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Learning styles in mathematics – the strength of the motivational factors at 10th grade Portuguese students

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This paper reports on a research project aimed at describing the learning styles in mathematics of the Portuguese students at the 10th grade and at relating them to the students' performance. For this quantitative, descriptive and correlational research, we used an adaptation of the ILS (Inventory of Learning Styles) of Vermunt (1994) that was answered by a sample of 579 students. An important result was the detection of a learning style that is strongly correlated to the motivational learning orientations, being however still undefined it what concerns the cognitive processing strategies. This style, if hold in a favorable context, may turn into a "meaning oriented" learning style. We also detected the four styles usually reported at Vermunt's ILS' applications: "meaning oriented", "reproduction oriented", "application oriented" and "not oriented", as well as the positive contribution of a "meaning oriented" style to the scholar performance in mathematics, opposite to the effect of the "reproduction oriented" one.

Keywords: Learning style, secondary school mathematics, motivation.

Introduction

The aim of our research was to characterize the learning styles and each of its components in relation to the learning of mathematics by 10th grade Portuguese students and to find out whether either the learning styles or any of their components show any correlation to the learning results. Such components are those considered in the Vermunt's model of the regulation of the learning processes (Vermunt & Van Rijswijk, 1988; Vermunt, 1998, 2005): cognitive processing strategies, regulation strategies, conceptions of learning and learning orientations. We opted for this model, because it follows a socio-constructivist insight of learning (Goldin, 1989) that has got in account both personal and contextual factors that influence the evolution of the individual learning styles. The reason for choosing mathematics as the discipline-object of this research lies on the personal interest of the researchers in the field of the Didactics of Mathematics, having in mind that several empirical studies reveal that the students don't use the same learning style in all the disciplines. For example, Severiens & Dam (1997) report different patterns of learning styles in four disciplines using the same sample of six secondary schools in Holland.

Following the above mentioned aim of the research, we present the questions of the study that are relevant to this paper, concerning the Portuguese 10th grade students:

- Which learning styles are more present at mathematics learning?

Which correlations can be found between the performance in mathematics and the learning styles?

Theoretical Framework

One of the most used definitions of “learning style” was written by a *task-force* of *NASSP* (*National Association of Secondary School Principals*), created in 1979 to set the diagnostics of the learning styles of secondary school students in USA:

The learning style is the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment. (Keefe, 2001, p. 140)

Though this study is not a longitudinal one, therefore limited by a synchronic data collecting, we conceived a conceptual framework (Figure 1) that has included some variables that, regardless the fact that they are not targeted to be measured in this research, we assume as being closely related to the four components of Vermunt’s model of the regulation of the learning processes. Therefore, the conceptual framework includes this model as a subset that interacts with other variables. For instance, the performance, as perceived by the student, feedbacks the components of the regulation model (Cassidy, 2011) and generates emotions that influence the affect for mathematics (McLeod, 1992). As a result, some changes in the motivation to learn may happen (Hannula, 2004). Besides that, the effect of the perceived performance on the self-confidence of the student may change the degree of the self-regulated learning (Malmivuori, 2006). The learning contexts, such as the school culture and the classroom dynamics, or even the social and familiar environments, are also considered at the framework. The goals of the student and the available resources also have an impact on the learning orientations (Hannula, 2006). The different mixes of attitudes and behaviors of a student within each of the learning styles components, shown in Figure 1, define the learning styles proposed by the model: reproduction oriented, meaning oriented, application oriented and not-oriented.

