

AGENCY FOR A SYSTEMIC COMPREHENSION OF WORK ACCIDENTS AND ORGANIZATIONAL ANOMALIES

PROTAGONISMO PARA UMA COMPREENSÃO SISTÊMICA SOBRE
ACIDENTES DE TRABALHO E ANOMALIAS ORGANIZACIONAIS

PROTAGONISMO PARA UNA COMPRENSIÓN SISTÊMICA DE
ACCIDENTES DE TRABAJO Y ANOMALÍAS ORGANIZACIONALES

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Abstract Analyses of work accidents and organizational anomalies are traditionally based on external consultancy, or internal or external analysis, which generally fails in terms of the engagement and involvement of internal actors during the diagnosis or creating solutions. This paper aims to analyze if the interventionist method called Change Laboratory used in the analysis of organizational determinants and latent conditions of work accidents promotes agency and expansive learning of the involved actors, contributing to visualize/construct possible changes in the conception and development of the activity of construction of large buildings. Six sessions of Change Laboratory were analyzed to identify the micro-cycles of learning, facilitated by series of double stimulation. The sessions led to the engagement of the actors who created their own artefacts or appropriated the concepts or models, such as the timeline of the airport building, vicious circle, activity system, contradictions identified in origin of the anomalies and the possible solutions for future building projects. The study showed that the Change Laboratory can be used in systemic analysis of work accidents and anomalies. It is a powerful instrument for organizational collective learning when the group of actors becomes involved at comprehending, analyzing and creating solutions.

Keywords agency; double stimulation; expansive learning; change laboratory; prevention of work accident.

Resumo As investigações de acidentes e anomalias organizacionais são tradicionalmente baseadas em consultorias, análises internas ou externas às instituições que geralmente não conseguem engajamento e participação dos atores internos tanto no diagnóstico como na construção de soluções. Objetivou-se analisar se o método intervencionista Laboratório de Mudanças, empregado na compreensão dos determinantes organizacionais e das condições latentes de acidentes de trabalho, promove agência (protagonismo) e aprendizado expansivo dos atores envolvidos e contribui para visualizar e construir possíveis alterações na concepção e desenvolvimento da atividade de construção de grandes obras. Foram examinadas seis sessões do Laboratório de Mudanças, a fim de identificar os microciclos de aprendizado propiciados pelas séries de dupla estimulação. As sessões resultaram no engajamento dos atores que criaram seus próprios artefatos ou se apropriaram de conceitos ou modelos, tais como linha do tempo da obra, círculo vicioso, sistema de atividade, identificação de contradições na origem das anomalias e indicação de soluções para obras futuras. O estudo evidenciou que o Laboratório de Mudanças se apresentou propício à investigação de causas sistêmicas de acidentes e anomalias, revelando que a metodologia é potente para o aprendizado organizacional coletivo, uma vez que o grupo se engaja na compreensão, na análise e na busca de soluções.

Palavras-chave agência; dupla estimulação; aprendizagem expansiva; laboratório de mudanças; prevenção de acidentes de trabalho.

Introduction

Work accident analyses should consider both proximal causes and latent conditions. In Brazil, studies aimed at preventing unwanted events, such as work accidents, usually focus either on operator human errors (Almeida, 2006), on visible technical aspects or on issues set forth by the legislation, but do not devote adequate attention to organizational determinants and to the latent conditions of the events (Llory and Montmayeul, 2014). Therefore, opportunities for organizational learning, for preventing new events, and the possibility of increasing system reliability are impaired (Vilela et al., 2014).

Work accidents, activity delays, occupational diseases, rework, turnover, and the waste of resources are among these constraints and anomalies.

Event Organizational Analysis (EOA) is an approach that seeks to understand the pathogenic organizational factors (POF) incubated in the institution, also known as latent accident conditions. This analysis is based on three dimensions of the organization: Historical, transversal, and vertical (Dien, Llory and Montmayeul, 2004; Llory and Montmayeul, 2014). In this process, the nature of the relationships among this system's actors and the strategies used to achieve common goals and bring power and autonomy to each person or social group (Daniellou, Simard and Boissières, 2010) must also be identified.

During work accident analysis, the subjective aspects that permeate the activities (Osório, Machado, and Minayo-Gomez, 2005) must be considered, both the workers' and analysts'.

Accident investigation methodologies are generally based on the knowledge of the analyst or of a reduced team that often only listens to the actors and whose participation is restricted to be informants, with a low level of protagonism in the analysis and solution stages. According to Alves and Osório (2005), these investigation methodologies are based on a preference for scientific rather than practical knowledge, and consider the analyst an expert, the holder of the knowledge. However, in this process, both scientific knowledge and knowledge coming from experience (Alves and Osório, 2005) should be considered, and the heterogeneity of the knowledge and experiences of the various professionals involved in the event (Osório, Machado and Minayo-Gomez, 2005).

Worker involvement at different levels in the hierarchy occurs in the exchange of experiences and concepts, which allows for a renewal or expansion of resources for them to perform their tasks and, thus, creates a change-friendly environment (Osório, Machado and Minayo-Gomez, 2005).

This article featured an empirical accident case that occurred during the construction of an airport to discuss, in greater depth, the problem of

the lack of methodologies that promote the protagonism and the expansive learning of workers in accident analysis and in the creation of solutions.

During the construction, there were two major accidents within a short period of time. After the second accident, the Labor Public Prosecutor's Office (LPPO) contacted the University of São Paulo's College of Public Health for assistance in analyzing the situation and preventing similar events. To do the work, we counted on a technical and scientific cooperation agreement signed between the two institutions (São Paulo, 2013), which provided the field for the doctorate research project. This article is one of the products of that investigation.

In a first stage of the research, accident analysis was carried out by applying the Model of Analysis and Prevention of Work Accidents - MAPA (Almeida and Vilela, 2010) and the EOA (Llory and Montmayeul, 2014). Under these approaches, the research team takes on a specialist role in the diagnostic and recommendation phase, and it does not provide conditions for the engagement, protagonism, and learning of the actors involved, a fact that decreases possibilities for change.

