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Influence of Learning Styles on Conceptual Learning of Physics

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Abstract

Several studies have reported the influence of scientific reasoning on the conceptual learning of students in courses developed with methodologies that promote active learning. Given that learning styles may also influence conceptual learning of physics, it has been conducted a correlational study which has used two different approaches of Learning Styles, the Honey-Alonso [1] and Felder-Silverman [1] models. This quantitative study was performed in groups using the methodology of modeling [3,4] in a course of introductory mechanics in college. To assess the conceptual learning, the Force and Motion Conceptual Evaluation (FMCE) test was used. The results confirm the strong dependence of learning styles on conceptual learning of Physics.

Introduction

The student learning can occur in many ways: watching and listening, thinking and acting, reasoning logically and intuitively, memorizing and visualizing, and drawing analogies or creating mathematical models. On the other hand, teaching methods also vary depending on the preferences of the instructor. Some of them teach by lecturing; some make experimental demonstrations or promote the discussion among students; others focus in principles or applications; and some others emphasize the memorization or comprehension. It is therefore interesting to know what proportion of the students' innate skills, their prior preparation, or the compatibility of their learning style with the instructor's teaching style govern their learning in the classroom [2]. There are also inconsistencies between common learning styles of the engineering students and traditional teaching styles of their professors.

As recently has been studied the dependence of scientific reasoning on the conceptual learning in courses taught with modeling instruction [6], it could be interesting to consider the Theory of Learning Styles in order to complement the understanding of the learning process for concepts in Physics. Hence the key problem in this study is to identify precisely the degree of influence that may have the learning style of students on their learning of Physics.

Theoretical Framework

LEARNING STYLES

Among the available models of Learning Styles (LS) those proposed by Felder and Silverman [2] and one from Alonso, Gallego and Honey [1] were chosen.

Honey-Alonso Model

Honey and Mumford designed an 80-questions test based on subjects' observations that provided a broad overview of learning styles [1]. The styles they discovered in their questionnaire are in terms of four phases of a cyclical process of learning.

- **Active:** People welcome new experiences. They consider and face challenges with determination, open minded, without skepticism.
- **Reflective:** These are observers, information gatherers, and meticulous facts analysts for decision-making.
- **Theoretical:** Looking for logic in every situation, they aim to explain everything with logic and complex theories. They present a logically structured thinking and tend to be perfectionists.
- **Pragmatic:** Interested in the practical application of ideas, they act immediately in situations which are of interest. Fast and practical decision-making, realistic and a little impatient.

Alonso, Gallego and Honey [1] traduced and applied that test to students from Universidad Complutense de Madrid. They made some adjustments and called it Honey-Alonso Learning Styles Questionnaire (CHAEA in Spanish).

Felder-Silverman Model

The model that Felder and Silverman [2] propose classifies students using a scale to rank preferences of receiving and processing information:

- **Sensitive-Intuitive:** Sensitive learners like facts, data and experimentation. They solve problems through standard methods and do not like "surprises". Intuitives prefer principles, theories and innovation before repetition.
- **Visual-Verbal:** Visual learners remember best what they see: pictures, diagrams, timelines, flow-charts, videos, demonstrations. Verbal learners remember much more what they hear and say.
- **Active-Reflective:** Active learners feel more comfortable with active experimentation instead reflective observation like reflective learners. Actives will not learn much in situations that require silence and reflection and reflective do not learn well if they are denied the opportunity to think about the information presented to them.
- **Sequential-Global:** students learn material either sequentially - understanding the material as soon as they get it- or globally - stumbling, spending days or weeks unable to solve simple problems or show a rudimentary reasoning until they finally "get it".

MODELING INSTRUCTION AND SCIENTIFIC REASONING

Modeling Instruction is a methodology for teaching physics based in the modeling theory given by Hestenes [3,4]. The methodology is characterized by the consideration of systematic discussion on the modeling process and the techniques required to solve problems; the selection of proper problems to work in teams is an important part of the methodology.

