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THE USE OF CONCEPTUAL MAPS IN SOLVING PHYSICS PROBLEMS

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Abstract

Conceptual maps allow us to graphically represent the existing relationship between ideas, associations, and hierarchies. In recent years, they have been used to learn all areas of knowledge and educational levels in academic and non-academic environments. Due to the fact that they facilitate reading, they favor memorization and metacognition; they also describe aspects that compose a whole. In Physics' learning, they have been used to identify previous knowledge, to evaluate acquired learning and summarize texts, but its use has been little exploited in the accompaniment to the solution of Physics' problems. This article presents an educational strategy that guides the student during the realization of problems through the use of conceptual maps and infographics, which can be applied to University students and other educational levels, using the Taxonomy of Introductory Physics Problems (TIPP) as reference.

Keywords: Conceptual maps, problem-solving, physics education, Taxonomy of Introductory Physics Problems (TIPP).

1 INTRODUCTION

"Education is liberating, errors in education are tremendously oppressive" [1], through education, people change their lives. Undoubtedly one of the challenges that our students, and we as teachers have, is to be able to anchor knowledge and make it practical. Learning is driven by ideas that are mutually constructed with the interaction between students, teachers, learning strategies, methodologies and scientific topics. In the search to facilitate the path of learning for University students, we work arduously throughout the world to design teaching/learning strategies that facilitate the development of higher-order cognitive skills.

Teodorescu et al (2013) stated physics problems that can be categorized according to a set of basic cognitive processes and knowledge. Based on the New Taxonomy of Educational Objectives (NTEO), they proposed the TIPP a classification of physics problems based on the cognitive processes and the knowledge they involve [1]. For problem solving, a variety of taxonomies have been carried out to classify problems according to their complexity and, therefore, to the skills that students need to develop in order to solve them [2].

Conceptual maps are a tool used to represent the knowledge associated with a main theme, indicating the relationship between the concepts associated with each other. They organize the information, allowing us to improve the reasoning processes and language (verbal or graphic) that are part of our daily lives, but express or read the ideas in a graphic form, which is more significant for learning [3]. These maps are constructed by relating concepts through links, hyperlinks and propositions. It is more a cognitive tool than a metacognitive tool, which greatly favors the organization of information. This hierarchical and branching characteristic generates the possibility of graphically representing the paths or proposed solutions to physics problems.

So, problem solving could be easier for students if they are able to categorize the concepts involved in the solution, and represent them graphically. In this article we propose one strategy to conduct and analyze problems through the use of conceptual maps.

2 AIM

The construction of knowledge is carried out through the use of cognitive skills, which are divided into lower and higher order. Students learn new concepts through different stages, evidencing their

learning according to the ability to perform various actions; from making lists, classifying information, relate characteristics between different groups, identifying the concepts learned in a specific context, evaluate situations, etc. There are different categorizations of these cognitive levels, and therefore of the experiences necessary to travel between the different cognitive levels.

Teodorescu *et al* (2013) design the Taxonomy Introductory Physics Problems (TIPPS), it was developed to address the following questions:

- a) Can physics problems be categorized according to cognitive processes and knowledge domains?
- b) Is there any relationship between physics problems, knowledge domains, and cognitive processes?
- c) Are there relevant cognitive processes that are not activated by existing physics problems?

They answered these questions and propose their taxonomy. The criteria and their characteristics are shown in the table 1. The authors propose to use the taxonomy to elaborate reagents considering the different levels of complexity of each physical situation to analyze.

Table 1. Description of Introductory Physics Problems (TIPP).

Criteria	The type of knowledge involved in the problem; knowledge here comprises information and mental procedures.	
	The highest complex cognitive process that is necessary to solve it (for both information and mental procedures).	
Characteristics	Purpose	It is a physics problem database that gives explanations and examples of problems that involve certain cognitive processes. This database can be used for establishing educational objectives, assessments, and for guiding curriculum design for physics instruction, also, it identifies gaps in the available curricular material.
	Structure	Use as many sections/subsections as you need. Features only examples of physics problems (mostly selected from existing traditional or research-based collections).
	Range of applicability	It organizes physics problems.

