MATHEMATICAL MODELLING OF PHYSICAL PHENOMENA WITH THE USE OF GOWINS´S VEE AND CONCEPT MAPS

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Abstract. At the Nacional Experimental University of Tachira (UNET), Venezuela, we have found that first year physics students often ignore the important role mathematics and particularly mathematical models play in the learning of physics. Students use equations frequently misunderstood as a set of 'cook-book' procedures applied to solve physics problems, without understanding the reason for using a particular function or model to solve a problem. This article explains a strategy for the teaching and learning of mathematical models commonly used in physic courses. It uses Concept Maps to improve understanding of basic conceptual structures involved in the mathematical modelling process of physical phenomena, and "Gowin´s vee" as a tool that facilitates the process of building student's own knowledge of a mathematical model for a particular experiment. Results reinforces the notion that in order to explain physical phenomena, the process of proposing appropriate mathematical models, verifying and justifying them is greatly facilitated through the combined usage of concept maps and vee diagrams and also serves to promote the process of "thinking about thinking" or more precisely metacognition.

1 Introduction

Mathematics is essential for the development and comprehension of physics. This science allows the construction of mathematical models to represent physical phenomena nevertheless students ignore the important role mathematics play in the learning of physics. They use equations often misunderstood as a set of 'cook-book' procedures applied to solve physics problems, without understanding the reason for using a particular function or model to solve a problem. This is evident when students have to create mathematical models to represent physical phenomena in the Physics laboratory. Thus we designed a new strategy based on the use of Concept Maps and Gowin´s vee due to the encouraging results obtained with these heuristic tools in our regular physics courses (Ramírez de M, Sanabria & Aspee, 2006; Sanabria & Ramírez, 2006).

2 The strategy

The strategy was implemented throughout four successive phases outlined in Figure 1. This strategy uses Concept Maps (Novak and Gowin, 1984) to improve understanding of basic conceptual structures involved in the mathematical modelling process of physical phenomena, and "Gowin´s vee" as a tool that facilitates the process of building student's own knowledge of a mathematical model for an experiment. During the initial sessions we encouraged students' use of concept mapping in order to explore basic mathematical function concepts as well as the concept of models in physics. Afterwards, students were encouraged to analyze and carry on experiments using Gowin´s vee to model physical phenomena.

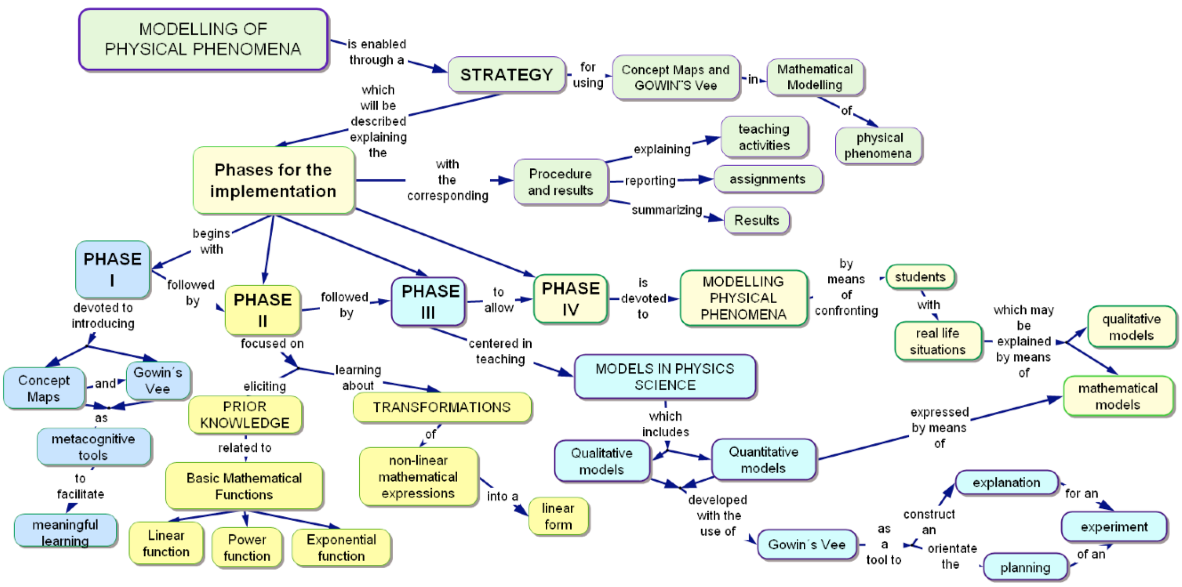

Figure 1. Concept Map of the Strategy for Mathematical modelling of physical phenomena.

