Cognitive styles in Industrial Design.

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Abstract **-** The article presents the results of a research Project aimed at making a characterization of Cognitive Styles (CS) in the dimension of field sensibility-independence, of a sample of 126 Industrial Design students of the Jorge Tadeo Lozano University (JTLU) in Colombia, 90,47% of them come from the central Andean region. The guiding approach of our project is the Theory of Psychological Differentiation in the version of the Sawa, Gottschadt, Embedded Figures (SG-EFT) [20]. The results of the SG-EFT tests are crossed to some variables of individual, eco-cultural and social study identifying the conditions of cognitive styles that favor processes of innovation. These indicate a trend toward students with a field independent style. The results support some correspondence to those of Hederich et al. and other researchers in the field independence trend. It is expected that this project contributes pedagogy and didactics within the university context, add guidance to future generations in the development of design abilities and play a role in the processes of innovation.

Index terms- cognitive, field sensibility-independence, industrial design, university students.

I. BACKGROUND

One of the founding theories that originated the concept of cognitive styles was initially advanced by Herman Witkin et al. (1962) known as the Psychological Differentiation Theory. This theory, product of the research of Witkin and his team, led them to organize it in a new structure which could no longer be understood based on the trend of a scheme of 'global personality'. The different findings were structured under the concept of 'differentiation' understood as 'a useful construct to conceptualize the wide range of individual consistencies…' [24] (pp.26-41).

Cognitive styles are associated to forms of processing and responding to the environment, according to previous schemes of perceiving, processing and storing information. This study is centered in the dimension of field sensibility/independence[1].

An ample part of the work in this field of contemporary research corresponds to inquiry in pre-undergraduate formal education (for example, Hederich y Camargo, 1995, 1998, 1999 y Hederich, 2004; Iriarte y cols. 1986) with interesting developments in basic education. Some work, though in a minor scale, in higher education has been identified and with limited work in the discipline of design in Colombia. Copeland [3] explored the cognitive styles showing high presence of the female gender. Other studies with university students are those of Sternberg & Zhang [23] evidencing the cultural relevance of the styles. Studies in the Colombian context such as those of Iriarte, Cantillo & Polo [4], [5] explore the relation between cognitive styles and professional University programs.

II. GENERAL PURPOSE

The general purpose is to make a characterization of the Cognitive Styles in the dimension of field sensibility-independence, of a sample of Industrial Design students of the Jorge Tadeo Lozano University in Bogotá, Colombia. While, this study aims to highlight the close relationship to the design, psychology and pedagogy.

