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ScienceDirect

Procedia Manufacturing 51 (2020) 1806–1813

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

30th International Conference on Flexible Automation and Intelligent Manufacturing (FAIM2021)
15-18 June 2021, Athens, Greece.

A framework to improve training and development of workers' technical skills: effects on operational performance during company relocation

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Abstract

A case study is presented in a food and beverage company, during the transfer of a production plant location. To address the problems of loss of industrial technicians and closing emerging gaps in knowledge of tasks' execution to be performed by new technicians, the company has implemented mitigation actions: work characterization, the creation of standard procedures, and the implementation of operational control routines, among others. The process of technical skills development for the production center was systematized by a framework developed for this purpose. The use of this framework, combined with a specifically designed training program, allowed for improvements in technicians' proficiency in performing operational tasks that have a direct influence on the process performance, as evidenced by the improvement of Overall Equipment Effectiveness. This framework could be adaptable to other manufacturing companies to improve Training and Development skills of their workers, aiming to create and transfer of intraorganizational knowledge.

Keywords: Framework; OEE; operational performance; standard work; training and development skills.

1. Introduction

1.1. Training & Development programs

The rising exigencies and volatility of the markets in the global economy lead to higher efforts yielded by companies and corporations so that they can be increasingly competitive. The distinction from the competitors in what concerns abilities, knowledge, and Human resources, has been assuming increasingly higher importance in companies' potential results [1], and in establishing leadership in the market segments where they operate. Thus, the implementation of projects for training and development (T&D) of technical skills has been revealing as an area of great interest.

These T&D programs, supported by solid tools for evaluation and monitoring of worker performance evolution, deliver consistent technical evolution, maximizing efficiency on a long-term basis [2]. Some initiatives to achieve a competitive advantage, like the acquisition of new technologies or the adoption of specific management methodologies, may guarantee a certain level of advantage on a short-term basis. These initiatives can be replicated by competitors, through the adoption of similar technologies or process innovations, achieving similar results. Nevertheless, efficient management of human talent and their focused application on processes can unveil the development of a solid long-lasting advantage over competitors. The way how organizations attract, develop, motivate, and reward talent, needs to be tailored to each case, considering the human and business context as a whole [3].

The corporate world and the associated rising competitiveness indexes, market globalization, and continuous technological development [2] suggest that company survival and long-term results imply the necessity of adopting business strategies where the persecution of sustainable competitive

10.1016/j.promfg.2020.10.251

advantage is a fundamental pillar. The perspectives that generally attributed these advantages to external elements have been becoming less accepted and hardly sustainable, while the perspectives that attribute the existence of success to the development of internal assets and elements, especially workers' technical skills and capabilities, have been gaining higher relevance [4].

The human element should be considered a source of competitiveness [5], particularly due to the intangible characteristics of human nature: knowledge, abilities and attitudes, and organizational knowledge [6]. Despite all the factors relating to human elements, the main activity that will guarantee constant growth and qualification, flexibility, and good technical preparation of workers is T&D [7].

Learning and continuous improvement are related concepts. The continuous improvement concept encloses the learning achieved through an iterative process [8]. Many initiatives to gain and maintain new technical knowledge fail. This may occur when companies seek the best learning and improvement activities, but end up halting their efforts due to demanding requirements or constraints. Despite this, building a "learning organization" with a focus on improvement requires not only analyzing, discussing and investing in resources, but also establishing an organizational culture that sustains and communicates the company values amongst its collaborators to achieve a never-ending focus in searching for development, as well as creating a favorable environment to learning [9].

1.2. Training as a tool for technical skills development

The concept of "training" is defined by the systematic approach towards learning and development, to improve the efficiency of individuals, teams, and organizations [10]. On the other hand, the concept of development concerns the activities that lead to the acquisition of new knowledge or abilities, with the aim of personal or organizational fulfillment.

