which represent each of the five stages that make up the methodology (Osada, 1989; Kobayashi, 2005):

(1) *Seiri* (organization, sorting). Remove all unnecessary tools and parts. Go through all tools, materials, and so forth in the plant and work area. Keep only essential items.
(2) *Seiton* (setting an order of flow, streamlining). Arrange the work, workers, equipment, parts, and instructions in such a way that the work flows free of inefficiencies through the value added tasks with a work division necessary to meet demand.
(3) *Seiso* (shining, cleaning). Clean the workspace and all equipment, and keep it clean and tidy ready for the next user.
(4) *Seiketsu* (standardize, visual control). Ensure procedures and setups throughout the operation promote interchangeability. Normal and abnormal situations are distinguished, using visible and simple rules.
(5) *Shitsuke* (sustain, discipline and habit). Make it a way of life. This means commitment. Ensure disciplined adherence to rules and procedures.

Fig. 1. Safety obtainment procedure.

Table 1
5S methodology implementation in the technological laboratories.

Stage	Action	Recommendations
1	Management teamwork training	– prior awareness (rating other experiences) – detailed training on 5S – implementation guide reading – seeking potential expert support
2	Test laboratory selection	– proper size – representative activity – stable, unchanging – representative – with receptive people – with improvement potential
3	Guide designation	– resources director or laboratory manager – well trained in 5S – plan project capacity – form, encourage and recognize other equipment users – manage meetings – seek materials support – edit and approve standard documents
4	Implementation team establishment	– representative and multidisciplinary – 3–6 people – participation of different groups – participation of the director – minimum 40 man-hour dedication – initial training – tasks: quests, analysis, ideas, actions
5	Implementation planning	– detailed planning – 2–4 months – provide time dedication and resources – budget preparation (recommended)
6	Launch meeting	– with all the implementation team – only 5S general concepts – advantages to achieving establishment – why implement it? – why this area? – why this team? – implementation plan
7	5S board establishment	– involved team – before and after photos – establishment of process indicators – improvement plan in process
8	Implementation development	– preparation – action, pictures, quests... – analysis and improvement plan – standardization
9	Results	– in the end – communication to other people – feedback – learned lessons
10	Other laboratories implementation	– go ahead taking into account criteria of the pilot laboratory – take advantage of the acquired know-how – take advantage of the initial team support
11	Continuous improvement	– periodical review – indicators monitoring – further training and learning – suggestions – advanced courses – experiences interchange forums

Errors to avoid: lack of commitment to direction, insufficient time dedicated, newly-incorporated Guide inexpert, skipped methodology steps, selecting a large or not representative experimental lab, thinking that the project ends in the 5th S.

The five phases are essential and should be dealt with separately and in order. The first three phases are operational, the fourth maintains the state reached with the previous phases and the fifth phase helps us to work for continuous improvement.

The procedure followed to implement the methodology has been as follows:

1. Obtaining the commitment from the management of the Center that sets the depth and duration of the project.
2. Definition of the work team:
   a. A team of teaching and non-teaching staff who take part in the involved laboratories.
   b. A guide, which provides documentation, training and resources to the team.
3. Implementation in a reference laboratory (pilot) to thoroughly learn the methodology and develop an enhancement that serves as an example.
4. Implementation elsewhere in laboratories (generalization).

A very important part in the 5S methodology implementation is to achieve the aim ‘zero accidents and injuries’.

The developed functions for each of the participants provided in the methodology implementation have been the following:

2.1. Direction

Formed by the Director, the Resources Deputy Director and the Department Director, being responsible for:

- the total responsibility for the 5S project
- ensuring commitment to maintenance and promotion of participation
- establishing the control process over the project implementation
- designating the operation area and the work team members

2.2. Guide

This responsibility has been assumed by the head of the laboratory, as its main functions include the dynamics and the team work project coordination, executing the following actions:

- training the team members in the 5S methodology
- collaborating with the directors in the implementation process planning
- ensuring the necessary resources availability
- ensuring the activities development, through team support and guidance
- keeping the 5S board indicators updated
- balancing the progress during the implantation process
- communicating results and experiences to other areas, facilitating the 5S methodology diffusion

Table 2
Total time expected of 5S methodology implementation in trial laboratories.

