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Framework of Awareness: for the analysis of Ergonomics in Design

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Abstract

The present paper introduces the Framework of Awareness to the analysis of ergonomics in design. The framework is part of a doctoral research that took the Lean Thinking perspective by adopting the concept of MUDA and its set of principles as dimensions to study designers’ behaviour in industry. Results were integrated into a Framework of Awareness to critical situations and crucial actions in design, with application in the research field of design and product development for managerial support, and of particular interest for the analysis of ergonomics in design. The framework is the result from detailed non-participatory research across five design disciplines. The framework proposes a mindful approach to the analysis of critical situations through a structured procedure but without requiring specific technical knowledge. The framework aims to support designers and developers to the awareness of critical situations and opportunities, through a set of principles-based, iterative and momentarily application. The Framework is proposed to the design practice to nurture a culture of awareness and provide guidelines to support designers’ framing their interventions and eventually change previously identified less successful behaviour.

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1. Introduction

In the past, design awareness was defined as the ability to understand and handle ideas expressed by the means of doing and making [1]. Nowadays, design awareness has become a relevant design aptitude in the context of complex...
and collaborative processes of design and product development. As these processes are taking place in a certain social and societal environment the context of the design activity plays an important role in creating influences and consequences in designers’ behavior and the design performance while managing the underlying mechanisms of Value creation in design. These situations take place due to unforeseen influences and consequences, lack or excess of prevention, a mind frame that does not allow to see further or refuses a sudden aspect. Inherent to the occurrence of downside consequences is the risk to diminish designers’ input of Value for the creation of design results in circumstances comparable to the concept of MUDA, in situations of value waste. The research-based framework [2] places in perspective the Lean Thinking concept of MUDA [3, 4] as a key dimension to study designers’ behavior in such situations and provide managerial support in the research field of design and product development. On a daily basis designers have to keep one’s countenance and stand for situations such as, postponement, hindrance and emergency. Occasionally some of these situations lead to valuable inputs essential to the design process, though, designers are not always prepared to attempt and succeed in taking the best from these circumstances. The concept of MUDA is reinterpreted and defined in the context of this research, as critical situations in designing. Such situations emerge and designers’ behavior is twofold: designers do not grasp a reaction to cope with the difficulties leading to missteps; designers are able to evaluate the dynamics of the situation and make the appropriate decisions to proceed. The first case waste the main concern, the second case wasthe goal: support designers with empirically derived knowledge on adaptive behavior to improve performance towards decision-making in critical situations in design.

As Lean Thinking embodies a motivational approach to keep procedures of value creation at high standard, this research proposes and extends such motivational approach with a framework of awareness to keep designers behavior and design artifacts in high performance.

2. Theoretical Background

From the literature in design research few attempts provide further understanding of the sources of fruitless or successful performance. In most contributions focus on downside aspects of specific issues such as stuckness [5], non-generating alternatives [6], inappropriate focus of attention [7] and confirmation bias [8].

Design and product development research has paid little attention to these design management issues on an empirical basis. The traditional prescriptive models such as the Basic Design Cycle [9] but also newer approaches such as the VIP approach [10, 11] and other product development structured methods [12, 13] do only partly represent the sources and possible effects of critical situations that designers and developers might have to cope with, as well as actions to improve performance.

