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LEARNING STYLES AS A TOOL FOR THE EDUCATION OF CHEMICAL ENGINEERS

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Abstract:-
Adaptive and flexible learning environments are expected to be a critical strategic option for the competitiveness of educational institutes in the 21st century. In a multicultural society, as that of the European Union, as well as in global (open) educational systems, students have different backgrounds, levels of motivation, attitudes about learning, as well as preferences and approaches to studying. Therefore, there is a need for educators to identify the factors that support the shift from lecture-based teaching to active learning strategies with such variable class audiences. One of the most critical factors is the identification of the students' learning styles.
This paper focuses on research models of learning styles and comments on the necessity, importance, and some positive and negative elements of various related approaches. In particular we assess the profile of a class of Chemical Engineering students who formed our research case study, through a pilot application of one of the approaches. Our target group was formed by the participants in the elective course "Topics of Information and Knowledge Society", offered at the 2nd semester of the undergraduate curriculum of the School of Chemical Engineering at the National Technical University of Athens (NTUA).
The ultimate purpose of the overall approach was to improve the teaching methodology, course material, and communication channels by indexing the students' learning styles in order for the course to be more interesting and useful to them.

Keywords:-*Chemical Education Research, Learning Theories.*

INTRODUCTION

In modern multicultural society, we have students from different social origins, possibly with different mother tongues and considerable differences regarding digital literacy. "Digital literacy" can be understood as "*a series of attitudes, opinions and skills which help us use and disseminate information and knowledge effectively using various media and forms*" (Shopova, 2014).

The model that has been generally followed until today, "a one-size-fits-all material, way of communication and of delivering the course", showcases its insufficiency in an emphatic way. Patrick (2014) claims that there is "*an inelastic need to move away from the monolithic, industrialized factory model of schooling and toward to a rich, flexible learning environment*".

The necessity to adapt the teaching material, the way it is delivered, as well as the educational methods to the personalized characteristics of the students seems to be a powerful objective in academic teaching, given that data collection, processing and assimilation differ considerably for each trainee. The importance of this dimension is emphasized by many researchers (Henry, 2005, Towns, 2001; Janicki and Liegle, 2001; Wright Martinson and Schindler, 1995).

Coffield et al. (2004) pose a series of insightful questions: how can we teach students if we do not know the way they learn? How can we improve their efficiency if we ourselves do not know how to learn more efficiently? In which ways can we boost the learning process? What if the trainees' learning difficulties showcase teaching problems? According to the relevant literature, research models of learning styles contribute to answering these questions.

Learning styles are "characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Keefe, 1979). As Jeffrey Kovac (1999) notice *"The essential idea of learning styles is that people have different preferred ways of obtaining and processing information*".

According to Felder, students learn in many ways: by seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualizing. However, teaching methods are usually the same for all types of students, and serious mismatches may occur between the learning styles and the teaching style in a class (Felder and Silverman 1988; Schmeck 1988; Lawrence 1993). The results of such mismatching might have a negative impact. From one side, we can see bored students with no attention on class matters; from the other side, instructors are confronted by low student grades and high dropouts, thus forming the puzzles of the icon (Smith and Renzulli 1984; Godleski 1984; Felder and Silverman 1988).

Felder (1993) claims that an indexing model of learning styles must be capable of answering the four following questions:

- What kind of information do students prefer to receive? (reception)
- In which channel do students prefer to receive information? (channel)
- Which is the way students prefer to process a piece of information? (processing)
- How is the processing of the information carried out by the student? (comprehension)

The good correspondence between the teaching modes applied and the learning styles of the students seems to be of an urgent need when it comes to distance learning and asynchronous e-learning courses. In this case, in the absence of the direct communication between trainer and trainee, the need to ensure an as easy as possible adaptation to the digital environment, to waive the obstacles which prevent the access and, most importantly, the need for an environment which will be compatible with the cognitive characteristics of the user, are more urgent and non-negotiable than in any other field.

The best way to the success of the educational work is an appropriately structured material, which allows the user to internalize and comprehend it easily. Active or reflective activities, diagrams of the syllabus structure, with pasted material from connected learning objects libraries, active opinion exchange for a or literature reviews must correspond, as far as possible, to each student's personality. The progress in the syllabus teaching and the selection of segments out of syllabus chapters (when possible) are powerful stimuli which contribute to the intensification of the distant learner's attempt. As Pashler et al. (2008) note, *"If classification of students' learning styles has practical utility, it remains to be demonstrated"*.

A review of the existing literature reveals a particularly keen interest in a considerable number of cognitive specialization fields; furthermore, there is a rich literature in many cognitive domains. This research area has been hugely popular and has a wide acceptance up to now. So Coffield et al. (2004), review and classify 71 learning style theories.

