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DESIGNING ENRICHED LEARNING ENVIRONMENTS: A CROSS-DISCIPLINARY APPROACH TO SOCIAL INNOVATION

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ABSTRACT
This study investigates the state of art in the contemporary scenario in the education of people with intellectual disabilities through industrial design and product development in a cross-disciplinary setup focused on children with Down Syndrome (DS), Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD). The article addresses social innovation contexts facing barriers of discrimination within educational environments and the potential of design discipline in this regard. This article revises key debates concerning: 1)the paradigm of inclusive education; 2)insights from fields of neurophysiology and neurobiology: neural correlates between learning and creativity; and 3)design driven innovation in education aligning social, political and technological factors. It hereby represents a contemporary reflection on the core ideas of Victor Papanek's work Design for the real world. An experimental outcome is presented outlining a framework of cognitive and emotional ergonomics in regards of creativity and ethics in product design education as learning tools for managing language, meaning generation and technology.

Keywords: Social innovation, cross-disciplinarity, creativity, cognition, emotion.

1 INTRODUCTION

Cross-disciplinarity in design has been regarded as valuable approach for developing innovative solutions that can respond to complexity of ill-defined problems. These are targeted to be 'wicked' because the knowledge needed for solving them is in a continuous construction and therefore they entail a constant reformulation of the problem and constant evaluation of the solution [1]. Achieving innovation by bringing together different disciplines into design process has been incorporated in public and private sectors as strategies for synthesizing a diverse range of information, providing focus and structure in managerial operations of technological processes [2].

In the other hand cross-disciplinarity has also been incorporated in the context of social innovation that aims to sustainable changes at a regional scale by activating citizen participation and collaboration among sectors of population [3]. In developing countries this participation has oriented its efforts to a considerable extent confronting marginalized needs of critical scenarios (e.g elderly people, extreme poverty, the disabled and sick [4]). Innovation in this regard is defined by a set of common goals which are pursued by communities for solving obstacles present in everyday life terms, and which have lead communities to explore in creative activities together with design initiatives.

Creativity as an isolated phenomenon poses vast research about anatomical and physiological mechanisms involved in its operation, whereas establishing an empirical and consistent framework is currently being investigated by multiple domains of science. For the purpose of this paper, creativity will be addressed as the ability to bring something into being that is original and appropriate [5], which involves the activity of neural circuits to process information and to generate novel combinations of that information [6] by engaging into co-activation and communication areas of the brain that are not usually connected [7]. Furthermore, several researchers outline its relation with modes of thinking immersed in creativity distinguishing among them: working memory, convergent and divergent thinking which have been also incorporated within constructivist models of learning.

In the scope of engineering and product design education, creativity is oriented for managing complexity and proposing coherent solutions that align technology with aesthetics, by taking into consideration the generation of value for users and competitive advantages for organizations. The processing of cognitive and emotional information hereby involved is a highly intricate recursive activity during the sophisticated and differentiated cascade effects that design products and processes entail (e.g electromagnetic waves of digital devices). Nevertheless, understanding the realization of creativity as a substrate for growing a set of relational behaviours in social systems can act as a learning platform for managing design processes at a tertiary level, or in other words, to contribute in the origin of design practices, theories and ethics [8].

This article reports specific learnings, insights and paradoxes resulted from a collaborative project with disciplines of Neurophysiology & Cognitive Neurobiology, together with Pedagogy & Education; responding to fostering creativity in children with SD, ADHD, and ASD in everyday life terms. The project was carried out as an experimental case study at the Chilean context in three main stages with consults to primary and secondary sources. The result was a line of products investigating a framework of cognitive and emotional ergonomics as human factor design, focused on multisensory stimulation within schools and families. The exploratory framework described in 'Figure 1' was derived from the project and seeks to complement design education with practical tools for developing creativity and ethics on design students formation in regards of cross-disciplinarity and design driven innovation [9].

