Learning Styles of Chemical Engineering and Food Engineering Students from Federal University of Santa Catarina, Brazil.

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Abstract. Among the models that aim to surpass the traditional teaching deficiencies, there is the one that tries to make the teaching style compatible to the heterogeneous public of pupils. In discussing this situation, this work describes the diversity of learning styles presented by undergraduates of Chemical Engineering and Food Engineering, obtained by the application of the Index of Learning Styles – ILS, based in the Felder & Silverman's model of learning styles. This model differentiates groups that prefer to learn through observation or introspection – sensing or intuitive learners; with graphical information, or written and spoken ones – visual or verbal; dealing with information through experimentation or thinking – active or reflective; and having the subject presented sequentially or randomly – sequential or global. The ILS generates a learning profile defined by four characteristics, varying of strong, to moderate, to weak preferences. It was applied from 1997 to 2005 in nine classes of the "Processes Analysis and Simulation" course, enclosing 290 tests answered by 257 pupils. The results regarding to the distribution of styles were analyzed over the general response and a comparison between the teaching profile and the learning styles grouped according to the course performances and to the moment where it was carried through (failure or approval), for students who had failed at the course and repeated the test. The objective of this was to verify environmental influences over the students. A predominant profile for the sample was also determined (Sensing-Visual), called basic-profile, which congregates around 80% of the pupils.

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1. Introduction

The act of learn is one of the most complex processes for which men passes during its personal development. In accordance with a research carried through in the middle of the 20th century, different teaching approaches results in different quantitative learning responses. In this research context it was observed that the learners keep 10% of what they read; 26% of what they hear; 30% of what they see; 50% of what they see and hear; 70% of what they say; and 90% of what they say, while making something (Stice, 1987). These numbers give us an accurate idea of how much the teaching and learning ways can modify the subject comprehension. However, when we deal with engineering education, some peculiarities of this field add to the inherent difficulties of the teaching and learning process. Amongst the diverse researches about it, there is:

The lack of didactic-pedagogical instruction of engineering professors. According to Pereira and Bazzo (1997), being an engineer is usually enough to become an engineering professor. Hence, mastering the technical knowing of a profession is considered sufficient for the exercise of teaching, when it's known that the reality of a classroom is much more complex and demands proper training.

The structure based on traditional education paradigms. The traditional education paradigms consist of ways that bond the engineering teaching to the exceeded models of education (Belhot, 1998). Old premises such as lecturing-based teaching, with the professor speaking and the students hearing; and the learning based on the memorization of contents, which many times presented non-contextualized with the engineering job, what for Fehr (2000) usually represents forgettable theoretical luggage for the pupils.

The existing conflict among the professor's teaching profile and the variety of learning styles. The different ways of teaching are normally in dissonance with the different types of learners, resulting in boring and unpleasant classrooms for the pupils (Felder and Silverman, 1988).

The objective of this article is determine the different learning styles presented by Chemical Engineering and Food Engineering undergraduates from Federal University of Santa Catarina – UFSC, based on the methodology of Felder and Silverman; analyze

them under some aspects, such as performances and adaptation; and define a describing profile for the whole sample, in order to compare it to the teaching profile characteristic of the "Processes Analysis and Simulation" course.

2. Felder-Silverman's Learning Styles

Learning styles qualitatively measure the influences of our individual characteristics, which configure our unique personality, in our learning process. Diverse models and instruments evaluate the different learning styles, but the model used in this study is the one created by Felder and Silverman, in 1988.

This model encloses four stages of the referring process to the receiving information act the information perception, input, processing, and organization. To each one of these processes, one of two preferential and opposing qualities is attributed. Adding each process qualities, we can define our learning profile. The binary of each process is detailed at the Table 1 below:

Table 1. Characterization of each learning styles.

Style		Characteristics
INFORMATION PROCESSING	**Active**	- The information is processed externally, by discussions, active experimentations, trying things out, engagement; - Learners who like to work with others and prefer to deal with practical issues.
	Reflective	- The information is processed internally, through introspection, reflective observations, thinking things out; - Learners who like to work alone and prefer to deal with theoretical issues.
INFORMATION PERCEPTION	**Sensing**	- The information is perceived externally, through the senses, by observation, sensations; - Learners who like facts, concrete subjects, traditional procedures. - Methodical, careful, meticulous learners.

