Influence of Learning Styles on Conceptual Learning of Physics

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Abstract. Several studies have shown 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, a correlacional study was conducted which used two different approaches of learning styles: the Honey-Alonso and Felder-Silverman models. This quantitative study was performed in two groups of students using modeling instruction in a college course of introductory mechanics. The Force and Motion Conceptual Evaluation test (FMCE) was used to assess conceptual learning. The results of this work suggest the dependence of the conceptual learning of physics on the learning styles.

Keywords: Physics Education Research, learning styles, introductory mechanics, modeling instruction.
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INTRODUCTION

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; others make experimental demonstrations or promote the discussion among students; some focus in principles or applications; 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 affect their learning in the classroom [1]. There are also inconsistencies between common learning styles of the engineering students and traditional teaching styles of their professors.

Recent studies have examined the influence of scientific reasoning on the conceptual learning in courses taught with modeling instruction [2], 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 the degree of influence that students' learning styles may have on their conceptual learning of physics.

The following sections outline the models of learning styles considered and the experiment developed to determine the relationship between learning styles and conceptual learning in physics.

CONTEXTUAL FRAMEWORK

The institution on which this investigation is carried out supports the use of innovative strategies for teaching physics in recent years. The physics courses have been redesigned using strategies promoting active learning. The institution also has a Physics Education Research Group that has been experimenting with strategies that improve student learning. Thus, recently has been implemented the modeling methodology [3] in some groups of Physics for engineering students.

This study has been made on two groups of introductory mechanics given 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 building models of the physical situations given by the instructor. With the help of whiteboards, the students could share and discuss their results with the rest of the class.

MODELING INSTRUCTION AND SCIENTIFIC REASONING

Modeling Instruction [3] is a methodology for teaching physics based in the modeling theory given by Hestenes [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.

The results about the first implementation of the modeling instruction in some courses at Tecnologico de Monterrey showed a strong positive correlation between the scientific reasoning and the conceptual learning of students [2].

LEARNING STYLES MODELS

Learning Styles Theory has acquired a great influence in the educational field and even though a recent literature review [6] concluded that there is not enough evidence to justify Learning Styles assessments in an instructional setting, they also noted the real existence of study preferences and recognize that there could be implications of such preferences for educational practices.Among the available models of Learning Styles (LS) those proposed by Felder and Silverman [1] and Alonso, Gallego and Honey [7] were chosen.

Both models consist of four non-equivalent, rather complementary, learning styles. The Felder-Silverman (F-S) [1] focuses on students' cognitive interaction with information: how they receive and process the incoming data, while Alonso, Gallego and Honey [7] use a psychological perspective of personality. Although some of the style names may be the same, the definitions that each model gives to that category differ in certain respects. Each model has a questionnaire to determine the learning style profile: a numerical value for each of the categories of the model indicating the degree of students' preference.

Honey-Alonso Model

Honey and Mumford designed an 80-questions test based on subjects' observations that provided a broad overview of learning styles [7]. The styles they recognized in the Learning Style Questionnaire (LSQ) are the following:

Active: people open to new experiences, they consider and face challenges with determination, open minded, without skepticism. People on moving, who would try everything, at least once.

Reflective: observers, information gatherers, and meticulous facts analysts for decision-making. They do not act without first having studied, understood and even controlled the situation.

Theoretical: looking for logic in every situation. They aim to explain everything with logic and complex theories. They present a logically structured thinking. They 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, especially compared to theoretical.

Alonso, Gallego and Honey [7] translated to Spanish and applied the LSQ to students of the Universidad Complutense de Madrid. They made some adjustments and called it Honey-Alonso Questionnaire of Learning Styles (CHAEA in Spanish).

Felder-Silverman Model

The model of Felder and Silverman [1] was designed for education in engineering. It classifies students according to a scale that ranks preferences for receiving and processing information. The learning styles they proposed are:

Sensitive and Intuitive Learners: sensitive learners like facts, data and experimentation. They solve problems through standard methods and do not like "surprises" while intuitive individuals prefer principles, theories and innovation before repetition.

Visual and Verbal Learners: visual learners remember best what they see: pictures, diagrams, timelines, flowcharts, videos, demonstrations. Verbal learners remember much more what they hear and say.

Active and Reflective Learners: The active learner feels more comfortable with active experimentation instead reflective observation and the opposite for 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 and Global Learners: 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".

METHODOLOGY AND EXPERIMENT DESIGN

The CHAEA test [7] results consist of four measurements from 0 to 20 indicating the students' preference for each dimension. The learning style profile is shown as an irregular polygon along with four axis 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 form the polygon, which represents the subject's learning style profile.

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) [9].

The conceptual learning was assessed using the Force and Motion Conceptual Evaluation test (FMCE). [10]. For this study, the FMCE was applied as a pre- and post-tests. The pretest was taken at the beginning of the semester while the posttest was taken near the end.

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

RESULTS

The results for the Honey-Alonso (H-A) Learning Styles model show a predominance of Reflective and Theoretical styles with 14.06 (SD=2.70) and 14.29 (SD=2.51) point respectively. Active dimension showed the lowest recurrence with an average of 11.91 (SD=2.78) points. Figure 1 shows the corresponding Learning Style Profile.