Laboratory	Guide	Team work	Personal area
Sheet metal forming and cutting	10 h/phase	5 h/phase	• organization: 5 h • order: 5 h • cleaning: 2 h • training: 1 h/phase
Integrated manufacturing systems	10 h/phase	5 h/phase	• organization: 5 h • order: 5 h • cleaning: 2 h • training: 1 h/phase
Welding	6 h/phase	3 h/phase	• organization: 3 h • order: 3 h • cleaning: 2 h • training: 1 h/phase
Metrology	6 h/phase	3 h/phase	• organization: 4 h • order: 4 h • cleaning: 2 h • training: 1 h/phase

- maintaining a continuous improvement of spirit in the know-how of the 5S methodology

2.3. Team

Four people are involved in the implementation area:

- two lab professors
- one lab technical worker
- one student

The developed functions are:

- training for 5S methodology
- project scheduling
- consulting the Guide for people communication and training in the work area
- collecting and analyzing information, proposing ideas for improvement and seeking solutions with a teamwork approach
- tracking and analyzing the 5S board indicators

The stages that have been followed to carry out the 5S methodology implantation process have followed the execution order showed in Table 1.

The 5S methodology has been applied in four laboratories: Sheet Metal Forming and Cutting, Integrated Manufacturing Systems, Welding and Metrology. The total time of the trial laboratories implementation has been 12 weeks (3 months), and the distribution is showed in Table 2. A reduction in the number of accidents is especially interesting in order to increase the safety in laboratories.

The 5S methodology implementation in the sheet metal forming and cutting laboratory has been performed on each of the machines. The most important elements involved in each operation were taken into account during the adaptation: machine tool deformation, fixture systems and cutting tools. All work operations were performed under 5S criteria.

In Fig. 2 we can see the cutting tools for using on a lathe, with direct impact on operations of the integrated manufacturing systems laboratory, before and after the 5S implementation in order to show the methodology need.

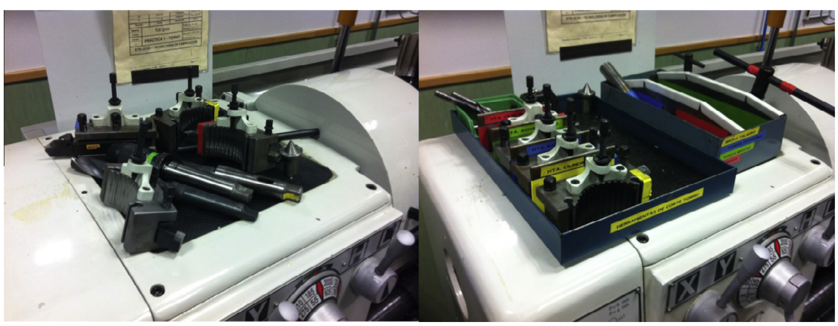


Fig. 2. Cutting tools of integrated manufacturing systems laboratory before and after the 5S implementation.

Fig. 3. 5S board.