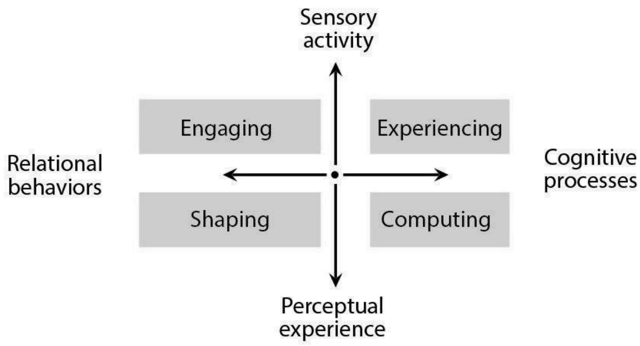

Figure 1. Domains of creativity immerse in design driven innovation in two dimensions: 1)modulator and 2) mediator

The maps represents the domains of creativity immerse in design driven innovation in two dimensions: 1)information embodied in shape language by modulation of social behaviours [8] through engaging the grade of participation that key social actors have in design processes; that is also 2) immersed in the mediation of the formative process of the user brain's architecture through the use of products, and thus influencing their physiological condition of entities organizing living social systems [10]. Is stressed that design activities modulating behaviours and mediating physiology are presented non-linearly, by simultaneity and causality in a differentiated manner. The map was built with insights from practitioners contributing actively in the design process of the experimental outcome.

The two relations of creativity applied in design language and hence in the design process involved were defined firstly as *modulator* forming values for an specific social system by a set coordinations of design activities described as a)experiencing, b)computing, c)shaping, and d)engaging; and secondly, as *mediator* of the user's physiological condition activating or inhibiting a)sensory activity, b)cognitive processes, c)perceptual experience, and d)relational behaviours.

2 CREATIVITY IN A CROSS-DISCIPLINARY SETTING FOCUSED ON A CASE STUDY OF SOCIAL INNOVATION

2.1 Background and overview

The development of creativity for attending the needs presented during the early childhood development (between 0-6 years old) was analyzed under the scope of social innovation. The Chilean context reports multiple obstacles in learning scenarios along the national territory, mostly based on the lack of a defined educational system [11] which can surpass discriminatory distinctions between children with and without Special Educational Needs (SEN)[12] in everyday life terms. This is evidenced through diverse cultural, political and technological barriers with adjacent edges in learning evaluation methods, formation of teachers and didactic resources.

In the last one, learning resources endorse these distinctions because they do not contemplate in their formulation physiological particularities of each learner. The objective of the project was to contribute with a technological definition of inclusive learning resources through designing a line of products that maximizes learning with creative abilities in children with 'cognitive limitations'. The project was accomplished in three stages in a one-year period applying quantitative and qualitative methods. This involved the participation of practitioners and academics from other disciplines in the phases of the design process: problem framing, research, concept development and evaluation.
The cross-disciplinary setup consisted in a field study with collaboration of 8 elementary school teachers, 4 specialist in education, focus group with 10 parents in a primary school, 4 specialists in neurophysiology, and test in 17 users between 2-10 years old. The result was a set of three products made in magnetized wood where each one can be rearranged to form predefined configurations to play with by developing cognitive skills of logical reasoning applying divergent thinking. The cross-disciplinarity was focused to co-activate and interconnect sector of population with a common goal applying creativity through design products and processes.

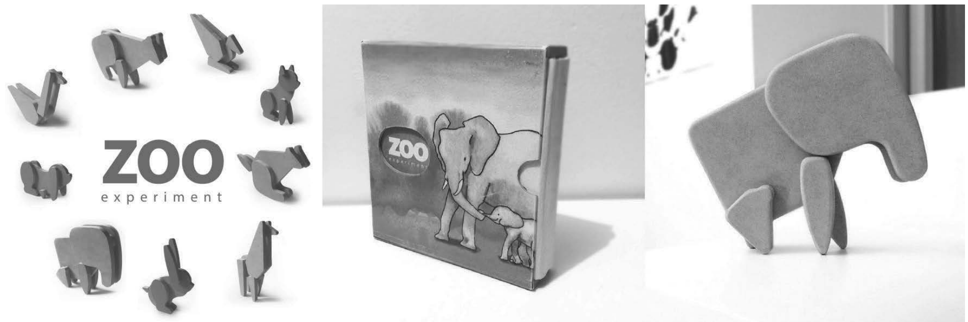

Figure 2. Experimental design outcome from a cross-disciplinary project for social innovation context in children with Down Syndrome, Attention Deficit Hyperactivity Disorder, and Autism Spectrum