It has been reported recently the results about the first implementation of modeling instruction in some courses at Tecnológico de Monterrey, which showed a strong positive correlation between the scientific reasoning and the conceptual learning of students. The Lawson Test of Scientific Reasoning [7] was used to assess the scientific reasoning of the students at the beginning of the semester, and the conceptual learning was assessed, as a pre- and post-test, using the Force Concept Inventory [5].

Contextual Framework

The physics courses have been redesigned using strategies promoting active learning. The institution also has a Physics Education Research Group that has been looking for strategies that improve student learning. Thus, the modeling methodology [5] has been recently implemented in some groups of Physics for Engineers.

This study has been carried on two groups of introductory mechanics taught with modeling instruction. This was the second time that the professor has taught with this methodology, so he is considered an early-adopter. Each group had 38 students that worked in cooperative groups where they built models of physical situations given by the instructor. With the help of some whiteboards, the students could share their results with the rest of the class and defend them.

Methodology and Experiment Design

The CHAEA test [1] results consist of in four measurements from 0 to 20 indicating the preference for each dimension. The learning style profile is shown in a regular polygon with four axes that represent the dimensions of the model. This graph is constructed by summing the positive responses to each of the 20 items in the set, thus the sum represents the axis point where the polygon vertex is located. Once mapped the 4 points the polygon, which is the learning style profile, may be built.

Each dimension of the ILSQ test [8] has 11 forced-choice items where each option ('a' or 'b') corresponds to one category and dimension. In this work, as in the online versions responses subtracting 'b' of the 'a' we obtain a score that is an odd number in the range (-11, +11) [8,9].

The Force and Motion Conceptual Evaluation test (FMCE) is one of the most popular surveys to assess the knowledge state of the students [10]. For this study, the FMCE was applied as a pre- and post-test. The pre-test was taken at the beginning of the semester while the post-test was taken near the end. To assess the conceptual learning it has been considered the difference between the post and pre tests.

There were 58 students, from a total of 76 enrolled in the courses that used the modeling methodology, that have taken all the surveys, both test of learning styles and the pre and post FMCE.

Results and discussion

The results for the Honey-Alonso Learning Styles model show a predominance of Reflective and Theoretical styles with 14.06 and 14.29 point respectively. Active dimension was the lowest recurrence with an average of 11.91 points.

Table 1. Honey-Alonso Learning Styles results

Learning Style	Mean	SD
Active	11.91	2.78
Reflexive	14.06	2.70
Theoretical	14.29	2.51
Pragmatic	13.82	2.88

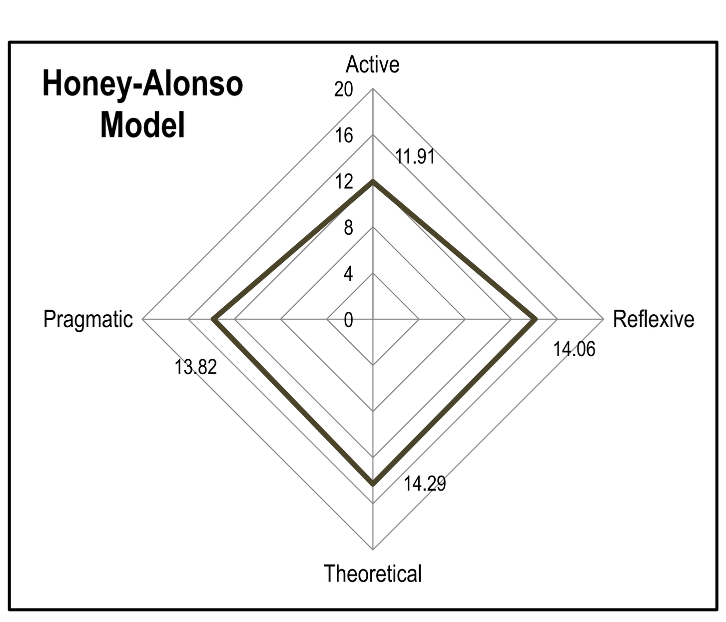

Figure 1. Honey-Alonso Learning Styles Profile

Unlike Honey-Alonso polygonal model, the Felder-Silverman is polarized, i.e. for each dimension the score indicates the strength of one pole and the weakness of the other.