	Intuitive	- The information is perceived indirectly, by way of the unconscious, imagination, insights; - Learners who like principles, abstractions, challenging problems. - Creative, innovative, intellectual learners.
INFORMATION INPUT	**Visual**	- The information is received by visual representation, with the use of graphs, pictures, demonstrations, films, schemes, flow charts; - Learners who remember better what they see.
	Verbal	- The information is received through words, spoken or written, with explanations, readings, writings, discussions; - Learners who remember better what they hear, say, read or write.
INFORMATION ORGANIZATION	**Sequential**	- The information is better understood if presented sequentially, that is in a logically ordered progression; - Learners whose learning process occurs linearly, from the parts to the whole. - Better at convergent thinking and analysis.
	Global	- The information is learned holistically, in fits and starts, in large "big pictures" jumps; - Learners whose learning process occurs randomly, with intuitive leaps, from the whole to the specifics. - Better at divergent thinking and synthesis.

(Felder and Silverman, 1988; Felder, 1996; Felder and Brent, 2005)

We can fit into each one of these dimensions with different intensities, being able to be intermediate between the styles, what means to not have strong preferences for none of the characteristics.

ILS applies. The instrument used to assess the student's learning styles and the professor's teaching style, according to the Felder & Silverman's Model was the ILS – Index of Learning Styles. The ILS was created by Felder and Soloman in 1991, and consists of a 44 questions of forced reply form, where the combination of answers will

define the preferred style for each one of the dimensions, with its respective intensities, varying of weak, to intermediate, to strong preferences (Felder and Soloman, 1991).

Researches using ILS have been done in several studies from different nationalities. Some uses the Felder & Silverman's Model and ILS just to assess the students learning styles. Others use them as guides in the construction of new teaching instruments and methodologies.

Among the diverse ones, there's Peter Rosati's work evaluating differences between men and women styles (Rosati, 1997) and between different graduation phases (Rosati, 1998). Professor Richard M. Felder, the own model and ILS creator, has applied the ILS in the courses of chemical engineering that he teaches in the North Carolina State University (Felder, 1996). In Brazil, Cury (2000) used the ILS successfully to minimize the difficulties presented for engineering undergraduates in courses of Differential and Integral Calculus. Kury and Truzzi (2003) had evaluated the learning styles of freshmen from civil, electric, mechanics and industrial engineering.

These studies point, with some few divergences, that most of the engineering students have preferences for the Active, Sensorial, Visual styles, and are divided between the Global and Sequential Styles. In turn, the studies where professors were also evaluated usually result in a passive, abstract, auditory and more sequential style of teaching. That is, more favorable to reflective, intuitive, verbal and sequential students, accurately the opposite of the most commonly found in a public of engineering pupils.

Overall, the results from all of them indicate that the proper use of this instrument favors the teaching/learning environment in engineering classrooms.

In this study, the ILS was applied in chemical engineering and food engineering pupils of UFSC that was attending the Processes Analysis and Simulation course, from 1997 to 2005, getting a total of 290 tests answered by 257 students. That is, 32 of these tests had been repeated by pupils who had failed in the course.

The professor's profile was also evaluated through the ILS, whose results are presented at the Table 2.

Table 2. Professor's profile.

Processing	**Perception**	**Input**	**Organization**
Intermediate	*Intuitive*	*Intermediate*	*Global*

The course of "Processes Analysis and Simulation" deals with the mathematical modeling of chemical engineering and food engineering processes,

with a following application of adjusted numerical methods for its resolution through computational simulation. The course teaching at this institution has two distinct parts:

Presentation of the theoretical contents. Course's section related to the lectures about the concepts present in the course summary; and

Students' seminaries. Course's section related to the presentation of seminaries done by the students. The essay is based on a scientific paper, of any area, that presents a mathematical model that allows the pupils to make its numerical simulation through a computational program.

Relating these characteristics to the learning styles and the professor's profile, we are able to define the course's profile as being:

Strongly global. Since the course uses previous courses basis in the elaboration of its problems. "Process Analysis and Simulation" may be considered a synthesis course; and

Strongly intuitive. Since it involves more abstract concepts, associated to the essentials. Moreover, its problems are normally challenging and creative, never repetitive or of mechanical resolution, schematics.

3. Results and Discussion

With the data obtained through the application of the ILS, the sample's data could be collected and analyzed under some specific items, present in the following sub-items graphs.

It is important to point out that the curves do not represent continuity between the scales. The real data are only represented by the points. The curve is an acquisition of the function "spline smoothing", which only serves as a support in the visualization.

