An Investigation on the students' Learning Styles in an Advanced Applied Mechanics Course

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ABSTRACT: In this paper, an application of Multiple Intelligence Theory (M.I.) to the analysis some adult students' learning characteristics is presented. The investigation is conducted over a group of students enrolled at the level of a graduate course in Aerospace Engineering of the University of Rome, *La Sapienza*. Results allow students to better understand their own characteristics in learning, and help teachers in tuning up the adopted didactical methods. The investigation offers the possibility of acquiring a comparison *learning profile* to be used during freshmen candidates' orientation.

1 INTRODUCTION

In the last decades, teaching styles have evolved. The new methods, stimulated by the rapid progress in Information Technology, have suggested to teachers new approaches to be used in classrooms.

Most of the newest theories in teaching methods directly originate from the Pedagogy Area and deal, mainly, with elementary and secondary education. In fact, these phases of the individual's life can be reasonably regarded as tremendously important. Young students have to be protected and guided, as best as possible, in some fundamental choices regarding their curricula and careers: a wrong choice at a young age is very effective and can lead to unpredictable bad consequences in one's life. On the other hand, higher education is also a complicated process. Adult individuals are more conscious about what they want, but they are also already shaped in some of their important characteristics. This makes a bit more difficult to plan a teaching style that could suit all the attendants' sorts.

The average age of the students attending curricula in Universities depends on various factors, as for example, the country's traditions, the curriculum's subject and difficulty, and the economic trend.

As for this investigation, the attention is focused on students attending Engineering Courses at the University of Rome *La Sapienza*, whose typical age runs from 19 to 25 years. In practice, people who are able to complete their curricula by the established time terms are only a small part, while most require two or three extra years. This fact has risen the average age of the students attending courses in Engineering.

The mentioned delays in the *"Laurea"* achievement have induced the various Italian Ministries of the Education which have joined up in the last decade, to undertake a significant process of evolution in University. To support this renewal phases, they have sponsored some Courses with well structured National projects, such as *Campus* and *Campus One* (CRUI, 2000).

The need of improving the teaching methods has induced the Authors of the present paper, who have been involved in some of the local activities related to the above mentioned projects (Belfiore et al., 2002), to investigate about students' characteristics. In particular, some aspects of the student learning preferences have been investigated in relation to the *Gardner's Multiple Intelligence* (M.I., for short) model, hoping that the results could be useful both to students and teachers, as well as to the course management.

2 LEARNERS' PREFERENCES AND STYLES: A SHORT REVIEW

Undergraduate and graduate students are about to be considered as adult learners. They undertake programs from different starting points and have different natural capabilities and prior instruction. For all these reasons, the success of the educational process is strongly dependent on the teaching strategy, which has to cope with such differences in classrooms. In the field of Engineering education, courses are rather difficult to be planned, maybe because of the subjects' intrinsic difficulty and of the strict and strong prerequisites. Hence, the teaching method becomes even more critical for the course's success, which is measured not only in terms of the students' test scores, but also of their personal satisfaction.

Among the possible activities that can be improve Courses' quality, there is the analysis of the students' *learning styles*, which can be useful for many reasons, as it will be better described in paragraph 3. For example, *cognitive* and *learning* styles can be, theoretically, used to predict the best instructional strategy for a given individual at a learning task.

Generally speaking, *cognitive style* is referred to as *the preferred way an individual processes information*, while the *learning style* is regarded as *the preferred way an individual learns*.

Cognitive style describes the individual's typical mode of thinking, remembering or problem solving, and *it is a personality dimension which influences attitudes, values, and social interaction*. It would appear very easy to jump to the conclusion that if there is a preferred manner a student uses *to organize information*, then *the same* manner must be used *to learn*. However, learning is somehow different from *organizing the perceived information*. In fact, the cognitive style represents a *cognitive strategy that can be defined in terms of the desired targets*. Hence, it may vary, for the occasion, from case to case, in the same individual, and it is not necessarily related with *temperament*. Furthermore, some recent investigations have shown only week relationships between learning and cognitive styles, although there are also example of useful applications of the learning models, to create teacher awareness of individual differences in learning.

Learning and *cognitive styles* have been ordered by Curry (1983) into a three-levels stratified scheme, whose innermost, middle, and outermost layers correspond, respectively, to the *cognitive style*, the *information processing style*, and the *instructional preferences*. The fundamental concepts regarding the three models have been extensively discussed in the literature, such as, for only representative examples, in (Reichmann and Grasha, 1974), (Witkin et al., 1977), (Kolb, 1984), (Gorham, 1986), (Riding 1991), (Sadler-Smith, 1996) and (Allison and Hayes, 1996).