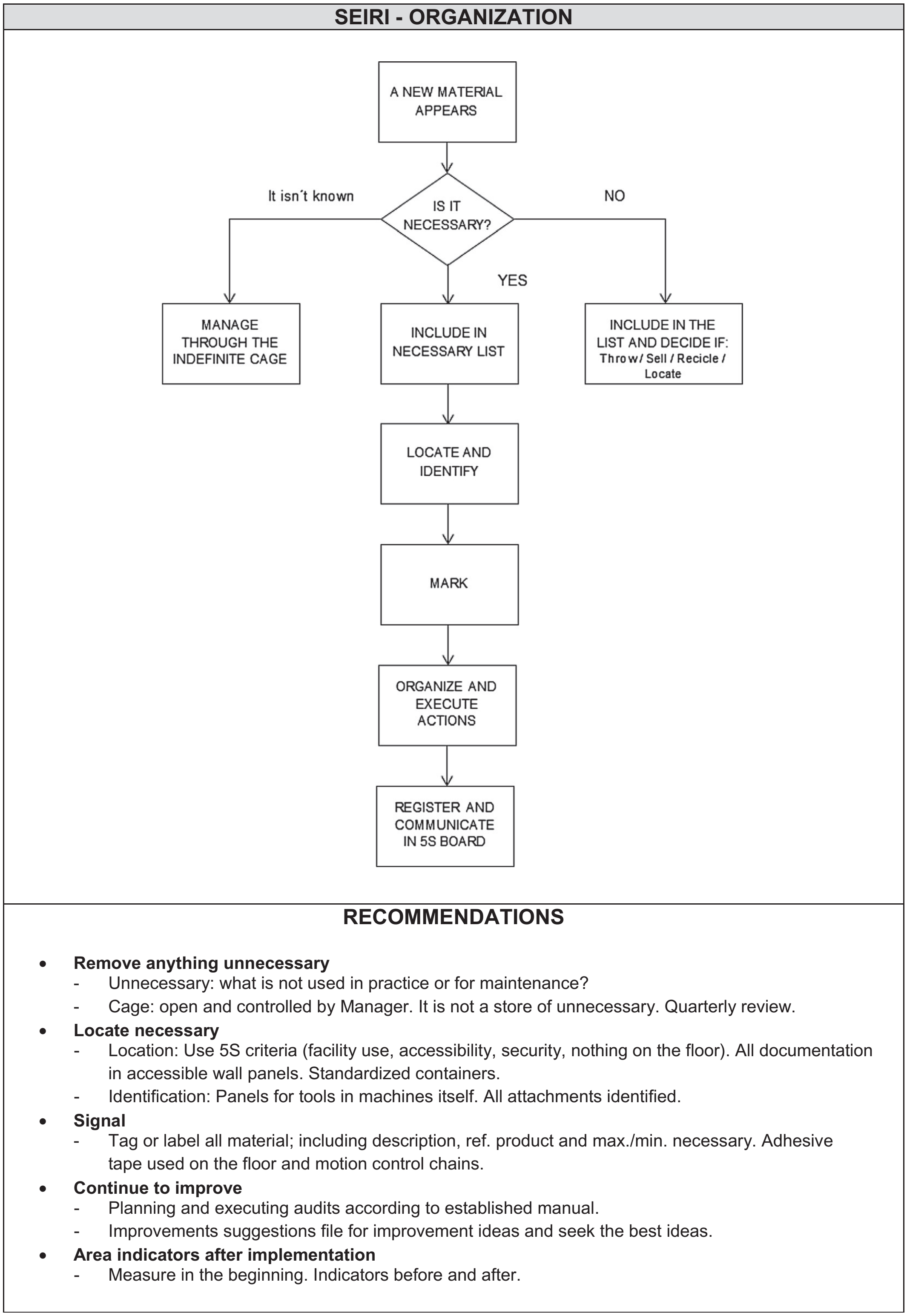


Fig. 4. New materials procedure.

3. Original contributions

One of the drawbacks that appears in this methodology implementation is the necessary investment justification to authorize the project. We must achieve safety increasing, profitability and a reduction in operating costs. The use of indicators that show cost evolution during the implementation process (Martínez and Pérez, 2011) is recommended. Some of these indicators have to be customized over time to truly show what is happening on site. The indicators used were:

- the degree of compliance to the established programme
- errors caused by incorrect use of the equipment
- practice preparation time
- lost time
- maintenance costs