To go beyond the diagnosis, build a more extended understanding of the systemic origins and latent conditions of the events and, simultaneously, visualize possible solutions with the actors, the research team made a collaboration with the University of Helsinki feasible to adjust and apply, under the Brazilian conditions, the formative intervention method called the Change Laboratory - CL (Engeström, 2007). This method is applied to guide actions in interventions aimed at expansive learning and agency formation for the actors (Virkkunen and Newnham, 2015).

The purpose of this article is to analyze the Change Laboratory's interventionist method, used to analyze organizational determinants and the latent conditions of work accidents, to promote the participants' agency and expansive learning, and, thus, contribute to visualizing and building possible changes in the design and development of the construction of major works to make them safer and more sustainable. Thus, this article also aims to answer this question: Can the CL help build the workers' agency and expansive learning and introduce, at a systemic level, organizational changes that help prevent future accidents?

Contextualization of the Cultural-Historical Activity Theory

The CL method has been being pointed to as a set of theoretical-methodological tools with potential to help transform activities. This methodology is based on the Cultural-Historical Activity Theory (CHAT) developed in Finland

by researchers from the University of Helsinki (Querol, Jackson Filho, and Cassandre, 2011; Engeström, 2007).

In the CHAT, the theoretical unit of analysis is an activity system (AS) in which the subject acts on the object (understood as meaning, motive, and purpose) through mediations that include the conceptual instruments and artifacts; the rules that encompass the regulations, norms, and conventions related to the context of the activity; the division of labor, which also includes hierarchy, and the community (individuals or groups that transform the object directly or indirectly) (Engeström, 2001a; Engeström and Sannino, 2010).

The CHAT can be summarized based on five principles: The theory of the cultural mediation of human actions; multivocality; historicity; contradictions as sources of change and development, and the possibility of expansive transformations in activity systems through the expansive learning cycle (Engeström, 2001a).

During this learning process, participants “learn something that is not there yet. In other words, the learners construct a new object and concept for their collective activity, and implement this new object and concept in practice” (Engeström and Sannino, 2010, p. 2).

Expansive learning can be systematized in a cycle that goes through a sequence of seven actions: Questioning; analyzing the situation; modeling; examining the model; implementing the model; reflecting on and evaluating the process, and consolidating and generalizing the practice (Engeström, Rantavuori, and Kerosuo, 2013).

During this cycle there is confrontation among the actors’s different views in an environment conducive to emotional involvement and creating agency. According to Virkkunen (2006 apud Emisbayer and Mishe’s, 1998, p. 63), “agency is a temporally embedded process of social engagement, informed by the past, oriented through evaluation of present toward future possibilities”.

The agency formation process is mediated using cultural artifacts or stimuli (Vygotsky, 1997) that allow the participants’ empowerment and protagonism during formative intervention sessions and can be obtained through the Double Stimulation Method. This method was proposed by Vygotsky (Engeström, 2007) and presents two sets of stimuli to the subject: The first consists of objects of their activity, while the second can be composed of signs, artifacts, or concepts. This double stimulation helps the subjects to solve the problem and, thus, expand their view about the object and activity they are inserted in, making it possible to master and understand their role as a collective actor and enabling the development of autonomy and empowerment (Engeström, 2007; Vygotsky, 1998).

In the CL, the interventionist presents mirror data, i.e. information that reflects the everyday reality of situations and problematic aspects of the activity, or in other words current practice data that help in the perception

that something needs to be changed, as a first stimulus. The second stimulus uses conceptual tools and models to analyze the mirror data (Virkkunen and Newnham, 2015). Participants generally replace or combine the conceptual models offered by the interventionists with formulated models or mediated conceptualizations (Engeström, 2011).

Methodological approach

The CL method intends to create and develop theories, models, and concepts about learning and development processes in organizational management through an expansion of concepts and ideas that help understand the system (Querol, Cassandre, and Bulgacov, 2014; Querol, Jackson Filho, and Cassandre, 2011).

During the CL sessions, the interventionist tries to systematize, accelerate, and intensify the expansive learning process by introducing successive tasks that lead to actions in the mentioned process (Engeström and Sannino, 2010).

Before starting the sessions, a first phase of ethnographic data collection was carried out through interviews, observations of work situations, and document analyses, a process that lasted approximately nine months in the field. These data were intended to help researchers to form an initial hypothesis about the contradictions that affect the AS being studied and to prepare the mirror data. In this first phase, joint venture workers holding different positions and working in different departments and outsourced workers were interviewed.

In the second phase, six CL sessions lasting two to three hours each, for a total of approximately 15 hours, were held at the company's auditorium, with an average participation of 11 actors from departments that were key to the progress of the work (engineering, planning, quality, production and health, and environment and safety departments). All sessions were filmed, recorded and later transcribed.

The first CL session began with an introduction of the entire group, of the project, and of ethical aspects. From the second session, all sessions began with the participants reviewing what had been done in the previous meeting. At the end of all the sessions, the group was also asked to provide feedback and suggestions to enhance the participants' engagement in the following meetings. In addition to the tasks proposed at the meetings, participants were encouraged with extra-session assignments to continue unfinished activities or to mature ideas for subsequent meetings.

The interventionists provoked the participants and facilitated the debate on the causes of the problems experienced in daily life. From the phase of recognition, the group covered a path in search of the systemic

and historical origins of the anomalies (Virkkunen and Newnham, 2015). For this, before the CL sessions got underway, prior planning was made of possible tasks for the sessions among the researchers and, then, with one of the participants to discuss tasks feasibility and, thus, plan other possibilities together.

After this stage, the research group planned all other tasks weekly pursuant to the expansive learning cycle and based on the principle of double stimulation (Engeström, Rantavuori and Kerosuo, 2013).

The interventionist researchers presented field data or tasks that allowed for the use of mirror data originating from the participants' memories (first stimulus), which were debated with the use of analytical instruments (second stimulus).

Data analysis began with a detailed description of the tasks done during the sessions. The planning done before each session and session films, recordings, and reports were used for this. During the descriptions, the tasks were divided into double stimulation (DS) series, presenting the first and second stimuli of each series, their actions, expansive results, and the sessions in which they occurred.