The systemic inputs of performance improvement relating to the training usually result in direct performance improvements of the system [11] but also other positive changes, such as new competencies and abilities acquisition [12]. These improvements can be subtle but are measurable and are usually manifested in behavioural aspects and tacit knowledge [13]. Arthur, *et al*. [14] state that training activities have a positive impact on the performance of individuals and teams, and in other fields, such as attitudes, motivation, and individual empowerment. Although these studies fundamentally show the positive impacts of T&D on employee performance, in certain socio-economic and organizational contexts, some negative impacts may also arise that should be mitigated [15].

The bigger effects over workers are declarative knowledge acquisition (i.e., what task to do) and executional knowledge (i.e., how to execute the task) [16]. Driskell et al. [17] consider that training has the potential of improving the consistency of individuals' performance, even when the system where the individuals are inserted suffers alterations or is under the influence of stress-inducing elements. This property can be the result of the improvement of trainees' capacity in what concerns self-management effectiveness [18].

1.3. Benefits of using T&D programs

Few organizations make big commitments with their T&D programs to the point of estimating their financial benefits. Swanson [19] asserts that only 5% of these do that kind of analysis. Studies about operational performance (i.e., where operational performance was related to the company efficiency and profitability index), conducted in some companies in the United Kingdom, Netherlands, Portugal, Finland, and Spain, demonstrated that some types of training, like the on-the-job training and the training delivered by internal trainers, are positively correlated with organizational performance and efficiency indicators [2]. These results confirm the ones obtained by [14], where it is determined that organizational benefits, coming from T&D programs, vary according to the type and method of training and the skill/task to be trained.

The shift in management paradigms through time has been leading to the alteration of the way that managers see value in guaranteeing the existence of (Human) talent in the organizations. The common practice, up until the end of the last century, was based on buying/contracting that talent, where companies made a significant effort to pay high salaries and give other benefits, to bring in for their teams the top-performing professionals [20]. Presently, the paradigm of talent acquisition has become broader and less literal. Instead of incurring high financial efforts by seeking talent in the external market, a lot of companies have been opting for applying their resources in the development of the talent they already possess in their workforce [21].

The remaining of this paper is organized as follows. Section 2 presents the problem definition and the objective of this work. Section 3 (the case study) describes how the T&D program was developed and implemented. Section 4 presents the framework used in the case study that can be adopted by other organizations. The paper ends with the main conclusions.

2. Problem definition and objectives

The context of the problem is a large-sized Portuguese company that acts mainly in the food and beverage sectors. This company employs around 1500 people, divided by three operational sites. One of these operational sites was sold to a third party. Despite this, the main brand produced in this site was kept in the company's portfolio. This situation resulted in the need for transferring the production lines and activities to the main site of the organization. This transfer was characterized by the existence of some major difficulties. The operational teams were dismissed, being only possible to guarantee the continuity of two of the people involved in the site's activities. Also, the inexistence of detailed process documentation did not allow for the easy planning of training activities for the new operational teams' members. The result of this situation was the comprehension that an extensive characterization of the productive activities needed to be done, followed by their integration on a training program, aiming to develop the technician's skills and knowledge about the line operations. This training program should also guarantee that "work specialization" was kept to a minimum. By complying with this, there would be favorable conditions to achieve a

balanced workforce, whose members would have the same level of skill to execute tasks.

The organizational objectives consist of the process definition for the production line, with the establishment of standard work practices, development of technical documentation, and the development and implementation of a T&D program, with tools and methods dedicated to measuring the proficiency level and evolution pattern demonstrated by the workers. The operational objectives consist of defining and improving relevant performance indicators to assess production line efficiency.

3. Case Study

The case study describes how the organization tackled the two general objectives.

3.1. Work definition, standards, and proficiency ranks implementation

The company had to implement mitigation actions to address the loss of industrial technicians and to close the emerging gaps in knowledge of the tasks and procedures to be performed by new technicians. The first step towards the implementation of T&D was to conduct a detailed assessment of the industrial activity developed in the original site.

The objectives of this assessment were to observe, interpret, and understand how the process flow was characterized, which were the process activities, identify and analyze the existent work documentation, and gather information to allow the development of Standard Operational Procedures (SOP), once the production line was transferred to the new installation. Two different process flow maps were designed (Figs. 1 and 2).

