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LEARNING STYLES AND TEACHING STRATEGIES IN CHEMICAL ENGINEERING: AN STUDY

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ABSTRACT

Several studies on educational psychology have shown that factors such as personality, life history, culture, motivation, and environmental factors may affect perception of reality, influencing the learning processes. The process of absorbing information is a complex activity related to individual and social aspects. Given that the traditional teaching method is no longer considered adequate to the professional formation of engineering students with the profile required by the labor market, the present study determined the learning styles of chemical engineering students in a brazilian public university, based on the Felder and Silverman model (Felder and Silverman, 1988), associating it with students' socioeconomic and cultural profile, aiming at identifying more appropriate teaching strategies.

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INTRODUCTION

Several studies have demonstrated over the last years the necessity of changes in the pedagogic projects and in teaching methods in chemical engineering, considering the new challenges of the globalized world. The engineer is classically seen as a technician specialized in the solution of specific and limited problems to determined fields of interest; however, at present, he needs to be seen as an apt multitask professional to contribute to the solution of a great diversity of human problems, working in team and in transdisciplinary topics involving cooperation with many areas of the knowledge. In this perspective, our interdisciplinary research group has the general purpose of trying to answer questions involving the following points:

How do engineering students absorb information?

a) How do professors notice the different learning styles?
b) How do learning profiles of students and professor relate?
c) Is the engineering course really forming engineers with the expected profiles for the labor market?
d) How to identify quality indicators in the teaching/learning process in engineering?

All these questions culminate in the identification of more adequate teaching strategies for the formation of these professionals, appropriately meeting the expectations of the labor market. The present study proposed raising the predominant learning styles between students and professors of the course, the analysis of the confrontation of these results with learning performance indicators, as well as evaluation of methodological procedures of professors and evaluation systems. The study was carried out by statistical data, with random stratified sampling. The used resources involved

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structured and semi-structured questionnaires, data collection from existing database, analysis of relevant literature, use of electronic spreadsheets and/or database. This study is in agreement with the guidelines of the teaching research projects program of the Universidade Federal de Viçosa (UFV) and Universidade Federal do Amazonas (UFAM), aiming at the interaction between investigators, professors and students, for structural, organizational and functional teaching improvement with the following purposes:

a) Implement initiatives and educational and methodological experiences aiming at improving the teaching-learning process at the university;
b) Develop studies on teaching in its diversity of contexts: learning environments; resources and educational tools; experiences and teaching and learning trajectories;
c) contribute with the teaching process dynamization, its relation with knowledge and with production of significant learning;
d) Develop actions that allow reduction of failure and dropout;
e) Promote reflection and enhancement of pedagogic-political teaching strategies at the university (secondary education, technical, technological courses and of graduation);
f) Promote curricular dynamization and value active involvement of professors and students in activities related to research in teaching, within the university;
g) Promote socialization of experiences in teaching practices in the Institution.

Professors and managers of engineering courses are increasingly concerned about questions related to modern challenges, and realize that it is no longer possible to face these challenges, adopting traditional teaching methods or not knowing how students absorb knowledge in search of competences and skills for the labor market and for life. Studies on education psychology have shown that factors such as personality, life history, culture, motivation and environmental factors modify individual perception of reality, influencing the learning processes. The discussion raised in these lines is on what is fundamental to the professional formation of an engineering student: a) technical knowledge exclusively concerned with the execution of an occupation, considering the great scale of knowledge he needs to dominate; or b) formation not so focused on grueling technical information, in other words, offer an engineering student not only finished knowledge, but the possibility of learning to build and produce knowledge, by a fundamental change in posture in which the student learns to learn. The act of learning is a complex activity that needs to be understood at the individual and social dimension. Learning depends both on motivation and interest of the subject, and on the quality of mediations between the learner and the object of knowledge. In this sense, the investigative study of the different learning styles of chemical engineering students at UFV, as well as their socioeconomic and cultural profile is relevant and necessary for the definition of teaching strategies that better match the characteristics of these students. Knowing the students' learning styles, professors will be able to propose appropriate interventions, aiming at improving learning and contemplating all students.