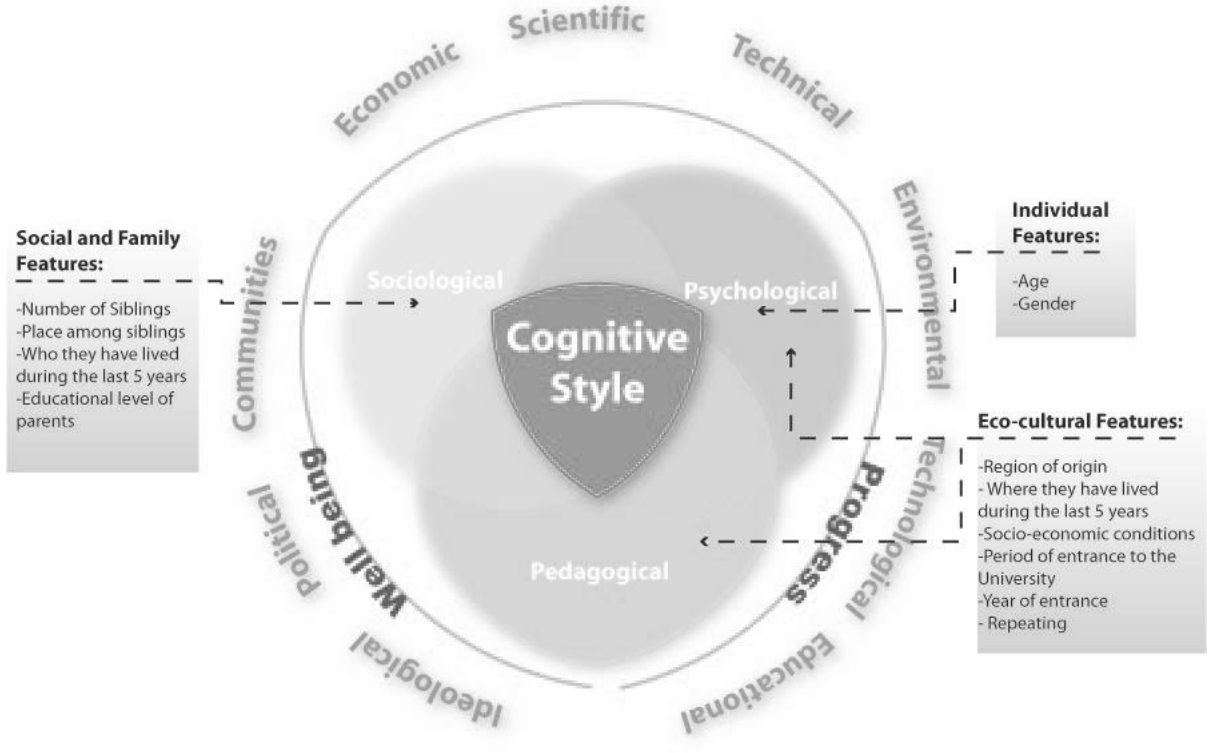
III. SOCIO-CULTURAL CONTEXT

The cognitive styles, in the case of design, present a complex process. It must be modeled through the capacity to identify and establish design opportunities, especially in the possibility to generate semantic richness when constructing problem space that make possible the proposal of a solution to the gap through a divergent mode, mediated by the designer's experience and capacity of adaptation so he can relate with his environment (Witkin, 1965) [24]. Maldonado and Andrade [22], note that "the designer is considered an information

processing system (IPS) of low capacity, which faces an environment of a complex task and great dimensions".

Figure 1 shows elements of the complex and systemic structure of relations that influence shaping of the cognitive style, dimensions (sociological, psychological and pedagogical) that are crucial to project personal and social innovation and to the individual and eco-cultural variables that are explored in this study[2].

Figure 1. Structure of the relations that influence the cognitive style.



IV. METHODOLOGY

The Hederich et al. (1995) version of the SG-EFT (*Sawa, Gottschadt - Embedded Figures Test*) was applied to 126 students selected through a random probability sample. The suggested approximation percentage was of 2% of the total population of students of the Industrial Design program according to Hernández, S. et al. [21]. To record the data an Excel 2007 spreadsheet was used and for processing and analysis, the SPSS v.15 program was employed.

4.1. MATERIALS

The Test of embedded figures: The research version of Hederich et al.[3] [20], [15] tool who made an adaptation Sawa-Gottschadt test (1966) has been widely used in Colombia[4]. It in turn proposes a test based on the initial figures of Witkin et al. (1950) [24]. This instrument has a Cronbach alpha reliability 0.91 to 0.96[5] and a Spearman-Brown corrected value of 0.9412[6]. Also, Iriarte et al. [4] y [5], citing data from Macias and Fernandez (1985), show high correlation indicators of the SG-EFT with the GEFT tool (group version for adults of 0.833).

The SG-EFT (Sawa, Gottschadt - Embedded Figures Test) was used, due to the fact that with it one can identify the capacity of students to unmask a simple figure within a well organized and additionally complex field of which it is part, measuring the speed of perceptual restructuring. As noted by Hederich taking up Witkin: "Thus, the field dependence-independence started to be conceived as a dimension of perceptive and analytic aptitude that would be manifested through all the perceptual exercise of the individual (Witkin et al, 1954)". [15], p. 14.