The DS series are understood as expansive learning microcycles that are variable and can last anywhere from minutes to hours, implying partial changes in the object or AS elements. The microcycles start when a first stimulus is applied and end after a second stimulus is applied and the task the researchers proposed is materialized (Engeström, 1996; Engeström, 2001b) with a product or model as a result.

During the DS series narrative, an attempt was made to identify evidence of transformative agency based on the participants' discourse and actions during and between the sessions. There are six types of transformative agency: Resisting, criticizing, explicating; envisioning; committing to actions, and taking action (Haapasaari, Engeström and Kerosuo, 2014).

In addition, an attempt was made to highlight the expansive learning and agentive actions by analyzing the expansion of the object, operationalized here as the way participants understood the systemic causes of accidents and their solutions with the tasks performed and the results obtained in the sessions.

The speeches were edited to correct concordance errors, but consistency was maintained with what had been said. For ethical reasons, the people's names were suppressed, and each person was identified with a letter 'I' (interventionists) or 'P' (other participants) and a number. A few of the products obtained during the sessions were also edited: Company names were replaced, and the elements of the vicious circle were rearranged to facilitate the visualization of connections between them.

The study that gave origin to this article met the ethical requirements for research projects in compliance with National Health Council Resolution No. 196/96. It was approved by the University of São Paulo School of Public Health's Research Ethics Committee under protocol nº CAAE 11886113.5.0000.5421. These are results of a doctoral thesis, and there are no conflicts of interest associated with this publication.

Expansive learning and double stimulation series

Nine DS series, detailed and summarized in Table 1, were shown during the sessions, which were planned in accordance with the expansive learning cycle (Figure 1).

Table 1

Summary of the double stimulation series during the Change Laboratories

C	C	C	C	C
Double Stimulation Series	Sessions	1st Stimulus	2nd Stimulus	Results
1st Series	1st	Task participants to list how they see the construction project and their activity, in addition to the main difficulties and facilities	Concept of difficulties and facilities	Collective analysis of problems and causes; Mobilization for the recognition of disturbances List of difficulties, facilities aspects and causes (temporal expansion of the problem)
2nd Series	1st 2nd 3rd	List of problems and causes; Historical data based on the participants' memory	Timeline concept	Historical analysis of the main milestones of the construction project Airport construction timeline (temporal expansion of the problem)
3rd Series	2nd	List of problems and causes; Timeline	Concept of origins, aspects and impacts of the vicious circle	Collective analysis of the causes and consequences of the disturbances List of origins, aspects, and impacts of problems in the airport construction (causal expansion of the problem)

To be continued>

Continuation - Table 1

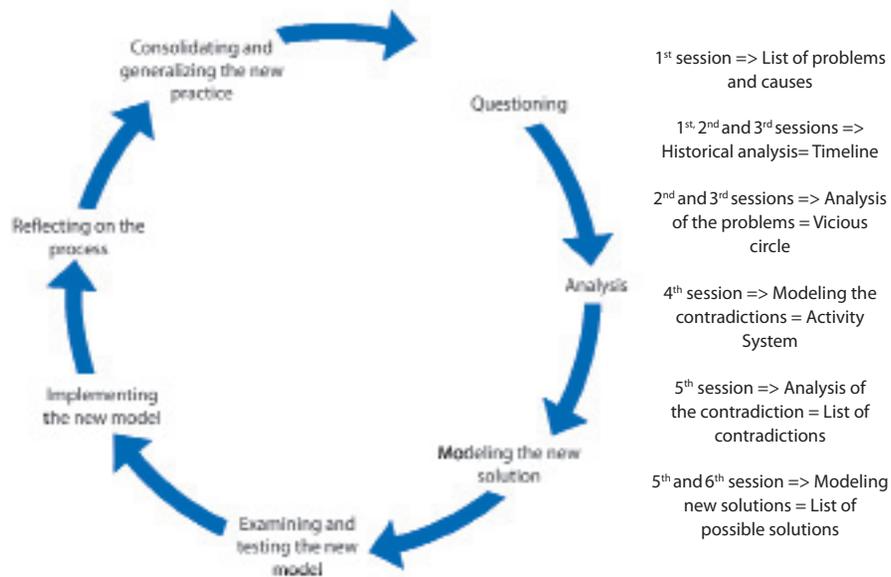
4th Series	3rd	Timeline; Analysis of the critical events with the greatest impact on the delay of the construction project; List of origins, aspects, and impacts of problems on airport construction	Concept of making the connections between origins, aspects, and the impacts of the problems in the construction of the airport	Collective analysis of the causes and consequences of the disturbances	Vicious circle (causal expansion of the problem); Understanding of the centrality of the temporal question
5th Series	4th	Vicious circle	Activity system concept	Modeling of activity system in subgroups	Activity system in subgroups (expansion of the understanding of the object, systemic view of the activity)
6th Series	4th	Vicious circle; Activity system in subgroups	Activity system concept	Modeling of the collective activity system	Collective activity system (expansion of the understanding of the object, systemic view of the activity)
7th Series	4th 5th	Collective activity system; IPT report	Concept of contradictions	Analysis of contradictions	List of contradictions (expansion of the understanding of contradictions)
8th Series	6th	Vicious circle	Concept of problems at the political, planning, and local levels	Solution modeling	List of the main problems at the political, planning, and local levels
9th Series	6th	List of the main problems at the political, planning, and local levels London Olympic Park Case	Concept of solutions; Comparison between two cases	Solution modeling	List of possible solutions (expansion of the understanding of the solutions)

Source: The authors.

Note: IPT – Institute for Technological Research

Figure 1

Expansive Learning Cycle - Airport Change Laboratory



Source: Adaptation of Engeström, 1987.

In the first DS series, participants were divided into four subgroups, based on the time the work at the company began, and were asked to discuss their views on their activities and on the construction project, in addition to the main facilities and difficulties aspects of the work (first stimulus). At the end of the discussion, each subgroup's responses were brought up and addressed with the whole group. Based on the concepts of difficult and facility aspects (second stimulus), the researchers asked which of them were the most important and their causes. The group discussion was based on the participants' practical experience.