Taking the Lean Thinking perspective to study designers’ behavior and performance, was seen as a challenge, similar to identifying the pathologies of designing, its causes, effects, typical behavior and coping measures. For the unacquainted, Lean Thinking (LT) is a domain-independent philosophy of Management that was brought from Japan to USA and Europe. LT was originally based on five principles, namely Value, Value stream, Flow, Pull and Perfection with the purpose of eliminating MUDA in any value creating activity. MUDA, the Japanese word for waste, is defined as ‘specifically any human activity which absorbs resources but creates no value’ [4, p.355]. Value is defined at the start of any process and MUDA, if inevitable, is converted into Value. Lean Thinking was initially derived from the manufacturing context [14], however its philosophy of guiding principles of behavior has applicability to a large variety of processes, people and organizations [15], with demonstrated practical results. Progress has been made in implementing and raising awareness of LT in several fields of practice and research, and it has been expanded to Lean Product Development (LPD) with contributions on techniques [16], sub-systems [17], principles [18], management domains [19], knowledge domains [20], system design framework [21] and the Lean Advancement Initiative several contributions [22]. However, a gap in the understanding and linking Lean Thinking and its principles to the creative dimension of design and product development has been identified. Though, as a motivational framework, LT provides concepts, which are relevant to the design activity and to designers’ behavior and performance such as the dimension of Flow [23]. At the same time, designers’ sustainability concerns and talent to create Value from waste, unintentionally makes them Lean Thinking enablers [24] in a world that disregards and keeps generating MUDA.
The knowledge area of design ergonomics is crucial for coping with the MUDA/critical situations that can take place in the design of artifacts. Lean Thinking is a philosophy guiding principles of behavior [15] for the business context where aspects such as quality, flow, time and cost play an important role in the creation of Value. Such elements are also of major importance for the designing activity, under the pressures of the business context. The reinterpretation of the Lean Thinking principles in design asked, in particular, for the translation of the concept of MUDA in design.

This research took the Lean Thinking concept of MUDA to a higher level of Value creation that relates to the search for variables of what is not known, while designing Value. From a research implementation point of view, Lean Thinking seemed to be the adequate motivational framework to identify characteristics of less effective designers’ behavior and coping actions to uphold performance, assuming first and foremost that design derives from a process where Values not completely defined in the beginning, once ‘The final outcome of designing has to be assumed before the means of achieving it can be explored.’ [25, p.10]. This unavoidable assumption opened the way for the translation of Lean Thinking into design as an activity that explores Value variants and invariants, where uncertainty, risk, and sometimes change play a resilient game. The design process is by nature iterative [26], designers seize the hints of a design problem and by making many essays designers and developers pursue perfection through iteration processes, correcting all the inaccuracies concerning the final result.

This research supports the premise that design can be studied as a distinct activity that transcends disciplinary boundaries [27, 28]. As a process of thought, design entails mental and physical actions that designers have to manage to be able to cope gainfully with the social process of designing in a business context. Designers and developers from different background disciplines specify attributes, properties and qualities towards design solutions and ergonomics concerned based results. Collaborating and sharing the design process are tasks that ask for management skills, which in turn requires concern with inter-professional collaboration and acquaintance to each other’s criteria of judgment.

To each background design discipline particular characteristics have crucial role and influence designers’ approaches. This is supported by the concept of object-worlds [29], the idea that different participants in design see the object of design differently depending upon their education, background, training, competencies, responsibilities and technical interests. Design involves mental models and a rich set of semantics [30], the materialization of the semantics takes different forms across design disciplines and designers’ approaches. Designers approach influence the teamwork that, similarly to the individual process, involves a shared perceptual act and a cognitive strategy and in addition, a co-development of problem and solution. Adopting LT, as theoretical perspective, provided a lens and the opportunity to take a non-discipline-related way to approach design across disciplines [31], for which the idea of eliminating MUDA along the design process is common across disciplines and entails specific situations to be supported. The research explored the analytical principles adopted from the Lean Thinking and took them as dimensions of analysis in the designing context to reach the synthetic principles and integrate the set into a framework.

Similar issues have been addressed as critical decisions in risk and uncertainty management approaches to design and product development [32, 33, 34, 35], and in risk management in Lean Product Development [36]. In design research, such circumstances have been differently tackled. About forty years ago, John Christopher Jones drew a list of five criteria for design project control from a long list of observations mentioned by many of the design theorists he refers in his seminal book, Design Methods [25]. The first of the five criteria is - the identification and review of critical decisions. Since then other related attempts were made, namely, the concept of critical design moves [37], derived from a study made with teams of product design engineers, the method of critical situations [38], derived from empirical studies in the engineering design practice that depicts mechanisms that lead to success or failure in different types of critical situations. However, research on critical situations misses empirical study of the nature of the phenomenon, its sources and copying measures based across design.