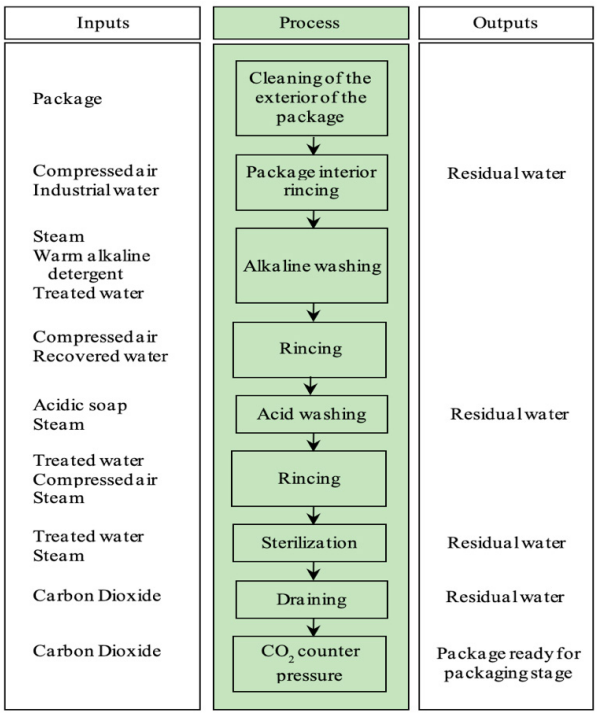

Fig. 1. Empty package cleaning process flow

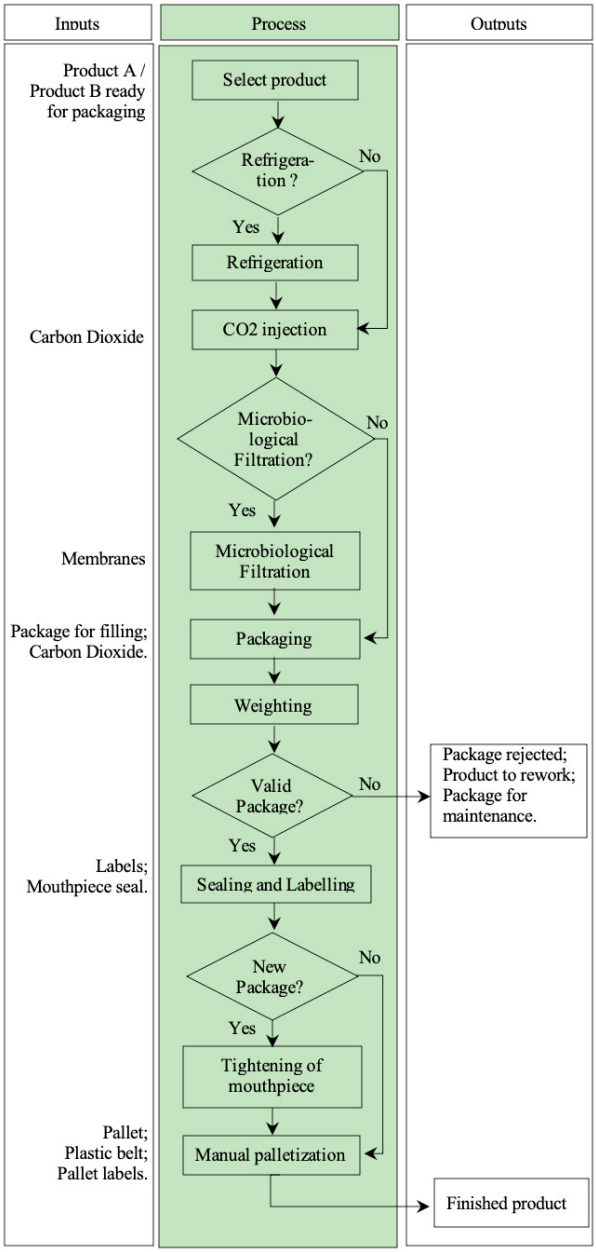

Fig. 2. Product packaging flow

Given the technical complexity of the product developed in this production line, there was the need to map the process steps in three separate flows: product packaging, package cleaning and preparation, and line cleaning. The purpose of the tri-partition of the process was to conduct a detailed work characterization, making it possible to devise the executed actions in different categories.