V. SG-EFT RESULTS

Some results of this study are presented. In Table 1 the results indicate how, of the 125 valid cases, 64 show a tendency towards field independence (51,2%). With respect to the results of the Hederich & Camargo studies ([17] p.48) the scores obtained by the University students indicate a greater independence with respect to the results obtained by high school students.

Table 1. FSI Range, Frequencies (Freq.) and percentages (%).

SG-EFT	Range	Freq	%
Very sensitive	0 - 10	0	0%
Sensitive	11 - 20	2	1,6%
Medium	21 - 30	22	17,6%
Independent	31 - 40	64	51,2%
Very independent	41 - 50	37	29,6%
Total		125	100%

Table 2 shows a mean of 36,09 of 0 to 50 points, indicating a tendency towards field independence and a median and mode of 37 presented in the results confirms the consistency of what was obtained. The standard deviation 6,75 indicates the distribution of the styles in the range of '*medium*' and '*very independent*'.

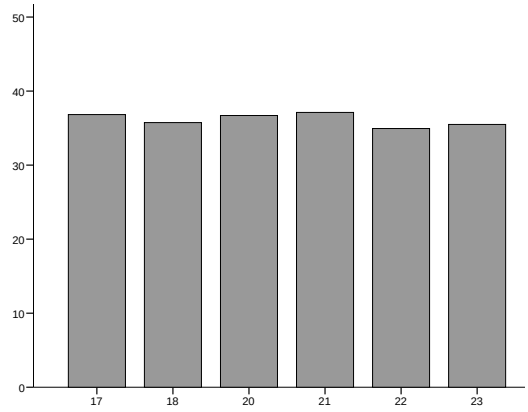
Table 2. SG-EFT. General Statistics

n Valid	125
missing	1
Mean	36,09
Median	37,00
Mode	37
Standard Deviation	6,750
Minimum	20
Maximum	48

5.1. AGE- SG-EFT RELATION

The average age is 21 with a standard deviation 2, 77. Figure 2 shows the relation between the variables of the SG-EFT average and ages: 15 years (min.) to 28 (max.). The results obtained with an average value SG-EFT of 36,09 characterize them as field independent.

Figure 2. Age - SG-EFT Average relation.



5.2. GENDER -SG-EFT RELATION

The group of students in the study presented a distribution of 80 women (63,5%) and 46 men (36,5%). The relation between the cognitive style and gender shows that women are less likely to independence than men, in spite of the fact that in the sample taken, there is a small number of men. This is consistent with the results of Hederich, Camargo, & Reyes [19], p.27.

Table 3. Gender SG-EFT average.

Gender	Mean	n	Stand. Dev.
Female	35,06	79	6,82
Male	37,85	46	6,30
Total	36,09	125	6,75

Table 3 shows the average obtained by men; it is almost three points higher than that of women. These results are also consistent with those observed by Copeland, [3] in the American context. She notes a greater tendency toward the dimension of field independence of men over women.

5.3. ORIGIN - SG-EFT RELATION

90,47% of the population who study industrial design at JTLU is located in the region covered by the central and southern Andes of the country. According to Hederich et al. [16] the inhabitants of the Andean region are characterized by having a cognitive style that tends considerably toward field independence [16],(pp. 75-77) y [20].

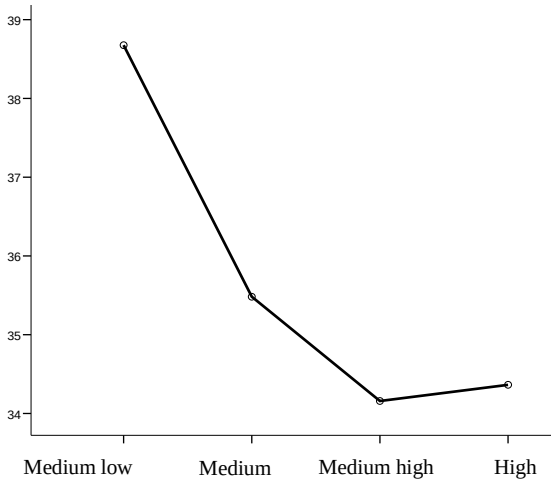
Table 4. SG-EFT Statistics by Region. Minimum (Min.), maximum (Max.), median (Med.), Standard deviation (Std.Dev.).