A general framework on the sources of critical situations and crucial actions to uphold performance in design and product development was missing. Though designers and developers might be experienced, they are not always prepared to cope with these situations and its consequential effects such as delays, conflicts but often also successful outcomes. In circumstances of uncertainty and risk, designers and developers can miss orientation and fail to perform effectively. Such situations require the identification of crucial actions and adaptive behavior to cope with
downside effects and sense opportunities for constructive outcomes and consequent management implications to designers’ decision-making.

3. Methodology

The explorative study was a Case Study based approach in five design disciplines gives ground to the research. Case studies provide a research environment propitious to gather practical, concrete and context-dependent knowledge essential to gain insight into causal mechanisms, and contextual considerations [39]. This research entails multiple Case Studies selected to compare clearly different examples, embedded [40] or nested as subunits [41] to investigate the phenomenon of MUDA in design as the principal unit of analysis.

In this research the case study method was based on periods of observation for the analysis of persons and projects studied holistically and in detail by one or more methods of analysis. From the progressive studies, instances of classes of phenomena provided analytical frames and guidelines to conduct the research to categorization systems [42], illuminating the explanations on how to integrate the complementary results in a whole picture of an integrative framework. Multiple cases from different design disciplines were used to strengthen the external validity and enhanced the generalizability [40, 41] of the Framework of Awareness. The careful selection of representative and instrumental case studies per discipline [43] was based on a variation in cases to obtain information about various situations of MUDA in the design process, complement data and refine results.

The case studies selection was focused on design disciplines, which design processes, go through stages of materialization of ideas with tangible and intangible effects. The research adopted case studies representative of each design discipline that could also have a revelatory character [41]. The case studies are based in four design consultancies established in the following design disciplines, graphic design, architecture, interaction design and mechanical engineering and one group of industrial design graduating students. The selection criteria of the case studies was based on the identification of trustworthy design consultancies known for its reputation, with an organizational structure of ten people average, where behavioral patterns could be derived from examples of competent performance and led by design experts. Context-dependent knowledge and experience are at the very heart of expert activity [39], thus the well-know experts’ ability to arrive at problem diagnoses and solutions rapidly and intuitively was a central criterion for the selection of design consultancies and its leaders [44]. Other criteria for the selection of design consultancies was to choose design environments where people like to work and feel engaged with, have free choice and freedom to speak so that their reports would be honest. Fulfilling these criteria, the validity of inquiry in the action context was not threatened by defensive routines of including self-censorship and face saving.

4. The Framework of Awareness

A Meta-level Behavior Framework derived from data analysis is depicted in Table 1. Main categories represent the sources of critical situations and crucial actions and the second level categories represent the challenges designers face in order to continue, keep Flow, and pursue their objectives. The definition of each category is provided.
Table 1. Sources of critical situations as drivers for crucial actions in design