2.2 Background and overview

The design project was prescribed in a specific marginalized scenario of collaborative citizenship facing the ill-defined problem of developing creativity in children with intellectual limitations. This was carried out through coordinations of design activities that allowed the discovery and establishment of organized relations among key social actors and scientific concern expressed in everyday life terms. The mechanisms for framing the problem were complemented by *experiencing* contact with other fields converging within the context. For example, framing the developmental background of users on real-life context made possible to identify previous ideas known by children with a grade of significance that acted as a platform for new associations of ideas: animals and puzzles.
The research activities were oriented for *computing* the diverse emotional and cognitive information experienced. This was done by establishing associations between the creative drive that communities explored in design initiatives with the impact that scientific concern reported in the case study. This information was used for setting guidelines of the design project and the solution. For example, inclusive approaches can be observed in Universal Design for Learning setting principles for maximizing accesses to the realization of learning processes through digital technologies and symbolic representation.
For the concept development phase creativity in design activities was oriented for *shaping* key sensory, cognitive and emotional information into coherent solutions that articulate the product structure. The embodiment of this information in the design outcome considered the user's brain cognitive and emotional functions [13] for building the learning experience that the product shall trigger. For example origami was taken as inspirational element to simplify the shape essence of animals in its folds and communicate this with magnetism, strategic materials and productive processes of local manufacturers.
In the evaluation phase through test with users, activities of iteration and integration were applied for *engaging* interactions among key actors of the social system enhancing the activity of an established social network by forming new connections when designing and placing the product. 'Figure 3'

exemplifies the process of shaping in the early stage of the process, where the technologies and language were defined by the experiences of communities involved.

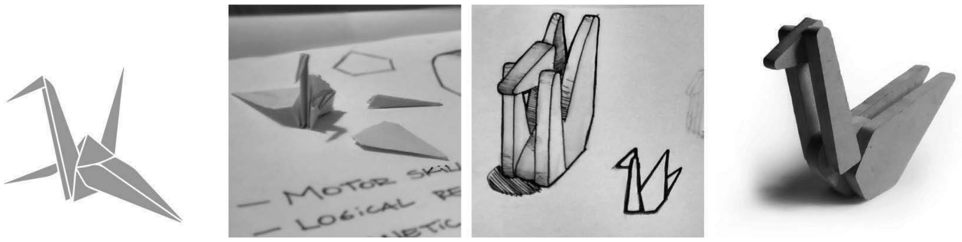

Figure 3. Example of shaping activities in one of the three modules of the game

These organized relations put together through experiencing, computing, shaping and engaging, were determined to characterize critical factors impacting in the user's social system. In the context of the project they are compiled in 'Figure 4' as the interconnection between real-life context in everyday life scenarios, key social actors expressed in scientific concern, design initiatives embodying language and technology, together with creative drives in the form of behaviours. The organized relations between these components were observed during the project to be intricately connected, and were differentiated for each user. This allowed the visualisation of isolated opportunities for developing new products and processes.

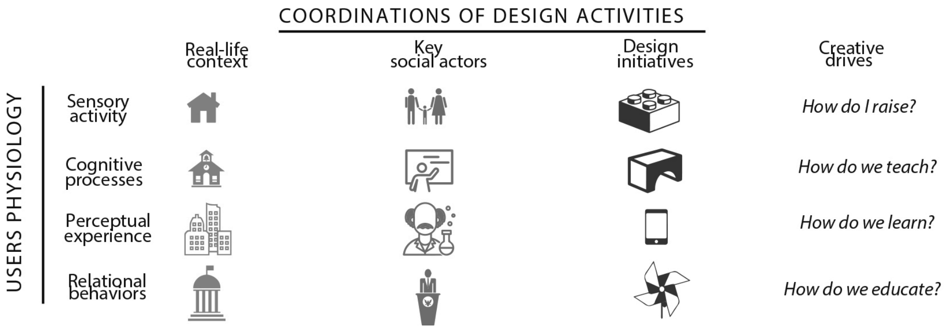

Figure 4. Organized relation modulating the coordination of design activities and mediating in the user's physiology

2.3 Insights

The physiological condition of users, defined by the formative processes of their brain's architecture where genetics, environmental and experiential aspects converge, are hypothesized above as the conjunction of a) sensory activity, b) cognitive processes, c)perceptual experience, and d)relational behaviours. The domains of creativity in design driven innovation processes in the project were observed to be activating or inhibiting neural mechanism during the orchestration of one of these events when positioning design products in the context of the case study.