3 Methodology and Results

PHASE	TEACHING ACTIVITIES AND ASSIGNEMENTS	RESULTS
I Learning about Concept Maps and Gowin's vee	-*Teaching activities*: Explain Concept Maps (Ramírez, Sanabria & Aspeé, 2006), and Gowin´s vee (Sanabria & Ramírez, 2006) -*Students Assignment*: Build concept maps for a single physics topic and a Gowin´s vee diagram for a simple real life experiment	Most of the students (84%) could produce the assigned maps successfully. Gowin´s vee seems to be more difficult for them when following up and reporting a simple experiment. (62% of the students completed them correctly).
II Comprehension of the mathematical functions: Linear Function Power Function Exponential Function	-*Teaching activities:* Linear Function, Power Function, and Exponential Function were explained by the teacher in a traditional way, without using Concept Maps or Gowin´s vee. -*Students Assignment*: Build concept maps for these basic mathematical functions.	Results were classified as follows: *a) Satisfactory:* Those maps which show clearly the main idea, the essence, subordinate concepts and relationship among them for a given mathematical function. (65%). *b) Insufficient* (35%): In this category we distinguish between maps exhibiting conceptual mistakes in mathematical prior knowledge (12%), and maps showing an incorrect application of the concept map heuristic tool (23%).
Transformation of non linear functions	-*Teaching activities:* Explain how these functions may be transformed into a linear form. -*Assignment:* Build a concept map to explain linear and nonlinear functions and how they may be transformed.	58% of the students ended up with satisfactory maps. Figure 2 shows a map made by a student about power function. Also, the concept map about transformations of linear and non linear functions made by a student is shown in Figure 3.
III Learning about models in science	-*Teaching activities*: Explanation of models in science. Quantitative and qualitative models. -*Assignment*: Build a concept map explaining the conceptual structure "model in science".	80% of the students, managed to produce maps evidencing acceptable understanding of the concept *"Model"* These results support previous findings evidencing that the easiest way for beginners to design a concept map is from the information given in a written text. In comparison, beginners find it more difficult to make a map from the contents given in a lesson. A lower percentage (58%) was obtained when students were asked to build concept maps in Phase II about mathematical functions following their class notes and what the teacher said in the lab class.
-*Quantitative models* -*Qualitative models* (which will not be explained in this article)	-*Teaching activities*: Explain Gowin´s vee as a tool to orientate the planning of an experiment. -*Assignment*: Make the experiment about a simple pendulum. Graph results and interpret them. Students must use Gowin´s vee to show their work.	Seventy four out of a hundred students managed to provide the adequate mathematical function (power function) for the set of values T against length of the string (L). The others incorrectly generated an exponential model from their analysis of the data graphed on a semi-logarithmic paper as they were convinced that an exponential function was an appropriate model. Students' concept maps about the mathematical functions helped them to find the adequate mathematical model.
IV Modelling of physical phenomena	-*Teaching activities*: Orientate the process of construction of Gowin´s vee, graph and mathematical models. -*Assignment*: Make each experiment. Graph results and interpret using Gowin´s vee.	Students get acquaintance with the use of Gowin´s vee and concept maps to understand physical phenomena and construct mathematical models to account for them. Also they finished with higher levels of confidence in their abilities to plan, carry out and analyze an experiment.

Table 2. Methodology and Results**.**

Figure 2 shows a map worked by a student to explain the concept *Power Function*. Figure 3 shows a map made by another student about *Linear and non linear functions*.