The innermost category, namely the *cognitive personality elements*, refers to particular bipolar dimensions of the *cognitive style*, such as: (i) *Field dependence-Field independence* dimension, which refers to an individual's greater or lesser tendency have confidence in external or internal references; (ii) *Intuitive-Analytical* dimension; (iii) *Wholist-Analytical* dimension, which refers to individuals' habit of processing information by organizing them into its component parts, or by retaining them from a global or overall view; (iv) *Verbaliser-Imager* dimension, which describes how an individual habitually represents information in memory during thinking.

The middle category, namely the *information processing style* refers to the individual's *learning style* and has been analyzed through special bipolar dimensions such as: (i) *Converger* / *Diverger*; (ii) *Accomodator* / *Assimilator*; (iii) *Activist* / *Reflector*; (iv) *Theorist* / *Pragmatist*.

Finally, the *instructional preferences* category regards how learners fit with particular instructional approaches which can be classified into three types: (i) *dependent* learners, who prefer structured programs and direct teaching; (ii) *collaborative* learners, who prefer group work, discussion, and interaction; (iii) *independent* learners, who like having a certain control over the contents and the methods.

Among the first specific contributions to the improvement of the teaching methods in Engineering Education, Felder's one deserve a special mention (Felder and Silverman, 1988). According to the model therein adopted, the preferred learning styles have been classified into five dimensions, each corresponding to two possible preferred categories, as reported in the following scheme:

DIMENSION	Dimension's categories	
Perception	Sensory	Intuitive
Input	Visual	Auditory
Organization	Inductive	Deductive
Processing	Active	Reflective
Understanding	Sequential	Global

The proposed dimensions are neither orthogonal nor comprehensive. Hence, there are a total of $2^5 = 32$ possible combinations of learning profiles.

More recently, Sadler-Smith and Riding (1999) addressed the importance of relating the *cognitive styles* to the *instructional preference*, arguing that cognitive styles have an important role to play in determining an individual's instructional preferences and that his may affect the learning performances.

3 THE AIM OF THIS INVESTIGATION

The first goal of this investigation has been the identification of the *preferred learning approach* adopted by the given group of students. The working hypothesis is that the students attending the Course of Aerospace Engineering at the University of Rome *La Sapienza* are characterized by a *typical learning style* and a *typical intelligence profile*, which are both different from those of the students who attend the other Programs.

The identification of these characteristics could be useful to induce teachers to organize their courses by adopting a method that better fits the students *learning characteristics*, and by suggesting additional and related activities specifically designed for the group. *Learning style* detection, for example, can be a useful tool mainly to help students which have the worst results in terms of progress in the selected curriculum. These students could receive support and counseling about the studying methods, without being considered as simply *obtuse* individuals. As the matter of facts, there are some evidences that some differences in students' success in University can be related to their differences in *learning styles* (Brunas-Wagstaff, 1998). However, there are many and complex factors which can affect success in studying, such as *anxiety* and *motivation* (Marton & Saljo, 1976).

Should the working hypothesis be true, it would be possible to identify a significant *tendency* that the analyzed class of Engineering students shows. This has suggested the idea of monitoring the characteristics of the younger students coming from the secondary level schools, who want to enroll that particular Course. In this way, younger students' *profiles* can be compared to seniors' ones, or, as another possibility, to the *profiles* presented by Junior or Senior Engineers who have archived success in career. Freshmen candidates would, so, have more information about themselves in relation to the typical characteristics of the best Engineers. Such information can be complementary to the results that candidates might have achieved in the classical attitude tests in Mathematics and Physics. After a reasoned analysis, which could be performed under the guidance of a specialized counselor, they could decide to practice more in some particular aspects of their cognitive and/or learning functions or, in alternative, to avoid to undertake a program which is expected to be not suitable for them. The advantages are quite interesting because, as known, the costs of a wrong choice are heavy, not only for the individual, but also for the whole Society.

4 THE ADOPTED METHOD

The adopted approach has been based on the analysis of the various aspect of *personality*. Concerned by the over-abundant different cognitive and learning models, we have decided to walk along a novel, and unknown, path. In fact, we tried to investigate about a new experimental approach to the problem, by restricting ourselves to a simple question: *which aspects of their intelligence the students have the tendency to employ in their activities and, mainly, in their educational process ?*

This question has lead us to apply a quite recent Theory called the *Gardner's Theory of Multiple Intelligence* (Gardner, 1983), with the purpose of attempting to identify a student's frame of mind, *as a personal cognitive profile in the educational (University) environment*.