The facility aspects the group listed were the logistics of the region; resource availability; good interpersonal relationships; good professionals; access to information; location; company financial conditions and resources, and the physical structure for the work.

Difficulties were a lack of professional training; lack of staff selection criteria; 'carteiradas';⁴ change of scope; change in the board of directors; high turnover rates; poor dialogue among leaders; different cultures; tight schedule; stress; overlapping activities; outsourcing; a poorly integrated organizational structure; a multi-level decision-making chain; lack of management integration; low product quality; long workdays; absence of feedback; lack

of performance appraisals; poor communication, and difficulties in the safety culture at all levels.

The group listed many difficulties related to time and exemplified with personal experiences. For the first time, the workers discussed the problems of the construction project collectively.

Ever since the 1st DS series, the temporal issue started standing out as an influence of historical origin in the accidents and anomalies that the airport construction project was experiencing related to mismanaged and poorly dimensioned scopes and deadlines:

I think the problem civil construction in general faces is poorly sized and poorly managed scopes. It often takes a long time for the construction to start, and when it does, the design project isn't quite ready yet. There is no consolidated project. Then the deadlines are mismanaged. At the end, there is the deadline to meet, and we need to rush (P 02).

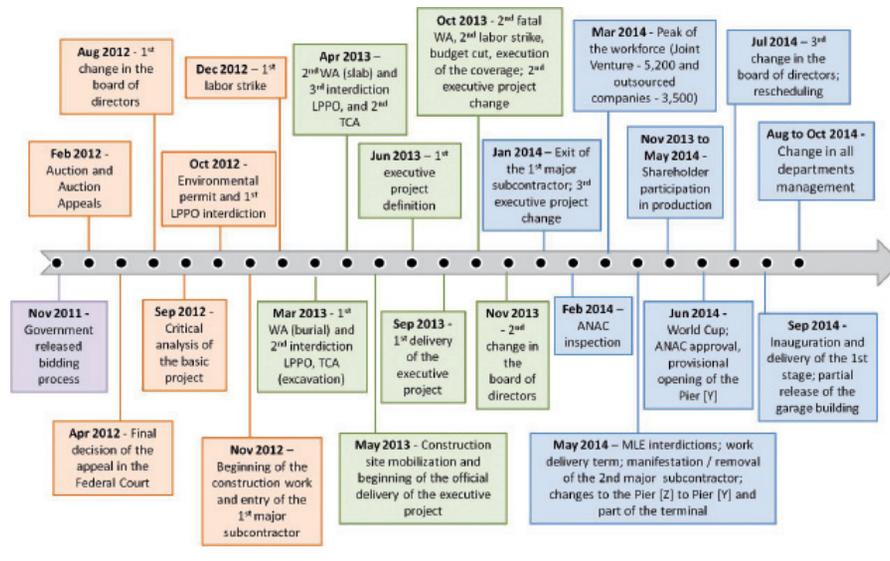
The proposal of the timeline as a possible tool emerged from the participants speech during the discussion of the time issue, as revealed by the following verbalization, and provided the link to the next DS series.

If we were to make a timeline, I think it would start back in the definition of the scope, which is the project that defines (...) So there are several steps, and because you do not have a defined scope, you do not have a feasible deadline to accomplish what defined as a scope, which depends on your scope. These changes in scope are the cause of everything we experience here (P 04).

Thus, the 2nd DS series started based on the results obtained in the discussion of the 1st DS series (first stimulus), by recognizing the temporal aspect as an explanatory factor for problems and disturbances. To explore this aspect in more detail, the researchers asked the participants to build a timeline (second stimulus - Figure 2) about the construction of that company.

Figure 2

Timeline built by CL participants



Source: CL participants.

Note: LPPO - Labor Public Prosecutor's Office; WA - Work Accident; TCA - Term of Conduct Adjustment; ANAC - National Civil Aviation Agency; MLE - Ministry of Labor and Employment.

The timeline is a chronological visual representation of important events about a given object that relates them to the date on which they occurred. During a historical analysis, it helps to identify and understand the origins of AS contradictions that lead to the observed disturbances (Querol, Cassandre and Bulgacov, 2014). In the intervention, the timeline was a tool that helped the participants to understand the temporal expansion of the construction of the airport from a historical viewpoint and, thus, the current contradictions in this AS. The participants themselves perceived and verbalized this:

I think this one will be important, huh? You have to take it out, keep this file and leave this history, and I think this will be the best activity that we will do here, because this is good for the company, the history of the company (...) so we can also know the cause, what impacted possible accidents, and that will be a lesson learned for everyone for the next construction projects, right? Since everyone is from the construction work (P 04).

This tool allowed the viewing of airport historical events years before its physical construction got underway, such as, for example, the delay in the bidding process. This allowed participants to list events that influenced not only the occurrence of the accidents, but also other current constraints, such as strikes, interdictions, changes in the board of directors, construction

project oversizing, the lack of a schedule, resource waste, rework, and changes in the executive projects.

At the end of the timeline construction, participants were asked to observe and analyze the critical events⁵ that would have the most impact on airport construction. Three critical events were listed for the delay in the construction project's schedule: The three major accidents due to the work stoppages; changes in the executive project and/or everything that changes the focus of the construction because of activity rescheduling, which may require rework and delays in material deliveries; and changes in the board of directors, which leads to a new form of management and demands more time for workers to adapt.

[when talking about the changes in the board of directors] until the guy gets used to the change and adjusts to the whole atmosphere, the way the guy is used to working, demands huge change, something that does not happen so fast (P 03).

In this analysis, time once again comes up as an important factor for the occurrence of accidents and anomalies. With this task, the participants visualized how these disruptions disturbances emerged, from a historical viewpoint, and, thus, had an understanding of the temporal dimension of the problem.

Some of the events included on the timeline are causes and are at the origin of accidents and anomalies; others, meanwhile, would be consequences. Thus, activities were planned and divided in stage 1 (3rd DS series) and stage 2 (4th DS series) to help the participants understand the causes and consequences with the construction of a vicious circle.