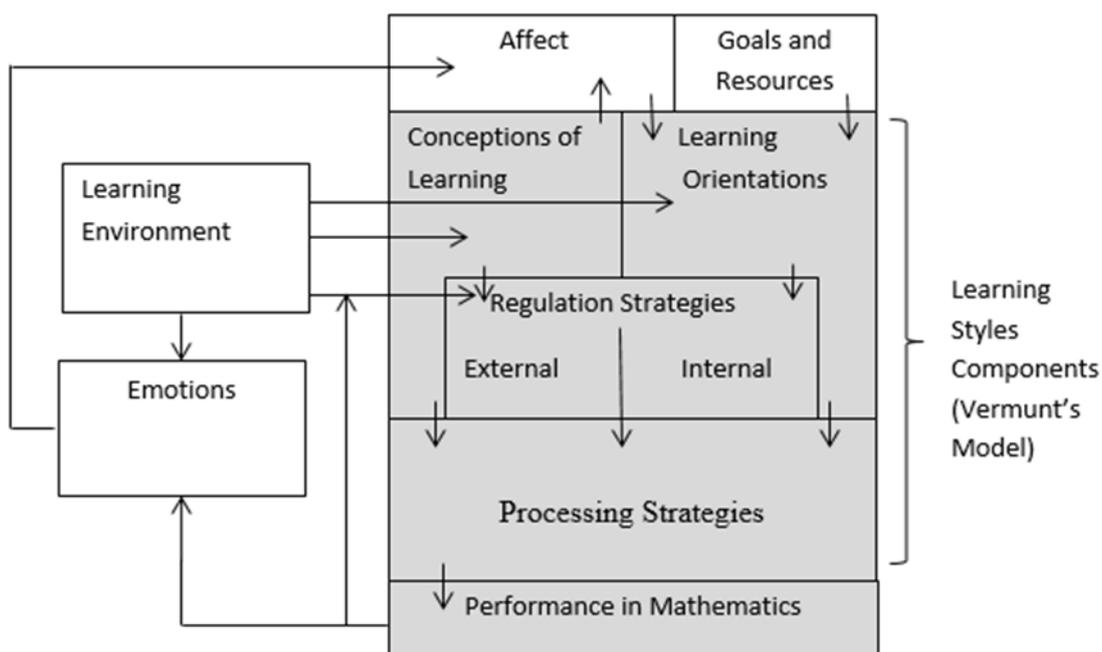


Figure 1: Research conceptual framework (the measured variables are those of the grey area)

Research Method

For this study, we targeted the 10th grade students that were learning the discipline “Mathematics A”. The advantage of choosing the 10th grade classes was the opportunity to observe students that have just done the qualitative step of the transition from basic to secondary school and that are supposed to be able to interpret the questions written on the inventory. This quantitative, descriptive and correlational research was implemented in two steps: there was a small-scale study (n=108) that allowed us to tune up the survey tools, followed by the large-scale study (n=579). At both studies, we used a multi-stage sampling process, as shown in Figure 2.

