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What Does The Factory's Suggestion Box Reveal?

An analysis of the design capabilities of a train maintenance center from its idea management system

Honorine Harlé ¹[0000-0003-1847-4506], Pascal Le Masson ¹ [0000-0002-3835-2875], Benoit Weil ¹,
Tony Bourlier ², Yann Veslin ²

¹ Mines Paris- PSL, Mines Paris – PSL, Centre de Gestion Scientifique (CGS), i3 UMR CNRS
9217, Chaire Théorie & Méthodes de la Conception Innovante, France

² SNCF, technicentre TER Pays de la Loire, 44000 Nantes

Abstract. Suggestion boxes have been used in factories to improve processes through a continuous improvement approach. From this perspective, the ideas with direct and quick implementation and visible results are favoured. This paper investigates the nature of design activities hidden behind the ideas suggested. The authors sort 132 ideas from a suggestion box of a French train maintenance center and highlight differences in the processing of the ideas through the suggestion box. The paper shows that a part of the ideas should have been rejected, as they present a gap in the design to be directly implemented. However, they are kept and collectively re-worked to be well adapted to the factory. This enriches literature on creativity and crowd sourcing for and by manufacturing. In particular, it gives a design perspective to innovation and continuous improvement in factory by revealing different design types in the box to fit the production system.

Keywords: Factory, Design, Suggestion box.

1 Introduction

In manufacturing, the shop floor operators are often involved in the performance of the production, especially in the continuous improvement approach [1]. For this reason, they have to detect the problems and the losses that become sources of potential gains when they are solved. Among the tools used to foster continuous improvement in a participative way, the suggestion box, physical or virtual, is classically used [2], [3]. The operators, as users of the production line, are better placed to propose ideas and to implement them. They receive their prize in function of the effect of the improvement of the production performance. However, this tool faces a major ambiguity: it is at the same time a tool to optimize the production process by involving operators in the continuous improvement process [4], but it is also expected for more radical innovation [5]. This later aim could appear contradictory to a production context. Indeed, when

used in factories, suggestion systems meet the constraints inherent to the shop floor production: the factory is a place of execution and not ideation; operators are highly prescribed, their objectives and the guidance, and time for processes are very precise and let a little place for innovation [6]. Moreover, the factory's performance should be maintained and cannot suffer from troubles caused by experimentation.

This article intends to overcome the conflict between the manufacturing impossibility to change and design new rules and the wish to make them evolve through the suggestion box. The authors went to a train maintenance center of the French railway company SNCF, and questioned the design opportunities and practices that the digital suggestion box could offer. They provided a new comprehension of the factory's digital suggestion box through a design perspective. The study shows that, even if the digital suggestion box of the maintenance center is designed to collect ready-to-implement solutions in a continuous improvement manner, it also admits derogations. A collective design action is launched to validate the conformity with the factory's rules and/or change them. Hence, this article explains how a digital platform which intends to collect and validate (or not) ideas with strict decision criteria is finally used to organize an ambitious design activity of the production rules. It contributes to information system literature by providing a comprehension of the design mechanisms and effects hidden behind a digital suggestion system in a manufacturing context. The results finally offer a method [7] to support, reinforce, and open new ways of using this type of digital collaborating system fostering the design capabilities of the factory.

2 Literature review

2.1 A short genealogy of suggestion systems

Suggestion systems emerged and were developed during the 19th century in the manufacturing industry [8]. Eastman Kodak was one of the famous first examples of a US company implementing a suggestion box for its employees to foster their creativity and raise their commitment [9]. Funding the scientific organization, F.W.Taylor separated the design and production activities, isolating the execution function on the shop floor. This organization led to high productive gains. However, the innovation function was not expected from the operators but from the engineering office. Nevertheless, suggestion systems were tested in Taylorian factories to support the shop floor performance: the French company Michelin, one of the first French enterprises to import and implement Taylorian ideas, already collected the operators' ideas in a physical box in the 1920s. At the same time, a suggestion engineer was in charge of motivating them to post and implement the suggestions. However, the suggestion box was given up on after few years [10]. Later, the suggestion systems principle was re-introduced in factories as a way to make the work more participative. The suggestion box has been a tool of first importance for continuous improvement (the Kaizen approach) in the Toyota production system ([11] [12]) and in lean manufacturing (e.g., [4]). Indeed, one of the principles of continuous improvement is the contribution of all the employees to the productive performance, including those working on the shop floor. Hence, according

to [13] the functions of the suggestion box are various: to collect employees' opinion, to be more democratic, and to stimulate employees' engagement and their creativity.