Table 2. Felder-Silverman Learning Styles results.

Learning Styles	Mean	SD
Active-Reflexive	0.6	3.59
Sensitive-Intuitive	2.2	4.14
Visual-Verbal	4.23	3.63
Sequential-Global	3.06	3.95

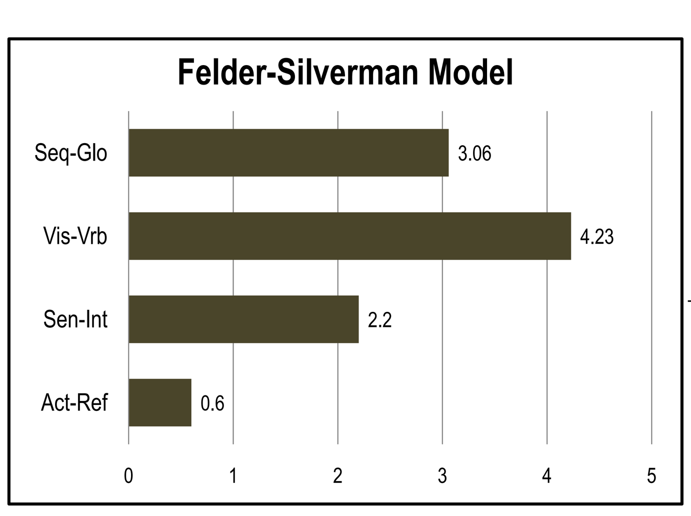

Figure 2. Felder-Silverman Learning Styles Profile.

We measured the gain of conceptual learning using the FMCE and ran a bivariate correlation with the 8 dimensions of learning styles.

Table 3. Correlation coefficients for conceptual learning and Learning Styles.

Model	Learning Styles	Delta FMCE
ILSQ	Activo-Reflexivo	-0.312*
	Sensitivo-Intuitivo	-0.049
	Visual-Verbal	-0.417**
	Secuencial-Global	-0.076
CHAEA	Activo	-0.251
	Reflexivo	0.177
	Teórico	0.085
	Pragmático	-0.363**

To compute the degree of explanation given by these learning styles we used a multiple regression analysis with variables Delta FMCE, Visual-Verbal, and Pragmatic Active-Reflective, which were significant in bivariate correlation analysis.

TABLE 4. Correlation coefficients for conceptual learning and Learning Styles.

		B	SE	Beta
Setp 1	Constant	32.6	3.79	
	Vis-Vrb	-2.40	0.70	-0.417***
Step 2	Constant	59.1	11.7	
	Vis-Vrb	-2.04	0.69	-0.355**
	Pragmatic	-1.99	0.84	-0.285*
Step 3	Constant	57.6	11.4	
	Vis-Vrb	-1.85	0.68	-0.321**
	Pragmatic	-1.89	0.81	-0.271*
	Act-Ref	-1.31	0.64	-0.236*

Best model found considered the three dimensions (Pragmatic, Active-Reflective and Visual-Verbal) with a value of R^2 = .306.

***Significant at the α=0.001 level.
**Significant at the α=0.01 level
*Significant at the α=0.05 level

Conclusions

- Students have shown a preference for theoretical and reflective dimensions, describing a cautious and analytical reasoning in learning.
- According to the Felder-Silverman model, modeling groups are mostly verbal, global, slightly reflective and not so intuitive.
- The dimension that proved to be the most balanced was Active-Reflective where students seem slightly more reflective.
- There is work to be done to increase the Honey-Alonso Active dimension considering that one of the aims of the institution is to promote this type of learning.
- More work is needed with the Visual-Verbal students. They have a high dependence on a verbal learning style, mainly identified with lectures.
- The negative correlation between the Active-Reflective and the FMCE shows that students have more difficulties for conceptual understanding since they are less active.
- Active students according to Felder-Silverman model are more involved in learning and therefore had a better conceptual understanding. Something similar happens with the Visual-Verbal dimension.
- Finally the learning of physics concepts of these students can be predicted by 30.6% if it is known their preference levels in the Active-Reflective, Visual-verbal and pragmatic styles.

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