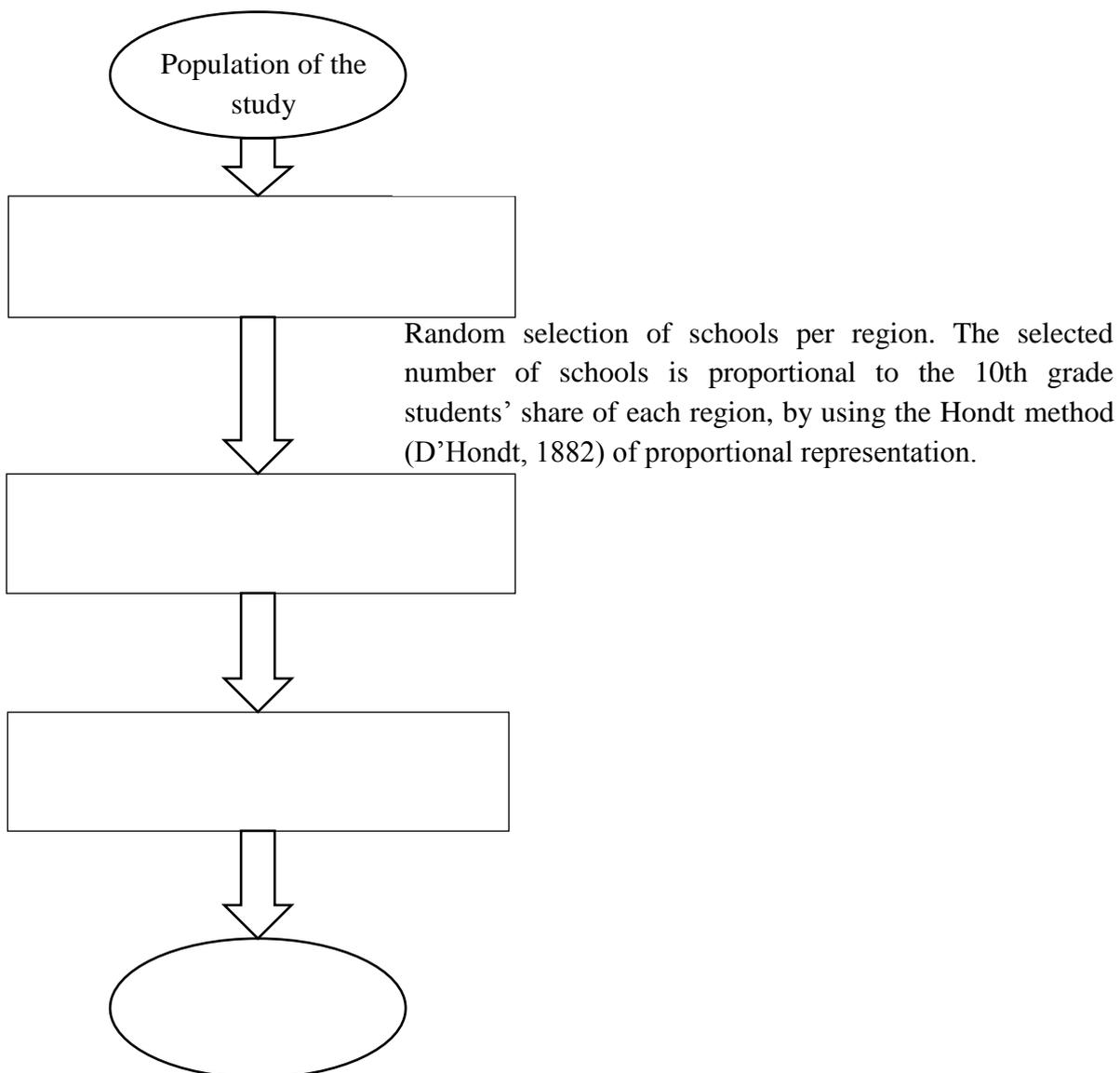


Figure 2: Research multi-stage sampling process scheme

The tool that we used for the primary data collection was an adaptation of Vermunt’s ILS – Inventory of Learning Styles (Vermunt, 1994). We adapted this questionnaire to a secondary school context and to the focus on the learning of mathematics. In this adaptation, we kept the structure of

the Likert scales used at the original inventory for measuring the attitudes and behaviours related to the four components of Vermunt’s model (Table 1).

Processing Strategies	Regulations Strategies	Learning Orientations	Beliefs about Learning
<u>Scales:</u> Deep processing Stepwise processing Concrete processing	<u>Scales:</u> Internal regulation External regulation Lack of regulation	<u>Scales:</u> Personal Interest Certificate Self-Test Vocational Ambivalent	<u>Scales:</u> Intake of Knowledge Construction of Knowledge Use of Knowledge Stimulated Education Cooperation

Table 1: Scales of the Inventory of Learning Styles

The questionnaire also included three questions related to the results in Mathematics (self-assessment and school assessments in the former year and in the current year) and two questions about the demographic variables of gender and age. For the two first components, that concern the processing and the regulation strategies, the scales are behavioural. For example:

When a mathematical problem is presented at the classroom, I prefer to wait for an explanation about how to solve it, either from the teacher or from my colleagues.

Never Sometimes Often Always

For the other two components, concerning the learning orientations and the beliefs about learning, the scales are attitudinal. For example:

I like to learn Mathematics.

I totally disagree I tend to disagree I tend to agree I totally agree

The data used at the large-scale study were collected in 2016, from 15th January to 15th March, at 28 schools along the continental territory of Portugal. A researcher was always present at the classroom during the fulfilling of the questionnaire by the students, in order to assure the homogeneity of the procedures and to guarantee the anonymity of the students answers.