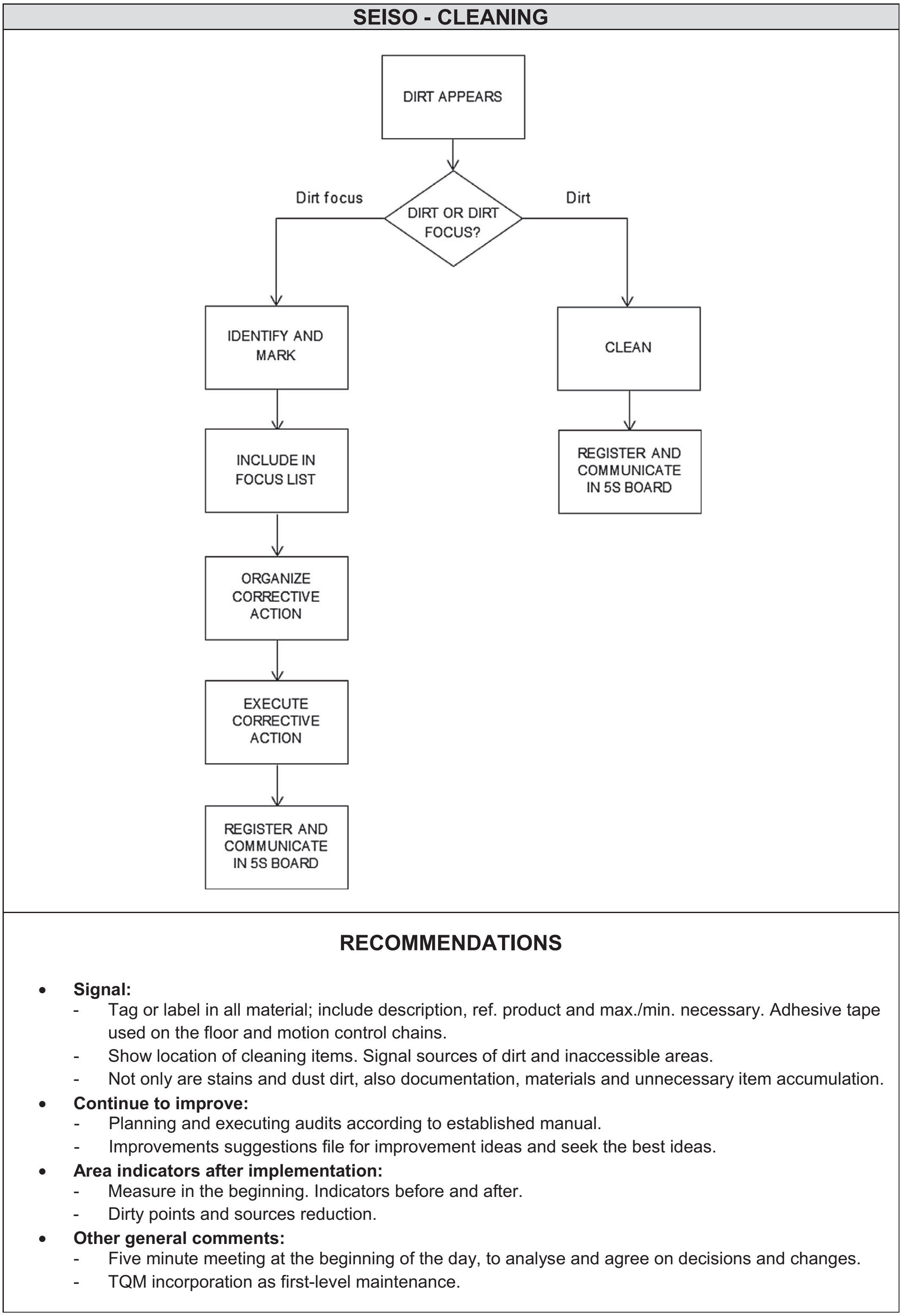