3.1. Overall Distribution

Figure 1 shows the general frequencies for each style. In scale x we have the intensity of each dimension of style, where the negative region is referent to the

styles: active, sensing, visual and sequential; and the positive region, referent to the styles: reflexive, intuition, verbal and global.

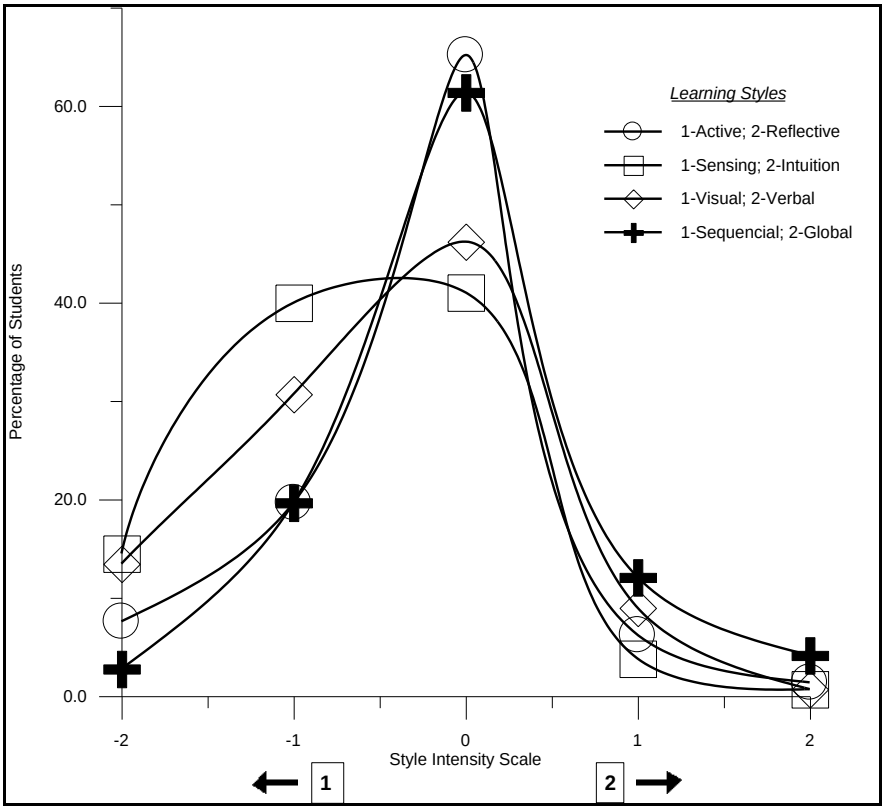

Fig. 1. Distribution of Learning Styles

It is observed that the dominant styles among students were active, sensing and visual. Sequential and global had practically been remained balanced. This result is consistent with other studies that had used the ILS.

3.2. For Grade Performances

An assessment of correlation was proposed for the different grade performances groups and their learning styles. Standing out that UFSC grades can vary in a scale of 0.0 to 10.0, being 10.0 the best possible score, performance groups had been set like this:

- Students who had achieved in the course a final grade between 8.0 and 10.0, grouped as “Best Grade Performances”;

- Students who had achieved in the course a final grade higher or equal 5.75 (but lower than 8.0, specific for the "Best Grade Performances" group), which is enough to get approval in the course. They were grouped as "Average Grade Performances";
- Finally, the students who couldn't get the minimum final grade required to get approval in the course (5.75), and had failed. They were grouped as "Insufficient Grade Performances".

The professor's profile is also evidenced in the results (through the straight line), so that allow us to compare the professor's style and of the course with the ones of the different groups of pupils. The objective was compare the learning styles with the teaching stile for the referred course, considering only the styles that are most characteristic of the course, in the case, the sensing-intuition dimension (Figure 2), and the sequential-global one (Figure 3):