The analysis of process flows made clear that the process design was optimal concerning the flow of activities. Thus, no change was proposed for the process flow.

Doing a detailed description of the process alone would not guarantee the capacity to train and develop the skills of the industrial workers. Therefore, a skill matrix was developed to identify which skills and knowledge the workers should have,

and which actions and activities should they know to execute in four different degrees of ability/proficiency levels. These degrees of ability were defined in a crescent order, having in mind that a higher degree of ability means that the worker shows a bigger aptitude and knowledge in the specific details for the given task or activity. The four proficiency levels defined can be seen in Table 1.

Table 1 - Proficiency levels

Proficiency level	Description
0 – No knowledge	Did not receive specific training, therefore not having the capacity to develop the tasks in a satisfactory way.
1 - Basic	Received basic and mandatory training for the standards in place for the work-area. Does not execute tasks in an independent way.
2 - Professional	Completely autonomous and strictly complies with the defined standards.
3 – Expert / Specialist	Demonstrate leadership and improves standards

After identifying the sub-categories of competencies to train the workers, a detailed characterization of each one of these began. To do so, the packaging line was divided into different areas: beginning & end of the line, cleaning and packaging, and inspection and codification.

The skill was organized into different categories and sub-categories of competence to specify the workers' skills and abilities to evaluate and develop (Table 2).

Table 2. Skill Matrix categories and sub-categories

Skill category	Skill sub-category
Machine Operation (Specific for each machine/ work area)	Equipment/work area safety
	Equipment/work cleaning
	Equipment operation
	Materials and process control
	Packaging order changeover
	Contingency plans
HSE	Site access rules
	Emergency plans
	Life Saving Rules
	Waste
Quality	Food Safety
	Process control
	Packaging line cleaning and sanitation
Lean TPM	Lean TPM Awareness
	5S
	PMS & Structured Problem Solving
	Process Confirmation
	Autonomous Maintenance
	SMED
	Gemba Kaizen
	Lean Flow (2CBS & Standard Work
	Handover
Management Systems	Documental System
	Control Tools

In each of these areas, all of the activities, actions, and operational knowledge were considered and analyzed. From the conjugation of these with the process flows previously designed, it was possible to build the specific skill for each operational area.

The skill matrices alone had little more than declarative value, indicating the general knowledge needed to manage in a specific operational area of the production line. To assure the delivery of the technical knowledge to the workers effectively and efficiently, technical documentation, such as work instructions, quality reference guides, and SOP were developed. These work documents and standards allowed not only for the detailed description of each element of the sub-categories of competency but were also the center pillars for establishing the evaluation and progression schemes for the workers. Following the conclusion of the skill matrices and technical documentation development, every element of the sub-competency groups was thoroughly reviewed during the transfer of operation location and operation rollout.

3.2. On-the-job training sessions

The strategy defined by the company for the implementation of this project imposed changes on the work teams that were responsible for granting the operation of the packaging line. Originally, two teams of four elements worked in the line, in two 8h shifts. After the transfer of installations, these teams were changed and the line started operating in three 8h shifts, with two workers per shift..

The training sessions for the new workers that were attributed to the packaging line after the transfer followed an on-the-job methodology. These sessions were conducted by the line manager, and by one experienced worker that remained in the company. Given the necessity for the comprehension of the process by all the new team members, an initial training session was organized, which was exclusively dedicated to the step-by-step explanation of the process identified in the process workflows. All the elements and functions where explained, and the structure for this session was:

- *Information to the workers:* workers have been informed which element of the process was being addressed and which were the main points to understand;
- *Explanation of the elements:* the information was presented, connections between different aspects of the process were established, and procedures to execute were thoroughly explained, creating space for debate and questions;
- *Incentive to experiment:* the workers were encouraged to experiment themselves, to execute, and intervene in the different process elements, manipulating equipment and materials, aiming to achieve a deep understanding of the different elements of the packaging line, as well as their functionalities;
- *Information Summary:* at the end of the session, the main points of the process were resumed to facilitate knowledge retention;
- *Involvement of the workers:* the closing of the training session involved a feedback request over the activity. The aim of this was to grant the sharing of the different perspectives, doubts, and experiences among the workers, looking for subjects and information that could potentially improve the training contents in the future.

