The social construction of design processes in complex organizations

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Abstract. One of the determining factors of functional mismatches in large industrial projects is the growing gap between operational and project teams. The consequence of this is predominantly organizational, which maintains a focus on project management rather than on the use of these units. This article discusses and analyzes the design process itself from the viewpoint of the participation of the authors in the development of a new Sulfur Recovery Unit (SRU). Ergonomics in this study identified the need to promote social intervention, considering the design experts and operators as actors of a unique social construction.

Keywords. Ergonomics Design, Project Management, Social Construction.

1. Introduction

One important point to be considered as a determining factor of functional mismatches in large industrial projects is the growing gap between operational and project teams, even when there is an expressed willingness to promote the participation of operators in the project and the return of accumulated experience in new projects.

This distance appears more immediately, in geographical terms, at large enterprises that create projects for new units to be run by teams working on a global scale. The consequences of this scale are predominantly organizational, creating obstacles that must be overcome to make the integration of operators more effective within the design process, where the core of the project seems out of place, as it maintains a focus on project management rather than on the operation of these units.

This article discusses and analyzes the design process itself from the viewpoint of the participation of the authors in the development of a new Sulfur Recovery Unit (SRU) in a petroleum company. This experience led us to question why the know-how and the technical knowledge from operational teams were not exploited in the design. Acting since the beginning of the basic and conceptual project, the ergonomic design is presented prematurely, identifying the need to promote social intervention in tandem with technical construction (Daniellou, 2005). This postulation, however, still requires more systematic studies on the actual design process from an organizational perspective, considering that the experts formulate projects not as receivers of information, but rather as other actors of a unique social construction, whose activities should also be analyzed to make the integration, from the point of view of the activity, possible. This old proposition from ergonomic work analysis (EWA) (Guérin et al., 2007), reset in this broader picture of the organizational analysis of the design process, now appears to be the general principle for

the effective design of work and organizations.

2. Methods

The EWA is well-structured in its general and operational aspects (see also Guérin et al., 2007). Its fundamental principle consists of identifying the "real work", as compared to the formal organizational, highlighting the practical knowledge (know-how, tacit skills) of the actors in a given situation, the criteria that guide their actions, and the conflicting aims that shape their behavior at work. This information instructs the design process, reinforcing the positive ergonomic conditions and avoiding inadequacies.

Specific tools are used in the process of analyzing the activity, such as the census of Typical Action Situations (TAS) (Daniellou, 2005). TAS are situations that, even after the new design, will maintain their essential elements, which allows one to create favorable conditions in which to carry out possible future activities in the new plant. This situation includes both the objective conditions and the subjective processes, that is, the means as well as the material and organizational tools needed to perform the tasks and the manner in which these are truly carried out by the individuals (strategies, decision criteria, operating modes, etc.). Upon observing the behavior in a given situation, what follows is the self-confrontation interview (Theureau, 2003) of the data surveyed carried out by the actors themselves, aimed at clarifying misunderstood aspects of the operating strategies and validating the observations made by the actors. In the present case, from the project of setting up a new SRU, the EWA made it possible to identify critical situations and to get to know the actors involved, with the poor conditions for maintenance work appearing most often in the initial observations.

Having received the TAS description and the initial framework of the basic project (plant layout, specification of the main equipment, and flow chart of the processes), self-confrontation sessions were carried out with the experienced operators and maintenance technicians, passing on all stages of the process, in a manner similar to that provided in the HAZOP procedures, but advising them to point out all ergonomic inadequacies.

3. Results

This company, an oil and gas multinational, adopts a typical corporate structure, including within its shared services an R&D center that develops state-of-the-art research and, in an internal customer-supplier relationship, attends to the project demands from the operational units, where project management teams are set up under the supervision of a local Board of Directors responsible for new investments. In the production units, the Business Sector takes care of the management of all expansion and revamped designs of the operational units. This decentralized structure facilitates the approximation of local realities, both in its ability to respond to the project demands as well as regards the facility's adaptation to the specificities of each production process.