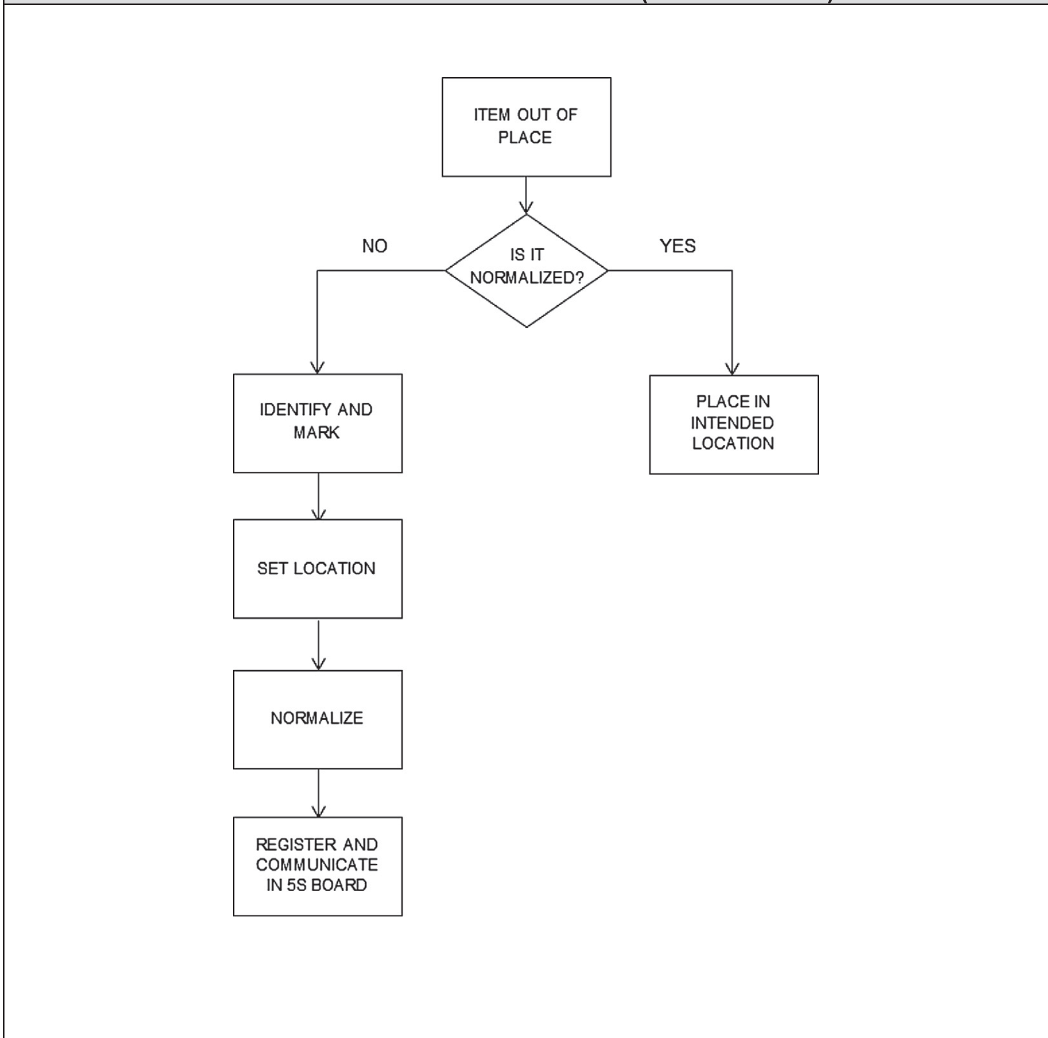