After the introductory training session, practical sessions were organized, so that the workers could further develop their

capacities for task execution. Scheduling was developed for 10 weeks so that the experienced industrial operative could rotate into different teams, and train all the other workers. Aiming for the sustainable development of the knowledge and work capacity of the newly introduced workers, the schedule also determined the worker with the responsibility to execute the major SOP.

3.3. Worker proficiency level evaluation

The evaluation of the training program was addressed in each project phase. The evaluation of workers' operational capacity was conducted in different moments, beginning at the moment when the training rotations started to determine the degree of success in the application of the new knowledge and operational capacity.

The evaluation methodology used in the project aimed to clearly and explicitly demonstrate the differences between the pre- and post-training periods. Before the beginning of the training sessions, there has been a characterization of the initial workers' capacity, based on their demonstrated proficiency degree for the execution of tasks and operational procedures. A questionnaire was used to assess the proficiency degree for specific tasks, based on each worker's perception. A Likert scale from 0 to 10 was adopted, corresponding the answer zero to, 'I am not able to autonomously operate machines and execute tasks' and 10 to 'I can operate all machines and execute all the tasks, and I can contribute towards improving the work standard'.

The line manager has the responsibility for the operational activity management of the production line. So, a similar questionnaire about his perception of workers' proficiency level was also applied. The aim was to compare these metrics with the ones obtained by the workers' self-evaluation. This evaluation element created the need to correspond the levels obtained in the self-assessment and line manager questionnaire, to those of the technical proficiency scale aligned with the skill matrix. To do so, the production management team developed the correspondence scale (Table 3).

Table 3 – Proficiency level correspondence

Level attributed by the self-assessment	Proficiency level
0	0
1, 2, 3, 4	1
5, 6, 7, 8	2
9	3
10	4

The criteria that led to the establishment of this correspondence were: (i) a zero answer on the self-assessment instrument represents the absence of knowledge and autonomy, thus having the same value in the proficiency scale; (ii) the self-assessment levels between one and four, below the average level of the scale, were seen as representative of insufficient technical proficiency levels, being their correspondence attributed to level one in the proficiency scale; (iii) the self-assessment levels situated between five and eight, corresponding to an above than average acquired knowledge, were matched to level two of the proficiency scale. The positive outcome of proficiency suggests a possibility for improvement; (iv) level nine in the self-assessment scale corresponds to level three of the proficiency scale since both represent the sub-maximal level of technical knowledge and autonomy; and (v) level ten of the self-assessment corresponds to level four of the proficiency scale since both represent the demonstration of complete knowledge and autonomy concerning the criteria being evaluated. The initial evaluations of the technical capabilities were made weekly between weeks 12 and 15 of 2019. Later on, to better characterize the progression in worker proficiency levels between two distinct moments, the final evaluation was carried out at week 20. These evaluations were made by the same method, giving use to the self-assessment tool as well as by live observation of behaviors and operational effectiveness by the line manager.

3.4. Results

According to the operational objective, performance indicators were designed and used. These performance indicators should allow the quantitative interpretation of the operational efficiency levels achieved in the industrial operation and assess the success of the T&D program. The overall equipment effectiveness (OEE) performance indicator was developed and its data analyzed.

Standard work establishment was achieved for the totality of the operational procedures executed in the production line until the project deadline. This work characterization resulted in the definition of 36 SOP that explain clearly and visually the tasks to execute; the instauration of four One-Point Lessons, which are a brief visual guide of quick interpretation about the reason and importance of some steps in the process; and the instauration of a process control routine. This process control routine aims to guarantee the detection and identification of deviations of process parameters and to describe the causes of these deviations, by establishing a history of the system's errors and malfunctions.