In stage 1 (3rd DS series), the researchers once again provided to the group the list of problems and causes drafted by the participants along with the timeline (first stimulus). When viewing these first stimuli, and based on the concept of origins, aspects, and impacts of the vicious circle (second stimulus), the participants listed the origins, aspects, and impacts of problems in the construction of the airport and started analyzing the relationships between origins and impacts among the disturbances listed and expanding the causal understanding of the problem.

In the interval to the next session, a researcher/interventionist sent the participants a graphical representation of the timeline and the list of origins, aspects, and impacts that were built for them to think about and complement other possible relationships between the origins, aspects and impacts to present during the next session. Only one participant did the extra-session assignment and e-mailed it to the participants.

Before starting the third CL session, this participant delivered a new version of the task to one of the researchers, with new analyses and links

in the vicious circle. His protagonism was denoted as an agentive action of taking action, i.e., he went beyond the group's discourse and concrete actions, and undertook an action that changed the course of the actions in progress (Haapasaari, Engeström and Kerosuo, 2014).

In stage 2 (4th DS series), the researchers/interventionists again presented to the participants the completed timeline (Figure 2), the analysis of the critical events with the greatest impact on the delay of the construction work, and the list of origins, aspects and impacts listed in the 3rd DS by the group (first stimulus). They then asked the participants to build a vicious circle (second stimulus) to explore the causes of the disturbances in the construction site.

The participants showed another form of agency during the construction of the vicious circle. They identified problems and criticized the way the work is done, thus a criticizing agentive action (Haapasaari, Engeström and Kerosuo, 2014, Heikkilä and Seppänen, 2014).

Constructing the vicious circle (Figure 3) allowed the participants to visualize and analyze the complex relationship between the difficulties and the critical events they pointed out in the previous sessions and to, thus, obtain a causal expansion of the problem. In the dialogue below, the participants discussed the relationship between the board of directors' inadequate strategic planning for hiring workers and the absence of skilled workers at the construction project, demonstrating this cause and effect relationship between the difficulties they pointed out in the first DS series.

In the beginning, there was a lack of skilled workforce to start the project and see how it would be. That is what led to all of this (P 02).

A lack of expertise generates a lack of strategy, and this lack of strategy even included qualifying the workforce (P 07).

This lack of strategy is also related to the board of directors, because where does strategy have to come from? From senior management, from above (P 02).

So, we must remove the inadequate structure and organization from here [referring to the change in place in the vicious circle under construction] (P 07).

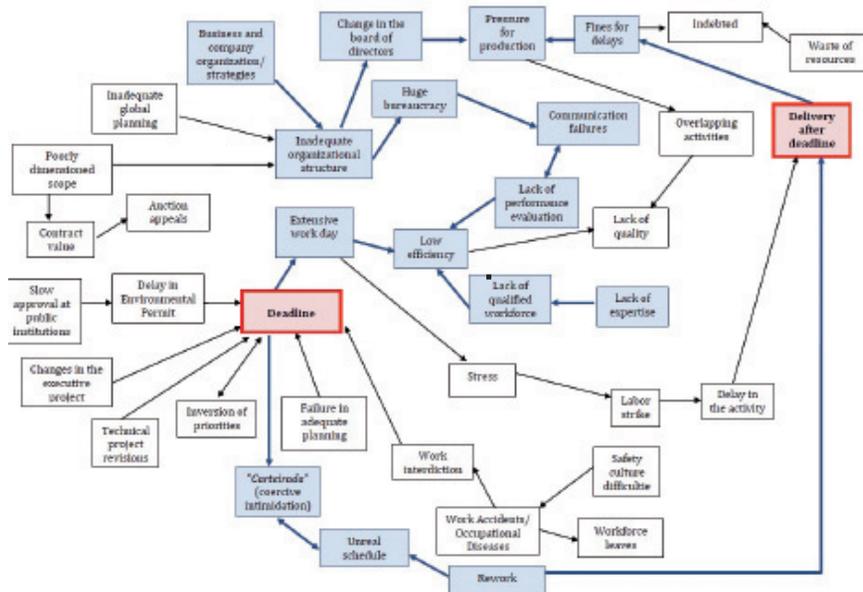
The board of directors that creates the strategic plan to be able to reach the workforce down there (P 02).

In the vicious circle, the deadline once again comes up as something of great influence in project construction, either as a cause or as an effect in these interactions. Associated with the deadline, the participants pointed to organizational and managerial aspects such as a lack of expertise at the

organization and even the lack of a strategic plan for the project, as can be seen in the sequence highlighted in blue in Figure 3.

Figure 3

Vicious circle built by the participants



Source: Change Laboratories participants.

The elements pointed out in the vicious circle and their interactions are part of the airport construction AS, and are related to its rules, community, division of labor and tools.

Thus, after the construction of the vicious circle, the researchers presented concepts about the elements of the AS to the group. The triangular activity representation model had the airport construction as its object, and it was e-mailed to the participants as an exercise for them to think about the elements and fill out its model. However, none of the participants did the assignment.

At the end of the 4th DS series, the group was asked about the inclusion of new participants as representatives of community institutions: LPPO, Ministry of Labor and Employment, and the Workers' Health Reference Center. The current members did not agree with this because, to them, including these representatives might inhibit them, and that would mean taking steps backwards, since they would have to go back and cover everything that had been done until then with the new possible participants. This action, in which the participants take the lead of the discussion, is interpreted as

evidence of a resisting agentive action by the participants during the process (Haapasaari, Engeström and Kerosuo, 2014, Heikkilä and Seppänen, 2014).

The 5th DS series began with the visualization of the vicious circle (first stimulus) the participants built. The researchers then reintroduced the concepts of the AS elements (second stimulus). Divided randomly into four subgroups, they built the AS, in which only the object (airport construction) was previously defined.