<table>
<thead>
<tr>
<th>Sources</th>
<th>Challenges</th>
<th>Examples of less successful behavior in critical situations</th>
<th>Examples of successful behavior in crucial actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dosage</td>
<td>Adequacy</td>
<td>Missing criteria</td>
<td>Look for essential criteria</td>
</tr>
<tr>
<td></td>
<td>Balance</td>
<td>Over/ under dosage</td>
<td>Make things matching</td>
</tr>
<tr>
<td>Planning</td>
<td>Probability</td>
<td>No risk evaluation</td>
<td>Contingency planning</td>
</tr>
<tr>
<td></td>
<td>Anticipation</td>
<td>No view of the future</td>
<td>Foreseeing opportunities</td>
</tr>
<tr>
<td>Framing</td>
<td>Orientation</td>
<td>Difficulty to choose</td>
<td>Reflected choice</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>Stuckness</td>
<td>Convergence</td>
</tr>
<tr>
<td>Information</td>
<td>Surprise</td>
<td>Missing opportunities</td>
<td>Opportunistic procedure</td>
</tr>
<tr>
<td>Assessment</td>
<td>Knowing</td>
<td>Clients that do not know what they want</td>
<td>Look for information</td>
</tr>
<tr>
<td></td>
<td>Transparency</td>
<td>Difficulty to grasp the features of a problem</td>
<td>Searching for indicators</td>
</tr>
<tr>
<td>Information</td>
<td>Communication</td>
<td>Confirmation bias</td>
<td>Transparent communication</td>
</tr>
<tr>
<td>Transfer</td>
<td>Exchange</td>
<td>“Tunnel view”</td>
<td>Awareness of the need for sharing information</td>
</tr>
<tr>
<td></td>
<td>Documentation</td>
<td>Not keeping record of sub-results</td>
<td>Keeping record of sub-results</td>
</tr>
<tr>
<td>Interdependency</td>
<td>Interfaces</td>
<td>Acting without reference to others involved</td>
<td>Awareness of the different interfaces involved</td>
</tr>
<tr>
<td></td>
<td>Suspension</td>
<td>Missing feeling of competence</td>
<td>Take time for decisions and keep in mind long and short term consequences</td>
</tr>
<tr>
<td>Envision</td>
<td>Open up solutions</td>
<td>Difficulty to think into the future</td>
<td>Generating alternatives</td>
</tr>
<tr>
<td></td>
<td>Representation</td>
<td>Difficulty to represent a concept</td>
<td>Providing clear examples, good graphics and visual proposals.</td>
</tr>
</tbody>
</table>

Dosage - refers to the need to find adequacy (enough in quantity or good enough in quality for a particular purpose or need) or balance (emotional, economical, aesthetical, or negotiable stability) in the quantity and quality of different activities and measures, in order not to overdo or be underdone.

Planning - refers to situations which need an action plan for the future regarding the extent to which results are likely (probability), and the extent to which something is expected or predictable and take action in order to be prepared (anticipation).

Framing - refers to situations that hinder or provide orientation (direction to proceed) and focus (concentrating interest, to adapt or adjust so that things can be seen clearly), that need to be framed or reframed.

Information assessment - refers to the awareness of the relevance of a situation that shows the absence or latest information and that relate to: moments of surprise (denoting something made, done, or happened unexpectedly), transparency (difficult to perceive or detect) and knowing (what is known or not about facts, information, and skills acquired by a person through experience or education), which create ambiguity and uncertainty that can hinder the process but can also be beneficial to generate alternatives and overview.

Information transfer – refers to situations where the transference of information requires to deal with different challenges such as: communication (the successful conveying or sharing of information, ideas, feelings, news, through the means of sending or receiving information), exchange (an act of giving or doing something to somebody and receiving something in return) and documentation (the act on recording material that provides official information or evidence or that serves as a record).

Interdependency – refers to situations where the need to establish or undo interdependencies, is made through the creation and recognition of interfaces (a point or moment where two systems, subjects, organizations, etc., meet and interact, such as people, companies, expertise, software, technical limitations) or suspension (the action of suspending someone or something or the temporary prevention of something from continuing or being in force or effect).
Envision - refers to situations that request to start imagining future possibilities regarding the design goal, solution or sub-solutions, taking different perspectives, giving form to mental images or making something visible to the eyes through representation and feasibility assessment.

Such situations can hinder or further the design process regarding the extent to which such mental or physical images of solutions are created with flexibility, taking different perspectives, providing a wider ideation space to be unfolded, and solutions to come into view.