The achievement of this work standardization effort allowed the deployment of the proposed workers' operational competencies T&D program. The balance made over this action for worker development was positive as shown by the evolution of the average proficiency level of the team, composed by six filling technicians from the *Vini* line, to the global learning units throughout the training weeks (see Fig. 3).

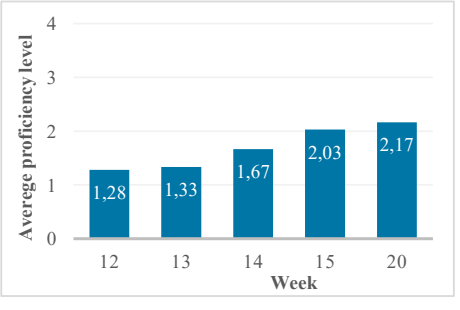

Fig. 3. Evolution of the workers proficiency level average

During the first two weeks (12 and 13) the workers' capacity levels changed less than the following weeks. This can be justified for the small period existent between the beginning of line operation and the evaluation moments. The evaluation of the progression of the proficiency levels showed that, by the end of the fourth week of training (week 15) the line workers demonstrated already proficiency levels corresponding to a level 2 in the developed proficiency scale. By week 20, it was possible to observe a clear positive tendency in the development of the technical capabilities of the working team.

The proficiency levels were analyzed by the following competence categories: process, operation of equipment's and task execution; execution of cleaning procedures; and packaging control.

The results achieved for the competence category "execution of cleaning procedures" are important to guarantee the integrity of the hygiene and quality standards during operations and belongs to a group of tasks that has a significant impact on the line productive time. This factor, associated with the need to execute all cleaning tasks (for line sterilization) manually, being this manual execution of considerable complexity, constitutes a good indicator to understand the possible gains for the line operational efficiency, by the achievement of higher levels of proficiency of workers.

The assessment of the time spent on the line's sterilization procedures in April and May 2019 (throughout the project) was 92 minutes and 80 minutes, respectively. This task time reduction in 13% can be seen as being associated with the development of the action mechanisms of the workers towards work execution.

The increase of the proficiency levels of the workers and the consequent reduction of task execution times, increase the available time to execute value-added activities. It can be confirmed by the analysis of the evolution of OEE reports for the line, as well as the evolution of total produced volume (see Table 4). The total produced volume increased by 34% between March and April, and 15% between April and May. Over the same period, the OEE increased by 10%.

Table 4. Monthly evolution of OEE and produced volume

Month	OEE (%)	Produced volume (hl)
March	40	4896
April	48	7380
May	50	8663

4. Framework for the implementation of T&D programs

The knowledge acquired with the planning and implementation of this T&D project (also supported by the positive results achieved and confirmed by the presented operational performance indicators) allowed for the development of a framework to support the implementation of technical knowledge and performance development projects directed to industrial workers.

The framework that describes the base elements and activities that constitute this approach can be seen in Fig. 4. This framework was grounded on the literature review and is the result of induced elements gathered throughout the case study.