The paper [3] insists on the fact that suggestion systems did not remain confined to the manufacturing field but appeared in other fields. Idea management, and more particularly the collection of ideas for innovation, were systematized and developed in companies [8]. The functions are multiple: e.g., to catch customers and collaborators' ideas to foster innovation and develop new products or to solve problems [8]. [14] comments the digitalization of the innovation tools: collaboration and idea management tools are facilitated under digital form. [15], [16] argue that digital platforms can be accelerator for innovation. However, one of the risks is to consider the suggestion system as a passive tool. Following this idea, [16] proves that in academic literature, innovation management and information system researches are only partially connected. Studying the design of intrapreneurship platforms that foster employee driven ideas, as in [17], is one of the means to address this research gap. Moreover, the specificity of industry and the precise mechanisms by which digital platforms transform industry are yet poorly known [14].

2.2 The contribution and known problems of suggestion systems

Suggestion systems and, more generally, participative approaches to collect employee's ideas constituted a pillar of the continuous improvement and gains in productivity in factories. However, it can suffer from many problems: e.g., suggestions systems are given up on after a certain time of implementation, and they do not collect qualitative ideas [3] or people are not motivated to post new ideas [18]. The literature gives a lot of insights into organizing and designing a system that collects ideas efficiently, by improving the collection of ideas with an adapted management or by making the process transparent and rapid with a rewarding system that provides enough incentive [3].

As a manufacturing tool, the suggestion box has been viewed as a means to foster innovation. However, the type of innovation that is possible as a result of a participative system in a factory is unclear. In particular, [19] shows that the suggestion box is efficient for small innovation and continuous improvement: according to [20] it brings forth solutions to optimize the performances on the production line, whereas more elaborate suggestion systems are used in product development to screen radical innovation. However, there are calls for radical changes across the industrial world to answer present and future challenges (e.g., cleaner production systems, mass customization, and so on). The transition towards industry 4.0 [21], sustainable manufacturing [22], agile factory [23], and more, generally towards creating a desirable future for factories will require significant efforts and not merely continuous improvement.

2.3 The selection of directly implementable ideas

The generation of numerous improvements was encouraged, but the very original or new ideas for which the implementation is not direct do not fit into the industrial frame and cannot be accepted. In this configuration, the criterion of evaluation of the ideas is often implicit and not highlighted in the literature: the ideas are validated if they are

implementable without any risk of perturbation of the system and rejected otherwise (for instance, in [24]). Thus, the validation criterion for this type of industrial suggestion system is a yes/no criterion based on the probability of success of the idea. Then, a more elaborated scale is used to sort the ideas and decide the reward to grant.

In a larger perimeter than manufacturing, for instance in the new product development or engineering design, suggestion systems are also used to enable the participation of people and the decentralization of the idea collection e.g. [20]. In this context, the validation criterion remains but can be enriched. [25] argues that idea management concerns different types of ideas: some are ready to implement, whereas others show a design gap before being developable and require a different development process. Then, during the collection of ideas, one should pay attention to the “false negatives” that are not considered as innovation and are put aside to be given up since they are not in the core business of the company. On the contrary, those ideas should have raised attention of the management since they could be relevant for the future of the company [26]. [5], [27] explain that a particular selection, treatment, and validation process is needed for the “out of the box” ideas. In particular, the criteria to differentiate them from the “in the box ideas” should be adapted. In [5] the differentiation between the ideas is made by experts assessing the novelty compared with the resources and the capabilities of the company. If the idea is considered to be “out of the box”, it will be treated like a radical innovation project. In other terms, according [28], companies should have an ambidextrous process for the collection of ideas: a specific procedure should be designed for the exploration ideas to distinguish them from the exploitation ones and to finally bring the appropriate support to bridge the design gap.