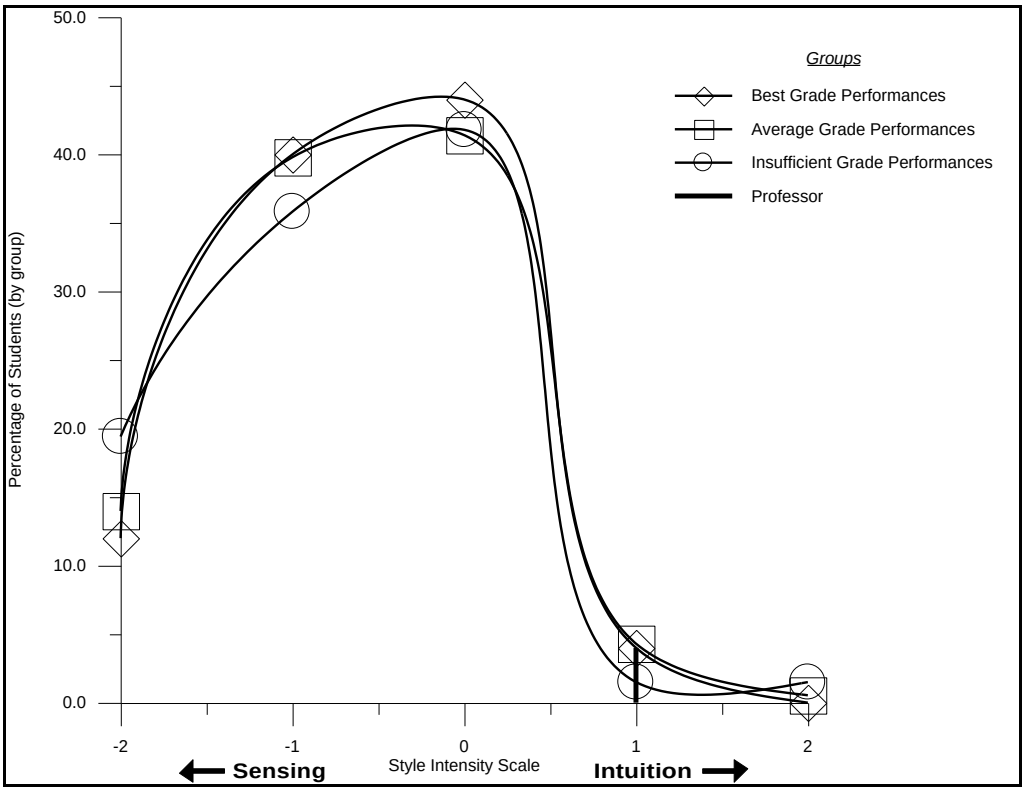

Fig. 2. Comparison of each group's predominant learning style and the professor's style, for the Sensing-Intuition dimension

For sensing and intuitive learners, all groups had contrasted strongly with the preference of the professor and of the course (intuition). The students were much

more sensorial. However, we observe that the group that was more distant from the professor/course's profile was the "Insufficient Grade Performances" group.

For the Sequential-Global dimension, the result was more significant. Recalling that both professor and course have strong global distinctiveness, it is observed that the pupils in the "Best Grade Performances" had been the ones that had more tendencies for this style.

These results indicate us that the courses and the professor's profiles can influence in the student's performances, regarding to the compatibility of styles, or to the lack of them.

