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THE REPRESENTATION OF WORK AS A LEADING THREAD OF SIMULATION: THE CASE OF THE PROJECT OF AN INTEGRATED OPERATIONS CENTER IN THE OIL INDUSTRY

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Abstract: Simulation, in ergonomics, is marked by a variety of approaches that differ according to the desired objectives and modalities. Two main types of simulation are frequently employed: engineering simulation and workplace simulation. While the first seeks to predict the future behavior of a production system, focusing on quantitative aspects, the second focuses on the work process and the difficulties faced by workers.

In the work simulation approach, the objective is to understand the work process and its characteristics, aiming to produce knowledge about situations that do not yet exist. Simulation becomes an essential tool during the design process, allowing you to explore different possibilities and reduce uncertainty.

There are three main orientations regarding the consideration of work activity in the design process: crystallization, plasticity and development. Each of these guidelines influences the simulation approaches adopted. Crystallization focuses on the representation of users and their activity in designed artifacts, while plasticity recognizes the variability and unforeseen events of real activity. The development seeks to integrate the activity of operators into the design process, promoting a participatory dialogue between designers and users.

Work analysis is essential to support the simulation, providing information for building models and scenarios. Simulation, in turn, expands the understanding of professional problems and allows them to be manipulated to find solutions. Methods such as Characteristic Action Situations (SAC) and usage configurations are developed to represent the work activity in a more generic way and guide the design process.

A case study of restructuring an Integrated Operations Center (IOC) exemplifies how work analysis and simulation can be applied to Operational Integration (IO) projects. This

study involved analyzing the functioning of the COI, mapping the layout of the new facilities and carrying out cycles of simulations to discuss the future functioning of the space with the workers and managers involved. This participatory approach based on understanding work activity shows how simulation can contribute to the design of more efficient and ergonomically appropriate workspaces.

Keywords: Simulation; Ergonomic Work Analysis; Design Process

Introduction

The simulation is marked by strong heterogeneity depending on the objectives that are to be achieved and the types of achievements that are requested (BÉGUIN; WEILL-FASSINA, 2002). During the design process, two types of simulation can be conducted: engineering simulation and work simulation. The first, engineering simulation, aims to build a representation of the reality of a production system to predict its future behavior (MALINE, 1994).

This type of simulation addresses the quantitative aspects of phenomena, that is, it works as a test bench for a situation or procedure aiming to test efficiency, validate this or that material, improve a device a posteriori, among others (BÉGUIN; WEILL- FASSINA, 2002; MALINE, 1994).

The second, work simulation (or simulation in ergonomics), changes the point of view of the analysis. Simulation no longer refers to performance, but to the work process, its characteristics and difficulties (BÉGUIN; WEILL-FASSINA, 2002). Interest is greater in the work necessary to achieve the expected results of production or service and less in the technical process to achieve this objective (MALINE, 1994).

According to Béguin and Weill-Fassina (2002), simulation, in this case, is an intrinsic dimension of the conception: at the same time as it allows an exploration of the field of possibilities, it participates in the process of reducing uncertainty, being an instrument of management design and ergonomic intervention.

Béguin (2010) explains that, in project situations, it is not enough to analyze only the current work: before the transformation, it will be modified as a result of the act of conception and, after this act, it is too late because the decisions have already been made. Therefore, according to Béguin et al. (2019), work simulation appears as an inevitable method to produce

knowledge about work situations that do not yet exist, configuring a response to the "paradox of conceptual ergonomics" (THEUREAU; PINSKY, 1984).

Simulating work situations is a method that combines a situation model (or part of the work elements) and the activity of one or more subjects (BÉGUIN; PASTRÉ, 2002). To do this, simulation support is needed to "stage" the work and allow dialogue between operators and designers.