The field of higher education has attracted a considerable number of researchers who record student types, in a broader effort of the academic community to create adaptive teaching models (Ramsden, 1991; Richardson, 2008, 2009, 2011). In addition to the above, recent investigations (Smith, 2000; Pithers 2002; Brennan 2003; Smith and Dalton 2005; Olivos et al., 2016; Smith, 2016) showed an interest in the field of vocational training. Furthermore, there is a considerable research interest in the investigation of modes and practices of efficient math teaching with respect to the study types of the students (Keast, 1999; Woolner, 2004; Gresham, 2007; Aral and Cataltepe, 2012; Adeniji, 2015).

Moreover, a continued interest is noted in the field of engineering, and especially in that of Chemical Engineering (Zywno and Waalen, 2001; Livesay 2002; Bird and Sieber, 2005; Byrne, 2007; Katsioloudis and Frantz, 2012; Freeman et al., 2014). In this field, it is worth mentioning the work of Professor Richard Felder at the North Carolina State University (Felder, 1987, 1996, 2002; Felder and Henriques, 1995; Felder and Silverman, 1998; Woods et al., 2000; Felder and Brent, 2005; Litzinger et al., 2007; Kolmos and Holgaard, 2008).

Material & Methods

The purpose of the research reported here was to index the learning styles among the students who chose the elective course "Topics of Information and Knowledge Society", offered at the 2nd semester of the Chemical Engineering undergraduate curriculum at the NTUA. The overall attempt, aimed at the adaptation of the overall course planning, methodology and material, according to the research results, in order to increase the usefulness and efficiency of the teaching process for the students.

The research tool we opted for was the Index of Learning Styles (ILS) by Felder and Solomon (1988), one of the most prevalent and widely used ones. This tool is comprised by four relevant axes, complementary to each other; in these, we register how a given student receives and processes stimuli (information) from the external environment (Felder, 1993). These axes (or opposites) are:

1. **Sensitive vs Intuitive**. Sensitive types prefer stimuli received by the five senses, sounds, visual impressions etc., as opposed to the intuitive types, who prefer theoretical approaches. Sensitive are practical types who prefer to handle events and like sophisticated, perplexing information. They do not enjoy math, unless it is directly correlated with/reduced to the real world, while they enjoy workshops and experiments. Their preferred teaching methods are presentations, Q&A and problem-solving teaching methods. They operate carefully but perform at a slow pace. On the other side Intuitive types are innovative types, good at conceiving ideas. They prefer theory and abstract approaches get tired with details, can put up with sophisticated patterns. They dislike repetitive chores and courses which require memorization and frequent calculations. They prefer conversation panels, games and simulations, role games, case studies. They operate fast, albeit rather carelessly.

2. **Active vs Reflective**. Active types prefer active interaction with the external environment and, consequently, the learning-by-doing methodology. On the other hand, Reflective types have an introspective tendency and normally present deferred and cumulative reactions. Active types understand better when they are actively engaged, they enjoy working in groups. They like workgroups, brainstorming, role playing and project methods and they prefer engagement in physical activity or discussion. On the opposite side Reflective types understand better after reflection and analysis, they prefer studying alone and tends to write small summaries. Also, they like listening and seeing and enjoy presentations and case studies.

3. **Visual vs Verbal**. The former prefers images, diagrams, shapes, mind maps etc., while the latter prefer auditory impressions, recordings and written texts. Visual types remember easily what they see (photographs, diagrams, tables, graphs, films). They prefer games and simulations, presentations. On the other hand Verbal types remember easily what they hear, read in text, say. They enjoy podcasts and prefer conversation panels, brainstorming, and the Questions and Answers (Q&A) method.

4. **Sequential vs Global**. The progress of the sequential types is made in a continuous, step-to-step approach, as opposed to the global ones, where the general image is fragmented in specific steps, followed by their analysis and synthesis. Sequential types process information in a linear way and present heightened analytical skills. They prefer presentations and the Q&A method. On the other hand the comprehension progress for Global types is performed through big/fragmentary leaps. They present heightened synthesis skills. They follow the top-down approach and prefer role-games, brainstorming and case studies.

The ILS model's scale includes the following value ranges for each axis:

- Values from +/-1 to +/-3; in this range there is a balance or polarization (mild condition),
- Values from +/-5 to +/-7; where a type tension (clear type orientation, moderate condition) is observed, and
- Values from +/-9 to +/-11; this range presents a particularly strong preference, usually binding and irreversible (type dominance, strong condition).

The accepted validity and reliability of the ILS model is pointed out by several researchers
(Zwanenberg and Wilkinson, 2000; Thomas 2002; Litzinger et al. 2005; Felder and Spurlin, 2005). Zywo (2003) argues, characteristically, that the discriminant validity of the ILS is supported by the significant differences recorded in relevant studies in heterogeneous student populations, such as engineering vs business administration students. The ILS tool was especially designed for Chemical Engineering students.

The questionnaire completion was carried out in class, with online access to the website of the North Carolina State University (NCSU). This questionnaire is on line available at https://www.webtools.ncsu.edu/learningstyles/. Each time, the completion was preceded by a relevant lecture on learning styles, while the process was explained and supported. Even though the questionnaire was in English, the completion was not problematic for our students, with the exception of a few phrases out of the 44 questions, to which assistance was given accordingly. The result of the completion is produced automatically by the website and the completion of this activity was carried out one off by all the students.

