Learning during design through simulation

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Abstract. This communication analyzes simulation as a method for learning during design, rather than a method for anticipates the future. More often, simulation is understood from as a "figurative" approach, centered on a future simulated situation. We will argue that an "operative" approach, centered on activity in a situation of simulation could be more efficient. Taking definitively this operative standpoint, the communication will propose three dimensions, each one contributing to an operative method: firstly, the simulated situation is a mediator, whose reference lies in activity rather than in the simulated situation. Secondly, simulation has to offer the possibility of exchange and dialogical learning between heterogeneous actors. Thirdly simulation methods must facilitate an ex-post activity, a reflexive "come back" after the event, giving the users the potential to learn about their own activity.

Keywords. activity, mediation, dialogical learning, reflexivity.

1. Introduction

This communication combines the results of researches on simulation in ergonomics (where the goal is to contribute to the design of technical systems, products, machines and tools) and training in a professional context.

Of course, simulation used in these domains has different goals. But we believe that confronting what comes out from simulation methods emanating from these different fields enhances the intelligibility of simulation techniques for three reasons. Firstly: whatever the finality (design or training), simulating work situations is a work oriented method, it is a means to place professional situations at the heart of training (in this case, it enables those concerned by building training programs based on situations, and no longer based on academic or disciplinary knowledge) or in the heart of design process (in this case, they allow work to become a criteria for decision-taking, similar in manner to economic or technical dimensions, which are often the only criteria taken into account). Secondly, simulation is an instrument for both the designer and the trainer. But what conditions are required to make the simulation become an instrument? Thirdly: even if simulation is not explicitly serving a learning goal, the use of a model appears undoubtedly associated to any questioning on learning. Simulation brings on learning in two ways: (i) through the building of a model, and (ii) in using the model (Morgan & Morrison, 1997). An all too clumsy distinction between learning and designing is therefore not completely satisfactory: design can be defined as a mutual learning process between designers (Béguin, 2003).

The paper is planned out as follows: first we put forward that two different points of view are possible to apprehend the simulation: figurative and operative. Taking an operative point of view, we will describe three invariants, from which we try to develop methodologically and theoretically simulating work situations.

2. Figurative and operative standpoints

Two standpoints can be taken to grasp a simulated situation: a *figurative* and an *operative* one.

The figurative standpoint brings us to question ourselves on "fidelity " or "ecological validity", and more extensively to the generalization of results: in what manner is the data resulting from such simulations representative of real work situations? Focusing on validation is reinforced by the way in which the simulation is most often thought out and built up: in reference to an experimental methodology, "*a technique that substitutes a synthetic environment for a real environment, in such a manner to enable work to take place under laboratory controlled conditions*" (Harman sited by Sanders, 1991). In a figurative approach, simulation is explicitly apprehended and thought out as a copy of a "*simulated situation*" (whether it is an existing situation as in training, or in a future situation as in design). However, a "*simulation setting*" can never replace reality nor real experience, whatever the trainer's or the designer's efforts to respect all the figurative elements of the simulated situation in as faithful a manner as possible. Even in full scale simulation, the activity that is set up (by the "trainee" or by the "user") within the simulated setting will be a simulacrum for the user of the situated simulation: passenger transport without the presence of passengers, carrying out risky processes without risk, etc... From a figurative standpoint, this is an unavoidable limit.

However, another standpoint, which can be qualified as *operative*, is possible. It consists to understand *simulation settings* as finalized and social settings that have to be understood and apprehended in their specificities, and to question the roles that simulated situations (through a model, a mock, etc) fill in the activity of the users. As we will see, what appears to be a limit from a figurative approach will appears as a resource from an operative standpoint.

3. Simulated situation as a mediator

We have underlined that simulation is an instrument for the trainer or for the designer. Work initially developed by Vygotski and others in Soviet psychology supply a rich and fertile approach to apprehend activities with instruments. As an activity consists in acting "through" an instrument (Bødker, 1989), artifacts must not only be analyzed as things but in the manner in which they mediate use (Bannon & Bødker 1996). Many forms of mediation can be observed during simulation. In this short text we will focus on mediation to the objects (rather than to the subject).