However, the transition from analyzing the activity to building the simulation is not a trivial exercise: it requires a better identification of what, based on the analysis of the work, can and should be staged and in what form (BÉGUIN, 2006). Therefore, this article aims to analyze how the representation and translation of the result of the Ergonomic Work Analysis is carried out during simulation in a design process.

To allow this analysis, we start from the consecutive reflection of the ergonomic intervention in the restructuring project of an Integrated Operations Center (IOC), in the context of Operational Integration in the Brazilian oil industry, which sought to expand its capacity to support operations maritime.

Theoretical Reference

There are three guidelines regarding the consideration of work activity in the design process: crystallization, plasticity and development (BÉGUIN, 2010). Thus, there are also different simulation approaches mobilized by these three orientations.

In the crystallization orientation, every technical device and every artifact mobilizes a model of the user, their activity and their work during the design process. This representation, once crystallized in the artifact, is conveyed in the work situation (BÉGUIN, 2005).

According to Béguin (2006), in activity ergonomics, this approach does not only focus on modeling the functioning of the subject, but on building a model of the activity in a given situation, which can be characterized as a "simulation of situations" (VAN DAELE, 1997 apud BÉGUIN, 2006).

In this regard, it is necessary to obtain a model of future activity. To carry out this anticipation, ergonomics has general knowledge about human functioning and knowledge about the adaptation of technical devices to humans (BÉGUIN, 2010).

The model of future activity is built from data obtained from the analysis of activity in reference situations. The association between these types of data makes it possible to

reconstruct the coupling and, by association, build scenarios to be mobilized in the simulation. However, the objective is not to build a model of the subject's functioning, it is a matter of modeling and simulating a coupling, the purpose of which is to make a prognosis (BÉGUIN, 2010).

The plasticity orientation considers that in real situations there are variabilities that are not always possible to anticipate. According to Béguin (2008a), operators encounter unforeseen events and resistance linked to the contingencies of the situation and fluctuations in their own state during their work.

In this way, design decisions can open or close possibilities for future activity for operators (DANIELLOU, 2005). The challenge is not, therefore, to predict in detail the activity that will be developed in the future, but to evaluate to what extent the design choices will allow the implementation of operational methods compatible with the chosen criteria, in terms of health, productive effectiveness, personal development, among others (DANIELLOU, 2007b).

In this orientation, according to Daniellou (2005), the main objective of simulation is to include space for “possible forms of future activity” in design decisions. According to the author, the ergonomist starts from reference situations to understand the variability of the work situation and build scenarios on which this type of simulation will be based. According to the author, the simulation can demonstrate whether, for any action situation that the ergonomist has considered, there are one or more acceptable modes of operation from the point of view of health, skill development and efficiency. Likewise, it must allow the operator to create other possibilities after the project.

In a way, as the activity cannot be fully anticipated, the predictive function of the simulation is reduced, but not abandoned: while the previous orientation simulation argues that it is necessary to anticipate with maximum precision, in this orientation, the simulation must anticipate plasticity or the margins of maneuver left to the operator (BÉGUIN, 2005).

The development orientation considers that the constructive activity of operators must be an integral part of the design process and that the inventiveness of the activity must be brought into line with the designers' developments. Development therefore consists of articulating in the same movement the development of situations, such as the artifact and/or organization, by designers and the development of action resources by operators, constituting a “distributed conception” (BÉGUIN; CERF, 2004).

Simulation in development guidance seeks to contribute to the dialogical process of conception (BÉGUIN, 2010; BÉGUIN; CERF, 2004). Thus, according to Béguin (2005, 2007b), guidance is intrinsically participatory, since, during conception, it favors dialogical processes in which designers and operators participate in the design process based on their diversities and their specificities.

Minimum Work Analysis Units and relationships with simulation

Job analysis is a prerequisite for simulation. To simulate, work analysis helps to make choices, identifying work problems, which allows the construction of the model. However, simulation usefully expands work analysis: it targets professional problems, stages them to manipulate them, in an attempt to understand or resolve them (BÉGUIN, 2006).

