Find learn strategies using multiples intelligences: case study in a discipline at Escola Politécnica University of Sao Paulo.

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***Abstract* - In the end of the last century the conception of an engineering course starts to oppose the Cartesian approach, exclusively related the solution of problems, to the Holistic approach, looking for engineering solutions that involves not only the resolution of problems with creative solutions, but also its effect in the neighborhood, including Earth. Thus, the solution of a problem should be thought in an integrated way, using knowledge of other areas such as biology, environmental science, sociology, psychology, ethics and philosophy. The question is how do we teach different approaches in an engineering course? Many learning styles have been studied in the last years. There is not a consensus in which learning styles is suitable for a specific group of students. Usually more than one is applied in classes to improve learning skills. In this context, Gardner theory of Multiples Intelligences (MI) can be utilized to guide some learning strategies on a discipline syllabus. The objective of this study is characterize the MI profile of a last year class of engineering students using a questionnaire with approximately 160 questions. Based on the MI profiles one can introduce some learning activities to enhance the MI of the group. Results showed a need to improve musical, linguistic and bodily-kinesthetic intelligences. On the other hand, students presented well developed logical-mathematical, spatial, interpersonal, intrapersonal, and naturalist intelligences. With this result learning strategies were proposed, applied, and results commented.**

Index Terms – multiple intelligences, learning strategies, case study.

I. INTRODUCTION

A. Motivation

A doubt that usually professors have is 'how to plan class activities connected to a syllabus of a discipline which motivates their students and keep focus in the subject discussed in each class'. In the end of the last century, the conception of an engineering course starts to oppose the traditional Cartesian approach, exclusively related to the solution of a problem looking into the defective part and not to the entire project, to a Holistic approach, looking for engineering solutions that involves not only the resolution of problems with creative possibilities, but also integrated in the neighborhood, including impacts in our planet. Thus, the solution of an engineering problem should be thought in such a way using the knowledge of other knowledge areas such as biology, environmental science, sociology, psychology, ethics and philosophy. The question is how do we teach different subject approaches in an engineering course using also some of these knowledge areas?

Many learning styles have been studied in the last years [1] [2]. There is not a consensus in which learning styles is suitable for a specific group of students. Usually more than one is applied in classes to improve learning skills. To find learn strategies, the professor should know the profile of the group regarding its own personal interests and what students expect from the discipline topics. One of this 'learning styles' is the Multiple Intelligences (MI) approach, which was chosen as the base for this proposed methodology.

B. Multiple Intelligences

Gardner defines intelligence as [3][4]:

- 'a bio-psychological potential where all human being has the capability to exercise a set of intellectual capacities, which the specie is capable'.

or

- 'a bio-psychological potential to process information that can be activated in a cultural scenario to solve problems or to create products that are valued in a culture'.

Some issues on Gardner´s intelligence definition should be pointed out: intelligence is not only genetic but also related with stimulation the human being received during life; intelligence can be exercised, and, finally, it is a cultural related subject to solve problems or to create products. The last phrase is exactly what engineers usually do, and, according to Gardner, this potential can be exercised depending upon the learning strategies used in classes.

Gardner proposed eight different intelligences based on neuroscience and observation of normal people and people where a part of brain did not respond to stimulations [3]-[5]. These intelligences are: linguistic; logical-mathematical; musical; bodily-kinesthetic; spatial; interpersonal; intrapersonal; and naturalist. The existential intelligence is suggested, but there is a lack of empirical evidence to put this intelligence in the list of the MI [5].

Linguistic intelligence is related to the capability to deal with verbal and written communications, and to learn and spoken different languages. For engineers this intelligence is essential to proper communication with other people and also

to understand what was expressed by others. Also, writing is important to correspond correctly to other people.

Logical-mathematical intelligence consists to the ability to analyze problems logically, to use mathematical operations, and to conduct scientifically investigation of facts. This intelligence is significant to engineers to do modeling of engineering phenomena, and to optimize process parameters.