The first form of mediation to the object is pragmatic, oriented towards transformation and manipulation of an object. Pragmatic mediations are dominant in design processes, even if they are not alone. In a previous piece of work we analyzed such mediations in the design process of an electrical device (Béguin & Rabardel, 2000). The point here is that the designer builds different models of the device. Two types of diagram are required: a functional diagram and a wiring diagram. Whereas the first aims at apprehending the operating principles in the form of logical rules (and's and or's), the second aims at apprehending an electrical structure, consisting of polarities, connections, and receivers carrying energy. These two diagrams are clearly different, from the logical standpoint no short-circuiting is possible. Furthermore, numerous drafts, that are far removed from the semic code used in technical drawing, are produced by the designer to solve local problems. The different models produced by the designer are operative external representations: partial representations that remove some of the non significant aspects of

the problems he/she is trying to solve at a specific time during the design process, and that save others thereby placing them within reach of the designer's reasoning and his/her action.

The second form of mediation is of "epistemic", it is oriented towards awareness of the object and of its properties. Epistemic mediation is central to simulating for learning purposes. Follow-up analysis of the use of simulating in the nuclear field shows that the reference of the simulated situation resides less in the figurative elements of the real situation than in the understanding of the trainees (Pastré, 1995). Effectively, if the model is either too close or too far from the subject's skills, then he/she will learn nothing. This analysis also leads to a centering on the operative character of the model from which the simulation has been built. What's important isn't to imitate reality, but to point out a problem (to be identified or to be solved) that requires the mobilization and adjustment of skills and competences. From this point of view, it is relevant to deform certain aspects to make them more obvious in the situation.

Through epistemic and pragmatic dimensions, mediation is made possible by the very fact that the simulated setting doesn't contain all the properties of the reference situation. It only retains that which is causing the problem, either to solve it (for design) or to understand or conceptualize it (for learning). In doing this certain dimensions of the reference situation pop out, enabling them to be grasped, to be spoken about, to be manipulated and to be thought about. Meyerson talks about "objectivation" when referring to the process of building an external form, on which the thinking process can be worked on. (Meyerson, 49). But the reference of this form resides in the subjects' activity (rather than in the simulated situation), their understanding and the goals they are aiming at. In a operative standpoint, the subjects' activity is a reference for the construction of the simulated situation.

4. Simulation settings as exchange situations between actors

The fact that simulating involves collective and multi-voice activities appears as a structuring dimension to simulated situations (for design or for learning purposes). Within the framework of simulation for learning purposes, the simulated situation is not a passive mediator. It is not only built by the trainer to guide the elaboration of skills and conceptualization of the trainees, but also piloted throughout the training by the instructor's learning games that can – according to the reactions of the different learners – modify certain parameters of the simulated situation, in the course of the session (Samurçay & de Keyser, 98). One of the reasons for these live adjustments emanates from the fact that trainers tend to make the situation evolve in such a way that the operators are always faced with a problem-solving task.

It appears that the same can be said for the design process. When designing, mediation is not only carried out by means of an operative representation that the designer elaborates as he/she goes along. A large part of the elements making up the model are found in the activity of others. For instance, we observed this inter-personnel mediation (that we have called "collaborative mediation", Béguin, 1994) when CAD is used in the framework of project management involving several draftsmen. In these situations, designers reuse part of the data produced by their colleagues, displaying it on their screens. By re-use of files, the activity of one designer is oriented by the result of the activity of a former.

Inter-personnel mediations are a core dimension when using a prototype between users and designers (Bødker & Gronbaek, 1997). From our point of view, the objective is to give the user's activity the possibility to "slot in" between the designer and his own

production to guide him/her and to provide direction. We have had the opportunity to set up such an approach in an alarm design process in a SEVESO classified sites (Béguin, 2003). An alarm prototype was designed and this was followed by a simulation phase enabling the prototype to be put to action in users' activity. The main idea being that the users' activity would provide direction for the designers. This hypothesis proved to be correct: three different versions of the alarm were produced before coming up with one that was satisfactory, whereas the designers considered the initial version ready for distribution. But the approach highlights the fact that the reference situation was neither conceptualized, nor apprehended under the same light by the users and by the designers. Effectively, whereas for the designers the reference was a major accident, for the users it was the "daily risks", probably less risky but nonetheless real. This was so apparent that it seemed possible for us to analyze the exchange situation between designers and users around the prototypes as a dialogical process between two professional worlds, belonging to two different types of actors. In this type of simulation there is not just one, but two areas of inter-personnel mediation: the first is where the conceptualizations and the designer resources are confronted to the user's professional world. The second one is where conceptualization and user resources are confronted to the designer's professional world (Béguin, 2009).

