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SIMULATION SUPPORTS AS INTERMEDIATE DESIGN OBJECTS: EXPERIENCES IN THE PETROLEUM REFINING INDUSTRY

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Abstract: Ergonomics is concerned with understanding the work to transform it. In order to increase its capacity for effective intervention, this discipline approximates engineering, especially production engineering, seeking methods, techniques and tools to assist it in the process of designing productive situations. The knowledge areas related to engineering design, and especially the work design, can substantially contribute to the effectiveness of the incorporation of the activity perspective (according to the concept of situated ergonomics) in this process. Based on a theoretical and conceptual articulation, which served as a reference for the field research in an oil refining industry, it is sought to understand how different simulation supports were determinant for the incorporation of the rationalities, interests, constraints and expectations of the participating actors of the design process. The research presents recommendations for the project of productive situations to carry out a continuous and distributed conception, with the simulation as object-oriented instrument (projective action of the technical system), to the other (coordinated action) and to the subject itself (by development, learning and transformation).

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Keywords: ergonomics, design, simulation, intermediate design objects.

1. INTRODUCTION

The observation of unfavorable working conditions that do not sufficiently consider the functioning of human beings and the activity of workers makes ergonomists intend to get involved in the processes of designing productive situations (BÉGUIN, 2007).

This perception is supported by the fact that ergonomics is not content with producing knowledge about work situations; it aims at transformative action (DANIELLOU; BÉGUIN, 2007; DANIELLOU, 2007;

GUÉRIN et al., 2001). This ergonomic action articulates various points of view and mobilizes a diversity of actors, seeking to influence their representations and decision-making.

For Menegon (2003), the introduction of positive changes at work occurs, in the first instance, through the construction of spaces for confrontation. Such space, for the author, is necessary for questions arising from the point of view of the activity. Braatz (2009) argues that spaces for interaction and confrontation can be created from simulation situations and, to this end, makes use of a computer tool for digital human modeling and simulation.

This research, in turn, expands the scope of the discussion to different simulation supports (in a broader concept) that act not only as a tool for incorporating the activity perspective, but have an active role in the social construction of interaction spaces, confrontation, deliberation and decision-making, as expressed by Maline (1994) as it favors the expression of the needs of different participants and serves as support for ongoing reflection. The concept of simulation is quite broad and has diverse applications, including within ergonomics and production engineering. Therefore, for the present research, the expression “simulation” is used according to the concept of “simulation situation” presented by Béguin and Weill-Fassina (2002) and not in a specific way related to any technique or tool. For these authors, simulation is a situation of exchanges that participates in a process of constructing meanings, considering perspectives of knowing content (mainly, actions and behaviors), transformation and mode of expression.

2. THEORETICAL FRAMEWORK

This theoretical framework seeks to understand, from an engineering perspective, the action of designing (engineering design) and then presenting the work project and its relationship with production models. In this context, the relationship with the discipline of ergonomics is introduced, its conceptual bases, analysis method, approaches and reflections that articulate this discipline with design activities from the perspective of activity.

2.1. Project activity in engineering (Engineering Design)

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Pahl et al. (2005) state that the engineer's mission is to find solutions to technical problems. To do this, it must be based on knowledge from natural sciences and engineering, considering material, technological and economic constraints, as well as legal, environmental restrictions and those imposed by human beings. For the authors, problems become concrete tasks when, to solve them, engineers have to create a new product (artifact). The mental creation of a new artifact is the task of the designer (according to the authors, synonymous with development engineer and design engineer) and the physical realization is the responsibility of the manufacturing engineer.

Engineering Design, according to Eder (2008), has a substantial overlap with the concepts of Industrial Design (or Industrial Design, as it is better known in Brazil) and Integrated Product Development, but without being coincident. For the author, Industrial Design mainly considers aspects such as appearance, usability, aesthetics and ergonomics for tangible products.

in general. The concept of Integrated Product Development covers the management process of products intended for consumers and produced on a scale. Engineering Design demands a broader consideration of technical information and is concerned with the feasibility of manufacturing in order to put into practice desired effects, safety, reliability and other technical aspects.