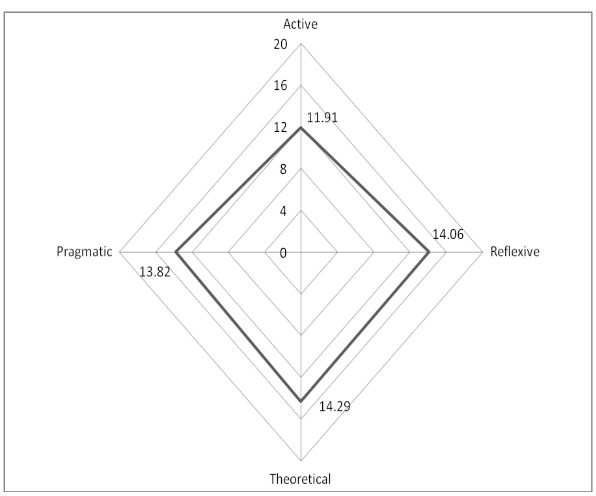

FIGURE 1. Honey-Alonso Learning Styles Profile

Unlike H-A polygonal model, the Felder-Silverman (F-S) has polarized parameters, i.e. for each dimension the score indicates the strength of one pole and the weakness of the other. The F-S model has a scale that goes from -11 to +11 for each dimension [9]. The obtained means values (shown in Table 1) were all positive, characterizing the students as Verbal / Global / Intuitive / Reflective.

TABLE 1. Felder-Silverman Learning Styles results.

Learning Styles	Mean	SD
Active-Reflexive	0.60	3.59
Sensitive-Intuitive	2.20	4.14
Visual-Verbal	4.23	3.63
Sequential-Global	3.06	3.95

To measure the influence of learning styles on the conceptual learning of physics, we used the pre- and post-instruction values of the FMCE test to define the dependent variable DeltaFMCE = post – pre FMCE scores.

A bivariate correlation analysis was carried out between DeltaFMCE and the 8 dimensions of learning styles. The coefficients obtained and their significances are listed in Table 2. The negative coefficients for the H-A model indicate a negative relationship between students' learning styles and their conceptual learning. With a coefficient r = -0.36 at a 0.01 significant level the Pragmatic learning style seems to interfere most with conceptual learning. According to Field [11], values of the coefficients of ±0.30 represent a medium effect between variables.

TABLE 2. Correlation coefficients for conceptual learning and Learning Styles.

Model	Learning Styles	DeltaFMCE	Sign.
F-S	Active-Reflexive	-0.31	0.02*
	Sensitive-Intuitive	-0.05	0.72
	Visual-Verbal	-0.42	0.00**
	Sequencial-Global	-0.08	0.57
H-A	Activeo	-0.25	0.06
	Reflexive	0.18	0.18
	Theoretical	0.08	0.52
	Pragmatic	-0.36	0.01**

**Significant at $p < 0.01$; *Significant at $p < 0.05$

Due to the continuous scale of the F-S model negative coefficient do not necessarily represent a negative relationship between conceptual learning and the learning style, but a positive relationship with one of the poles of the dimension. For instance, r = -0.417 in Visual-Verbal style, represents a positive medium effect between Visual preference and conceptual learning. The analysis of bivariate correlation between the conceptual learning and learning styles yielded three significant values. The F-S's Active-Reflective dimension (r = -0.31) at a 0.05 significance level. Visual-Verbal (r = -0.42) and Pragmatic (r = -0.36) both with significance level under 0.01. The highlight of these results is the negative correlation between the H-A's Pragmatic dimension and DeltaFMCE.

Assuming that there is a correlation between students' preferred learning styles and their physics conceptual learning, the following step is analyze the degree of explanation given by these learning styles variables. To answer this we run a multiple regression analysis between DeltaFMCE and H-A's Pragmatic dimension and both F-S's Visual-Verbal and Active-Reflective, which were significant in bivariate correlation analysis, as independent variables.

Table 3 shows the parameters and models obtained in the analysis. Best model found considered the three dimensions (Pragmatic, Active-Reflective and Visual-Verbal) with a value of $R^2 = 0.31$ as shown in Table 3.

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

Model		B	Std Error	Beta	R^2
1	Constant	32.6	3.79		0.17
	Vis-Vrb	-2.40	0.70	-0.417^{***}	
2	Constant	59.1	11.7		0.25
	Vis-Vrb	-2.04	0.69	-0.355^{**}	
	Pragmatic	-1.99	0.84	-0.285^{*}	
3	Constant	57.6	11.4		0.31
	Vis-Vrb	-1.85	0.68	-0.321^{**}	
	Pragmatic	-1.89	0.81	-0.271^{*}	
	Act-Ref	-1.31	0.64	-0.236^{*}	

***Significant at $p < 0.001$; **Significant at $p < 0.01$; *Significant at $p < 0.05$

CONCLUSIONS

Students have shown a preference for H-A's Theoretical and Reflective dimensions, describing a cautious and analytical reasoning in learning. A lower score in the active dimension describes students who are not used to play leading roles in their own learning process, students who are limited to receiving and process rationally the information. The score obtained for the pragmatic dimension displays a slight ease in practical, hands-on activities.

According to the F-S modeling, these students are mostly verbal, global, slightly reflective and not so intuitive. According to the F-S model, the more balanced dimension was the Active-Reflective where students seem slightly reflective. Students have a high dependence on a verbal learning style, mainly associated to lectures and students with lack of active roles. The negative correlation between the Active-Reflective and the FMCE shows that students with a bigger preference for the active pole of this dimension have a better conceptual learning of physics. Something similar happens with the Visual-Verbal dimension, it seems that the more visual they are, the better they perform on the FMCE.

It is finally note that a value of $R^2 = 0.31$ of the regression model can be interpreted as 31% of the conceptual learning of these students could be predicted by knowing their preferences of learning styles along the Active-Reflective, Visual-Verbal and Pragmatic dimensions. This result is bigger than the dependence of the scientific reasoning previously reported in [2].

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