Study purpose: The general purpose of this study was to verify if the learning style impacts academic performance of chemical engineering students at UFV, as well as, identify more suitable teaching strategies for the professional formation of these students, stimulating professors to give up the traditional teaching method and participate effectively in the formation of engineers, appropriately meeting the demands of the labor market, developing the proper competences and skills, as established by the National Curricular Guidelines and the Political Pedagogical Project of the program.

The specific purposes of the study are the following:

1. Discuss questions concerning the binomial teaching and learning in chemical engineering, involving professors, students, technicians and interested members of the community.
2. Discuss questions concerning teaching practice strategies.
3. Try to answer the following questions, among others:
   a) How do students absorb knowledge?
   b) How do course professors notice the different learning styles?
   c) Which is the predominant teaching\learning profile of professors and students of the course?
   d) How do learning\teaching profiles of students and professors relate?
   e) Which learning strategies are used by professors?
   f) Is there incentive to reflexive critical learning, contextualized between academic life and daily practice of the occupation?
   g) How are evaluations carried out?
   h) Are the forms of evaluation adequate?
   i) Is the engineering course really forming engineers with profiles demanded by the labor market?
   j) How are professors working in their disciplines with the expected competences and skills for course graduates?
   k) How to identify quality indicators in the teaching/learning process in engineering?
4. Consolidate the research group of Industrial Process Engineering and Education in Sciences and the creation of the research line Engineering Teaching.

CONCEPTUAL REVIEW

The current social and economic context of performance of engineers prioritizes energy, high technology, creativity, simultaneously with great environmental and social concern. According to proposals for modernization of engineering education in Brazil, Inova (2006), the activities of engineers are increasingly broader and less focused on technical aspects only: "THE functions of the engineer have more interfaces with other areas, inside and out of the company, demanding a broad range of knowledge and capacity of analysis on social, legal, environmental and economic reality, besides communication and team work skills". The new technological scenario requires changes in the engineer profile which in turn require an alteration in the engineering education profile. In this sense, the National Council of Education (CNE), instituted in 2002 the new National Curricular Guidelines (DCN) for Engineering Courses (Brazil, 2002), which in coherence with the new demands of the labor market determine that the professional finishing engineering courses have a generalist, humanist, critical and reflexive formation, enabled to absorb and develop new technologies, stimulating his critical and creative role in the identification and solution of problems, considering political, economic, social, environmental and cultural aspects, with an ethical and humanistic view, serving

the needs of the society. According to Inova (2006), to reach the purpose of forming engineers with the desired profile, the transmission of contents that are part of the engineering program needs certain caution: "The development of such skills demands that technical disciplines projected in the curricular guidelines are supplemented with interdisciplinary content and that theory is associated with problem-solving. The cooperation between university and industry in this case is fundamental. Understanding the historical context in which several countries developed their engineering helps breaking cultural barriers".

Inova (2006) still adds that the main focus of contents to be transmitted is: "… a strong foundation in sciences and mathematics, properly contextualized in the engineering universe; must not have specialist or polytechnic focus, allowing a personalized formation, according to students interests and regional socioeconomic context of educational institution, but without losing the perspective that engineering assumes an articulated set of knowledge; and must guarantee the domain of facilities offered by computer science and foreign languages". Besides a well-prepared curriculum and disciplines in agreement with the purposes of the course, another challenge for modernization of engineering education in Brazil is the search for teaching strategies that provide students with opportunity for working independently or in groups, preparing them to make decisions and be proactive, besides allowing students to really learn the presented information. Hence, the traditional teaching method on transmission and reception of fixed and finished knowledge seems to be no longer appropriate to this new scenario. Inova (2006) proposes that, "traditional expository lectures based on intensive use of blackboard and verbal exposure of knowledge should be replaced by more efficient and participative systems. An effort should be made for production of educational material, using all kinds of modern Information and Communication Technologies (ICT) resources, especially interactive software, videos, etc. The relevance of this is that these technologies potentialize classroom interactions, avoiding mere unidirectional presentations". Teaching must prioritize significant learning and leave mechanical learning behind. In significant learning (Carvalho; Porto; Belhot, 2001), the individual assimilates new information anchoring it in pre-existing knowledge which gives meaning and support to the new information; while in mechanical learning simple memorization of concepts that are not incorporated to the learner's cognitive structure occurs (Machado; Pinheiro, 2010). Prior to the stage of identification of teaching strategies that allow significant learning, it is necessary to understand how students learn better, what can be accomplished by learning styles model, since this way, professors are able to use more efficient methods with their teaching-targets.