Source: Elaborated according to Teodorescu et al. (2013) pp. 010103-1 and 010103-6.

Hanáková & Klvanec (2016) analyze the Taxonomies of Physics Problems in Physics Education, where they found that taxonomies are useful tools for the planning of physics instruction, and assessing students. It is applicable to University students as its advantage is the clear distinction between the attained levels in cognitive processes, and knowledge domains that can be identified using this method [3]. They represent the TIPP with a diagram who facilitate the relation between different elements.

The conceptual map is a network of hierarchically ordered concepts. In the upper part, there are the concepts of greater generality, and in the lower part, the concepts of less generality [4]. In most cases, the conceptual map is generated from a note or class notes, which is why the hierarchy depends on the theme or context [5]. In literature, we find some applications of conceptual maps to the teaching-learning of physics, specifically to describe the concepts related to a central concept [6] [7]. Conceptual maps are used in all areas of knowledge and at all educational levels, but have been little used as accompaniment tool in solving problems.

Traditionally, there are physical class representations made of physical situations through graphic models. For example, a car is represented as a particle (solid sphere, where the mass of the car is supposed to be concentrated in a small point), and the direction of the movement is represented by an arrow, or vector.

As students learn such procedures, it is common that they have difficulties to solve the problems, spite having the free body diagram or the other graphic representations. It is possible that these difficulties can be minimized if a description of the activities during the construction of the proposal, uses a conceptual map and a list of verbs that represent the actions according to the TIPP. That is the

proposal presented in this article, to conduct the student to represent their mental procedures in a conceptual map.

In Figure 1 it is observed, according to the perspective of Hanáková & Kluvanec (2016) who analyzed the potentialities of the TIPP, the cognitive processes summarized in integration, symbolizing, matching, classifying analyzing errors, generalizing, specifying and metacognition.

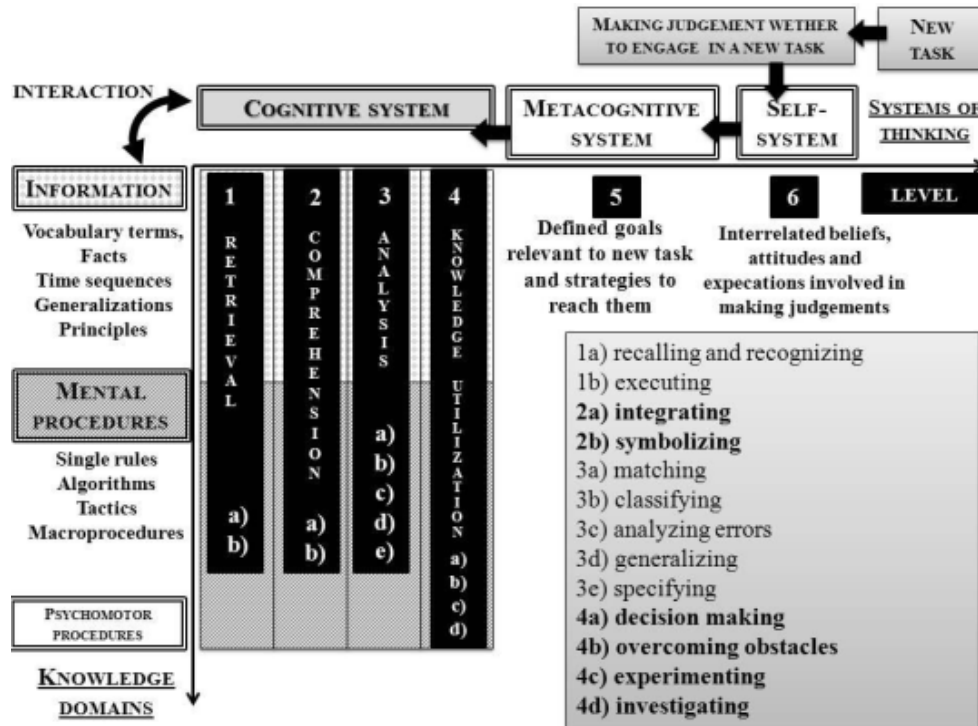


Figure 1. A Scheme of the taxonomy of Introductory Physics Problem (TIPP).
 Source: Elaborated by Hanáková & Kluvanec (2016) according to Teodorescu et al. (2013)