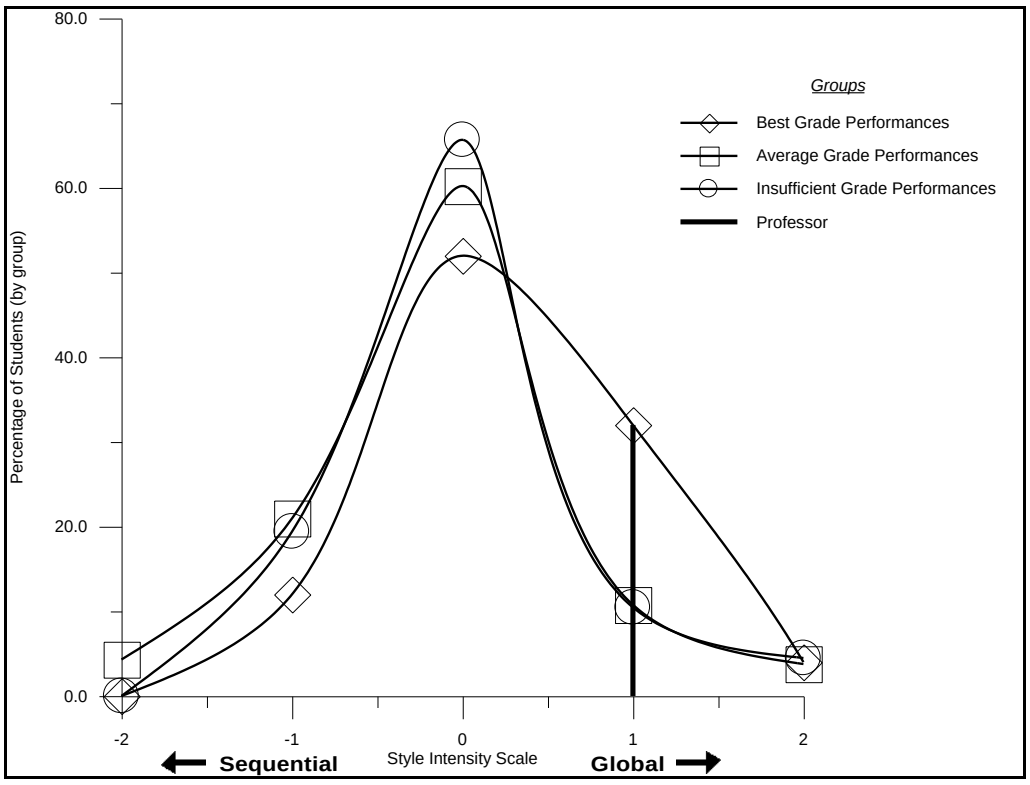

Fig. 3. Comparison of each group's predominant learning style and the professor's style, for the Sequential-Global dimension

3.3. For Repeated Tests

From the total sample of the study, 33 pupils had failed in the course and had repeated the ILS test. Through Figures 4 and 5, it's possible to analyze these tests at the two distinct moments: the first one, when they had failed in the course, and the second, when they had gotten the approval. It's also done a comparison

between them and professor/course's styles (represented again by the straight line). Once more, just the styles most characteristic of the course/professor had been considered (sensing-intuition and sequential-global dimensions).

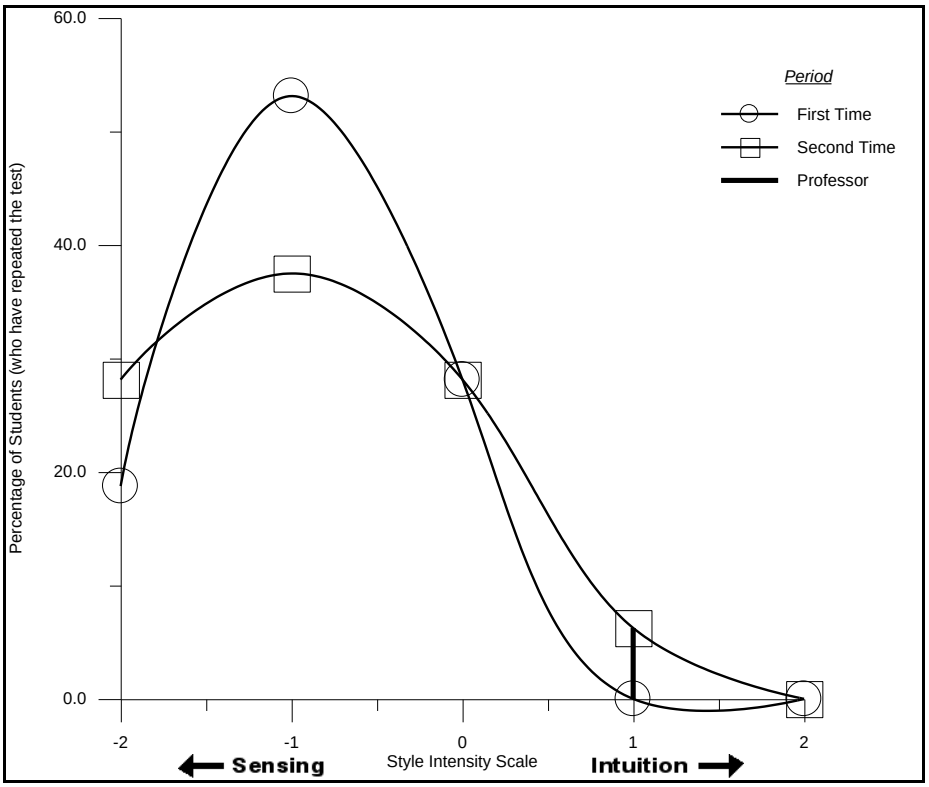

Fig. 4. Evolution of the Sensing-Intuition distribution among the failed students, in accordance with the professor/course's preferred style (Intuition)

Both in the sensing-intuition dimension and mainly the sequential-global one a significant increase is observed amongst pupils who had evolved its styles for one more compatible with the professor/course's styles (intuitive and global). Hence there is an indication that the students try to adjust their learning styles with the adopted teaching style.

3.4. General Profile

The different profiles had been grouped so that we could define a predominant profile of the sample referent to all styles. Herewith, the Figure 6 was developed

in order to distinguish the predominant profile of our sample and its proportion amongst the other groups.