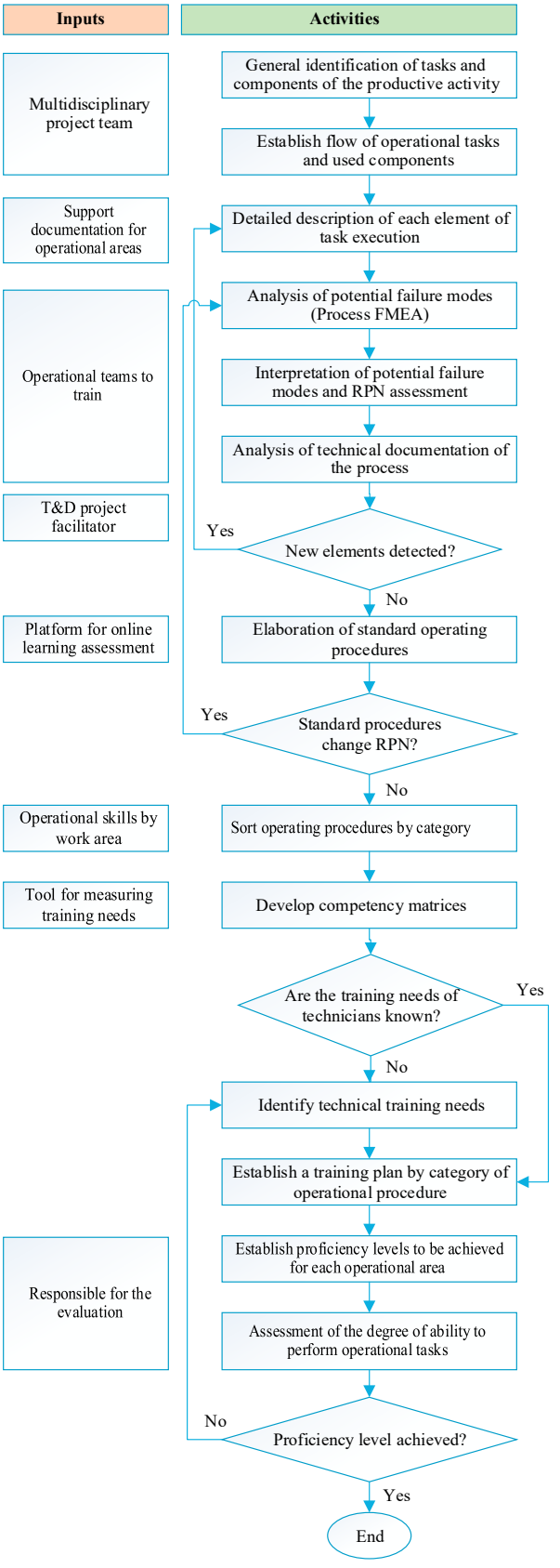

Fig. 4. Framework for the implementation of T&D programs

The framework is structured on inputs and activities / decisions. The inputs are the Human and material resources, the methods and tools, and a set of various skills, which are necessary to carry out the activities and decisions of the T&D process represented in Fig. 4. Some of the inputs and activities / decisions are explained in the next sections to better understand the details they represent and their context.

4.1. Inputs

- *Multidisciplinary project team:* refers to the need for an operational team with experience in the activities to be trained. This team, made up of entities internal and / or external to the company, will conduct the main tasks of the T&D project.
- *Support documentation for operational areas:* it includes all types of available documentation whose content has some type of information about any of the activities carried out. These documents can be: process maps; activity and maintenance plans; lists of products, by-products and components used in the process; quality control plans; work instructions; SOP; security instructions; equipment manuals; operation manuals; etc..
- *Platform for online learning assessment*: it is recommended since it facilitates easy access and assessment for some types of theoretical training. However, it may become irrelevant for training with a mostly practical profile that focus on the execution of operational tasks.
- *Responsible for the evaluation*: person who is accountable for interpreting and valuing the variation in learning manifested by the trainees. As a rule, this person should be a member of the management teams with responsibility for the functioning and performance of the work area.