All the sources of critical situations can be found in circumstances that make decisions vulnerable that might do not intend side and long-term effects, risk and uncertainty. Therefore, being aware of sources of critical situations and crucial actions to cope with these circumstances is essential for practitioners, students and design teachers.

Results from the Likert scale-based questionnaire show an agreement of 83.8% with the categorization system. Average of the 16 sub-categories is 4.2 (1-5). The average of each of the five categories are between 4 to 4.3. The average of importance attributed to the seven categories is 5.2 (1-6), all the seven categories over 5.

The empirical studies accomplished through the perspective of the Lean Thinking philosophy led to the identification of the following set of characteristics that constitute the Framework of Awareness. Three stages are relevant to the framework of awareness:

Input - There is an input situation based on a request to discuss a Priority Issue that starts with a question based on a doubt or update request regarding an essential feature.

Instance of evaluation – There is an instance of evaluation that from the analysis of the request evolves to a point where one of the team collaborators states opposition based on the identification of not-existing, not assured or not working essential features. The discussion involving all the present collaborators is focused on the opposition and each designer argues his/her point of view based on the set of values inherent to his/her own activity. The identification of the source of the critical situation is spontaneous or based on the proposed categorization system, which can help keeping track and eventually mapping the sources of critical situations. A categorization of challenges defies designers to figure out what can be done and which action should be taken in case a resolution does not arise spontaneously.

Output - There is an output situation where a team-based decision is made. Two things can happen, a decision based on the agreement of a crucial action to be taken, or a postponed decision based on interdependencies with other design issues, uncertainty or ambiguity among other aspects, that leads to iteration processes.

5. Conclusion

As a result of 5 case studies in five different design disciplines a framework has been developed which provides a meta analysis to reflect on thinking and acting in critical situations. Using this framework can help the designer to what prevents designers from changing. The usefulness of the practice of this framework involves an internal review so that each designer can become aware of the degree to which usual performed patterns are consistent with a less successful process and outcome. The framework thus contributes to the designers’ professional competence and to professional education assuming that competence is based on the ability to analyze critical situations and also to theories of what to do in new situations and to behave effectively [45].

The Framework, if adopted by designers and developers, can lead to a mental state that allows reflection on a meta-view of the situation. The practice of this mental but also tangible exercise in critical situations of the design practice brings an educational aspect of adaptive behavior that can be absorbed into a more natural behavior with time. Consequently, it can lead to better communication, and a more thorough analysis and awareness to adaptive behavior.

The empirical evidence of such characteristics contributes to transdisciplinary knowledge on elements of decision-making in design with application in design practice and education. Design practice, management, and education in the areas of design and product development field can benefit from the present contribution.

Findings aim to enhance the knowledge about designers’ and improve behavior and performance supporting designers’ need to “observe their own thinking in a objective way” [45, xii] for an effective Value definition in the design process. The thesis extends the notion of performance to a broader meaning, not just product performance but people performance with procedures that can be quantified, not just quantitatively but also qualitatively.
This research speculates that a principle-based approach still remains systematic but also a flexible approach to design. The usefulness of the practice of this framework involves an internal review so that each designer can become aware of the degree to which usual performed patterns are consistent with a less successful process and outcome. The framework contributes to designers’ professional competence and to professional education supporting designers with empirically derived knowledge on adaptive behavior to improve performance toward decision-making and design artifacts effectiveness.

This research proposes a principle-based and domain-independent approach that can help designers with sources of critical situations and the elements of crucial actions that can influence decision-making and the trajectory of the design process but also understand the consumption of several types of resources, such as time and creative stability, while upholding performance, persevere with motivation and assuring the design artifact reliability.

This doctoral research proposes crucial management for a systemic view of critical situations and support research of coping mechanisms of crucial actions. Detection mechanisms such as, anticipating, sensing, reacting to, containing, learning from, and redesigning effective organizational procedures constitute mental and physical actions that nurture awareness in the acts of management and designing.

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