Nevertheless, this last selection and process used in new product development appear to be not suitable for a factory. A factory focuses mainly on the preservation of the production; a change can put the manufacturing system at risk [6]. The notions used previously to characterize innovation, such “out of the box” or “exploration ideas,” are not directly comprehensive for a manufacturing context: how can an idea be “out of the box” if it goes against or beside the industrial rules? Regarding the complexity of an industrial system and the numerous constraints in it, the factory’s suggestion box is designed to select the ideas that are implementable in a straightforward manner.

3 Research questions

This article intends to test this later hypothesis: the suggestion box, due to its manufacturing context, rejects not-directly implementable solutions. Alternatively, the factory’s suggestion box accepts a wider range of ideas. It also collects solutions that present a design gap before their implementation and that need to be treated separately, as the former paragraph suggests for the field of new product development.

Research questions: What types of ideas can be found and processed in a factory suggestion box? How could this tool be improved to foster the potential of innovation and of collective creativity in manufacturing?

To answer to these questions, the paper evaluates both the idea types and the added design step necessary before implementation. Thus, this research highlights the role of this digital suggestion system to organize a design activity hidden in factory. The context of this study is very specific: it focuses on suggestion systems in production, which constitutes, as shown in the literature review, their roots, but at the same time their limitation. First, the manufacturing sector requires ready-to-use solutions from the operators; it is not organized to liberate time and development means for the operators to design more ambitious and impacting solutions on the shopfloor [6]. Second, in production, the processes, organization, standards, etc. rule the activity in order to produce complex outputs at a chosen quality level in a repeatable way. In this context, a minor change can put the production system at risk and cause significant failures. Hence, design activity in manufacturing is dedicated to improve and optimize the rules (methods, processes, organization, etc) in place but not to change them [29]. All these constraints are not present in other sectors where there is a place to test, try, and implement new approaches, products, services, organization, etc. Then, the implementation, the management, and the effect of a suggestion system are different between a productive and an administrative department. [30].

4 Methodology

In order to answer these research questions, the authors conducted an in-depth case study [31] in the maintenance center of regional trains at Nantes (France). The next parts gives the details of the material and the method used.

4.1 Research context: the Nantes SNCF maintenance center

The maintenance center, located in Nantes, is dedicated to the maintenance of regional trains of the French railway company SNCF, for the trains linking the cities of the region around Nantes (the region “Pays de la Loire”).

The maintenance center employs about 150 people, with various technical qualifications: electric specialists, heating specialists, interior systems technicians, mechanics, and so on. The center can operate up to seven trains at the same time, with three shifts around the clock. It performs the maintenance of 35 trains each day. The technicenter operates the control of the trains and undertakes preventive actions according to the methods department’s rules; it also makes small repairs on the trains. An innovative manager is in charge of the continuous improvement and innovation of the site. Among his tasks, he animates the suggestion system of the technicenter, that is to say, he follows the process of the good treatment and implementation of the ideas. His work and tasks correspond to those of the “continuous improvement officer,” a manufacturing classic, who supports continuous improvement implementation. However, the term “innovation” marks the wish of the SNCF to deeply change its maintenance centers to address the big industrial challenges of the future (e.g., more sustainable, smarter, and so on).

This field was very relevant to study innovation since it has a very long history of continuous improvement. For instance, the 5S method is implemented, the QCDS (Quality Cost Delivery Safety) is narrowly followed in daily briefings, and, among other tools, the suggestion box was officialized in the SNCF maintenance center in 1954 and has been used ever since [32]. On the other hand, in this center, the nature of the activity of the train maintenance evolves at the rhythm of the automatization of the systems in the trains, which makes the maintenance skills evolve train generation after train generation. Hence, this center is the result of a long heritage of rules, practices, and know-hows in train maintenance.

The authors were in narrow partnership with the maintenance center's director and innovation manager. They visited and came to the technicenter 3 times. Eight two-hour meetings took place between the industrial partners and the researchers to guide the exploration and discuss the partial results. They corresponded by calls and emails when precisions were required. This determined the design methodology based on the study of the suggestion box, and complemented the reading and the comprehension of the panel of the 132 ideas investigated by the authors.