With this aim in mind, a novel test has been set up in order to measure the student's inclinations of using particular capacities. The developed test has been tailored to measure *preferences*, and not *capacities*.

4.1 *Gardner's model of Multiple Intelligence*

A plethora of different models of the human thinking have been conceived. Among them, the selected one has received increasing attention during the last years, specially in the field of Pedagogy. Accordingly, the human mind relies on seven distinct forms of intelligence: Verbal, Logical-Mathematical, Musical, Kinestetic, Visual, Interpersonal, Intrapersonal (the latest *Naturalistic* form has not been taken into account for the purposes of this investigation).

Gardner's frame has been adopted to define seven corresponding dimensions, although the *Verbal* dimension has been divided in two ones, namely, *Verbal* (written) and *Auditory*. For each dimension a raw score has been defined. Finally, the individual mean of the 8 scores has been also considered as variable to be investigated.

4.2 *Characteristics of the adopted test*

The developed test consists in a list of about 130 statements concerning the students' preferences in various cognitive contests, with special reference to learning in their Academic Course. To each statement, the student has been called to can give one among 5 different answers: one neutral, to which correspond a null score, two of agreement (either moderate or strong) and two of disagreement (either moderate or strong), corresponding, respectively to positive and negative scores or viceversa, depending on the nature of the statement. To give an idea of the kind of statements that have been submitted let us consider the following group of three of them, as a representative example.

1. I think that the following diagram *(actually, the one depicted in Figure 1)* is the best way to introduce the concept of stiffness constant of a linear spring.

2. I think that the best way to introduce the concept of stiffness constant is the following:
   "If: x = spring elongation; F = applied force; and k = stiffness constant of the linear spring; then: $F = k\,x$ "

3. I think that the best way to introduce the concept of constant of elasticity is the following:
   "*in a linear spring, the elongation x is always linearly proportional to the applied force F, the constant of proportionality being defined as the stiffness constant k*"

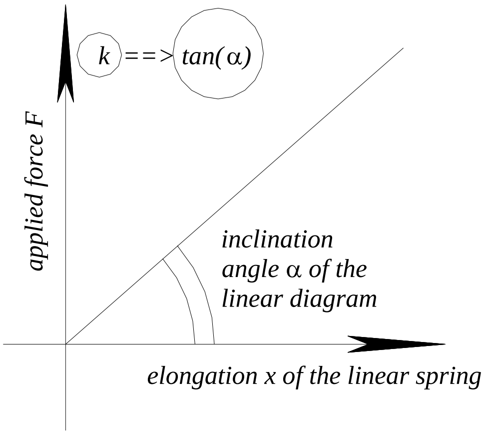

Figure 1. Graphical definition of the linear spring's stiffness constant.

A large grade of agreement with statements like the 1, 2, and/or 3, give, for example, the higher scores in the variables related to the *Visual*, *Logical-Mathematical*, and/or *Verbal* Intelligences, respectively. From the presented sample statements it will be clear that the scope of the questionnaire is the identification of the *preferences* in studying, rather than the measure of the individual's *capacities*. Of course, the latter are still of a capital importance for the students in order to achieve success, but they are, at the same time, among those characteristics which can not be easily improved in a simple supporting activity.

Table 1: Correlation Matrix relative to the nine analyzed dimensions in the sample *Group 1*.

1	0.311	0.343	0.296	0.314	0.433	0.257	0.319	0.671
	1	0.308	0.110	0.150	0.472	0.186	0.100	0.520
		1	0.185	0.178	0.394	0.015	0.170	0.543
			1	0.193	0.257	0.226	0.335	0.554
				1	0.420	0.292	0.225	0.610
					1	0.152	0.202	0.745
						1	0.039	0.509
							1	0.487
								1

5 RESULTS AND VALIDATION

The results presented in this paragraph have been checked by means of simple statistical indicators. Unfortunately, the number of examined individual exceeds 30 only in one case. Some of the presented results must be, therefore, considered as only provisional.

5.1.1 *Group 1*

The first group consists in a sample of 88 male students enrolled at the 4th year of the Italian Laurea V.O. in Arospace Engineering, who have an average age of 23.

A first check has been made on the samples by referring to a *null Hypothesis* H_o based on the assumption that an infinite number of individuals had randomly answered to the questions. This allowed to evaluate the means (all null) and the standard deviations of the Populations relative to the considered dimensions, and the means (all null, as well) and the standard deviations of the *sampling distributions of means* which are, respectively

0.622	0.500	0.783	0.603	0.754	0.917	0.839	0.754	0.259

for the nine analyzed dimensions, ordered as follows: 1) Verbal; 2) Auditory; 3) Logical-Mathematical; 4) Musical; 5) Kinestetic; 6) Visual; 7) Interpersonal; 8) Intrapersonal; 9) Individual mean of the eight previous scores.