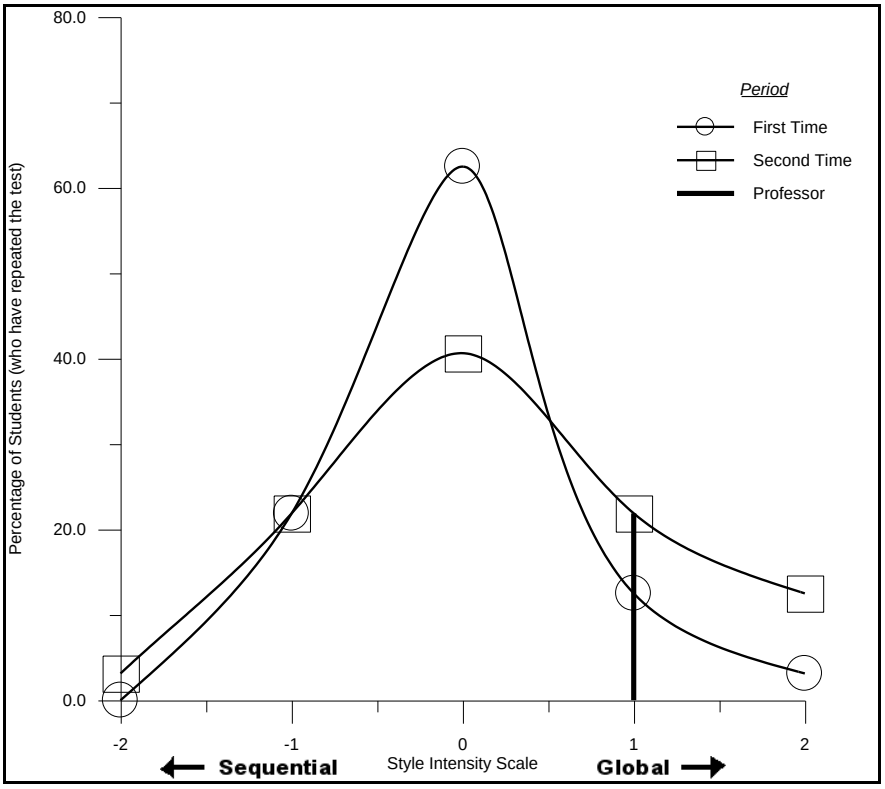

Fig. 5. Evolution of the Sequential-Global distribution among the failed students, in accordance with the professor/course's preferred style (Global)

With this figure, an unquestionable majority number of students present, among others things, a Sensing-Visual predominant profile. Thus, on a general way, we can classify the pupils of our sample as Sensing and Visual. Having this basic-profile, the course can be worked so that it attends this main group. This can be made through a reformulated class, especially with respect to the first part of the course (predominantly verbal and intuitive) with the addition of more visual resources and with experimentation (in the case of this course, through computational programs and numeric simulation).

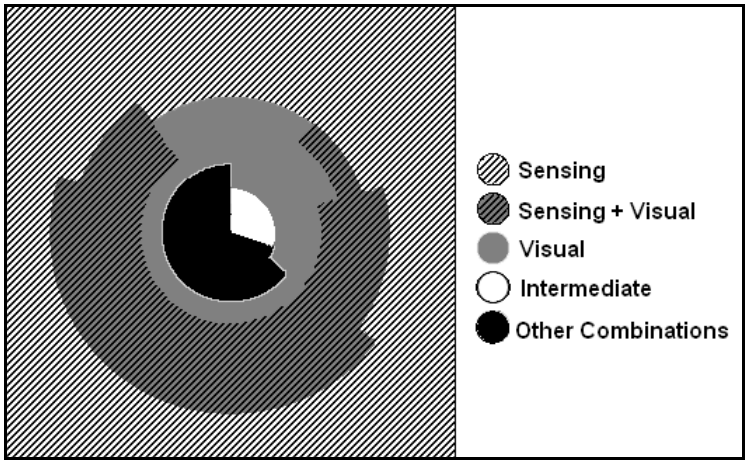

Fig. 6. Set of the sample's profiles

4. Conclusions

It can be concluded that the application of the ILS in our sample was satisfactory, since the results presented corresponded with the expected and with other similar works.

The styles influenced in the students individual performances, in accordance with the compatibility or not of styles with the professor/course's profile. There was also an adaptation of learning styles to a course style matching one. Finally, the most predominant profile was of "Sensing and Visual" pupils.

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