LEARNING STYLES

Each student has his own learning method or preferred learning method, which determines their learning style. However, a good professional must be able to use all learning styles, since information comes in several different forms and those who are not able to adapt to the different styles will not totally absorb the transmitted information. The key for professors to develop in their students this capacity of developing all styles is balance: it is not possible to teach using exclusively strategies that less favor the preferred styles of students, as enough discomfort may be caused to interfere in students' performance. It is also not necessary to exclusively teach using the preferred learning style of students, since that can lead to learner accommodation, without developing in them the necessary flexibility and skill for the academic and professional life. Although, for some reason, it is not possible for professors to use teaching methods that benefit all students, learner awareness of his learning style and, consequently, of his study habits, strengths and weaknesses, provides him conditions to perfect his learning process alone, which already characterizes a benefit of the use of the learning styles model. In the literature, many definitions are found for learning styles, as described by Kuri, Silva and Pereira (2006). From these concepts, a generic definition for learning style might be: learning style is the way through which the individual notices, processes and keeps information. While the focus of cognitive styles is on organization and control of cognitive processes, the focus of learning styles is on organization and control of learning strategies and knowledge acquisition. Nogueira (2009) affirms that the study of learning styles provides greater explanation on how learning processes occur. In this study, the author evidences Felder-Silverman's teaching-learning models, Myers and Briggs' MBTI and emphasizes the Learning Style Inventory (LSI) prepared by David A. Kolb, which was used in this study. Thus, as the investigator affirms, when identifying the students learning preferences, it is possible to better plan the teaching methods to be used, so that the construction of knowledge can be achieved in the teaching-learning process (Nogueira, 2009).

Felder and Silverman (1988) define learning styles as preferences in the form of noticing, absorbing, organizing, processing and understanding knowledge and/or information. These authors take into account the aspects of personality, cognitive and psychological types for the construction of the model. The studies of Kolb (1984) are influenced by Vygotsky's cognitive theories and information processing. According to Kolb (1984), learning style is a lasting and stable state that derives from solid configuration of interactions between the individual and his environment". The learning style model of Kolb (1984) presents two dimensions: perception and processing of information, in other words, information can be noticed by concrete experiences (for example, hearing, speaking, seeing) or abstract (mental concepts). The stage subsequent to perception would be the processing of information. This dimension of information can be active (denominated active experimentation), in which processing occurs by doing something, or reflexive (reflexive observation), in which processing occurs by thinking about something. In agreement with Kolb (1984), these two dimensions combine, originating four learning styles: 1) type I – Divergent (concrete and reflexive); 2) type II – Assimilating (abstract and reflexive); 3) type III – Convergent (abstract and active); 4) type IV – Accommodating (concrete and active). In contrast, Felder and Silverman (1988) summarized findings of several studies to formulate a learning styles model that contemplates five dimensions of learning styles: Active/reflexive, Sensory/intuitive, Visual/verbal, Sequential/ mglobal and Inductive/deductive. The preference of students on a given scale can be strong, moderate or even not existent and can vary with time and according to subject or learning environment, as the authors explain. Although Felder and Solomon (1991) point the characteristics of each learning style, they emphasize that all students are sometimes active and other times reflexive and that balance is ideal. They also affirm that studies demonstrate that students are characterized