In ergonomics, work analysis and simulation must be carefully articulated, as these methods complement each other. However, it is necessary to move from the analysis of existing situations to the simulation and design of new situations. To deal with this paradox, activity ergonomics sought to reflect on the formulation of work situations in an elementary, minimal form of activity (DUARTE; LIMA, 2012).

In the search for more general models to support simulation and design, some proposals have been developed for the ergonomics of the activity. Some propositions seek to describe the minimum units of representation of the activity in the work simulation, such as: (i) the Characteristic Action Situations (SAC), developed from the future activity approach (DANIELLOU, 1992); and (ii) use configurations (DUARTE; LIMA, 2012), developed to allow the creation of project recommendations.

• Characteristic Action Situations (SAC):

The future activity approach (DANIELLOU, 1992) seeks to intervene in projects with the prediction of the space of possible forms of future activity, evaluating to what extent the design choices will allow the implementation of operational modes compatible with the chosen criteria, in terms of health , productive effectiveness, personal development, among others (DANIELLOU, 2007a).

The approach consists of analyzing the work in existing reference situations (current situation that will be modified or situations with technology similar to that planned), where it will be possible to identify the Action Characteristic Situations (SAC), with varying degrees of detail, combined and structured descriptions in scenarios that will inform simulations of possible future activity (DUARTE; LIMA, 2012; GARRIGOU et al., 1995). SACs (or typical

situations), whose concept originates from Jeffroy (1987 apud DANIELLOU, 1992), constitute the elementary units of design ergonomics (MALINE, 1994).

The result of the analysis of reference situations is an identification of the forms of variability that may arise in the future system (DANIELLOU, 2007b). In this way, it is possible not only to highlight normal operating situations, but also situations linked to incidents, adjustments, cleaning, maintenance, among others (GARRIGOU et al., 1995).

For Maline (1994), SACs constitute the irreducible and operational link that allows instruction of the future from the existing. However, their enumeration in the project still offers a partial view of the conditions under which operators carry out their work activities. Furthermore, according to Maline, it is not the sum of identified SACs that provide a global image of the future: there is a need to stage typical situations, based on SACs, in the simulation, placing them in a temporal perspective and articulating them with the design criteria.

Thus, work analysis within the framework of a simulation approach to identify typical work situations is a projective phase, of developing scenarios, and also depends on a prior understanding of the characteristics of the project (MALINE, 1994). The identified work logics, transported to the future situation, offer a possible structuring of the activity while offering the freedom to evolve to explore different action logic scenarios (VAN BELLEGHEM, 2018).

- *Usage Settings:*

The concept of usage configuration aims to answer the question of how to integrate ergonomics into design. It is a way of translating knowledge of the activity, in a more generic way, based on the ergonomic analysis of the work of a reference situation, to guide the design process.

According to Duarte et al. (2008), the general principle that guides cooperation between ergonomics and engineering is to build project specifications based on activity, based on a strong conception of migration from the experience of use to the project function. But, for the authors, this migration of work experience to the project presents itself as a resource and, at the same time, brings a challenge, precisely due to the situated, historical and singular nature of the work activity analyzed.

In this sense, as a response to this challenge, usage configurations function as substantive content and as a scenario for designers to engage with future users through the experience of current users (DUARTE; LIMA, 2012). In this way, they allow the

specifications that will guide the conduct of the project to be constructed based on the work experiences of the workers themselves.

Usage configurations are an abstraction of the analysis of Characteristic Action Situations (SACs) and constitute an intermediate path, lying between the general principles of ergonomics, such as "facilitating access to the operator", and the details of this access in a given project (DUARTE; LIMA, 2012).

In this way, what defines the configuration of use is always the combination or coupling between, on the one hand, the physical-technological aspects (environment, space, instrument, object, equipment), the social context and the cognitive orientations (example: “open a valve to ...”) and, on the other hand, the practical scheme, which underlies a certain activity (DUARTE; LIMA, 2012).