4.2 A sample of 132 ideas from the suggestion box of the maintenance center

This digital suggestion box received about 170 ideas in 2019. It is daily animated by the direct managers of the work groups in the briefing at the beginning of each shift: the managers encourage the operators to post good ideas in the suggestion box. They also follow the idea process and its implementation with the operators. If the idea is not rejected, the operator earns a minimum of 30€, and the financial incentive is scaled in function of the QCDS results of the idea after implementation. Each month, an “innovator of the month” is nominated in the center and each year a national competition chooses the best suggestions from among the various similar SNCF technicenters.

An idea is an electronic form including the date, the innovator(s) name(s), and the decider's name. The forms include the following categories: description of the problem, description of the solution, advantages, manager(s)' comments; then, a category “recommendation for the implementation” can be added, where the manager can add specifications of the solution. Finally, a category labelled “treatment step” appears, where the successive status of the idea are written, and comments can be added to the status. Hence, the reading of the idea informs the nature of the idea as well as all the potential comments of different managers and experts while the idea was processed.

The box has existed for a long time, is well known and used in the factory, and has a manager dedicated for its proper working. Its digitalization consisted in a platform which gathers pre-structured idea forms to be digitally fulfilled. Generally speaking, there is no problem of giving up or lack of motivation or implementation of ideas. Second, the suggestion box gathers the innovation of the technicenter and makes it visible and comprehensive from an external point of view. It seems to be a good instrument to capture the meaning of innovation and continuous improvement for a train maintenance center.

The sample of the 132 ideas contains the following characteristics. It covers the period between 1st January 2019 and the 30th September 2019. There are 93 contributors, over 150 people in the center. On average, each author published 1.9 ideas. 68% of the contributors (63 people) published only one idea, while 3 people published 6 or 7 ideas. In majority, the ideas are written by an author alone or with a colleague: 73% of ideas are written by only one author and 20% of the ideas are written in duo. The box was used by the operators throughout the year, with an average of 14,6 ideas per month. July was a particularly remarkable month as an operator decided to post 7 ideas at the same time. There were 3 ideas that remained not fully completed by their author. Moreover, 11 were not accepted, as the solution was already studied or another solution had already been proposed or because it was not considered as an idea (for instance, somebody who would complain about the organization).

4.3 Steps of analysis of the sample

Step 1: Filtering the ideas presenting at first a lack in design

First, the authors picked the 132 ideas from January to September and looked at the history of comments at the end of the idea forms. Some comments were just the validation or the appreciation of the idea (e.g., “good idea that improved the maintenance delay”; “implemented a month ago and works well”; and so on). Others showed an investigation step to design the solution (e.g., an expert is called, the design goes on in a dedicated team with a supplier, for example, and so on). The authors sorted the ideas between those without investigation comments and those with investigation comments. In this manner, instead of making assumption about the degree of novelty or the innovativeness of ideas to conduct their analysis, the authors filtered the ideas which were supposed to be rejected from the process (as not directly implementable ideas).

Step 2: Determining the nature of the supplementary design and resources required

To have a better understanding of the supplementary design and management required before the acceptance of the ideas, the authors identifies 5 categories of investigation comments. Thus, the ideas with these comments were coded. The authors carefully discussed with the innovation manager and the director’s center during two semi-directive interviews of one-and-a-half hours to understand the resources and the organization devoted to the idea treatment, especially when a supplementary design step was necessary.

5 Analysis and results

5.1 The two hidden categories of a unique suggestion box

The authors sort the ideas in two categories: the ideas with or without investigation comments, as described in the former section.

A first category of ideas: the tricks directly implementable

The category gathered ideas that include only validation comments or do not include any comments. A validation comment is a manager's comment that underlines the quality of the idea, e.g., "good idea," "too be implemented soon," "to be awarded," and so on. It does not improve or change the nature of the idea itself. 101 ideas (77% of the ideas) belong to this category. Hence, this category includes ideas that are directly implementable. Examples of this category are : a tool for a better ergonomics (e.g., by adding a handle, or colouring in yellow to increase the visibility), a best storage organization to save time, a change in the garbage place so as to put them nearer the operations, a trick not to lose the security keys between two shifts, and so on.