Fig. 5. Dirt appearance procedure.

- anomalies identification
- accident rate

A key implementation element has been the 5S panel or bulletin board (Fig. 3). It quickly reflects the necessary information for programming activities, responsibilities and main results. All personnel involved have followed the project status on the 5S panel. *To improve*, *you must measure*, and a quick communication of the improvement results can be made using the before and after photo control.

SEIKETSU — VISUAL CONTROL (STANDARDIZE)



RECOMMENDATIONS

- **Signal:**
  - Stock control cards/key in all material; including description, ref. product and max./min. necessary. Adhesive tape used on the floor and motion control chains.
  - Signalling elements to quickly deviations or irregularities detection.
  - Strategic formulas for the visual control, e.g. *kanban*, colours, numbers, etc.
- **Continue to improve:**
  - Planning and executing audits according to manual.
  - Improvements suggestions file for improvement ideas and seek the best ideas.
- **Area indicators after implementation:**
  - Measure in the beginning. Indicators before and after.
  - Lost or misplaced items reduction.
- **Other general comments:**
  - Five minute meeting at the beginning of the day, to analyse and agree on decisions and changes.

Fig. 6. Lost or misplaced items procedure.

The different procedures followed to deal correctly with new materials, dirty material and out-of-place items are shown in Figs. 4–6.

4. Results

If we want to make an impact on the organization in the workplace and productivity, the 5S methodology should not be understood as a specific project.

The 5S methodology implementation success begins when all organization members understand that 5S is a new way of working and, therefore, their behavior must be adapted; everybody must to learn new things and make a continuous effort.

Allowing 5S to become 3S must be avoided, for example by abuse of *seiketsu* (visual control) which can lead to a worker with a highly autonomous control, or by the abandonment of *shitsuke* (discipline and habit) leaving the organization without standards or well-defined responsibilities. From these observations which

Table 3
Differences between the absence of 5S and the 5S methodology implementation.

Indicator	Course 09–10 (without 5S)	Course 10–11 (with 5S)	Course 11–12 (with 5S)	Course 12–13 (with 5S)
Degree of compliance with established practice programme (%)	80	95	96	100
Errors caused by the incorrect use of equipment	20	5	3	1
Preparation time of the practice (hours)	24	15	12	10
Spent time for practice implementation (hours)	80	70	66	65
Maintenance costs (€)	3600	2100	1850	1600
Time for anomalies identification (hours)	3	1.5	1	1
Accident rate (number)	2	0	0	0

emerged during the implementation process, the results of the laboratories involved were as follows:

- A new team working mentality has been created that has increased the commitment of all participants, professors, staff and students, including a better understanding of the resources available in the laboratory.
- The number of faults and accidents has decreased (there are no accidents in the labs).
- The inventory has decreased.
- We achieved a 30% reduction in practice preparation time, movements and waste transfers.
- We have approximately 25% more space in the work area.
- Materials and unnecessary tools have been removed.
- Urgent cleanliness and order processes are not needed.
- Resources are sorted and identified.
- Dirty sources have disappeared and machines are cleaned in less time.
- Professors and students can make a fast visual control, which allows us to immediately detect deviations or failures.
- We have a serious commitment to the maintenance of results and continuous improvement.
- We have 100 h/year savings in practices.

Differences detected between the absence of 5S and the 5S methodology implementation can be observed in Table 3.

Fig. 7. Comparison between before and after 5S methodology application.