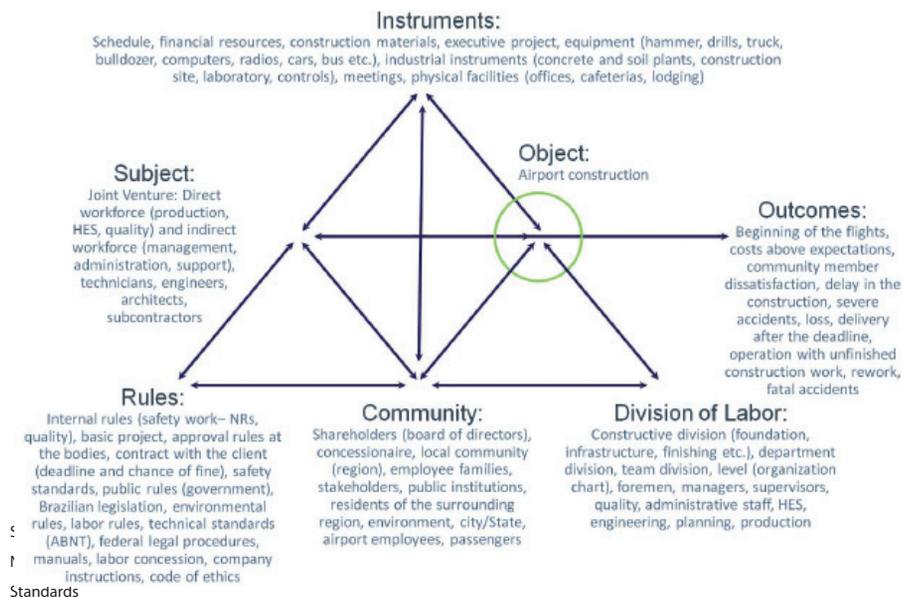
In this task, there is an expansion of the understanding of the AS among the participants who, based on a conceptual model, systematically analyzed the different elements of the airport construction AS, not only its isolated activity.

The 6th DS series was a continuation of the 5th DS series, in which there was a paper with a triangle drawn it and, again, only the object (airport construction) was defined. The vicious circle was shown to the participants, and each subgroup's responses were placed in the respective elements of the triangle (first stimulus). Through the AS concepts and its elements (second stimulus), the group discussed and, in consensus, built a collective AS (Figure 04), with an expansion of the understanding of the AS for the whole group.

In this collective AS, the subject was defined as the joint venture constructive board and the indirect workforce (outsourced), which were submitted to internal work safety rules, bidding rules, joint venture internal rules, to the contract with the client (concessionaire), to the Brazilian legislation, and to labor and environmental rules. Some tools mediate this activity, such as schedules, financial resources, executive project, equipment, meetings, physical facilities, and industrial instruments. The community is made up of the shareholders, local community, stakeholders, the concessionaire, public institutions and airport workers. The division of labor was categorized into constructive division, department division, and team division. In the period of the sessions, part of the airport had already been inaugurated, and flight commencement was considered as an expected result. Some elements of the vicious circle reappeared in the unexpected results, such as over-cost, work delays, rework, and severe and fatal accidents.

Figure 4

Activity system built by the group



These unexpected results reflect disturbances due to manifestations of AS contradictions. These, in turn, represent structural tensions, historically accumulated within and between activity systems, which generate disturbances and conflicts, as well as innovations, and aim to change the activity (Engeström, 2001a).

The representation of the AS helped the participants to understand the relationships between that activity system's elements and the existing contradictions (Engeström and Sannino, 2011). Thus, the origins of the accidents and anomalies were explained in the triangular model, and the problems and disturbances described in the mirror data were brought to light (Engeström, 2007).

In the 7th DS series, the collective AS built in the 6th DS series (first stimulus) and the concept of contradictions (second stimulus) were provided to the group. The participants analyzed the AS to identify the contradictions in the relationship between their elements (Table 2).

During the group discussion, it was noticeable that the participants had a little more difficulty performing this task when asked what they thought about the session:

I think it is getting harder, you know? (P 12).

We want to find the solutions, and it is getting harder now (P 09).

It is believed that this happened because of the complexity of the object, which is composed of different subsystems, and the present actors did not have information about and mastery of all the elements of this AS. Each department of the construction site could be considered a subsystem with a shared object.

To facilitate the understanding and analyze the proximal causes of the accident, the researchers/interventionists introduced a new first stimulus: A concrete case of an event that occurred at the construction site. The case of the second accident, when the slab collapsed, was presented with information collected in the ethnographic phase, added of information extracted from the report of the Institute for Technological Research (IPT) issued about the event. However, most of the participants were not working at the joint venture at the time of the event, rendering the discussion abstract and reducing it to the level of hypotheses arising from experience in other construction sites or from other facts that occurred during airport construction. This can be characterized as an explicating agentive action, i.e., new possibilities or potentials are explained in the activity, and they relate them to past positive experiences or former well tried practices (Haapasaari, Engeström and Kerosuo, 2014), as per the following verbalization:

I was working for a company that started concreting a slab at 7 am, and (...) at 8 pm, (...) there were about 60 people on that slab, and it gave way a little. (...) I saw the production engineer, and he slapped his chest and said: 'You can't stop, you have to continue. It is a lot of money. You must finish it today. Go on.' (...) It was a lot of work, and everything culminated in the time that this guy had and in the loss. (...) He put (...) his career, his life, and everyone else's life at risk because of it. (...) It often comes back (...) to the question of time. Because an employee will hardly ever (...) turn to his superior and say: 'Look, I am not going to do this because there isn't enough time, the work will not be done properly, and the staff is going to be at risk.' (...) This is not a company issue. This is in general (P 09).

In the reported case, there are cultural elements, a lack of operator autonomy, and strict hierarchical relationships, facts that help to explain organizational aspects and the role of management, which is pressed by

deadlines and financial pressures and exposes people's lives to serious and imminent risk, which might lead to accidents.

At this stage, even with the difficulties the participants pointed out to perform the series, they approached an explanatory diagnosis when listing central, historical, and organizational aspects, and, therefore, an expansion of the understanding of the manifestations of contradictions in this AS.

The participants reflected on the AS that was produced and again focused the discussion on the issue of time, as the following speeches show. Together with the vicious circle, the AS helped determine the fact that time had more weight than other factors.