It is possible to observe in Pugh's theory (1990), defined as Total Design, a different view of the systemic approaches presented by Hubka and Eder (1987) and Pahl et al. (2005). The characterization of the design process as iterative and non-linear and the interdependence of multiple internal and external factors (global vision) are aspects that differentiate it, together with the integration of the concept of social psychology of groups. Pugh (1990) concludes that in the context of design there are activities that include group decision-making and that, in a simplistic way, could show that design is a form of decision-making. Therefore, the most important thing is that there are detailed analyzes of the processes involved that will be used by project participants in their reflections and decision-making.

In the same sense, Bucciarelli (1984; 1988) argues that design, even when done by engineers, is not a mechanical process. Thus, a process flowchart may be useful in the business world to help organize, schedule and plan the work of the project team or to teach students, but it is neither a real nor a factual description of the project process as it occurs. , except on a superficial level. Thus, design is not something rational as expressed by managerial or economic sense. For the author, participants in the design process sometimes behave in a utilitarian way, seeking, based on the restrictions in their area of activity, to maximize their objectives. Often, they do not behave this way, due, for example, to participants not having a shared, clear and coherent understanding of the constraints and priorities of the design process.

Another serious deficiency that Bucciarelli (1988) points out in this perspective is the inability to deal with artifacts, the object of design. The challenges of manipulating the tools and “getting your hands dirty” are ignored. There is a presumption that once the right objective is articulated, the right motivation is given, the schedule and budgets well defined, and the working group assembled, then design quality will be achieved.

2.2 Ergonomics and Design

Since the Second World War, ergonomics has sought to associate knowledge from the health sector with knowledge from engineering and organization. In that context, the Human Factors approach, as ergonomics of Anglo-Saxon origin became known, emerges and is guided by the production of knowledge, especially physiological and cognitive parameters, based on controlled experiments and surveys (in the laboratory, for example) to subsidize the work project. The effectiveness of this approach is limited, in particular, because it disregards the variability of workers (psychophysiological characteristics) in a real work situation and the variability of the environment and real conditions, which are decisive for the development of productive activities. In response, another approach, centered on activity, was developed.

Activity Ergonomics, of French-speaking origin, developed in order to understand real work and subsequently transform it (GUÉRIN et al., 2001). The practice of this approach is based on the analysis of the activity, which is considered the structuring and organizing element of work situations; The main method that incorporates such understanding is Ergonomic Work Analysis (AET). This perspective allowed ergonomists to understand more deeply the determinants and constraints to which workers are subjected.

Thus, if during the 1970s and 80s, ergonomists of this line became specialists in working conditions, in the following decades they were faced with transforming themselves into actors in the design process of work systems (JACKSON, 2000). For this, according to Jackson (2000, p. 62), “ergonomics developed methods of participation in projects, based on the job description and the search for a prognosis of future work”. The role of the ergonomist, initially seen as that of the analyst who generates recommendations, changes to a form of direct action on the processes of designing work resources, in order to allow, in all phases of these, decisions to be guided by a reflection on future work.

Béguin and Weill-Fassina (2002) point out operational issues that involve the place of ergonomics in the design process. Historically, correction ergonomics has faced crystallized environments with little chance for profound changes. This ergonomics has progressively transformed into design ergonomics, which seeks to interact early in the design processes of productive situations. For Daniellou (2007), when ergonomics is called upon to act at an early stage of the project, it can contribute to enriching its objectives and discussing the principles of solutions. For this function, the ergonomist must gather the necessary ingredients and prepare the conditions for simulating the future activity.

Thus, it is understood that the design must be oriented towards the creation of spaces of possibilities, in order to allow developments for a productive activity (taking into account the variability and singularity of situations) and for a constructive activity (allowing and facilitating development by workers of objects, resources and conditions of their activity – instrumental genesis). The approach proposed by Folcher and Rabardel (2007) for a distributed design thus brings new elements to the design process that considers the perspective of the activity more broadly.