Qualitative analysis and comment.: The ideas of this category look like a standardized form to be checked and stamped. Indeed, the solutions are directly implementable without any specifications and present observable and direct results. They rely on the slight modifications of organization and techniques to improve the processes in term of security, ergonomics, cost, and so on. They use the common sense or the employees' creativity applied on technical gestures, the tricks found by the operators. For these ideas, the solutions were not far from the existing one, the effects could be observed immediately and the validation was direct. This is an expected result in factory: the innovation relies on continuous improvement in which the employees have a major role. The innovations captured by this system includes the improvements that enable the better implementation the rules and optimize the prescription, in accordance to the traditional gap between the real and prescribed in factory [33].

A second category of ideas: the ideas with design gap

The authors took all the ideas that had investigation comments and gathered them in a category. An investigation comment is a comment where the manager investigates the solution, such as the following:

- The written solution can be considered as not sufficiently detailed nor specified to have a decision about its implementation; "What diameter, length, would you need?"; "Do you have any reference of this solution in a catalogue?"; "Do you have any picture of its implementation where else?";
- The manager calls a SNCF expert who gives precision on the form (on the technical characteristics or on the rules). "We saw the health and safety committee, who advised to avoid this solution."
- The manager asks for a quotation to a supplier and finishes the specifications and the design with him.

Of all the ideas, 31 were noticed to have investigation comments and thus belong to the second category. Among the 31 ideas, the 7 ideas with the status "in-depth investigation" received investigation comments. The comments were precision to the necessary investigation (Manager 1 to Manager 2): "Can you tell me if this innovation is taken into account in the rules?"; (Manager 2) "Relayed to the supplier"; for another

idea: “Does it exist somewhere? (pictures, catalogue, references)”. The solution is considered as not implementable, and the design is not finished. The 3 ideas with the status “closed and failed” indicates that the idea was judged good, and awarded but failed in the implementation. Two of them received comments about a future study to be launched (“there is no system for this problem”). One of them noticed in the comments that the idea was good but already explored; the technicenter was not able to decide alone (cf. example in part 2), but the idea was considered good enough not to be rejected.

Qualitative analysis and comment: Finally, the investigation comments show the following elements: the managers commented the solutions and suggested other ones, debated via the form with other managers on the solution, or made checks into the rules and changed the solutions afterward. In other cases, the solution was explicitly given to design with the supplier, and the design work went on between the operator, the manager, and the supplier. Thus, the ideas could not be validated immediately but needed changes, verifications, an expert’s advice, or the supplier’s intervention. The authors called “**design gap**” this complementary investigation. Hence, the criterion used by the managers of the suggestion box is a “pass or fail” criterion. However, the criterion “pass” is richer than the direct implementation. It encompasses various situations. In particular, 23% of ideas are denoted “pass” with a design gap. At first sight, this design gap necessary to complete the solutions can be viewed as undesirable in a factory where the solutions should be implementable directly. One can consider that 31 ideas in this category is a low number to assess the phenomenon that the authors are investigating. However, ideas of this category are highly unexpected in this suggestion box (they do not fit with the rules of the tool) and should not have been processed. From this point of view, 23% of the ideas is a significant amount, and this category should be analyzed more carefully.

5.2 The nature of the investigation necessary to complete the design

The idea with design gap were analyzed. An illustrative example is detailed.

An illustrative example: the “fake” platform

An operator indicates that the tool to control the good working of the sensors of the automatic doors is not reliable. He suggests to adopt another process to control the sensors, by testing the doors in real conditions on the recent storage platforms of the maintenance center. The manager answers that it was a good idea, but suggests a new tool-platform on wheels.

The history of the comments written on the idea form was the following:

5th July: (innovation manager to the tool manager) Hello, Tool Manager! Can you help the author on this idea? Thank you! The idea would consist of doing a “fake platform” on wheels and using it on the platforms x, y, z.

12th July: (Tool manager to innovation manager): Hello, Innovation Manager. A fake platform on wheels, why not. But there is no use to limit it to the platforms x, y, z.

We could use it on other platforms. But, if I understood well, the idea would be to realize a true platform on the storage platform. To be discussed with the author directly.

18th July: (Manager N+1) approved. The author has to make a drawing of the fake platform, with the help of the tool manager.