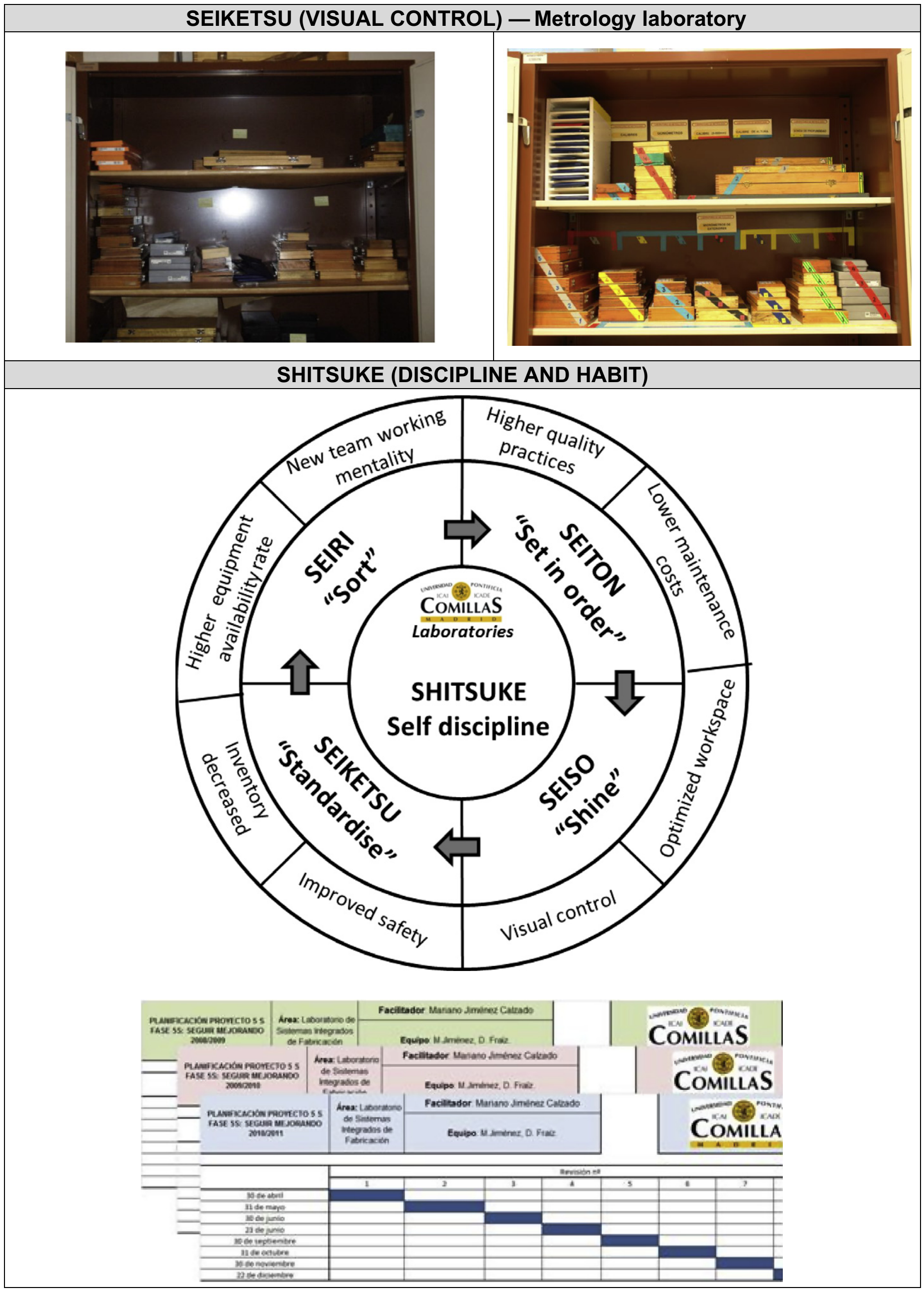


Fig. 7 (*continued*)

As presented below, Fig. 7 shows through images the result of some of the improvements obtained with the application of the 5S methodology.

5. Conclusions

The 5S methodology application in University organizations provides a basis to create an organization culture and start working with continuous improvement criteria. This applies both in the processes related to the students learning, and in the teaching and non-teaching activities. The new culture has resulted in an improvement of the working environment and an increase in the motivation of the staff involved.

Laboratories have become industrial laboratories, adapting to the conditions of security and organization that are routinely used in the metalworking industry.

Learning, control and maintenance of the involved resource activities are performed in less time and with a considerable decrease in the cost, with an increase in available space dedicated to the equipment. This results in an increase in the degree of compliance with established practice programmes and a decrease in the practices preparation time, maintenance costs, the anomalies identification time and the accident rate.

Because of the 5S methodology implementation success in the pilot laboratories, its implementation in other laboratories and other university services is justified.

On the other hand, a natural consequence of the introduction of the 5S methodology is the systematic risks reduction. The concept 'zero accidents and injuries' becomes viable when the accident prevention, risk identification and elimination is an integral part of the 5S programme.

To ensure that all personnel involved in the 5S implementation are sensitive to safety in the workplace, there is the possibility to extend the scope of the 5S methodology to one more S – safety.

A clean workplace, well-organized and with visual indications of risks, is a safe workplace. The boards and labels installation allows workers to know at all times what the potential risks are.

Future work will discuss the methodology implementation process in other environments, as well as the adaptation of the 5S methodology with safety as the 6th S.

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