4. METHOD

The methodological approach adopted for this research is based on a posteriori reflection aligned with the methodological precepts of reflective practice developed by Schön (1983), which defines the participation of the researcher as an actor directly responsible for the transformation of working conditions. The author also considers reflection on experience essential for the construction of knowledge, since these are constructed in practice and not before it, as proposed by the model of technical rationality.

Thus, the present research can be separated into two distinct moments: a first of practice (or action) and a second of reflection (production of knowledge). The first refers to the creation of a partnership between a research and extension group from a university and an oil refinery. This partnership lasted around 5 years, starting in April 2007 and concluding in March 2012. In a second stage, the research sought to reflect on the experiences lived and the use of information collected throughout the interventions carried out by the research group.

The university's technical team was mainly responsible for carrying out the AET and developing the conceptual design of jobs, environments and work systems in order to make them more compatible with people's needs, skills and limitations.

To better understand the role of simulation in this process, the objective of this research, demands that used this resource during their development were selected. It was initially decided that the number of demands addressed would be necessary to reproduce the breadth of data collected throughout the project. The objective of working with as little as possible was to prioritize the detail and depth necessary for the construction of analyzes and reflections, which would be difficult if the 207 demands analyzed during the five years of interventions were addressed. Table 1 summarizes the demands used as reference cases for the research.

Table 1 - Characterization of the demands selected for the research outline

Demand (Start/duration)	Local	Origin	Final State in 2012	From Action	Nature Simulation
Case 1: Platforms and Access Stairs (2006/1a6m)	Transfer and Storage	Management	Deployed	Correction	CAD, Human Simulation, Game
Phase 2: Ultrasound Lab	Engineering	Auditor the Internal	In Deployment	Correction	Human
Case 3: Decoking Room (2001/11m)	Production	Workers	In testing / Validation	Correction	Physical prototypes, CAD, Simulation Human
Case 4: Manual Supply Platform (2010/3m)	New Ventures	Committee/Technical Team	deployed	Correction	CAD, Simulation Hujmana Design Review

Source: Authors

The main criterion used was the diversity related to "Simulation Supports". The objective was to allow reflection on the applicability of different techniques and tools as mediators in the design stages. A brief description of each support is presented in Table 2.

The first case addressed has as its object of analysis and conception several accesses used

by operators in a park of product storage tanks (oil and derivatives). Such accesses, distributed over an extensive area of the refinery, are

they were between the tank areas and the traffic routes (surrounding streets and avenues).

The second case recovers the development of devices in an engineering laboratory with the objective of, initially, meeting recommendations from an internal audit and, subsequently, improving the storage and movement of specimens from the perspective of the activity of operators.

The third case, located in an operating room in an industrial area, arises from a typical ergonomics demand: analysis and selection of furniture. Based on the analysis and reformulation of demand, it is divided into three fronts with dependent and parallel developments: design of a mask for a panel interface; modification of the physical structure of the dashboard console to better accommodate the lower limbs; and, analysis, selection and testing of chairs for console operation.

Finally, the fourth and final case differs from the others because it is a completely new situation and presents a dynamic of the ergonomics team's actions in the initial stages of the installation project and how it acted in the situations encountered, in particular, regarding the design of a chemical supply platform at an industrial waste treatment plant. Figure 1 illustrates the application of some supports in different cases.

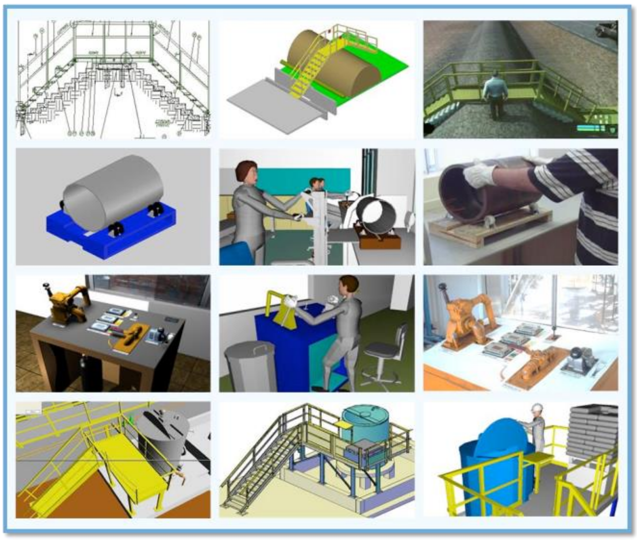
Table 2 Main simulation supports applied in design processes