Musical intelligence involves aptitude in performing, composing, enjoying musical patterns, listening perception, noises and sounds discrimination, understanding sound patterns, and discriminating rhythmic structure. Although this intelligence is supposed to be an 'artistic intelligence', like bodily-kinesthetic and spatial intelligences, it is essential to engineering students. Music is a combination of mathematics and feelings, which activates both sides of the brain, and is also crucial to develop analogical reasoning, like exemplifications, comparisons and similarities, and consequently, the creativity. The capacity of recognize rhythms, tones, and pitches is also fundamental to work in an industry.

Bodily-kinesthetic intelligence is connected to the capability of using the whole body or parts of the body to solve problems. It also involves motor coordination; tactile coordination; visual coordination and perception of forms, weights and sizes; taste; smell; touch and hearing. All these issues can be used to create a new product or a new solution. This intelligence is also closely related to creativity.

Spatial intelligence involves the potential to recognize and to solve problems in space such as use of maps and diagrams, visualization of an object by other angle of vision, laterality, and spatial orientation. This intelligence is important to engineering courses to help students to concept a new product or a new solution to an old product, by increasing its creativity.

The next two intelligences are sometimes called 'personal intelligences'. *Interpersonal intelligence* is associated with the capacity to perceive different people personalities and its intentions, and understand the motivations and needs of other people. This intelligence is key to work and to have a good relationship with other people and to built up a good work environment.

Intrapersonal intelligence entails the capacity to comprehend oneself, such as the identification of its own emotions and fears, the self corporal perception, the self-knowledge, and the social relationships. An engineer should have this intelligence developed in such a manner to control its emotions, for instance when he/she is under pressure to finish a work.

Naturalist intelligence is related to the recognition and the classification of certain features and patterns in the nature. This intelligence is also significant for engineers to distinguish patterns, which helps analogical reasoning and, consequently, to find a creative and different solution to an engineering situation.

It is essential that all students have the eight intelligences reasonable balanced, in such a manner that none of them should be a barrier to their future personal and professional development.

After mapping the MI profile of the group, the professor may include some group activities to exercise all intelligences in activities in its discipline and also motivate students in a pro-active attitude [6].

According to Masetto [7] [8] learning strategies can be classified as: *first contact, warming-up* = to promote a bigger integration and knowledge of the group; *simulated situations* = to simulate the reality through case studies; *confrontation with real situations* = contact with the reality of the subjects presented in the disciplines; *small group activities (3 to 7 students per group)* = to promote the diversity of interpretations, to developed arguing of a subject; *experts and/or previous preparation* = to promote the maturity and the intellectual independence of the students; *action centered in the professor* = to present the "state of the art" of one determined subject, to expose new technologies, to present a demonstration or a modeling technique; *research and projects* = to search and to select information to developed research and projects; *activities based on reading and writing* = complementation of concepts developed in class, organization of ideas through writing.

In this paper, a methodology to map the group interests will be presented based upon the theory of Multiple Intelligences (MI), proposed by Howard Gardner and further some learning strategies will be discussed based on this map.

It is important to point out that all intelligences should be practiced during classes, but attention should be focused in the intelligences which needs some stimulations and/or improvements.

II. METHODOLOGY

The MI group map is based on a list of approximately 160 questions, proposed by Antunes [9], and involving all eight intelligences main aspects, with about 20 declarative questions per intelligence type, and all 160 questions mixed up to avoid student intelligence identification during answering the questions. Also it was asked if they play regularly a musical instrument or if he/she practices any kind of sport. For each question they have four different answers: never, almost never, almost always, and always. It was assumed a discrete value, from 1 to 'never answer' up to 4 to 'always answer'. This criterion permits to calculate a mean value for each intelligence and to classify the results in 'positive', which means almost no need to exercise this particular intelligence, when the mean of a particular intelligence is higher than 3, or as a 'negative' result, which means this intelligence should be more exercised than others, where the mean is lower than 2. It is important to point out that the classification 'negative' and 'positive' means respectively that a particular intelligence should be practiced or not, and this classification has no relation to the usual meaning of the words 'negative' and 'positive'. The questionnaire was applied to 20 students in the ninth of tenth semesters. In some intelligence kinds, there were fewer than 20 questions, but at least 18 questions and, in this case, the frequency of response was corrected to 20 questions to standardize the frequency of answers.