I don't think it is a global and complete scope, it is an unachievable scope, so to speak. (...) They wanted to do too much in the amount of time that they had (P 07).

And then things go back to the first day we talked. (...) It all goes back to deadlines. Where did the deadline come from? It came from a bidding process that came from the government, and both the government and federal institutions planned and did things that ended up as they did. Oh! Come on. It is the PAC 1, PAC 2, PAC [Growth Acceleration Program -PAC in Portuguese]⁶, whatever. It is for yesterday. But what about the project? And did the government agencies have the basic project ready? That is where things start. Then you suffer at the other end [when referring to the airport construction and its workers] (P 04).

The seventh DS series helped the participants to identify the contradictions (Table 2), and, thus, to rank and differentiate what was decisive, between aspects or isolated factors. In other words, they identified the structural tensions within the system that explained the accidents and anomalies, so they could think about possible solutions.

Table 2

Contradictions and solutions identified by the participants

Contradictions	Solutions
Short deadline x Tight schedule; Lack of airport expertise x Public institution surveillance; Low budget x Resources available; Quality of the finishing x Resources; Schedule x Activity duration; Lack of material x Lack of planning; Lack of materials x Lack of control; Lack of project surveillance x Improper execution; Changes of the project in the field x Lack of designer engineer communication; Lack of skilled workforce x No execution of the project; Faulty process control x Resource availability; Supplier delay x Changes of the project in the field; Under-dimensioning of the project engineering team x Scope; Engineering project fragmentation x Quality process.	Proof of percentage of experience in the field of the object in the bidding and funding process; More precise cost calculation in the bidding process; Bidding process based on techniques and prices; Schedule analysis by some public institution; Management action standardization; Ombudsman connected to the board of director; Weekly meetings with all departments and within the departments; Increased surveillance, demands, and accountability; Broader communication matrix; Improvements in the document control system; Transfer and charging of goals; Transfer of information and of planning; Interface meetings; Bureaucracy reduction; Teamwork; Disclosure of the financial health; Creation of a cost department; Specific and continuous training; Stricter material quality surveillance; Creation of a department to store materials; Improvements of outsourced company management.

Source: Change Laboratories participants.

Solution modeling was divided into stage 1 (8th DS series) and stage 2 (9th DS series).

In the 8th DS series, the vicious circle was again shown to the participants (first stimulus) and discussed with the concept of the main problems at the political, planning, and local level (second stimulus), and, thus, the two most important problems at each of these levels were listed.

As for the political level, the delay in the issuing of the environmental permit and the political landscape were emphasized. The latter was understood to be a construction work with deadlines determined not by the real time that the construction project required, but by political decisions due to the 2014 World Cup and presidential elections in Brazil. Regarding the level of planning, the mismanagement and the lack of an executive project were considered. Because of the strong pressure regarding the construction's deadline, airport construction began without a definitive executive project.

Finally, at the local level, issues such as the inversion of priorities and local mismanagement were posed as more important issues.

In the 9th DS series, the list of the main problems listed in the 8th DS series (first stimulus) and the concept of solutions (second stimulus) allowed the group to discuss and list possible solutions (Table 2), in the long or short term, for each of those levels to the airport AS.

The researchers also brought the worldwide success case of the construction of the London Olympic Park, in 2012, as a first stimulus. In that construction site, which was completed almost 12 months before the deadline, there was no fatal accident and there were financial resources left over (Bolt et al., 2012). The group became very interested in this case and sent material on this experience.

Using the concept of solutions and comparisons of two different realities, the participants analyzed and highlighted what it was possible to take advantage of and/or adapt it to the case of the Brazilian airport.

Most of the solutions proposed at the political level were related to the bidding process, which should consider not only prices, but also the techniques and a more accurate cost analysis. In addition, the deadline proposed at the time of the bidding should have been analyzed by some public institution so that bidding providing construction schedules that could not be met would not be approved.

In the solutions at the planning level, management action standardization, bureaucracy reduction, teamwork, improvements of outsourced company management, specific and continuous training for all areas and positions, and the creation of a cost department were proposed. During the sessions, the joint venture went through a financial problem that was reflected in the solutions. At the local level, the group pointed out there were weekly meetings with all departments and within the departments, a broader communication matrix, improvements in the document control system, and increased surveillance, demands, and accountability.

By analyzing the vicious circle the group constructed and the manifestations of contradictions the participants listed, it was found that the temporal aspect emerged both in the contradictions and in the possible solutions proposed. The latter were understood in an expansive process in the course of the meetings.

At the end of the CL, the participants went back to what had been done and expressed their feelings about the intervention. The speeches were positive, with suggestions for the continuity of these sessions, because, for the first time, they had had the opportunity to discuss what they did at the construction site and, thus, to understand how that AS worked. Prior to the CL experience, participants were often unaware of exactly what was

done in other departments, and now they had a broad understanding of airport construction.

Collective and systemic analysis in the formation of agency

The DS series sequence can be compared to the participants taking steps up a ladder, in which the products of the previous series contributed to enhancing the understanding about the problem. Participants carried out, collectively, a historical and organizational analysis of the AS of large-scale construction works, which can be considered expansive learning among everyone involved in the sessions (participants and researchers).

During the sessions, the participants discussed, for the first time, the problems that occurred at the construction site, and, at the end of the sessions, after successive analyses with the introduction of the first and second stimuli, they were able to draft a diagnosis and create solutions that can be generalized to similar construction works. In this empirical case, the double stimulation method propelled the subject beyond the problem initially given, leading to a new perspective about and expansion of the object (Engeström, 2009).

In the 7th and 9th DS series, the application of the first and second stimuli, as previously planned by the researchers, failed to achieve much success in obtaining a product or model. Therefore, it was necessary to apply a new first stimulus. The DS series or expansive learning microcycles were only considered finished when a product or model was obtained. It is a learning action cycle coming and going process within an expansive learning cycle (Engeström, Rantavuori, and Kerosuo, 2013).

These actions can be viewed more concretely in the results obtained during the sessions (timeline, vicious circle, activity system, identification of contradictions, and possible solutions).