Technique	Tool	Description
Manual Illustration	Writing Material/Paper	Material to graphically present solutions or problems observed.
CAD 2D e #D	AutoCAD	Computer Aided Design – is an engineering graphic tool that allows bi- and three-dimensional with a high level of precision
3D animation	3D Studio Max	Allows the creation

		of animations (films) in three dimensions with a level of realism moderate/high
Digital Human Modeling and Simulation (MSHD)	Jack Tecnomatix	Jack Tecnomatix
Game Engine	Cry Engine	They are characterized by high graphic quality, interaction features with the model and the possibility of programming of events and responses to stimuli from the controller.
Physical Prototyping	University Laboratory	The physical prototype is characterized by the construction on a natural scale (1:1) of the object designed. It also seeks to meet the functional requirements of operation and materials applied . The big The advantage of this type of prototype is its handling by actors in the design process. Thus, a different perception is sought from that obtained by digital supports.

Source: Authors

Figure 1 – Example of simulation supports used in the cases.



Source: Authors

5. DISCUSSION

In the selected cases, different simulation supports were observed that acted in an articulated manner throughout the project processes and contributed to incorporating the analyzed activity and developing future activity. The supports were also decisive in considering and allowing the technical issues of the different contexts addressed to be crystallized in the solutions developed.

In this way, we seek not only what is idealized and desirable by each of the logics involved in the design process, but also to reveal the feasibility, characteristics and technical limitations of the elements involved in the solution and the design process itself.

The dynamics of use and development of simulation situations were also evident in each demand. Situations where a certain support was essential (such as the use of physical prototypes in two of the cases) were opposed to situations where the available options allowed the team to judge the most appropriate one(s) for the context (choice between use human simulation and the Game Engine, as occurred in one of the cases).

Likewise, it can be seen that there are situations where negative findings can be quickly addressed and re-projected with the help of the supports used; In other cases, there is a clear need to end the simulation situation created so that new analyzes and developments can culminate in new (evolutionary) scenarios and, with the use of appropriate supports, create a new simulation situation.

In this sense, it is interesting that participants in the design processes have at their disposal a series of simulation supports that act as intermediate objects in their different postures and forms of expression (BRAATZ, 2015). Thus, it is possible to define which one(s) to use depending on the context, participants, object to be designed, available resources and complexity surrounding the situation.

The objective is to propose that supports act as objects, already used by engineers and designers, have well-defined functions and help reduce the dichotomy between technical aspects and social aspects in the design process. Vinck and

Jeantet (1995) state that there is a diversity of intermediate objects that are characterized by being found between several elements, several actors or successive phases, thus generically designating drawings, files, prototypes that mark the transition from one stage to another, circulating from one group to another or around several actors. However, these objects located “between” actors are expanded by Vinck (2009). The author states that, unlike the concept of border objects, the notion of intermediate objects is still in its “infancy”, leaving the given interpretative structure open to researchers, that is, whether or not the objects will be interpreted by different actors, will or will not be vehicles of standardization, will cross different social worlds or will be applied in a specific social world.

6. CONCLUSION

According to Jeantet et al. (1996) intermediate design objects are part of a production of objects throughout the design process of different natures with the aim of being evaluated, discussed and modified. Such objects, which can be drawings, plans, models, reports, among others, also act as instruments of coordination, between the different specialties involved and throughout the development, as they define the project's time frames (VINCK, 2009).

Simulation situations must be prepared to, in addition to the use of supports, facilitate

the free expression of knowledge about workers' activities, experiences and skills in a way that is compatible and understandable to all participants. By inserting different actors into the design process, especially with the use of simulation supports, acting in a way that allows interpretative flexibility, creating a space for confrontation and validation and ensuring that the evolution of the project goes through this simulation situation, it guarantees a degree of effective and real participation, in addition to the necessary conditions for incorporating the perspective of the activity into the solutions developed.

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