The latter computations have been performed according the well known equations:

$$\mu_{sd\_i} = \mu_{o\_i} \qquad (1)$$

$$\sigma_{sd\_i} = \frac{\sigma_{o\_i}}{\sqrt{N}} \qquad (2)$$

where subscript i = 1… 9 denotes the i-th considered dimension, while subscripts o and sd refer, respectively, the *original* population and the *sampling distribution* (N is the sample size).

The significance analysis has been firstly based on the evaluation of the probability that the students might have given random answers to the questions. According to (1) and (2), and accepting a level of significance α = 0.01 (bilateral), the critical values of the means, for the nine dimensions,

1.276	1.027	1.609	1.238	1.548	1.883	1.724	1.548	0.332

were all lower than the ones measured over the sample:

4.580	0.659	8.989	6.432	11.864	4.330	-2.239	10.898	5.689

with the exception of the one relative to the *auditory* dimension, which could be, however, accepted with a level of significance of α = 0.05 (bilateral), since in this case its critical value is equal to 0.640 < 0.659.

The means, which characterize the *group's typical profile*, can be used as a reference frame in the individual's score interpretation, during counseling.

Finally, by elaborating the *standardized scores*, it has been possible to obtain the correlation matrix, reported in Table 1. There is not strong correlation among dimensions, except for the *Individual mean*, which seems correlated with all the other dimensions, specially with the *Visual* one (see Figure 2), and *Auditory* and *Visual* dimensions, which show a weak positive correlation (see Figure 3).

5.1.2 *Group 2*

The second group consists in a sample of 10 female students enrolled at the 4th year of the Italian Laurea V.O. in Arospace Engineering. This group is smaller than the previous because the number of female students in the Italian Engineering Faculties is generally relatively small.

The values of the standard deviations of the sampling distributions are for this case:

1.844	1.483	2.324	1.789	2.236	2.720	2.490	2.236	2.174

while the critical values of the means for $\alpha = 0.05$, are the following:

2.363	1.900	2.863	2.293	2.866	3.486	3.191	2.866	2.786

which can be compared to the measured means:

6.100	0.200	13.400	3.900	11.100	6.000	0.600	7.300	6.075

which show that the values are quite significant except the one relative to the Auditory and the Interpersonal dimensions, which do not differ significantly from a random distribution of answers.

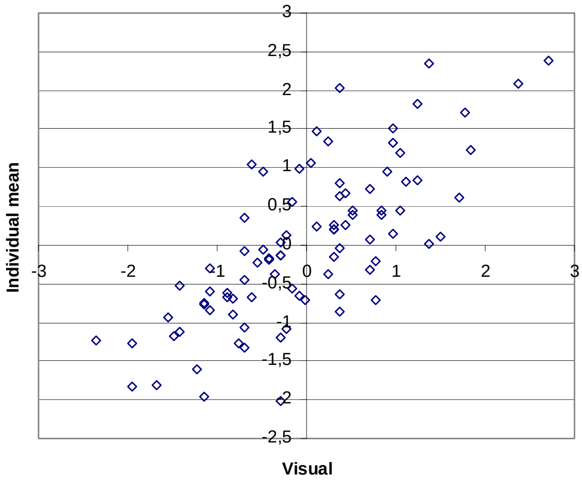

Figure 2. *Visual – Individual mean* dispersion diagram in the sample *Group 1*.

5.1.3 *Comparing the class group by gender.*

A further analysis can be made by comparing the first two samples. In particular the distributions of the differences of the means can be analyzed. Since the second group has only a size of 10 elements, the *Student's t distributions* must be recalled, in order to decide about significance. By using relations

$$t = \frac{\mu_{s1} - \mu_{s1}}{\sigma\sqrt{1/N_1 + 1/N_2}} \quad \text{with } \sigma = \sqrt{\frac{N_1\sigma_{s1}^2 + N_2\sigma_{s2}^2}{N_1 + N_2 - 2}} \qquad (3)$$

the *t scores* of the 9 differences of the means are equal to

-0,567	0,202	-1,280	0,734	0,224	-0,337	-0,643	1,124	-0,192

while by accepting a confidence coefficient $\alpha = 0.05$, the 9 critical values for the *t scores* are all equal to 1.290. Although the value of the confidence coefficient is rather low, the critical value is always higher than the *t scores* reported. Therefore, it must be stated that there are not significant differences due to gender, in the analyzed class.