III. RESULTS

Result for each intelligence is presented in a histogram and group frequency for all kind of answer.

A. Linguistic intelligence

The result for linguistic intelligence is presented in figure 1.

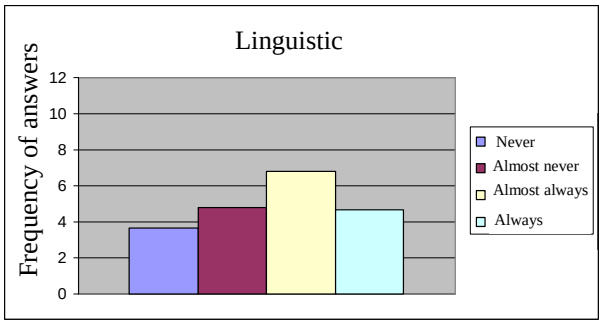

FIGURE 1
HISTOGRAM OF LINGUISTIC INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

Analyzing this result one can note a trend to more positive answers of the group for this intelligence, in spite of approximately 42% of the students presented some difficulties in this intelligence. To exercise this type of intelligence the learning strategies would have to be based on 'reading and writing' or 'experts or previous preparation' involving activities such as: elaboration of texts and/or interpretation of texts, seminaries, and activities that involve 'to speak in public'.

B. Logical-mathematical intelligence.

The result for logical-mathematical intelligence is depicted in figure 2.

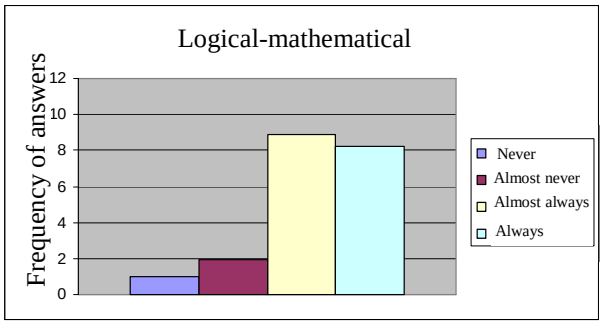

FIGURE 2
HISTOGRAM OF LOGICAL-MATHEMATICAL INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

As was expected for engineers, most students have this intelligence very well trained; only 15% had presented some difficulty in this intelligence (5% 'never' and 10% 'almost never'), which can be practiced by 'simulated situations', 'confrontation with real situations', and 'research and projects' learning strategies.

C. Musical intelligence.

The result for musical intelligence is shown in figure 3.
Analyzing this result one can note a bimodal distribution with two groups: a big group with some need for practices this intelligence (approximately 51% of the students) and other with almost no needs to practice musical intelligence. A group close analysis showed a large number of students, which plays musical instruments, justifying these results. To improve this intelligence, professor should include learning activities like warming-up or small group's activities, with music to stimulate them to think on a determined subject of the class. It might be a subject suitable for this class strategy and music with lyrics adequate to the reaction professor intend to promote.

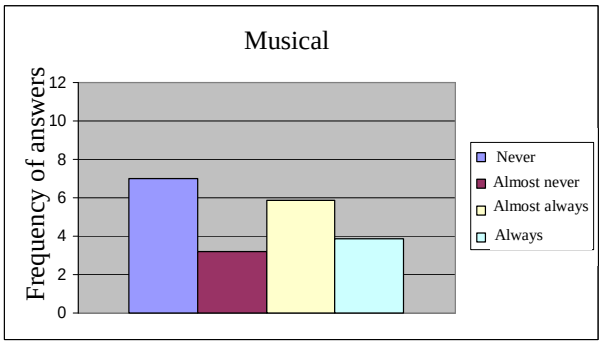

FIGURE 3
HISTOGRAM OF MUSICAL INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

D. Bodily-kinesthetic intelligence.

The result for bodily-kinesthetic intelligence is presented in figure 4.