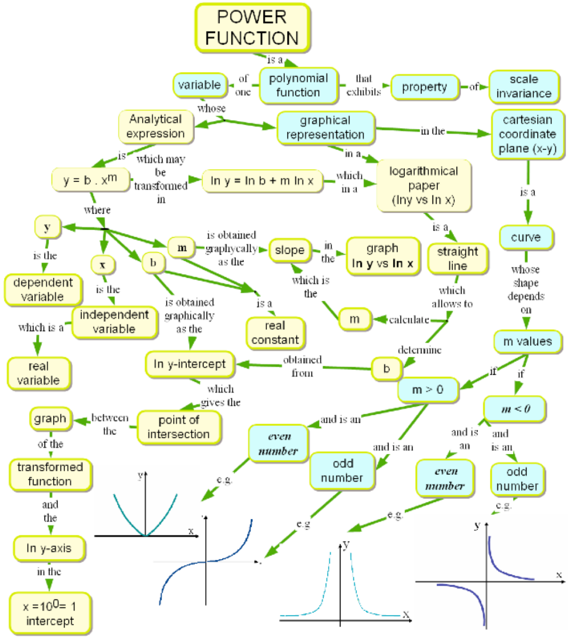

Figure 2. Student's Concept Map of "Power Function".

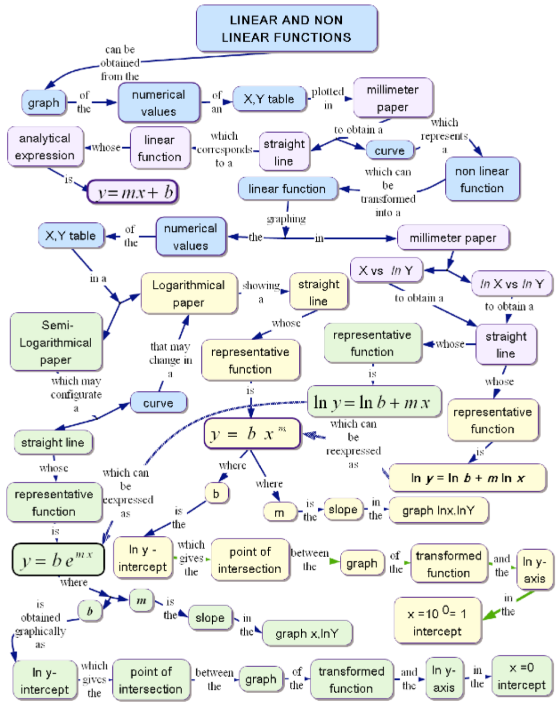

Figure 3. Student's Concept map of Linear and non linear functions.

As it was explained before, in phase III students are encouraged to use our own adaptation of Gowin´s vee (see Figure 4) in order to organize, plan and carry on the analysis of a physical phenomenon which may be explained by means of a quantitative model. The teacher explains the different steps and helps students to carry on the experiment using this heuristic tool. After that students are encouraged in Phase IV to develop their own Gowin´s vee for each experiment. Figure 5 shows the diagram produced by a student for the experiment about simple pendulum.