Moreover, considering the historical and organizational dimensions (Llory and Montmayeul, 2014), their lessons can be generalized to understand and prevent similar accidents. In this perspective, accidents are understood as AS anomalies, an unexpected result that comes from inner contradictions of the activity system.

Civil construction has highly dynamic activities, and the concreting activity, which was being carried out at the time of the slab accident, had ended at the site approximately 10 months before the beginning of the sessions. As mentioned before, many participants were not working at the construction site at the time the slab collapsed. When introducing a concrete piece of information, i.e., IPT's analysis of the accident, the discussion was limited to the hypothesis level and based on the participants' experiences in other construction works, since they did not know the reality of the

site at the time. This impaired the analysis and the participants' dialectical visualization between the proximal causes and the distal causes of the accident in question, which was considered a study limitation from the proximal cause analysis point of view. However, even without having been able to analyze the immediate causes, the participants had 'explicating' agentive actions in this task in which they were able to identify AS contradictions.

Participants showed agency during the sessions, which was evidenced by the demonstration of different types of agentive actions, such as 'criticizing,' 'resisting,' 'explicating,' and 'taking action.' They questioned and reformulated a few tasks the interventionists proposed, taking the lead in the intervention process.

The interventionist plans do not always match the participants' learning actions, which can be considered a source of agency and innovation (Engeström, Rantavuori, and Kerosuo, 2013). Expansive learning during an intervention requires participants to take a leadership role in the intervention process by rejecting and reformulating tasks, thus being actions that alter the interventionist's plans (Rasmussen and Ludvigsen, 2009 apud Engeström and Sannino, 2010).

Even in systemic approaches such as MAPA and EOA, as a rule, workers act passively, only providing data through interviews, field observations, and documents. Change and learning need to be incorporated into the accident analysis strategies, so that the analyses do not end at the diagnosis, such as putting a puzzle together and an investigator construction that will have little impact in the organizations. To achieve the learning and implement changes in an AS, the participants must take a leading role and taking agentive actions during these analyses. In the empirical study, the CL was shown to be a tool with potential for use in promoting the agency of the organizations' internal actors. In addition, this method can help in the systemic and historical understanding of work accidents and provide a learning environment among the actors involved, facilitating solution development, testing, and implementation.

In this empirical case, the expansive learning cycle was hampered by the loss of some participants due to political factors, which caused the construction work stoppage before fully completed. Between the third and fourth sessions, a corruption scheme involving major construction contractors was discovered in Brazil. The airport was built by a joint venture hired by a concessionaire. The concessionaire was composed of three companies, and one of the companies was involved in this scheme, thus the concessionaire made a financial cut to the joint venture. Thus, in this period, many construction workers were dismissed or removed from the joint venture, among whom three CL session participants. Because of these layoffs, seven participants missed the fourth session, since some of the participants who continued on

the construction work could not attend because they had no one to replace them in their departments.

Final considerations

The construction site started while the executive project was still underway, in a social context of pressure related to time constrained by a political-electoral agenda and a sporting event calendar.

The organization of the production process had a high social and human cost, with three serious accidents that led to the death of two workers, to conflicts such as labor strikes, shutdowns, interdictions by public health and safety surveillance institutions, as well as other anomalies, such as regular overtime, communication and coordination difficulties between departments, a lack of professional training, coercive intimidation ('carteiradas'), turnover, changes in the board of directors, change of scope, pressure for production, waste of resources, the lack of an executive project, etc.

These accidents and other anomalies had as historical determinants a hiring process based on the EPC modality under which a company, without engineering project expertise, is hired to design the project, procure materials, and build the entire construction site. The outsourcing strategy was adopted for this in a context of great pressure for time and without the necessary coordination.

The joint venture modality that was chosen, on the other hand, implied bringing together companies with different management and safety cultures, which resulted in unstable, turbulent planning, aggravated by the turnover of the board of directors (four board of directors of the joint venture in two years), which led to instability and constant changes in scope. These changes made it even more difficult for the safety department work to be carried out, usually being put on the back burner in relation to the production department, a fact evidenced by the habitual practice of fraud ('carteiradas,' or coercive intimidation).

Through session tasks, the participants had the opportunity to collectively discuss the problems and disturbances in the construction site, as well as to analyze the origin of these problems historically, which provided an understanding of the temporal expansion of the object. In addition, they had a broader understanding of the airport construction AS. Previously, they had been restricted to their departments, and did not understand the activities carried out by the neighboring departments very well, even if they shared the same object (the construction of the airport).

The CL, as an expansive learning and systemic orientation process, helped the researchers and participants to understand and visualize important changes

in the AS of large-scale construction works. In addition, they identified latent conditions for the occurrence of accidents and other anomalies, which can be generalized to other large construction works. The carefully planned sessions, based on the principle of double stimulation, provoked collective thinking and an increase in the agency of the actors involved, who had an increase in confidence and increasing contribution during the sessions, which allowed for expansive learning.

The expansive learning afforded by the CL can be expressed as a diagnostic synthesis that represents a re-reading of the findings of the collective, i.e., what the CL produced as an organizational diagnosis, evidenced the main contradictions identified in the context of the construction site and its prior history. Based on the diagnosis, the group was able to point to a few guidelines and premises to overcome the current contradictions and avoid unwanted results, such as accidents and other anomalies, opening a future perspective for the AS of large-scale construction works.

It is also important to emphasize that the learning that took place during the session is not enough to lead to the expansion of the object of the activity. Therefore, it is necessary to continue actions towards learning sustainability until the end of the cycle. In this case, the cycle was interrupted prematurely.

Collaborators

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Notes

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⁴ A term used by workers to refer to a type of coercive intimidation practiced by a worker holding a hierarchically superior position when giving orders that involve breaking procedural rules.

⁵ Critical event defined as a sequence of events that result in more radical and durable structure transformations (Sewell Jr., 1996).

⁶ The Brazilian Federal Government developed the Growth Acceleration Program (PAC, in Portuguese) which provided financial support for civil construction industry to build large-scale infrastructure construction works.

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