Simulation setting could gain from being apprehended as a sort of bridge laid down between heterogeneous actors – designers and users, trainers and trainees – as a common ground and carrier of exchanges by means and through simulated situations (Béguin & Weill-Fassina, 1997). Simulated setting enable participants to liberate the stakes at hand and the temporal constraints inherent in a reference situation. But because no simulated situation exhausts access to reality: there are different possible and acceptable versions of the simulated situation, each one giving account of different possible worlds (Goodman, 1978). It follows that simulation situations enable experiments to be carried out on different versions of the world. But this can result in numerous disturbances or disagreements, whether intra-psychic (within the same subject), or inter-psychic (between subjects), leading to many cognitive conflicts. These cognitive conflicts provide the grounds for new developments.

5. Simulation and reflexivity

Making use of a simulated situation not only enables participants to liberate the stakes at hand and the temporal constraints inherent in a reference situation, it also allows for a certain distance to be taken from the action itself. This is an important idea: it is not possible to achieve action and to understand everything that is going on at the same time. So we take part in it and put off the understanding until later. When simulation situations are led correctly, they have to give the opportunity to reflect back on the action itself.

In simulation situations for learning purposes, this reflexive "come back" after the event is part of the training session: it is the debriefing stage, the follow-up to the simulated action. Despite the fact that it is only for the sake of research, the importance of this ex-post analytical phase presents itself as one of the most significant results in research carried out on learning programs for driving nuclear power plants using simulators (Pastré, 1999) : in the heat of the action, the trainees are often "rolled around" the events.. It is only after the event and from using the video recordings of their actions and from traces left from the evolution of the process that they are able to discover the logic behind the chain of events.

It is this ex-post analytical approach that French ergonomics call "self-confrontation". This implies making it possible for a subject (a "user") to exercise a reflexive "come-

back" on his/her own action using recorded traces of observable parts of the activity (on video) and of the situation (by the record of the parameters). During self-confrontation, the action itself then becomes the object of the activity. This method is particularly interesting within the framework of participatory design. One example is the re-modeling of command and navigation positioning for a French Marines fighter plane (Amalberti & Coll., 1999), highlighting the interest therein. The objective of the research was to compare two approaches: (i) approach a - collecting remarks and suggested technical solutions for the current interface from 7 user-pilots, (ii) approach b - organizing a simulation situation followed by self- confrontation. Then, collecting remarks and suggested technical solutions for the current interface. The results show the spectacular effects of simulating followed by self-confrontation. Effectively, the latter approach provided a 42% increase in the total number of remarks formulated, when comparing to the approach a (the approach b being at the origin of 57% of the fine-tuning of remarks, 45% of technical solutions and 30% of complementary remarks centered on the context of action that has be taken into account by the designers).

Two points can be outlined based on this. The first lies in the necessity to lead a thorough ex-post analysis of activity. This role is often filled by the trainer or by the designer who don't always master the fundamentals. The second point is that results of self-confrontation, such as those that have just been presented, are considered in the French ergonomics world as the approach during which the operators develop the conceptualizations they require in order to speak about their own activity. With this in mind, this method is one of the conditions for the participation of users in the transformation of their work situations (Schwartz, 1988).

6. Discussion

The framework of a dialogical design supported by a simulation method lie also in the actors' power relations and the values they put into practice. Because design is characterized by heterogeneity and polysemy, the actors of design can legitimately disagree. These divergences can be treated in two different ways: (i) conflict, for example authority, or the exclusion of certain actors), (ii) or design: the characteristics of the object under design are altered, the criteria are changed, and the objectives are redefined so that the solution is acceptable to all. In the former way problems are solved by eliminating diversity within the group, but the complexity of reality remains. In the latter, design is intended to solve problems by coming to terms with complex reality, expressed through the diversity of points of view within the group. Foucault (2004) stressed the distinction between two forms of 'dispositives'. The first one (named *'Normation')* is characterized by the fact that knowledge is transformed into power. It thus becomes the norm and anything outside of that is abnormal. The second dispositive (*'Normalization')* consists in drawing developmental curves of knowledge to institute normality locally. In many respects the proposals put forward in this paper aim to orientate simulation method towards a less 'normative' form, so that normality is instituted locally through dialogical forms of design.

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