Method

This research is based on the restructuring project of the Integrated Operation Center (here called COI-Alfa), where an Ergonomic Work Analysis and three cycles of Ergonomic Simulations were carried out to support discussions with workers and managers to create work solutions. project. The subsequent analysis of the ergonomic design process used in the case study aimed to understand how Work Analysis and Ergonomic Simulations can contribute as participatory methods in IO projects.

Context of the case studied:

This research was carried out in an oil production unit of a Brazilian oil industry. With the expansion of pre-salt operations and the arrival of new platforms in 2021, the production unit began the project to restructure the Integrated Operations Center (COI), an existing onshore support initiative for offshore production, to expand its production capacity. support for maritime operations.

The new COI project would move its location of operations, currently in separate rooms, to a large center that would be located in an unoccupied old restaurant and kitchen in the same building. The objective was for the center to be able to accommodate the increase in staff and allow for the reinforcement of interactions between teams, making the integrated support nature more effective.

Participants and Intervention Approach

Study participants are made up of existing CCO teams, which are: 3 predictive monitoring cells for equipment and systems on offshore platforms; 1 logistical support team;

1 operational support team, which controls the gas network and provides emergency support for offshore operations; 1 support team for planning and optimizing the gas pipeline network; 1 infrastructure support team for the CCO itself and the IO management team, project demanders.

The field research was divided into three main stages:

(1) Study of the work, which consisted of:

- initial analysis of the general functioning of IOC-Alpha, seeking to understand how these teams work and what the integration relationships are between them;
- a more in-depth analysis of the COI-Alpha activity, accompanied by brief visits to other reference situations, such as the COI of the Beta Production Unit;
- the formulation of the usage configuration (DUARTE; LIMA, 2012) for discussion among the actors during the simulation phase.

(2) Study of the design and specification of work spaces, which consisted of:

- mapping the layout of the facilities available for the new IOC spaces and the forecast for team expansion;
- integration of the technical team (architects, engineers and designers);
- and in the creation of initial layout hypotheses, these hypotheses being the starting point for the dialogue between the simulation actors and the development of the layout.

(3) Simulation cycles, developed in three stages to advance the discussion on the future functioning of the IOC in a new space, as follows:

- First cycle of simulations, whose objective was to initiate dialogue with teams and managers, in order to select between two layout proposals created by the team of ergonomists. This was the workers' first contact with the space project;
- Second cycle of simulations, which aimed to understand the integration relationships between teams in space. To this end, an interactive floor plan (like a game board) and paper plans were used as discussion aids about the organization of spaces. This simulation was carried out in two stages and in the same environment that would be transformed to receive the new COI;
- Third cycle of simulations, whose objective was for participants – operators and managers – to discuss the work. These dialogs were based on the

previously produced layout, which was complemented by a 3D representation of the future layout, including devices, workstations, windows, etc. As in the previous simulation, the meeting took place in the room to be transformed and a game board, paper plans and 3D images were used. As the game board was two-dimensional with a superior view of the space, the intention was to give other dimensions to the discussion.