Results

The results here reported are those of the large-scale study. However, it is remarkable that the findings were very similar to those of the pilot-study. This feature can be seen as a confirmation of the robustness of the adapted ILS used for the data collection. Concerning the internal validity of the scales, almost all the results of the calculations of *Cronbach’s alpha* ranged from 0.6 to 0.9, showing an acceptable or even good internal validity. The single component with some scales with *Cronbach’s alpha* lower than 0.6, but higher than 0.5, was the one concerning the beliefs about learning. This may have happened due to the fact that the concepts involved in the questions about those beliefs are probably not yet clear at the students mind.

The sample was quite balanced in what concerns the gender of the students: 52% female and 48% male. Most of them (78%) were 15 years old and there was a significant group (18%) aged 16 years. The minimum age was 14 and the maximum age was 18. Concerning their performances in

Mathematics, only 16% of the surveyed students assess their own performance as non-satisfactory. However, both school assessments of the 9th year and of the first trimester of the 10th year point out to 22% non-satisfactory performances.

Using factorial analysis, an adequate tool to reduce the amount of behavioural and attitudinal variables to identifiable learning styles, some common trends of attitudes and behaviours at mathematics learning could be found out. As expected, the Kaiser-Meyer-Olkin test value reached nearly 0.9 and the significance level obtained at the Bartlett test was less than 0.01, so both tests revealed that the sample was very good for this purpose. Proceeding to the factorial analysis and selecting the principal components with eigenvalues higher than 1, we could obtain five components that explain 70% of the variance within the sample. The factorial structure of these components in terms of the ILS' scales is shown by the matrix of Table 2, where we can find out the correlational saturations after the use of Varimax rotation at the analysis.

Scale	Component				
	1	2	3	4	5
Deep processing			.828		
Stepwise processing		.856			
Concrete processing				.637	
Internal regulation	.408		.775		
External regulation		.604	-.426		
Lack of regulation	-.396	.445	-.429	.355	
Personally interested	.870				
Certification oriented	-.544	.361			
Self-test oriented	.730				
Vocation oriented	.838				
Ambivalent	-.725		-.364		
Learning as intake of knowledge		.838			
Learning as construction of knowledge			.338	.625	
Learning as use of knowledge	.564			.440	
Learning as stimulated education				.738	
Learning through cooperation					.971

Table 2: Factorial structure with 5 components

The first component is strongly associated to the three learning orientations that result from the motivation to learn mathematics: personal interest, self-test and vocational orientations. So, it can represent a learning style that has got features that belong to the “meaning oriented” style, but it neither correlates to the deep processing strategies, nor to the belief that learning is knowledge construction. We named this style “personal fulfilment oriented” and we propose the conjecture that this style may evolve to the “meaning oriented” one, if the context of learning is favourable to this evolution. This conjecture must be submitted to longitudinal research. The second component shows features that correspond to the “reproduction oriented” style of Vermunt’s model, namely the stepwise processing, the external regulation, the certification orientated learning and the belief that

learning is an intake of knowledge. The third component sticks totally to the attitudes and behaviours associated to the “meaning oriented” learning style, such as the deep processing, the internal regulation and the belief of learning as a construction of knowledge. What is noticeable is that the motivational aspects are very strong at the “personal fulfilment oriented” style, but almost absent in the “meaning oriented” one. Our interpretation of this fact is that the first one, observable at the beginning of secondary school is more determined by the discipline-object than the latest, which is not so dependent on motivation, thus more stable. The fourth component that was extracted at the factorial analysis reveals a style similar to the “application oriented” one of Vermunt’s model, though not so clearly defined as the other styles. The main features of this style are the relevance of the concrete processing and the belief that learning is a result of educational stimulation. The fifth component is absolutely undefined in what concerns the processing and regulation strategies as well as the learning orientations, so it may be seen as a “not oriented” style. However, in this study, this style appears strongly and exclusively related to the belief in learning through cooperation. Having in mind that, as mentioned above, the correlation of this belief with the performance in mathematics tends to be negative, it is possible that the individual lack of learning strategies at this school level leads some students to look for support at group work. Observing the results that concern the linear correlation between the learning styles and the performance in mathematics assessed through three different ways (Table 3), we find that all but one are significant for $p < 0.05$, but not strong.