This assumption was based on the brain research revolving the notion of enriched learning environments [14], where enrichment provides instances of complex interaction, social and sensory stimulation through objects. In this project, communities reported this notion as a common goal of inclusive educational strategies for developing creativity and learning processes in children maintaining a harmony and rhythm in colours, textures, smells and sounds in the didactic resources used.

The *sensory activity* relates to the information operated through electrical impulses by physiological mechanisms of the user for managing sensory inputs and motor outputs in the interaction with the product. Memory mechanisms were identified to be crucial for developing creativity and learning in users, which dexterity was commonly exercised through problem solving tasks potentiating logical and mathematical reasoning skills in concordance with collaborative activities such as construction games.

The *cognitive processes* in the user's dimension involve activities of associating and computing information during interaction with the product, where diverse brain's areas co-activate and interconnect emotional and cognitive information. For example models such as meaningful learning pose strategies for managing novel idea generation, creative drive and divergent thinking in educational environments using musical and artistic composition in classes of language and mathematics.

The *perceptual experience* of reality of each user relates the conjunction of conceptual thoughts managed in computations of cognitions and emotions (e.g the definition of a self-consciousness in children) mediated by supra-conceptual thoughts managed in extra and trans-linguistic information in a relational space within a social system [15]. Describing a consensus in the correlate of the neural circuits associated with emotional mechanisms during cognitive processes is currently being studied.

Furthermore the *relational behaviours* of the user were described as the coordination of computations for triggering motor and emotional responses based on the user's perceptual experience when using the product. The design of learning instances was identified to be the core of education providing the formation of new behaviours for organizing social systems, where posing creativity and inclusion as relational behaviours in collective and universal terms has been incorporated in political and technological agendas across multiple countries as a long-term pathway towards sustainability for managing at a macro-social scale the complexity of the global economic environment [16].

3 CONCLUSION

The development of cross-disciplinary process focused in a social innovation context through the realization of the project made possible further cognition, mentation and reflection on paradoxes for elaborating the maps as learning tools for creativity and ethics in engineering and product design education at a tertiary level. The models presented were a result of projects based on a reduced sample analyzing creativity with few quantifiable data and so they do not comprehend a valid representative study. This reductionist approach poses difficulties in the definition of finite technological solutions of inclusive learning resources through relating product with experience to create value in a specific sector of population. The project was focused on potentiating logical and mathematical reasoning skills where design language came to being through reducing the gap between real life scenarios and scientific concern, whereas other areas of development were excluded. The modes of convergent and divergent thinking involved in the relation between creativity and learning are arranged simultaneously and causally along the formative process of the central nervous system in a continuum holistic and integrated way. With the project the application of a holistic stimulation during the milestones of early childhood development was observed to be a functional need driven by experience of products, and it stands paradoxically as a contrast to reductionist approaches of product design examining isolated events for problem solving situations. Nevertheless the article provided an exploratory framework of cognitive and emotional ergonomics, together with tools for integration and convergence of diverse design methods for contributing the development of creative capabilities and capacities of design students for cross-disciplinary projects based on design driven innovation. The article also presented an experiential-based design project where the designer became aware of the application of different modes of thinking strategically oriented in decision making process in design driven innovation.

4 DISCUSSION

In industrial design engineering, the focus on intellectual disabilities or marginalized needs in general is not a main field of interest. However by scouting in this area it was found that design language have a level of influence in the self-productive activity of users and social systems through the experience designed behind products and could provide a substrate for inclusion. This influence is evidenced when language and technology meet as a social self-productive activity between learning and creativity in material. The paradoxical relation in integrated products between holistic or reductionist design processes can be observed in contemporary streams such as product and service system design (PSS), which locates new products designed as an integrated whole in the form of product and services offerings that takes into consideration a life-cycle perspective in relation to customer's value [17]. However in this project the role of education providing learning processes in the form of services demands a more cautious review, since the study case revealed a shifting of perspectives from students as consumers to students regarded as creators as a common vision of possible future. This shifting can be regarded in the emphasis of streams such as universal or inclusive design in the formation of a collective consciousness to face universal needs. The discussion then is suggested to delve in the extent that this shifting in the service approach oriented to communities which points out to the foundations of design processes can serve as a learning platform of design ethics for future designers managing challenges of innovation contexts.

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