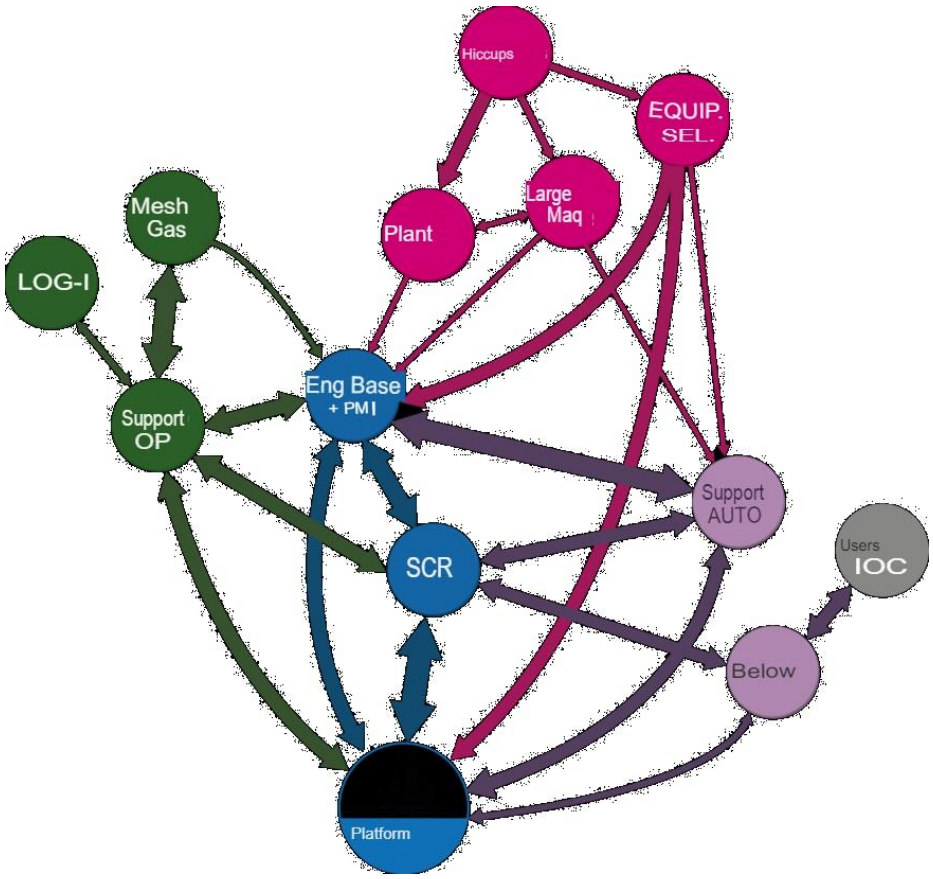
Results

The initial analysis of the work, with the understanding of the general functioning of COI-Alfa and the main activities of the teams, stage of the ergonomic analysis of the work, allowed the construction of the first layout proposals for discussion with operators and managers in the first simulation cycle . At this stage, knowledge of the work and the main interactions between teams guided the discussions.

The study of general functioning made it possible to characterize the existing integration between the IOC-Alfa teams, which were represented through an interaction scheme, shown in Figure 1. This scheme allowed the ergonomics team to visualize the relational intensity and communication between operators on the same team and between different teams.

The frequency of interactions is represented by the thickness of the arrows. The thicker the arrow, the greater the intensity of the relationship between the teams. These relationships were due to the need for communication and exchange of information and data to carry out the work. Each color in the sociogram represents a nature of integration between onshore teams to support oil platforms, here called integration groups.

Figure 1 - Scheme of interactions between IOC teams



Source: The author

For simulation cycles, in-depth work analysis allowed the creation of usage configurations, bringing work elements into the simulation dynamics. Therefore, the discussions between the project actors covered both the definitions of the physical arrangement choices and the future work to be performed in these environments.

The second phase of the work study aimed to deepen the work analysis to create usage configurations for each team analyzed. In this way, it was possible to build scenarios in simulation cycles. Each usage configuration sought to describe both routine tasks and work variability, such as emergency situations.

During the simulation meetings, references in relation to work allowed operators to reflect on the construction of new ways of working, which necessarily involves reflection on the current work performed in the teams. This reflection was possible through the mobilization of usage settings by the team of ergonomists during the simulation dynamics.

The dialogue clippings between ergonomists and operators during the second simulation stage exemplify how work elements influenced changes in the layout, such as: (1) the sharing of information between team members, (2) the monitoring characteristic and the resulting in the physical organization of workstations in light of these specificities and (3) the interaction between different monitoring teams.