by significantly different learning styles and that educational problems can be a result of failure in directing teaching to reach all students distributed in the learning styles spectrum. According to Felder and Silverman (1988) and Felder and Solomon (1991), active students learn more easily by trying to solve a practical problem and prefer working in groups, while reflexive students prefer thinking about the problem and how to solve it before trying, and prefer working individually. Sensitive students prefer learning with concrete material, such as examples, they tend to be more practical and careful with details, whereas intuitive students prefer abstract material, such as theories and concepts and like challenges, they tend to be more innovative than sensitive students. Visual students better remember what they have seen; while verbal students prefer words, either written or spoken. Finally, sequential students learn in linear steps, prefer pre-defined linear paths, and are guided by the learning process. In contrast, global students learn in wider steps and prefer more freedom in the learning process. Studies on learning styles have become more frequent, mainly in the engineering area, since engineering course professors rarely have pedagogic preparation to teach. Thus, they end up administering similar and frequently archaic lectures, based on premises like: memorization of concepts, application of methods and repeated techniques, besides fragmentation and standardization of contents, which exclude any relation with other subjects of the area, or with the student/professional reality (Rosário, 2006). Therefore, it is important, as reported by Pereira, Kuri and Silva (2004): "to recognize that students are different, each one with his own way of receiving and processing information, solving problems and exposing ideas, in other words, each one has his own learning style. Teaching methods, ways of presenting information and personality traits of professors affect learning and students, differently. Thinking about learning styles may lead professors to consider the best teaching method and how to vary teaching methods and learning activities to reach the highest possible number of students, enabling learning. In order to meet the different learning preferences, it is necessary, first of all, that educators have a better understanding of learning itself, in other words, how people learn, recognize the different learning styles of their students and use instructional strategies that stimulate students to explore ideas, explicit reasoning strategies and be aware of how they prefer to learn and communicate".

MATERIALS AND METHODS

The characterization of the chemical engineering course students of the Federal University of Viçosa was based on data collected from a questionnaire prepared on Microsoft Excel package and available by e-mail to students and professors of the university, based on the studies of Felder (1996) and Felder and Silverman (1988). The obtained data were analyzed by statistical software (SPSS and Atlas. TI). The study involved the following goals and activities, as presented in Table 1.

RESULTS

In order to obtain some personal information and outline the students' profile, questions concerning year of birth and sex were asked. A wide age group was observed, ranging from 18 to 26 years, being the largest number (12 students) of students 22 years of age. As a reflex of the growing insertion of women in the labor market and participation in activities previously recognized as masculine, the distribution of students as for gender was extremely balanced – 48.6% masculine gender and 51.4% feminine gender. Students' socioeconomic characteristics were also analyzed. For that, participants were questioned as for type of high school they attended, parents schooling, family income and ethnicity. Out of 35 students, 14 affirmed that attended public high school partially or integrally and 21 attended private schools. For the parents schooling level, there were three answer options: both completed higher education; only one concluded higher education; and none has a degree course. Most students answered that neither the father nor the mother had completed a degree course. From the answers to the 44 questionnaire questions, based on the ILS model, it was possible to determine the students' learning styles based on Felder and Silverman's model (1988). As previously mentioned, in each learning stage, there are two antagonistic styles and the learner may present one among three preference levels for each style: balanced, moderate or strong. In the processing stage (Table 2), it was noticed that most students (61.3%) demonstrated being able to process new information and ideas both for experimentation, and for reflection, which is very positive, since balance is always desirable: if the individual always acts before thinking about the subject he may anticipate himself and make incorrect decisions which, in turn, may cause problems, while, if the person spends too much time thinking on the subject, he may end up never taking a stand. Following this trend to balance, it is noticed that only one student presented a significant preference for a style. As for the perception stage (Table 3), although a great number of students demonstrated balance as for the way of grasping information, the style that obtained higher frequency was the moderate sensory one. This behavior converges with that demonstrated by Felder and Silverman (1988), where it is recognized that most engineering students are sensory. Felder and Silverman still affirm that several studies show that professors are generally intuitive, suggesting an incompatibility of teaching/learning in engineering courses.

Table 1. Detailing of activities

Activities	Detailing
Study of Models of Learning Styles	Several models of learning styles frequently used in engineering studies were analyzed.
Evaluation of Population	A systematic investigation of available data on the population to be analyzed was carried out.
Determination of Sample Size	With data from previous step, several existing sampling models were studied, for appropriate determination of sample size, permitting the adequate representation of the analyzed populations.
Systematization of sample data collection	In this stage, after defining the sample to be worked with, pilot tests and eventual adjustments were carried out in the collection procedure.
Collection of data and Registration of data collected in database/ electronic spreadsheet	After confirming relevance of sampling procedure, questionnaires/forms were applied, according to selected methodologies. Data collection was performed by questionnaire filling and transferred to electronic spreadsheet.
Descriptive statistics of results	Descriptive statistical analysis of collected results, concerning learning styles.
General analysis of results	In this stage, several statistical procedures and use of computational tools were studied, for statistical analysis of obtained data.