For the sake of completeness, it can be reported that in the smaller sample (female) *Visual – Logical* Intelligences results positively correlated by $r = 0.832$, while *Interpersonal – Auditory* are negatively correlated by $r = -0.724$.

5.1.4 *Group 3*

Finally, a *check* group of 14 female students enrolled at the graduate programs in *Arts and Humanities* have been analyzed. This allowed to have a test sample to be compared with the ones of interest.

Once again, the values of the standard deviations of the sampling distributions have been obtained, namely:

1.558	1.254	1.964	1.512	1.890	2.299	2.104	1.890	0.650

while the critical values of the means for $\alpha = 0.05$, are the following:

1.997	1.607	2.517	1.938	2.422	2.946	2.696	2.422	0.833

which can be compared to the measured means:

5.143	0.929	-8.929	8.286	3.429	9.286	-3.214	7.000	2.741

The absolute values of the measured means are always greater than the corresponding critical values, which shows that the answers do not come from a random population. The same result can be found by using the *Student's t* distribution.

Since the results obtained for the first two groups do not differ much, the test group can be conveniently compared with group 2, since these samples are characterized by the same gender, and so are more homogeneous. By following the same method of analysis, based on the *Student's t* distributions, the confidence analysis shows that there is one dimension in which there is an enormous difference: by accepting $\alpha = 0.001$ the differences in the *Logical-Mathematical* dimension can be expressed, in terms of *t score* as 3.723, while the corresponding critical value is only 3.213. By accepting a confidence coefficient less restrictive, namely $\alpha = 0.05$, two other dimensions show significant differences, that are *Kinestetic* and *Individual mean*, for which the *t score* is equal, respectively, to 1.585 and 1.381, both greater than the corresponding critical value 1.321. Hence it seems reasonable inferring that the Engineering students show a *M.I. profile* where the *Logical-Mathematical* and *Kinestetic* approaches are preferred in learning, with respect to a given *test group*.

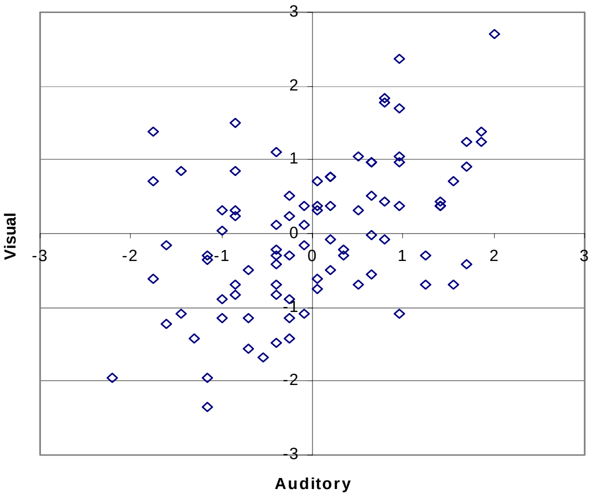

Figure 3. *Visual – Auditory* dispersion diagram in the sample *Group 1*.

6 CONCLUSIONS

This investigation has been motivated by the unsatisfactory results obtained in terms of share of students which are able to complete their program successfully at the Italian Engineering Courses. This paper is intended to contribute, hopefully, in changing the old philosophy that the *only* thing learners must do is working hard. The idea is that learners should be conscious that they can reach knowledge and skills, by using one or more methods tailored over their typical capacities.

M.I. Theory has not been well experimented yet at the highest level of education. For this reason, the present research has offered the opportunity to test another application of Gardner's model. According to the adopted model, the examined group of Engineering students has presented a very high score in the *Logical-Mathematical* dimension, while a less strong superiority in the *Kinestetic* dimension, with respect to another test-group. No significant differences, within the Engineering group, have been detected due to gender.

Results (in standard scores) have been communicated to the students with some comments. Among them, the interviewed ones have shown a great interest in the test and in the obtained results. However, some important aspect of the *cognitive styles* and of the *instructional preferences* could be not detected. For this reason, it seems that the M.I. model, although very general, promising, and appealing, can not be considered as completely satisfying for the given contest.

The future work concerns: (i) the use of the actual test (revisited) in combination to a standard Cognitive Styles Inventory and an Instructional Preference test; (ii) an efficient Web implementation in dynamic form; (iii) the setting up of a counseling service for the enrolled students who need help, which could take profit from the result of the test.

ACKNOWLEDGEMENTS

Miss Amanda Iorio is gratefully acknowledged for her help in data collecting and processing.

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