Example:

A mass m slides along a frictionless surface along an inclined plane, describing the forces present, their components and the direction of movement. Please use TIPP to build a mental map that identifies the important phases associated with the problem, the situation is represented in Figure 2.

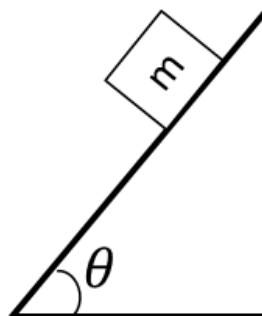


Figure 2. For use in the example.

Possible solution using TIPP and conceptual map is shown in figure 3.

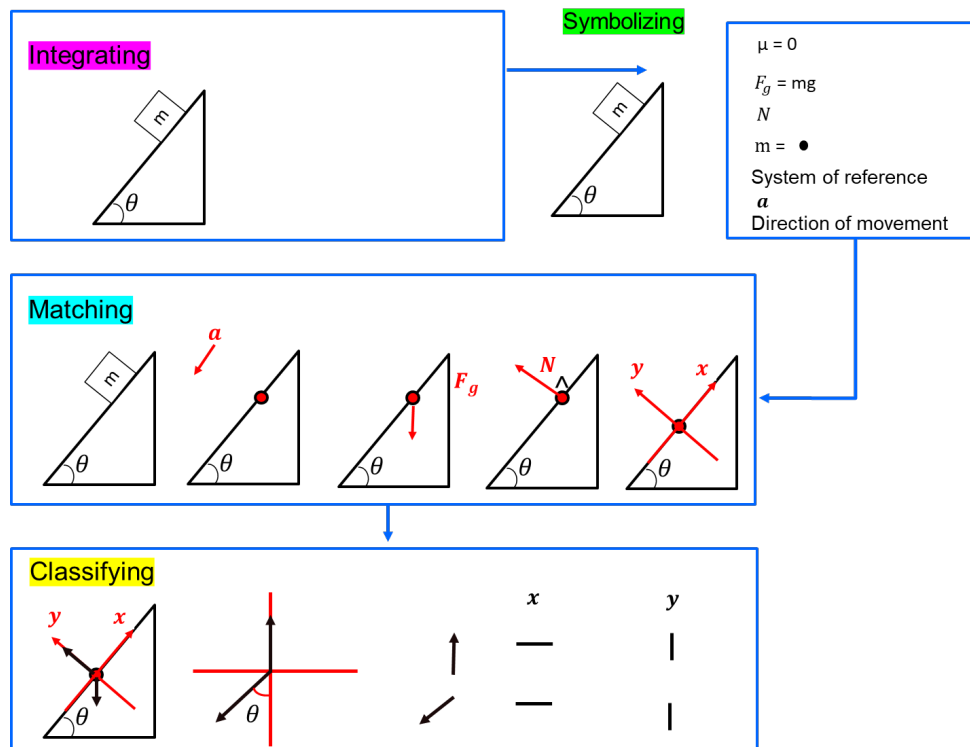


Figure 3. Example of Conceptual map using TIPPA.

3 FUTURE WORKS

After reflecting on the importance of the use of specific taxonomies for the teaching of physics in the resolution of problems, a range of possibilities of its use is opened in combination with other strategies. In this first work, the possibility of using TIPPA as a guideline in the elaboration of conceptual maps, graphic organizer and other for the solution of physical problems, has been discussed.

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