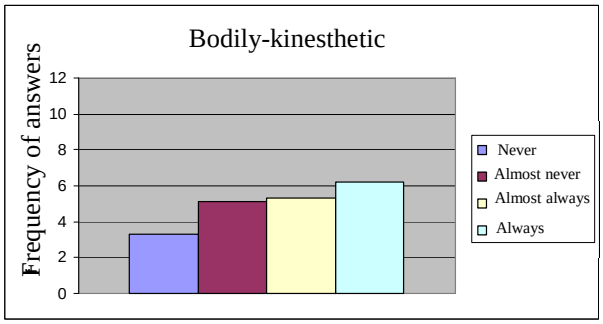

FIGURE 4
HISTOGRAM OF BODILY-KINESTHETIC INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

Observing better this result, one notices a positive trend to this intelligence. But, approximately 44% of the students had answered negatively. These results show that a part of the group presented some necessity to work this intelligence, through simulated situations class strategies, such as: dramatization; group activity coordinated by music, and so on. This intelligence can also be practiced in extra curricular activities such as: sports, cooking, dancing, etc.

E. Spatial intelligence.

The result for spatial intelligence is depicted in figure 5.
In the spatial intelligence, the great majority of the students answered positively (only 32% presented a negative answer). To improve this intelligence they should have class activities involving creation of mental models and dramatization of real situations.

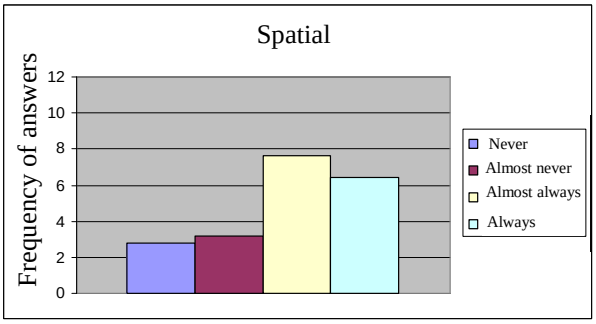

FIGURE 5
HISTOGRAM OF SPATIAL INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

F. Interpersonal intelligence.

The result for interpersonal intelligence is shown in figure 6. The great majority of the students possess this intelligence developed, with only 29% of the group with 'negative' results. To exercise this intelligence the class strategies should promote activities in group, where the people have that to defend its opinions and to debate them in group.

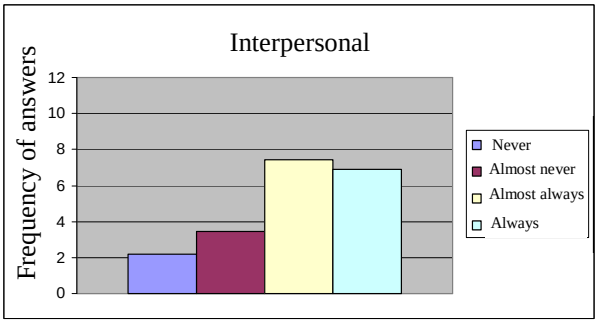

FIGURE 6
HISTOGRAM OF INTERPERSONAL INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

G. Intrapersonal intelligence.

The result for intrapersonal intelligence is shown in figure 7.

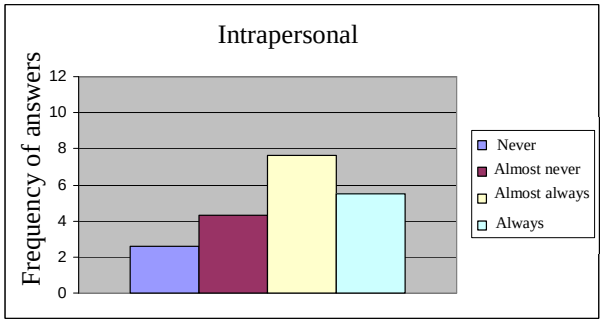

FIGURE 7
HISTOGRAM OF INTRAPERSONAL INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

For the investigated group, most of the students presented this intelligence developed. Of the total, only 26% had presented 'negative' results. Intrapersonal intelligence can be improved through class strategies that involve a self-knowledge of the students. Depending upon the needs, an analyst should be suggest to improve student self knowledge.