The demand for the insertion of ergonomics from the onset of the conception of new production units stems from the many years of cooperation between universities and the Brazilian oil industry. However, although it is a corporate guideline, conception ergonomics has yet to be integrated within the design processes of the company itself (regarding the relationship of engineers with ergonomics, see also Broberg, 2007).

The results of the ergonomic intervention consist of advice concerning the basic project, which aided in drafting the documentation for the contracting of external suppliers. Begun within a typical scenario of conception ergonomics, reference situations were identified, focusing attention upon the main equipment of the SRU production

process. For each piece of equipment, main TAS were identified, organized in design concepts, which provided the basis through which to formulate ergonomic recommendations for both the basic and the detailed projects. This grouping facilitated the dialog with the owner group's technical staff (CENPES), whose project is set up in specialized disciplines that are not always talking to each other in the design process.

It is interesting to note that the main TAS for the production unit studied here dealt with the maintenance area. One of the characteristics of SRUs is their operational stability, requiring little intervention from operators, most of which are taken care of by the control room. As a result, this project was conducted focusing on maintenance work as well as on the activities performed by the maintenance technicians in the mechanical, electrical, and electronics areas.

To create ergonomic work conditions for the maintenance staff, what was proposed were concepts referent to the battery limit, a set of control valves of the SRU entrance pipes, which receives gases from various units, whose growth over decades of use tends to reduce the space available for the installation or substitution of components. Though maintaining the relative position of the macro layout, the use directions for many large pieces of equipment were changed to avoid interferences whenever it was deemed necessary to remove long components (cases of pipes from boilers and from liquid sulfur storage tanks). Many manholes were expanded to facilitate inspection, and permanent access platforms were suggested to replace the temporary scaffoldings. To facilitate the access, removal, handling, and displacement of the heavy components (tanks, pumps, large valves), in addition to adequate routes, the concept of local autonomy for maintenance personnel was developed, providing devices for the movement of cargo without the need for large cranes.

As regards operations, the main concept proposed was aimed at increasing the diagnostic capacity of the product solidification points, which block the pipes and force a plant shutdown. By favoring the diagnostic capacity, the interventions can be more precise and performed more quickly, thus isolating the equipment or blocked line. Other concepts related to the localization of the instrumentation – concentrated in batteries or distributed – favored both operations, also facilitating the diagnosis of plant problems, and maintenance, as will be explained below.

Up to this point, the results presented in this study have consisted of traditional ergonomic recommendations. What we would like to accentuate in this article are the organizational barriers that make it difficult for these results, which emerge from operational experience, to regularly and permanently feed the design process. Below, we shall see why the advantages of the proximity between the project management and the local operating units have yet to be taken advantage of.

4. Discussion and Conclusion

In addition to the contributions to the conceptual design of the new SRU, presented here in a summarized form, our participation in this design process generated interesting results for all involved, of which we would like to emphasize: 1) the critical situations concentrated in maintenance activities; 2) the function of the ergonomist in the integration between internal and external actors and their respective logics; and 3) project management as a whole.

4.1. Maintenance as a focus of ergonomic work

Traditionally, ergonomic work has been guided by demands related to production workers. However, in continuous process industries, considering maintenance to be

secondary or in opposition to production is a mistake in judgment, as a shutdown for maintenance can augment the overall efficiency of the plant. As expressed in the concept of Total Productive Maintenance (TPM), maintenance is also productive. Nevertheless, the ergonomic demands still do not give priority to maintenance. It is interesting to note that the concept of maintainability remains secondary to manufacturability. This can be explained by historical reasons and others relative to the nature of the activity. Historically, the problems associated with operations, due mainly to operational instability, attract more attention. The technological changes have also been more intense in process controls, such as automation and centralization of control rooms. Maintenance itself, despite these technological changes, seems to be an activity that has remained unchanged, barring the need for new expertise, such as the maintenance of digital systems. Moreover, it is, by its own nature, a more sporadic activity that is less frequent than operations in real time, and, for this reason, is also more invisible. Maintenance still has the stigma of being a waste of time and providing no positive contribution to overall efficiency. By contrast, the SRU case has led us to direct our efforts toward creating proper ergonomic conditions for maintenance, not only to grant a voice and opportunity to the forgotten maintenance staff, but also because it is a function that has proven to be more strategic in increasing the overall efficiency of the SRU. In this sense, the separation between production and maintenance, which still persists despite the concept of TPM, has gained more objectivity within this project thanks to the work of ergonomics.