Results

The results of recording the responses of the 22 second semester Chemical Engineering undergraduates of National Technical University of Athens are summarized in Table 1 below.

Table 1. The learning styles of NTUA Chemical Engineering students divided into groups of strong, moderate and mild preferences according to the Felder –Silverman model

	Strong (-)	*Moderate (-)*	*Mild (-)*	*Mild (+)*	*Moderate (+)*	*Strong (+)*
Active (-) / Reflective (+)	0	7	10	4	1	0
Sensitive (-) / Intuitive(+)	1	9	5	5	0	2
Visual (-) / Verbal (+)	9	10	2	0	1	0
Sequential (-) / Global (+)	3	3	3	7	3	3

The analytical image of the students for the Active/Reflective criterion (axis), according to the registered scores with regard to ILS, is: {0, 7, 10, 4, 1, 0}. As we can see the percentages for Active is 77/% against 23% for Reflective, that is remarkable 3/1 ratio for Active type learners. Therefore, we observe a strong turn to a tendency towards the Active types. This observation corresponds to initial assumption that the majority of engineering students are Active, Sensitive and Visual (Felder and Silverman, 1988). Also, our results correspond to the findings of Kolmos and Holgaard research at Aalborg University of Denmark (Kolmos and Holgaard, 2008).

For the Sensitive/Intuitive axis, the scores are: {1, 9, 5, 5, 0, 2}. If we apply the aforementioned approach, we obtain: Sensitive/Intuitive percentages are 68% versus 32%. The Sensitive type learners are over the double number of Intuitive ones. We observe also a clear turn towards the Sensitive learning types. These results correspond to Felder and Silverman and Kolmos and Holgaard findings as above, accordingly.

Moving forward to the next axis–criterion, the Visual/Verbal types, we note the following set of scores: {9, 10, 2, 0, 1, 0}. In accordance with the above, we obtain: Visual/Verbal ratio = 21/ 1 or a 95% percentage for visual against a 5% percentage for verbal type. Therefore, in this case we observe an impressively strong turn to the visual types. These results represent a highest percentage of visual learners compared to the results of the above-mentioned researches. We can say that NTUA students are considerably more visual.

Lastly, as far as the final axis (Sequential/Global) is concerned, the following scores were recorded: {3, 3, 3, 7, 3, 3)}. In this case, the ratio is: Sequential/Global = 9/13 or 41% percentage for sequential against a 59% percentage for global. In this case too, we observe a mild turn to the global type. In this case as Kolmos and Holgaard (2008), we can say that sequential and global learners are relative equal.

In Table 2 the results of the 22 ILS scores of this research at NTUA's School of Chemical Engineering are shown together with the 62 ILS results from Aalborg University, Chemistry, Bio and Health Technology Department), as represented by Kolmos and Holgaard (2008).

Table 2. Comparison of learning styles preferences of NTUA and Aalborg U. students

	Active	*Sensitive*	*Visual*	*Global*	*Population (N)*
National Technical University of Athens	77%	68%	95%	59%	22
Aalborg University of Denmark	53%	77%	77%	32%	62

Table 2 illustrates several mild mismatches between learning styles of Chemical Engineering undergraduates of the two Universities. More specific in the Active/Reflective axis of the ILS model both dominant turn is for Active learning type. But we observe a plus 14% percentage for the NTUA students. The active turn is a bit stronger for them. For the Sensitive – Intuitive axis-criterion the differences of the percentages is even narrowed. We can observe a statistical minor difference here. Moving forward to the next axis–criterion, the Visual/Verbal learning types we can notice a rather remarkable stronger tenth for Visual type among NTUA students. This shows a very impressive orientation to visual type for our students, a 20% over the Aalborg score; as our study was done almost ten year later that the Kolmos and Holgaard one, this is a point to consider in future research. Lastly, we find a clear mismatch on the Sequential /Global axis. Aalborg students were classified as Sequential learners (68%), whereas NTUA students are classified as Global learners (59%).

Conclusion

There is a clear message to the teaching staff from this work: consider adapting the educational material and the teaching techniques used in lectures (teaching/lectures style) towards a more student-centered approach. Focusing on our educational function as a teaching group, and bearing in mind the findings of this study, we have started to modify all presentation material, enriching our slides with diagrams, incorporating video clips and animated introductions. These attempts aim at the facilitation of the dominant visual and active learner's types in order to motivate them and increase their course engagement.

As far as the active teaching techniques are concerned, such as web search and construction of mind maps right after relevant lectures, we have witnessed already at the pilot stage of our research a growing interest and a positive reception by the class. In addition to lectures on the course subjects, we have introduced additional presentations by visiting experts in an attempt towards a broader, global approach, which was greatly appreciated by the students.

Future steps of this work will include an ex-ante running of the research, before the starting day of semester, as well as the possibility to run the ILS questionnaire among the students of other NTUA Schools, i.e., Mechanical, Electrical or Naval Engineering, in order to get a wider point of view and the ability to cross-reference the results.

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