For the monitoring teams, which carried out predictive monitoring of turbomachinery, safety equipment and processes at the offshore plant, there was a managerial demand for the use of large screens (videowall) in the future environment. Therefore, the question of whether or not to use the video wall was an important topic when conducting the simulations. During the second simulation cycle, a monitoring operator emphasized the difficulty of understanding how the large screens would be used, as they were not currently necessary, but were leading to an in-line layout, with all workstations facing the video wall.

From this, the ergonomists guided the discussion, citing the monitoring characteristic of trying to anticipate deviations in onboard equipment, as shown in the extract from the following dialogue:

> ***Ergonomist:*** *- Your actions are not immediate, they are not in real time.*
>
> ***Operator:*** *- Our maintenance is predictive, medium and long term. Because, for the short term, you have the operator in front of the screen, the unit's supervisor. There's no point in me talking, calling the guy and saying: look, there's a high temperature in that place! He is already seeing this there, his supervisor is already warning him! I want to see it first!*
>
> ***Ergonomist: -*** *What can you anticipate, right?*
>
> ***Operator: -*** *Exactly! I'll see before I alarm him! It's cool to follow, but it's not an operation... That's not our focus! It's not about putting out a fire and solving a problem that's about to happen that day. That's what the onboard unit has to resolve.*

This dialogue ends up being a driver for the operator to reflect on what could effectively help with the monitoring task, if there were a video wall:

> ***Operator: -*** *What has already happened, I don't want to get involved. But I think the idea of putting the machines, their status, their efficiency so we can be there and monitor it is interesting. Suddenly, you look and see: look, the efficiency of this machine is falling, guys! Let's focus on her! It might be interesting to add these efficiency tags, which is the same thing that will be used for plant monitoring! Process plants have a very close border with large machines.*

Discussion

The knowledge that work is at the center of the development of Activity Ergonomics as a discipline, with the objective of building knowledge about human beings in activity (FALZON, 2007). However, ergonomics has a transformative perspective: it aims at action.

So that this knowledge can effectively transform the reality of work, the discipline has been transforming its methods to contribute to the point of view of the activity even in the conception phase.

In this way, work activity is the integrating element (GUÉRIN et al., 2001) that allows structuring the conditions for carrying out work from the origin of the project, in the sense that it articulates and recomposes in action a set of technical, organizational and social (DANIELLOU, 2007a; MALINE, 1994).

The analysis of the activity is, therefore, the basis that makes it possible to understand the professional practices to be considered in the design. However, translating knowledge from work to the project is not trivial and requires the development of strategies that allow its mobilization during this process.

For work to be at the center of the dialogue promoted by the simulation, it is necessary that a representation of work is constructed and mobilized during the simulation. It is necessary to transpose and stage the result of the work analysis in the simulation.

Transposing means moving, in some way, from the analysis of existing situations to the simulation of new situations. Therefore, work situations must be formulated based on the elementary form of the activity. This minimum unit of activity contributes to the construction of scenarios (MALINE, 1994) that allow guiding simulation meetings so that construction can work in the future.

However, the choice of the way in which the work activity is transposed into the simulation indicates which type of guidance, regarding the consideration of the work activity in the design process, will be mobilized. In the crystallization approach, for example, the challenge is to produce a model of the future activity, that is, a better-founded model of the coupling between the subject and the object designed as a design resource (BÉGUIN, 2010).

To this end, Béguin (2010) highlights that the association between Characteristic Action Situations (SACs) (DANIELLOU, 1992) and typical situations (MALINE, 1994) allows us to build this coupling and, therefore, also allows the creation of scenarios that will be experienced during a simulation. However, the purpose is to make a prognosis, an anticipation of the future situation.

In the plasticity approach, which is anchored in the concepts of diversity and variability, simulation must contribute to the design of possible forms of future activities, defining margins of maneuver for the project. In this orientation, according to Béguin (2010), the analysis of SACs no longer aims to identify task units that can be transposed to future

situations, but rather to allow an assessment of the diversity and variability of work contexts so that the operator, Given the variability of the situation and your own condition, you can implement operating modes that allow you to achieve production objectives without putting your health at risk.