H. Naturalist intelligence.

The result for naturalist intelligence is shown in figure 8.

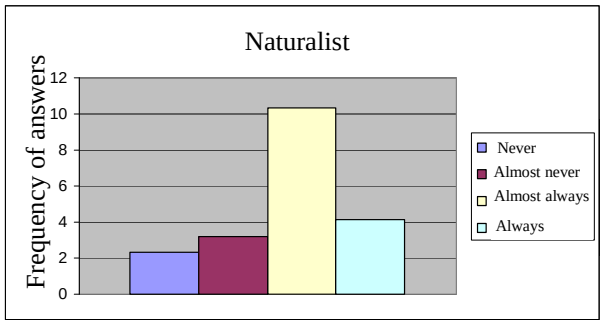

FIGURE 8
HISTOGRAM OF NATURALIST INTELLIGENCE RESULTS OF A NINTH SEMESTER ENGINEERING CLASS.

The result of this intelligence showed that only 27% of the students answered in a 'negative' way. Comparing the disciplines they had during the Metallurgical and Materials Engineering courses, this result is accordance to course objectives. They are frequently exposed to problems to correlate different materials with their properties, performance, and processes of manufacture. To evaluate naturalistic intelligence it can be created class activities such as case studies where classification of process should be correlated to different performances.
Table I summarizes the 'negative' results of intelligences obtained for a group.

TABLE I
SUMMARY OF THE OBTAINED RESULTS.

Intelligence Type	'Negative' result (%)
Musical	51
Bodily-kinesthetic	44
Linguistic	42
Spatial	32
Interpersonal	29
Naturalist	27
Intrapersonal	26
Logical-mathematical	15

Based on the results presented, students have to practice intelligences such as: musical, bodily-kinesthetic and linguistic intelligences. This can be done by a proper choice of the learning activities.

IV. SOME LEARNING STRATEGIES UTILIZED IN CLASS

Based on learning strategies proposed by Masetto[1] and the group MI map some class strategies had been proposed. Table II shows the typical distribution of the learning strategies used in the discipline.

TABLE II
STRATEGIES USED IN FUNCTION OF THE PERCENTAGE OF THE TOTAL OF LESSONS OF DISCIPLINE 'WELDING AND JOINING PROCESSES'.

Type of strategy		%
Action centered in the professor		35
First contact, warming-up		7
Small group activities		21
Seminar		22
Confrontation with real situations	Video activities	10
	Technical visits	3

Two class strategies will be presented based on table I result. Both are strategies related mainly to musical intelligence, but other intelligences may also be practiced using other learning strategies [10] [11].

A. Eliciation technique.

Eliciation is a neurolinguistic technique [12] which was used in the beginning of each class as a warm-up procedure. This class strategy has been utilized for years, in two disciplines, one class with approximately 30 and other with about 70 students. Eliciation consists in remembering a subject using relaxation technique. The term 'to eliciate' is more recent used in neurolinguistic methods. Its meaning is: “the act of discovering and detecting some internal processes” [12]. In my disciplines I played an instrumental calm music to help them to relax. The duration of the technique is the duration of music, usually 4 to 6 min. long. The objective of this class strategy was to remember the main topics presented in previous classes and relate them with the subject that will be exposed in the class. When this strategy was used, they accepted the activity but initially with some restriction, maybe due to the application of music and relaxation techniques in an engineering class. This scenario changed after few classes, with students waiting for the beginning of class using eliciation technique. Some spontaneous comments about the technique were: 'each time that the activity was done, I felt as if I opened my class notes and made a review of the given class subjects'; 'it is very enjoyable to remember the class topics in this way”. The result during the classes includes a class more calm and focused in the theme of the class, in particular in the case of the discipline with 70 students in class. This activity worked mainly with musical and spatial intelligences.