		SG-EFT			
Region	**n**	**Min.**	**Max.**	**Med.**	**Std.Dev.**
Andean	113	20	48	35,90	6,705
Total	113				

5.4. SOCIOECONOMIC CONDITION -SG-EFT RELATION

Reading Figure 3 one can observe that the socioeconomic conditions of the sample present averages with a clear tendency to be located in a range of –independent- (see Table 2), with a –medium low- representing the highest score 38,68. The next level is -medium-, which renders an average of 35,48; followed by level –high- with 34,36 and in last position, students at level –medium high- with 34,16 presenting a slight difference with respect to level –high-. With these results, one could say that there is a certain tendency of the Industrial Design students of the JTLU of medium-low socio-economic conditions to have higher levels of field independence, despite the homogeneity of the averages.

Figure 3. SG-EFT Results by Socioeconomic Level.



In making a comparative reading of the studies of Hederich et al. and the results obtained in this study, where it is observed that the averages do not differ much mucho (HSD de Tukey (a,b); sig.=0,125) some difference can be observed because the assumption of the authors is that higher levels are associated to a tendency toward sensibility [16], (pp. 50-52); [20], (pp.59-62).

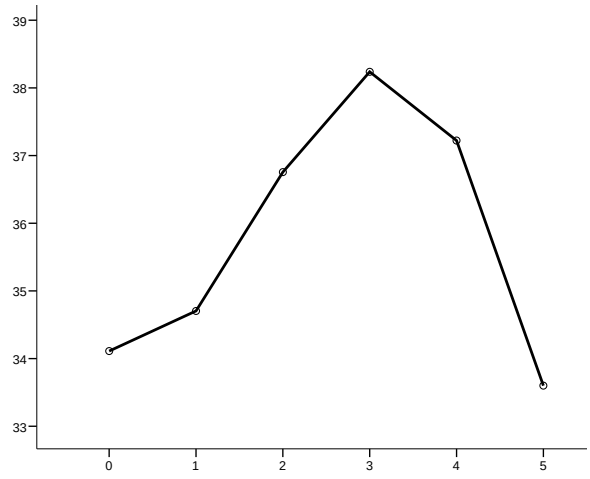
In order to relate these results to the field of industrial design, some clarifications should be made. From the perspective of Wiener (1995) in his book -invent-, when he states that to conceive ideas it is necessary to count on a network of relations that are established between the intellectual (scientific and technological), the technical (manufacturing-reproducing) social (human-cultural) and the economic (cost-benefit) environments, it is possible to accomplish a structure that supports the processes of innovation. It is important to note that a higher access to these conditions improves innovation.

The processes of innovation are also linked to disciplines related to the world of applied social sciences[7] that requires specific demands. However, it is interesting to note that the medium-low and medium level, have more highly related SG-EFT, which would be associated to visual-spatial and drawing abilities key to the performance in industrial design. [17], (pp.60-65).

5.5. NUMBER OF SIBLINGS -SG-EFT RELATION

The students in the sample show a greater tendency toward field independence when their families are composed of 3 siblings; having more than 3 presents a slight decrease in the curve as shown in Figure 4, where being an only child or having one sibling and having more than 4 siblings, generates low scores in the test SG-EFT. According to the ANOVA variance analysis, there is no statistically significant difference in the averages related to number of siblings (F=1,249; sig.=0,291).

Figure 4. SG-EFT Average Curve with Respect to Number of Siblings.



VI. DISCUSSION

An alternative for the University to offer these environments is to provide settings in which projects can be generated and offer experiences in social contexts, business connections, systems and equipment management to empower their talent; the student independently from his socioeconomic and cultural condition, can build meaningful experiences for the development of his creative processes.