4.2. Recognition of the conflicting partial logics

Systematizing and organizing the diverse partial logics of use of the same object and searching for answers to the specific demands from each of these logics is one of the bases of the EWA (Guérin et al. 2007). Nonetheless, when dealing with demands from complex organizations, the dimension of the ergonomic action broadens.

During the project, we faced two ways of positioning instruments (pressure, temperature, leakage scanners, etc.): one **concentrated**, which follows the logic of the design of discipline, facilitating the dimensioning and execution of the designs, truly allotting an aesthetic quality to the presentation of the project with grouped and parallel piping networks; and another **distributed**, with instruments installed near the equipment where it would perform its readings. In the case of the need for some type of local operation, the variations in the parameters can be monitored more easily and the maneuvers guided by the device. On the other hand, the concentrated instrumentation facilitates the maintenance and the inspection of the scanners. Thus, the scanning of process tendencies is easier due to the fact that all of the readings can be found in the same place. However, this does create a problem for the maintenance, as it increases the duct network, which is installed at high altitudes and with more connections, which increases the probability of leakage. The alternative presented in the basic project, anticipating more in-depth studies for the detailed project, sought to survey each piece of equipment from the instruments necessary for local maneuvers. At this moment, in the basic project, these two concepts – concentrated or distributed location – should be preserved and treated in a reflexive manner, that is, as determined by conflicting logics of production, maintenance, inspection, and even the design itself, and not only according to the description offered by the design experts in instrumentation. This case questions the sequential methodology of the project used in this company, which is based on the stage-gate model, with formalizations that support decisions at the end of each stage, which ignores the return of accumulated experience. As this does not deal with the act of opting between two concepts of exclusive projects, but rather seeks to find the combination between them, the decision to be taken requires information that is necessary only in the detailing stage. This paradox

is resolved, however, when we depend more on operational experience, making it possible to speak about whether each instrument should be near or not to the equipment to which it is associated. With this indication, the designers will have sufficient information to define which concept to choose: concentrated or distributed

4.3. Focus on management at the expense of project quality

In large corporations, the coordination of projects tends to concentrate its efforts on the formal management of the process at the expense of the final quality of the project, following operations or work conditions criteria. Making an analogy to the concepts of prescribed work and real work, one can see a distance between the panning of actions and the stages, as established within the adopted stage-gate model. This distancing between project management and the real project and its causes have been treated by the ergonomics team not as obstacles outside of the intervention process, but rather as the object of their actions. This gap, under current conditions, proved to be impossible to be resolved by the internal actors of the organization, thus generating distortions that, in conception ergonomics, must be an integral part of the social construction in tandem with the technical construction of the intervention.

The temporal pressure, for example, creates a mismatch between the flow of information that feeds the decision-making and the possibilities of the ergonomics team to raise the data necessary to instruct them. Although the company stresses ergonomic actions in its conception processes, the scheduling is defined according to the technical, financial, and legal needs, to which the ergonomic analyses should be adapted. In the definition of deadlines and flow of information, ergonomic enters as merely another technical discipline that makes information available to managers and decision-makers, restricting its contribution to project management as a whole.

A representative episode of this mismatch was the description of part of the equipment before the end of the basic project. Taking advantage of a "window" of time availability, the piping design team anticipated the description of the lines that would transport the product to the new SRU. However, this anticipated description, justifiable in that it would generate more time for the project, interfered in the design of the battery limits, which in turn created a critical situation, since its unplanned growth created difficulties for the maneuvering of operations and maintenance. The anticipated definition of the entrance lines defined the space for the battery limits before the end of the ergonomic research, which was making a historical survey of the onset of operations of the current units and the outlook of investment, aimed at ensuring, in the future, a space capable of absorbing new refinery units.