B. Integrated panel technique.

This is a small group technique which is suitable to be utilized after the end of a unit of knowledge of a discipline. In my case, the integrated panel was used after a unit of knowledge about welding and joining processes. At that time, most students might be curious regarding the rules to choose the best welding process for a determined application. The strategy of the integrated panel with music was used as a tool to discusses the criteria for the best welding process application. The learning strategy consists of three different parts. First, the class was divided in small groups (5 to 6 students depending on the numbers of students in class), each group received a subject to discuss which influences the choice of the welding process and a task: after discussion all group components shall have a identical summary of the group conclusions. At this time the students doesn't know the objective of this activity. Before starting the second part, each component in each group received a letter as identification. For instance, if the class was divided in five groups, each student in each group received a letter from 'a' to 'e'. In the second part, new groups are formed with same letters just to guarantee that all subjects discussed in the first part were presented to the new group. After presenting the former group conclusions, they started to discuss the best criteria to choose a welding process. At the end of this part a member of each group presents the final conclusions. The professor takes notes in the blackboard of the opinion of each group and made the final analyses of the criteria proposed by the groups. In the third part of this activity, a lyric of a music containing a message of behaviors modification, was distributed to all students as motivation for a final discussion of the activity. After hearing the music, a very tradition and well established application of an industrial welding process is presented to all groups to criticize. With this last part the discussed concepts and criteria are correlated with a real situation. Their participation in this activity, that lasted 50 approximately minutes, was very good. Some comments of the students after the evaluation of this learning strategy:

'The technique is interesting to observe different points of view of the groups and the people”. There were more four opinions similar to this one.

'I liked very much, mainly the inclusion of the comparison of music with the evaluation technique of a typical industrial welding application. It was strange in the beginning, but interesting, exactly for being a new activity'. They had more five opinions similar in content to this one.

'This activity was a different experience and the benefits will be seen in future, I hope.'

'My participation was weak because I did not have anything to add to the group discussion.'

'I, particularly, did not like the activity. I have a 'math oriented' mind and I like problems with a more direct solution. I don't like subjective discussions in the discipline classes. I prefer to solve problems on the basis of very objective decision criteria. Anyway, the experience was valid.'

'Interesting, mainly in the last part of the activity, where the rational vision of engineers was left behind.'

This class strategy deals mainly with musical, interpersonal, intrapersonal, logical-mathematics and linguistic intelligences.

V. CONCLUSIONS

In the process to built a discipline with is attractive and really included, with dignity, the student, but also motivate them I tried to transmit a little of my professional experience as engineer and professor. One lack in engineering courses was the absence of student flexibility facing the real world, regarding its technical acquired knowledge and acquired experience.

The MI map of the group helps to find ways to have an attractive discipline by using the results to apply class

strategies which improves the student 'way of life', its technical formation and also its motivation. The motivation is achieved by a balance between usual strategies, as classes centered in professor and seminars, and group activities.

In particular, musical intelligence is a way to join the objective and the subjective parts of the brain. Music is mathematics, but music also produces feelings in the person. I believe this intelligence will be a key intelligence for future more creative engineers. Music also relax people, thus it was possible to bring from unconscious the subjects previously learned in class and also creates a pro-active atmosphere to learning.

The application of these strategies also presented its negative sides. These strategies were modified until a 'final version', according to students' evaluation. Another factor that interferes in this process is when one only a discipline adopts this type of methodology in the semester, while the others disciplines of the engineering course adopt the "conventional methodology" (one seminar, two tests and a final exam). In this in case, they leave apart a discipline with 'not conventional methods of evaluation', to study hard the disciplines with uses 'conventional methodology'. This question was raised, clearly and frequently, by the students in an auto-evaluation of the discipline and by colloquial talks with professor. A solution to overcome this problem is to mix 'conventional' and 'non-conventional' type of strategies, and it worked very well in my case.

The MI map is also a tool to verify their formation, based on the profile the school desire for its formed engineers, and to generate actions to change strategies in class to improve the typical MI profile of the students of a specific course.

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