In the following months, the idea's author, the tool responsible, the innovation manager, and a supplier created and produced a new "fake platform" on wheels to test the automation system of the doors. In this example, the idea's author highlighted a problem in a tool and proposed a solution. His managers considered the solution but found another one, apart from the idea form, in a collective design effort.

The type of comments clarifies the nature of the design gap:

The comments can be classified in 5 categories. All the investigation comments fit in one or more category of comments.

Category 1: The comments that imply another person than the direct manager N+1: "The operator should consult the tools manager to implement its idea"; "see with the supplier"; [Manager N+1 to manager 2] "Dear Manager 2, could you study the idea?"

Category 2: The comments that question the solution and that show that there is a lack of details or specification : "Relevant idea. (...) Can you give an example of the beacon (pictures) and find an adequate storage space?"; "What are the visits concerned by this dimension measurements? What are the series concerned? How to do with the dimension measures with tolerance?".

Category 3: The comments that show that the solution is not satisfying, implying that the problem remains: "This idea would be difficult to implement. But it is indeed a problem to have to isolate 6 batteries"; "After discussion with Manager Y, it is rather a no from our part."; "Already tested. See for another solution".

Category 4: The comments that make an explicit check in the system of rules to validate (or invalidate) the solution : "The rule asks to each agent who would need to work locked out to protect himself."; "a form does already exist, the form "Y", which explains the eco- parking process.

Category 5: The comments that mention an explicit change in the rules: "The whole file has to be transmitted to the technical department in order to maintain this relevant tool"; "Do you think that the rules should be modified or a mere verbal opinion by the hierarchy would be enough?".

The authors completed in the following table (Table 1) the nature of the comments found in each idea form. One comment can belong to several categories.

Table 1. The coding of the investigation comments for the ideas with a design gap (extract)

Idea number	more people	more details	the problem re-mains	explicit check in the rules	explicit change in the rules
1		X			
2		X			
3				X	
...
31	X				
total	21	10	6	8	2
total in % of the 31 ideas	68%	32%	19%	26%	6%

Qualitative analysis and comments

All the investigation comments are included in one or more categories. These comments can be interpreted as marks of the design process necessary to fill the design gap. Indeed, they give evidence of the necessity to build the solutions with more people, including experts. There is a concern about the feasibility of the solution, technically but also in compliance with the industrial rules. This appear to be a particularity of innovation in the factory: the prescription, i.e. the good realization of the production, at the standards of performances in terms of quality, cost, delay, safety, gives a fixed frame to the novelty. In contrast, the ideas that are in this frame can be directly implementable, a design process step has to be added for the ideas that present an incertitude or ambiguity or incompleteness relative to the rules. To sum up, the nature of the comments provides insights on the type of investigation carried outside the form, in the maintenance center. The design activity requires a collective action, rigorous specifications of solutions to be validated and inserted in the production system, and a new phase of ideation to tackle the problem. This design activity also presents an effect on the maintenance rules since the rules are checked and evolve, if necessary.

5.3 Results: a hidden design activity to change the manufacturing rules emerged from the suggestion box

Finally, this study demonstrates that the selection of ideas from the suggestion box is not based solely on a binary pass/fail criterion, as supposed at a first glance. The box is used by the managers to check the idea's validation conditions, to look for rules, and ensure that the solution adheres to the rules. The re-discovery of the system of rules is implied by this exploration. For some of the ideas that do not directly fit with the rules, the technicenter organizes teams to design the validation of the new rules (or its change) implied in the ideas. Thus, this study also highlights the nature of design activity occurring in the maintenance center: beyond the radicality of the ideas, it deals with the revision of the rules.

Consequently, the suggestion box's management and design could have resembled those of a gate: a list of defined criteria and a decider who checks and validates the criteria. However, unlike a gate, the SNCF suggestion box reveals another organization around it. In the technicenter, new actors congregate and discuss ideas, new knowledge about the rules is shared, and the inquiry and validation phases begin with the idea form. A new room was built for the innovation teams to investigate broad concepts and questions in collaboration with other actors; partnerships with local actors (universities, public labs in cities) were formed to design, test, and prototype; and a network of SNCF experts was formed to answer technical questions. The innovation manager and the director of the technicenter were heavily involved in following the innovations, allocating a dedicated budget, creating an innovation workshop to pursue the ideas, and rewarding the creative employees.