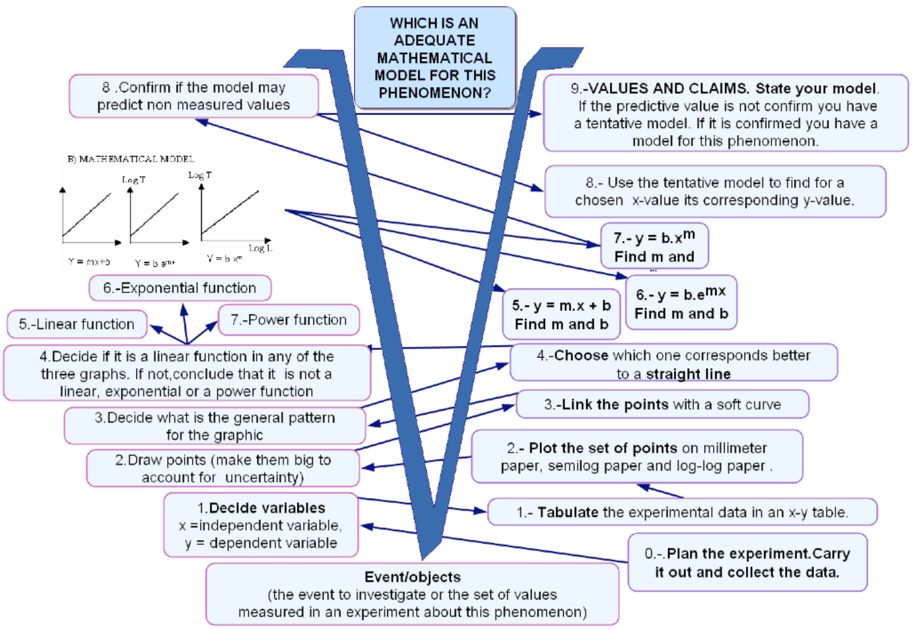

Figure 4. Adaptation of Gowin´s vee used with the students to analyze a physical phenomenon.

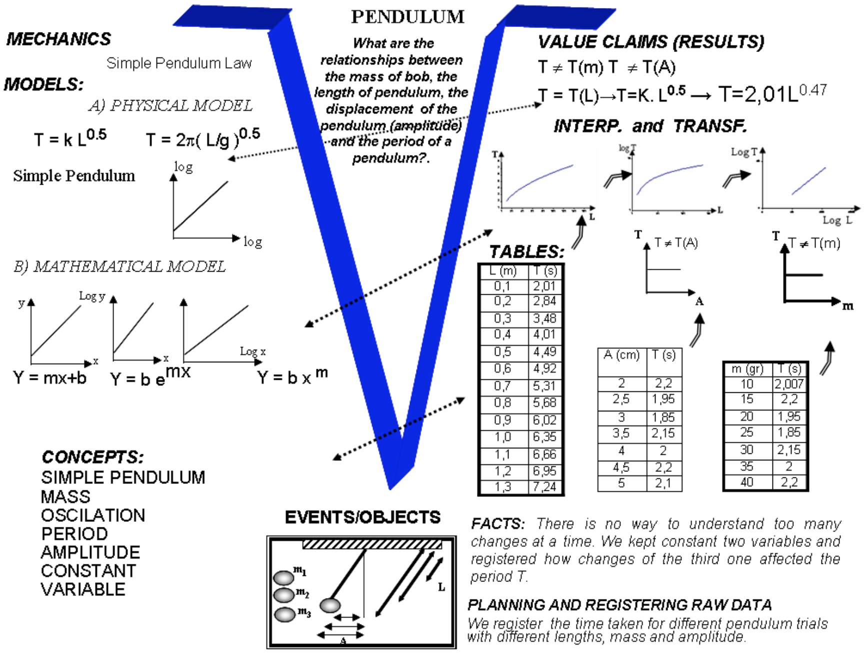

Figure 5. Gowin´s vee for the experiment of Pendulum made by a student.

4 Conclusions

Previous research results allowed us to propose that the main problems faced by students which fail the physics laboratory course were mainly due to (a) lack of motivation for studying models; (b) insufficient prior knowledge of the linear, power, exponential and functions; (c) Students' difficulties when explaining the process that leads them to build their models; (d) Students' difficulties in communicating results of their experiments.

We overcome these difficulties with a strategy that uses concept maps to improve understanding of concepts and basic conceptual structures involved in the mathematical modelling process of physical phenomena, and "Gowin´s vee" as an adapted tool that facilitates the process of building student's own knowledge of a mathematical model for a particular experiment.

The results after the application of the strategy showed that 81% of students passed the course. Results allows us to propose that improvement in overall performance along the lab course may be due to (a) An increase in student's motivation to develop the experiments with the aid of the heuristic tools concept maps and Gowin´s vee; (b) Consciousness of the necessity to improve knowledge about mathematical functions and the plotting of curves in order to find adequate models to explain physical phenomena and (c) An improvement in students' ability to communicate results and to interpret their findings while studying physical phenomena. We have continued using the strategy with satisfactory results. We are convinced that the process of proposing, verifying and explaining physical phenomena is greatly facilitated through the combine usage of concept maps and vee diagrams. Finally, the ability to model physical phenomena serves to promote the process of "thinking about thinking," or more precisely metacognition. This strategy can be adapted for other purposes and in other educational contexts.

References

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