A special feature among the average number of siblings in the central Andean region [17] is established with respect to those obtained in this study. Because families of numerous children would be associated to a sensitive CS, the results obtained indicate that the sample evaluated is found in the dimension of field independence in spite of having an ample range of 0 to 7 siblings; thus, because of what was mentioned in the previous variable, this can be due to factors associated to the restricted size of the sample in this study.

The fact that the sample is distributed between a number of 0 to 7 siblings and this influences the style dimensions, from the perspective of a *school inclusion approach*, of the *mobility of the polarities* and the *academic processes* in forming industrial designers, it presents an interesting option for the development of collaborative activities in projective tasks of innovation, where the field sensitive as wells as the field independent get involved in finding design solutions.

The collaborative design approach is a contemporary trend in the work of design activities that articulates the understanding of communities [6], [29] and the integration of the field sensitivity with field independence polarities, to achieve contextualized and relevant socio-cultural innovation.

In projecting and planning pedagogical, didactic and evaluative strategies in the industrial design program, this perspective of collaborative work, that favors such integration of these style dimensions, would enhance the dynamics that the University proposes in its IED (Institutional Educational Project) in terms of continuity and permanence in the undergraduate education because of the critical and creative thinking that emerges which point to the processes of innovation.

Table 5. Design Processes and desirable FSI dimensions.

Author	Processes related to design and creativity	FSI DIMENSION		
		Sensitive	*Intermediate*	*Independent*
Boden (1994)	Establish generative rules			*
	Identify restrictions			*
	Generate search spaces	*		
	Explore heuristics		*	
	Generate creative Ideas		*	
ICFES	Interpret		*	
	Argument			*
	Propose		*	
Andrade	Manage information		*	
	Perceive the problem	*		
	Structure the problem			*
	Solve the problem		*	
	Show technical capacity			*
DIT	Discover		*	
	Define			*
	Develop		*	
	Communicate	*		

The first issue, with respect to the partial results obtained related to cognitive styles, especially with the tendency of industrial design students toward field independence, invites a question: How can we improve, based on this information, the levels of school inclusion, not only with respect to the FSI but also to other multiple bipolarities of the styles that guarantee educational equity?

Part of the results of this research and others, that have found creativity associated to one or another style, confirm that it is difficult to associate

the preference toward any polarity FSI [11]; both the field independent and the field sensitive are potentially creative; this is why in teaching design it is necessary to implement inclusive didactics that promote mobility [2], the learning styles and thinking styles of students, as well as forming work groups around the individual design. [26], [6], [29].

Meneely and Portillo [7] consider the concept of 'creative adaptability' of the designer, that is, that when different stages in the development of a design of objects occurs [12], cognitive processes that can be privileged by determined style can appear.

Some perspectives of the processes related to design are shown in Table 5 and an approximation toward the desirable polarities for their development is established.

The characterization of CS of the Industrial Design students of the JTLU, seeks to consider and construct a reference scenario to examine from the cognitive (meaningful learning) and academic (disciplinary specificity) perspectives, some guidelines for discussion to find points of convergence and divergence that enable us to strengthen the curriculum with respect to the pedagogical, didactic and evaluative practices, in the design program. In the same way, it also claims to take into account the processes of innovation around creative learning as an identity quality in and for the design of everyday product thinking: research, business and creation of the discipline.

The configuration of the bipolar mobility of CS is considered from the dynamics of thinking, action and expression, which in turn is critical collective and critical collaborative. This permits rethinking structures, relations and fairer meaningful processes, participatory and inclusive of both directed and autonomous learning. This would permit the possibility of integrating in team work in which the virtues of the field sensitive and field independent combine, through the development of integrating learning habits.

Table 6 shows a rubric that relates the FSI dimensions with the process of the social, innovative contemporary projective praxis in the stages of discovering, defining, developing and communicating.