Another conflict of interest concerns the allocation of the working hours established for operators, maintenance and inspection technicians, and SST specialists to participate in the project, which were always short of that needed to include accumulated experience. In organizational terms, this implies that the dimensioning of the effective measures cannot be treated only as an operational problem, but also as a condition for effective participation within the projects. Without this, the participation and return from accumulated experience remain as empty principles, and thus fall by the wayside. On the contrary, if the participation time is set beforehand, the project activity ceases to be an event circumscribed in time and space, and becomes an activity that is present in the daily routine of production, in turn modifying the engagement of workers and the nature of accumulated experience. In this sense, a virtuous cycle is created in which a continuous process of ergonomic enhancements can be implemented, rather than the vicious cycle that has engulfed this company. When the ergonomic intervention began, the workers were resistant, since their consideration had not been considered in the detailing of previous

projects. This lack of credibility in the participation process consumed valuable time from the schedule until worker confidence could be regained. This case of the SRU project, illustrated in the ergonomic concepts and recommendations for the design of main equipment, allowed us to understand the diverse organizational causes that maintain the distance between the operational and project teams, and this occurred even while there was an expressed willingness to promote the participation of the operators and to create mechanisms that would favor the incorporation of prior experience. These organizational barriers to participation reflect a common principle that is the inversion of conception and use. The predominant rationale is that of the design (time, information flow, etc.), which is the core. Everything occurs as if the moments of creation were superior to the operational practice, seeking to include the users within the design process and not reallocate the project to operational services (to a new area, defined as "critical participation", to be occupied by engineers and other experts, see also Downey, 2009).

Hence the need for the broadening of the social construction of ergonomic intervention in tandem with technical construction, considering the design experts not as receivers of the information, but rather as actors within a collective construction, whose activities must be also be analyzed so as to make the integration, from the point of view of activities, feasible, in turn instituting a continuous process of ergonomic enhancements based on the return of accumulated experience as well as on the effective participation of the operational teams. The situations and conditions of the work of designers and of the actors involved in the project must also be the aim of the EWA. Technical and social constructions therefore seem to be more interlinked, insofar as the organizational conditions of participation must be the explicit aim of the organizational design, as can be seen when creating mechanisms to incorporate the return of accumulated experience or adjusting the project times to the production time, and not the contrary, as can currently be seen within the company. The participation is not an act of pure willingness; it presupposes material and organizational conditions to render it effective. And not only conditions so that the operational teams make the necessary time available, but also so that they imply subjectively, which presupposes that the credibility of a long-lasting participation will be maintained.

References

Broberg, O. (2007). "Integrating ergonomics into engineering: empirical evidence and implications for the ergonomists", Human Factors and Ergonomics in Manufacturing, 17(4), pp. 353-366.

Daniellou, F.(2005). The French-speaking ergonomists' approach to work activity: cross-influences of field intervention and conceptual models. Theorethical Issues in Ergonomics Science. 6(5), 409-427, September 2005.

Downey, G. (2009). What is engineering studies for? Dominant practices and scalable scholarship. Engineering Studies, 1: 1, 55-76.

Duarte F.; Lima, F., Remiro R. & Maia N. "Settings of usage for the design process". In: Proceedings of the 17th World Congress on Ergonomics, Beijing, China, 2009

Guérin, F., Laville, A., Daniellou, F., Duraffourg, J., & Kerguelen, A. (2007). Understanding and transforming work. The practice of ergonomics. Lyon: ANACT.

Theureau, J. (2003). Course-of-Action Analysis and Course-of-Action-Centered Design. In: Hollnagel, E. (ed.). Handbook of cognitive task design. Mahwah, New Jersey/London, Lawrence Erlbaum, 2003, p. 55-82.