4.2. Activities/decisions

- *Establish flow of operational tasks and used components and Detailed description of each element of task execution:* they relate to the characterization of all the execution points necessary to carry out operational tasks. Here the continuous flow of the various iterations where the components and intermediate products are involved must be characterized, as well as a detailed description of all the transformations and actions they undergo in each task.
- *Analysis of technical documentation of the process:* it involves the careful analysis of all technical documentation related to the process. This action aims to cross the information present in the documentation with the information collected through the characterization of each of the stages of the operational tasks, thus guaranteeing a more detailed characterization of the process.
- *New elements detected?* gives an indication of the decision that should always be considered at the end of the documentation analysis. If the presence of non-coincident or missing elements is detected between the task description and the current documentation, a new reconsideration of the previous elements must be made, rectifying the task description or the documentation in question, and introducing the new element of the identified process in the analysis of failure modes (process FMEA).
- *Elaboration of standard operating procedures:* after completion of the creation and acceptance of the SOP it should be considered whether the existence of new standards affect the Severity, Occurrence or Detection indices indicated in the failure modes for each of the tasks under consideration, as explicit in the *Standard procedures change RPN* decision. If this situation occurs, the indicators must be reevaluated and a new RPN index must be assigned. The acceptance of SOPs must be followed by their categorization according to the general typology of the task that is performed, as explicit in the *Sort operating procedures by category* activity. This action will facilitate the organization of training actions, allowing them to be planned and evaluated according to the segmentation of the type of task performed at each moment.
- *Establish proficiency levels to be achieved for each operational area:* it refers to the definition of the training objectives to be achieved in terms of developing technical proficiency. These objectives must depend especially on the needs defined by the company in view of the requirement of each particular process, being necessary a realistic structure based on the available resources and time to be applied in the T&D project.
- *Assessment of the degree of ability to perform operational tasks:* the responsible of this activity should be the T&D project facilitator / manager, in collaboration with the member of the management team responsible for the process or work area. To validate the mode of execution of the training application, as well as to make small changes that are perceived as necessary to achieve the objectives, the evaluation should be done frequently during the first weeks (for example, once a week during the first four weeks of the project), reducing its frequency when the level of technical proficiency gets closer to target.

4.3. Outputs

Based on the literature review and the case study findings, a set of results, can be expected from the application of this framework. The following list presents the outputs as perceived by the researcher and project manager:

- *Increase in technical knowledge*: it can be perceived through the observation of the attitudes of industrial technicians, making them more proactive and responsive to the various situations inherent to the process and issues raised to them.
- *Gradual increase in the capacity to perform tasks*: it was evident by the value of performance indicators that improved and its variation reduced, such as setup times, operating performance per unit of time, etc..
- *Increased perception of failures and improvements*: it was noticed from the technician's opinions about various process elements, and it became common for them to present suggestions for possible improvements or identification of failures that have so far gone unnoticed.
- *Greater capacity for work organization*: it can be experienced in various ways, but it was evidenced

particularly through the increasing autonomy of industrial technicians over certain process elements and more attribution of responsibilities to the team members.

- *Changes in corporate policies*: it is a type of improvement that is often subjective, but that must be considered in the follow-up of the company's strategic planning.
- *New standards for the management of human heritage*: by defining key elements for the various functions in the company, as well as competence matrices structured at various levels of proficiency, the company has a model available that allows assisting recruiters in defining relevant technical and methodological aspects in hiring new employees.

Overall, this framework could be applicable to guide the implementation of T&D programs for manufacturing companies, enabling them to design similar T&D projects, based on worker technical proficiency, if properly adapted to the application context.

5. Conclusion

The need for the implementation of this T&D program was first understood during the initial characterization of the production line. Achieving a transference of operation location and work team reformulation, while minimizing a long period of an operational performance drop, could be achieved through the implementation of standard work practices that would be the base for worker technical training.

This T&D program showed the definition of the technical knowledge to be presented by workers and the development of workers' operational competencies. It produced positive and observable effects in the work method implementation and the establishment of control and inspection routines. This case study showed how the T&D program contributed to the increase of the production line operational efficiency in a short period, as demonstrated by the reduction of task execution time, and an increase of produced quantities and OEE.

Considering the improvement observed in workers' behaviors and their competence improvement, it was possible to achieve a progression of the technical proficiency levels of operational teams, to a level correspondent to an autonomous capacity to execute the work on the production line, thus confirming the findings of [11-14]. These conclusions and improvement of several performance indicators are only from one single case study and, thus, generalization should not be made without further studies.

Finally, the case study induced the development of a framework for knowledge transference within the organization through the implementation of T&D programs. As a future research hypothesis, the applicability of this framework to other manufacturing companies with a need to implement a technical competency program for their workers, as well as guarantee a technical knowledge transfer throughout the organization, should be investigated. Accordingly, the authors propose, as future research directions, to apply this framework in different context to further validate or refute its elements.

Acknowledgements

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

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