As the activity cannot be fully anticipated, even in plasticity, the predictive function of the simulation, despite being reduced, is not completely abandoned, since in this orientation, the simulation must anticipate the margins of maneuver that will be left to the operator.

In the development approach, however, simulation aims to contribute to the process of joint development of situations and activity (BÉGUIN, 2010). In this sense, the simulation cycles of the IOC-Alfa project combined the development of the layout and the development of the activity by the operators in the same movement, contributing to a dialogical design process.

It is observed that, in this case, the simulation contributed to the project being configured as a non-teleological process (BÉGUIN, 2010). Based on a layout pre-established by the ergonomics team, based on work analyzes and managers' inferences, the simulations began a process of "construction, exploration and journey" (BÉGUIN, 2010), in which the artifact (COI layout) and the activity are developed in parallel in the design process itself.

However, for this development to occur, the way in which the work activity is represented during the simulation must lead to an articulation, a coupling between the task and the subject (BÉGUIN, 2010). No longer fitting into a perspective of anticipation, but of building a way of working in a new place, with new tools and technical devices designed together.

In the COI example, the unit of analysis used to represent the work in the simulations was the Usage Configuration (DUARTE et al., 2008), which allowed representing a dimension of the situation (the task, with such means) and a dimension of the action (the activity of the operator, the actions he uses to achieve such a task).

According to Duarte and Lima (2012), usage configurations are abstractions of Characteristic Action Situations. It can be considered that SACs are an inventory of the diversity of situations that operators may encounter and, therefore, are related to tasks. The usage configurations are based on the situations expressed by the SACs and reveal a way of doing things, they are invariant to the activity: they are related to "how the operator will do to fulfill the task, given a certain condition".

There is a change in the way the usage settings are used in the project. Created to serve as a basis for decision-making in the act of designing by designers, in simulation it becomes a vehicle for representing work for the construction of new ways of doing things for operators.

In the case of the monitoring team, the in-depth analysis of the work to identify usage configurations also allowed an understanding of the characteristics and specificities of monitoring, issuing and controlling alerts for the platforms. This characteristic of the monitoring work of trying to anticipate possible deviations in the equipment on board, guided the discussions in the simulation so that the operators could reflect on what the positioning of workstations would be and what equipment was needed.

“Our maintenance is predictive, it is medium and long term” or “it is not an operation, (...) it is not putting out fires”, are statements from the operators that indicate the way the team is monitored and the reason for not needing the videowall for work that requires analysis and not short-term actions: “because, in the short term, you have the operator in front of the offshore unit screen".

In the operators' view, the large screens were necessary equipment for those who actually operate the equipment and need to have the variables readily available during this task. Unlike the operators' vision, the manager saw the video wall as a way of sharing unified information (which he did not yet know was relevant) to the teams, equalizing knowledge of the situation among operators.

In this way, conducting simulations through scenarios based on usage configurations allowed work to be mobilized and put into action by workers, even when managers insisted on a vision of integration based on large screens (videowalls). It is observed, however, that during the simulations, when there was no representation of the work originated by the elements of the activity, the dialogues between the actors (including the workers) were more focused on the technical devices and less on the work.

Conclusions

The objective of this article aimed to understand how the work perspective is mobilized and represented in the simulation. From this point of view, work analysis and simulation maintain dialectical ties while the project is executed.

On the one hand, ergonomic work analysis allows the production of work knowledge, which guides the choices made during the project. On the other hand, the detailed analysis of

the activity promotes debates about work in simulations to concretely contribute to the transformation of working conditions in the future.

To achieve this, it is necessary that the result of the work analysis be transposed into the simulation based on the elementary form of the activity, contributing to the construction of scenarios and the discussion on the development of new ways of working in the future.

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