When crossing the two qualities of CS the FSI with a creative process, it was possible to establish differential characteristics between the two styles with respect to the process identified by DIT and correlated to those recognized by Boden, ICFES and Andrade. The characterization is established in the following Table:

BIPOLARITY OF CS	***DISCOVER*** Interprets Perceives-identify problems	***DEFINE*** Arguments Structures Problems	***DEVELOP*** Proposes Solves problems	***COMMUNICATE*** Represents Shows Technical capacities Collaborates when working
	THINKING THROUGH DISCOVERY	**CRITICAL THINKING ARGUMENTING**	**STRATEGIC THINKING**	**DECLARATIVE THINKING**
FIELD SENSITIVE	**PERSONAL INTERESTS, EXPECTATIONS:** -Shares interests.	**PROBLEM SPACE:** -Shows empathy with the problem forwarded. -Maintains intact a given problem be it of a weak or strong structure Guides toward discovery	**SYNTHESIS CAPACITY** Presents difficulties to round up the analysis	**REPRESENTATIONAL ELEMENTS** - Displays difficulties in making abstractions in the symbolic representation - Displays difficulties establishing analogy and homology
	PERCEPTION OF THE TASK ENVIRONMENT: -Illustrates a global approach but parts are diffuse	**SOURCES** -Prefers multiple social interactions to collect information	**PROOFS** -Draws upon the approval of experts	**ARGUMENTING** -Demonstrates weak Reasoning -Displays high semantic richness
FIELD INDEPENDENT	**PERSONAL INTERESTS, EXPECTATIONS:** -Displays individual interests	**PROBLEM SPACE:** -Demonstrates limited commitment when posing the problem. -Shows a structural approach when posing problems -Modifies a given problem be it of a weak or strong structure -Exhibits self-discovery	**SYNTHESIS CAPACITY** -Demonstrates high capacity and precision	**REPRESENTATIONAL ELEMENTS** -Uses multiple means to represent. -Establishes analogies and homologies easily
	PERCEPTION OF THE TASK ENVIRONMENT: -Illustrates an approach centered on details and not globally	**SOURCES** -Prefers local quests	**PROOFS** -Appeals to limited verifications.	**ARGUMENTING** -Proves high reasoning. -Shows limited semantic richness

Table 6. Structure of the projective processes in each of the FSI polarities. Some distinctions.

VII. CONCLUSION

Some results about industrial design students' sample have been presented. The Theory of Psychological Differentiation has been used like frame work, but only the dimension of field sensibility-independence has been used (actually, exist an extense list of polarities) and also, few cognitive style relations have been presented with some variables of individual, eco-cultural and social studies.

These kinds of research results are very important for technology and design education but they attend the increasing necessity of research efforts upon this polarity; furthermore new relations (for instance, the teaching style of the design teachers), and behavior of cognitive style for innovation (for instance, cognitive style in creative problem solving in the industrial design students).

In the Colombian context, the industrial design education it´s important for identify the conditions of cognitive styles that support processes of innovation, due to the fact that this country have big responsibility not only with the environment also with the traditions, but also with society and with a better world.

VIII. ACKNOWLEDGMENT

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[1] Although, the name of this dimension is field dependence/Independence (FDI) (Witkin & Goodenough, 1985), we changed dependence for sensibility.

[2] The tables and figures were designed by the authors for this article.

[3] Within the Masters Program on The Technology of Pedagogy the authors took a class with professor Christian Hederich (2002), there they had the opportunity of working with him and shared the results of his research; additionally, they learned how to manage the EFT Test given by the professor to carry out a work with a general sample from which information was registered related to the style of students most of them of different academic levels from basic education to graduate students since the teachers taking the course applied the test to their respective classroom students.

[4] For example: Hederich & Camargo, 1993, 1999; Hederich, Camargo, Guzman & Pacheco, 1995; (Iriarte, Cantillo, & Polo, 2000).

[5] [19], p. 48.

[6] The particularities of the validity of the test can be studied in Hederich [15], pp. 259-262.

[7] "As such, a science for design has to be a social science, one that is open to technological considerations, to the multiplicity of understandings by users, actors, or commentators on technologies, and can cope with change." [22], pp. 207-271.