Table 2. Learning Styles in the processing stage

Strongly Active	Moderately Active	Balance	Moderately Reflective	Strongly Reflective
3.2	22.6	61.3	12.9	0.0

Table 3. Learning Styles in the perception stage

Strongly Sensory	Moderately Sensory	Balance	Moderately Intuitive	Strongly Intuitive
6.5	45.2	35.5	9.7	3.1

Table 4. Learning Styles in the entry stage

Strongly Visual	Moderately Visual	Balance	Moderately Verbal	Strongly Verbal
12.9	19.4	58.1	3.1	6.5

Table 5. Learning Styles in the comprehension stage

Strongly Sequential	Moderately Sequential	Balance	Moderately Global	Strongly Global
3.2	25.8	61.3	0.0	9.7

Table 6. Distribution of learning styles by gender

Learning Style	Men (48.57%)			Women (51.43%)		
Active	5.9	23.5	52.9	0.0	22.2	72.2
Reflexive	0.0	17.6		0.0	5.6	
Sensory	5.9	23.5	58.8	22.2	55.6	11.1
Intuitive	0.0	11.8		5.6	5.6	
Visual	17.6	23.5	41.2	5.6	33.3	61.1
Verbal	11.8	5.9		0.0	0.0	
Sequential	0.0	11.8	70.6	5.6	33.3	55.6
Global	11.8	5.9		5.6	0.0	
Intensity	**Strongly**	**Moderately**	**Balance**	**Strongly**	**Moderately**	**Balance**

Again, it is important to emphasize that an efficient learner is able to interchange between both styles. If the person emphasizes intuition very much, she may miss some important details and make mistakes for inattention in calculations and practical tasks, for example. On the other hand, if the person sticks too much to sensory aspects, she may become dependent on memorization and pre-established methods and not assign the proper importance to real comprehension of the topic or to innovative thought. For the entry stage (Table 4), again, it was noticed that most students manage to absorb both information presented through illustrations, diagrams, videos, and those presented orally or in written form. This balance seems even more advantageous due to the fact that lectures, in general, are administered using few visual resources, which affects visual students very much. As for this aspect, it is interesting noticing that visual learners add up to 10, while verbal ones are only 3, suggesting that many students suffer with this disharmony teaching/learning. Finally, in the comprehension stage (Table 5), the results showed the following: most formal education, from elementary education, involves presentation of content in a logical and progressive order, following a calendar and a study plan. When the content is passed on to students by professors, students are tested on what they learned and then professors follow to a new content. This system is typically sequential; consequently, it was no surprise that most students followed it. However, fortunately, most interviewees seemed balanced in this dimension. Since participation of students was voluntary, those who participated demonstrated interested and curious in finding out which learning style better described them. In addition, it was proposed to students that they returned, after receiving their test result, in an agreement scale, their opinion of it. It was observed that all those who returned, agreed with the result, and some agreed completely. When to describe the data by gender, it is noticed that men and women have different ways of learning. Table 6 shows the percentages for each group for each style and with their respective intensities.

The results from Table 6 shows:

- In the processing stage, men have proven to be somewhat more reflective than women and almost all of them proved to be balanced.
- To Perception stage, while most male students showed balance between styles, most students were characterized as moderately sensory.
- As for the way to capture the information, it is worth highlighting the fact that no woman has presented verbal style. The proportion of men visual style was approximately equal to the balanced style.
- Finally, we note that for Comprehension stage, the proportion of sequential women is much higher than for men, while most of these shows is balanced.

In order to find statistical relationship between the investigated factors, analyses were carried out in the IBM SPSS software, at 10% significance level and when the following results (Tables 7 to 12) were obtained by chi-square test.The hypotheses tested by chi-squared are: H_0: There is no association between the study variables; H_1: There is association between the study variables.

a) The learning styles are present irrespective of age, type of school where student attended secondary education, ethnicity or gross family income;
b) There is association between learning styles for perception and student gender, being that most women, 55.6% were moderately sensory and 58.8% of men were balanced in this learning stage.
c) There is no association between gender and learning style for processing, entry and comprehension stages;
d) There is association between learning styles for processing and the fact that parents completed higher education;

e) There is no association between the fact that parents completed higher education and learning styles for perception, entry and comprehension.