6 Discussion, managerial and design implications for suggestion systems

6.1 The nature of design in factory: re-discussing the notion of radicality

This research enriches the understanding of the “novelty” (or the “radicality”) of the ideas (vs “the marginal,” “the continue”) in the factory, according the well-known distinction [34]. The “radical ideas” are not radical themselves, but the radicality can be understood as a distance to the existing solutions. Slightly differently, the article invites to re-think the nature of the distance for a factory. Indeed, an idea can be near the existing solution, and at the same time very far from validation, because it does not exactly fit to the production rules. Hence, the distance to validate and, consequently, the design gap is high. What remains to design is not another idea newer and more radical but the validation of the idea in the factory. This is also true while reflecting in term of ambidexterity [35]: the article shows that the routine can be an object of re-discovery and the design of a solution among the routines is neither properly an exploitation problem, nor an exploration problem, hence refining [28]. It mixes both of them to explore the routines and validate the solutions regarding them or rethinking them. This refinement could be supported by the notion of creation heritage [36], which indicates the capacity for an existing system (“the heritage”) to innovate and to achieve a transformation within itself (“creative”). The article indicates that the novelty and so-called radicality is made possible by a careful attention and rework on the rules. The digital suggestion system, gathering employees who post ideas, manager who assess the conformity of the ideas to the rules, and other technical and rule experts, becomes a medium through which this activity can be organized. In this view, the article contributes to the research on the innovation mechanisms derived from digital platforms in industry [14].

6.2 Design principles and managerial implications for suggestion systems in constrained environments

In accordance to the design principles for digital suggestion systems, a recommendation can be derived from this study [17] : the evidence that a special process does exist for not directly implementable ideas claims for designing digital suggestion systems in coherence with this fact. In the validation process, the digital system should incorporate an explicit category for these ideas, and visible process steps for them. Thus, the ideas could be considered as entire collective projects, requiring appropriate means, and not only as derogations. This is coherent with the design principles of transparency of the process and the identification of informal roles identified in [17].

On the managerial level, this study highlights an idea management system in a factory that involved all levels of the hierarchy in a design approach. The studied suggestion box is an example of a traditional manufacturing tool that was developed in the nineteenth century to recognize and encourage employees' creativity while also involving them in the production process on an individual or group level. Following investigations, this tool allows for more than just the collection of tricks. It also coordinates an intensive and collaborative design process involving a wide range of stakeholders, including the idea's creator, the supplier, various experts and specialized managers, engineers from the local or national material center, and the innovation manager. They each have a role to play in the design process. Wide ideas or concepts that could be new axes of exploration for the maintenance center and its partners can be found on the outskirts of the suggestion box. Because many rules are compatible with this design activity, this significant organization for a continuous design activity in a factory could be found in other factories and other suggestion boxes. The system's management rules gave the managers various degrees of freedom in this study, including the ability to add comments, improve the solution, call various experts to check the rules, and finally, time, place, and financial resources dedicated to this goal.

6.3 Limits and further research

This article relies on a study of a particular digital suggestion box in a maintenance center. The sample of 132 ideas allowed the authors to conduct a detailed analysis of the process followed by ideas, beyond what was expected by the suggestion box. 31 ideas (20% of the sample) were found to be out of the classical scope of this tool. The methodology used by the authors could be used in other factories and in other contexts to increase their generality. In the same way, the design principles for the suggestion systems could be tested in further research, as well as the management and organization needed in addition to these systems to drive the design activity.

This research discusses the innovation tools and information systems available in the factory. If the factory design is able to explore the rules and re-discuss them, tools and management adapted for this property are needed. This analysis is also true for innovation in industry 4.0, which is often viewed as a technological change to implement [37],

potentially implemented by a central technologic or innovation team in the manufacturing engineering department [21], [38], whereas this article implies a wider spread of the design activity among the teams, a new inventive regime with a reasoning on the system of rules. Other environments, which also deal with constrained rules (administrative services, enterprises, etc.), could have the same relation to radicalness, and the same need for adapted suggestion systems. Other research works could be undertaken to enrich this argument and understand this design activity.

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