Learning Style		Self-assessment	School assessment (9th grade)	School assessment (10th grade, 1st trimester)
Personal fulfilment oriented	Pearson’s r	.453	.284	.328
	Sig. (bilateral)	.000	.000	.000
Reproduction oriented	Pearson’s r	-.233	-.256	-.346
	Sig. (bilateral)	.000	.000	.000
Meaning oriented	Pearson’s r	.281	.181	.248
	Sig. (bilateral)	.000	.000	.000
Application oriented	Pearson’s r	-.091	-.027	-.115
	Sig. (bilateral)	.029	.517	.006
Not oriented	Pearson’s r	-.152	-.144	-.148
	Sig. (bilateral)	.000	.000	.000

Table 3: Correlation between the learning styles scores and the assessments

It is however important to notice that the polarity of the correlations is coherent along the three different assessments. The correlations with the assessments are positive for the “personal fulfilment oriented style” and for the “meaning oriented style” and negative for all others. So, we conclude that there is a slight but observable trend of these two learning styles to generate a better performance in mathematics, whereas the other styles conduct to worse results. It’s also noticeable that the positive correlations of the styles with the assessments are more positive with the self-assessment than with the other assessments and the negative correlations are more negative with the school assessments than with the self-assessment. Our interpretation is that those students whose

learning styles are predominantly “personal fulfilment oriented” or “meaning oriented” are more aware of the results of their learning processes.

Conclusions

Starting to discuss the results by the constitutive components of the learning styles, we conclude that, in what concerns the beliefs about mathematics learning, the students at the 10th grade still didn't develop clear concepts and that the motivational dimensions are those that play the strongest differentiating role between their learning styles in mathematics. We believe that it is very important that all the contextual factors, such as the teaching methods and styles, keep this motivational predisposition in a high level, in order to give way to the evolution towards a meaning oriented style. For example, if too much stress is put on the assessment of mathematics performance, particularly when such assessment is required for any kind of certification, it may cause a drift to certification oriented learning and therefore to a learning style of a more reproductive kind, which tends to lower the performance of the student in mathematics. The four learning styles found out in many researches that used Vermunt's ILS at university or high-school students were also found in this investigation. However, another learning style, that we named “personal fulfilment oriented”, is preponderant and contains features that may lead to a “meaning-oriented style”, if the contextual variables help to induce the concept of constructive learning as long as the student will develop clearer concepts. These two styles of learning tend to be more suitable for better performances in Mathematics at the secondary school.

Having exposed the conclusions of our research, we must express some limitations that are inherent of our methodology. First of all, one may ask whether these results can be generalized to the population of the study. There are some factors in the sampling process that could cause interference in the randomness of the sample, namely: the convenience of the selection process of the classes, the risk of having selected classes instead of individual students, considering that some of these might be absent at the moment of the data collection, and the stratification of the population by regions in order to obtain a representative territorial distribution of the sample. If we define a random process in terms of the equiprobability of selection for each sampling unit, the assumed no correlation between the conveniences of the researcher and the schools makes this part of the sampling equivalent to a random process. Concerning the absent students, generally there were no more than one or two missing the class. Therefore, we consider that there is a high degree of generalization of the research results and that another sampling process would hardly obtain a so close approach to a random process. There are also limitations that result from the data collection process. The answers given by the students can be influenced by subjective norms, in the sense that they may consider answers in terms of the opinion of contextual agents and not of their own. Besides that, some answers may require cognitive constructs that need the use of the memory of the thoughts and emotions that have occurred at mathematics learning. The possible misinterpretation of some questions and terms might have been a limitation too. However, we believe that these limitations had little impact at the research, since the results of the pilot study and of the large scale study were very similar.

Some follow up of this research would contribute to further knowledge about the learning styles in mathematics of the secondary school students. Longitudinal studies along the secondary school cycle would help to describe the evolution of the learning styles and to test our conjecture that there is a learning-style that can turn into a meaning oriented style, if some contextual conditions are favourable to this development. Those studies could also check to which extent the assessment methods at the end of the secondary school are influencing the learning styles adopted by the students.

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