Table 7. Statistical index for gender

Learning Style	X^2	p – value
Processing	1.811	0.404
Perception	9.576	0.008
Entry	3.863	0.145
Comprehension	3.934	0.140

Table 8. Statistical index for age

Learning Style	X^2	p – value
Processing	18.861	0.400
Perception	17.953	0.459
Entry	15.130	0.653
Comprehension	15.900	0.600

Table 9. Statistical index for the year of admission to the course

Learning Style	X^2	p – value
Processing	10.097	0.607
Perception	8.745	0.725
Entry	10.177	0.600
Comprehension	6.897	0.864

Table 10. Statistical index for type of school in high school

Learning Style	X^2	p – value
Processing	2.729	0.255
Perception	2.343	0.310
Entry	1.005	0.605
Comprehension	3.582	0.167

Table 11. Statistical Index to family income

Learning Style	X^2	p – value
Processing	8.005	0.628
Perception	8.106	0.619
Entry	7.003	0.725
Comprehension	10.542	0.394

Table 12. Statistical index for ethnicity

Learning Style	X^2	p – value
Processing	0.996	0.608
Perception	2.173	0.337
Entry	2.408	0.300
Comprehension	0.832	0.660

It was noted a tendency of Chemical Engineering students of this university to balance in learning stages, this result is very satisfactory as it demonstrates that they are apt to significantly learn in several ways. This result also provides signs of the life history influence in the learning style of the individual pointing to an evolution of the learner along the years. Unfortunately, a statistical relation was not yet established between most parts of investigated factors, making it impossible to infer students learning style from his age, gender or income, for example. Such impracticality can be justified by the small number of participants in the study, resulting in a sample that does not represent the Chemical Engineering student population of this university. Thus, the results could not be generalized. Conversely, the present study can still be used as subsidy for identification of the most appropriate and efficient teaching strategies to students of the Chemical Engineering course. Moreover, this is a pioneer study aiming at improving chemical engineering teaching in this university, and it is also expected that this study helps professors realize the necessity of providing better quality education, more consistent with the current needs of the labor market.

CONCLUSION

With the results, it is possible to see a trend of students of Chemical Engineering to balance the learning steps, this very satisfactory result to demonstrate that they are able to learn significantly for several ways. This result provides further evidence of the influence of life history in learning style of the individual pointing to a maturing of the learner over the years. This statement can be grounded in the work of Alves, Sales and Cordeiro (2009), who analyzed the learning styles of high school students in two schools of Viçosa. The research has indicated that students at the time were mostly in perception stage, visual stage in the input and balanced in the other two learning styles. Although this is not the same group of students, this comparison suggests a propensity to equilibrium as the learning process progresses. In general, one might also conclude that the socioeconomic characteristics of individuals have no association with statistical learning styles, such as exception Perception Stage, which demonstrated relationship with the gender of the respondent and the processing stage, with the level of education of parents. As students of Chemical Engineering proved to be essentially balanced in their way of learning, was not required a discussion with teachers about the best teaching strategies to be used with them. However, according to Felder and Silverman (1988), there are teaching techniques that can be used by teachers to cover all learning styles present in the classroom. To benefit both sensory as intuitive, you can try to find a balance in the content so that it does not get extremely concrete, with many facts and results, favoring only the sensory nor too abstract, using many theories and interpretations, behavior that would favor only intuitive. Make use of diagrams, graphs, figures, and other visual materials, before, during and after the verbal presentation of content allows both verbal as visual learners absorb information. Have the habit of having practical lessons developing learning assets and, even if they are only demonstrative, that already make it much easier to understand for sensory and visual students. A very effective alternative for active students are also group discussions. In order to promote a time for reflection on the subject matter discussed in class, teachers can try to make a break for it, even if brief, reflective benefiting students. Finally, a valid practice for all learning styles is to talk with students about the existence of these different ways to learn and show them some difficulties they may be experiencing in the course are not due, in large part, to their inadequacies and yes, the unpreparedness of teaching in general, to minister their classes in order to reach all students.

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