PORTUGUESE TEACHERS' VIEWS ABOUT GEOSCIENCES MODELS

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ABSTRACT: Geoscience teachers use models to help students to learn phenomenon, because they simplify the explanation of abstract scientific theories. For that reason, modelling is an important tool to be used in geosciences classrooms to help students to understand theories. However, resorting to that strategy implies that teachers recognize its importance and are prepared to guide students in their learning processes through modelling. In the present research we analyse the views of Portuguese science teachers about geosciences models covered by Portuguese science curriculum. Data analysis led us to the conclusion that the majority of teachers have solid scientific knowledge regarding the geosciences models. It's crucial that teachers understand scientific models, so they can present them clearly to students, through a model-based approach.

KEY WORDS: models, teachers' views, geoscience, modelling.

OBJECTIVES

Being the research question "What are the views of Portuguese teachers about geoscience models?" the aim of this study was to analyse Portuguese science teachers views regarding some models referred in science curriculum. To pursue that aim more specific objectives were elaborated, such us: to validate and to apply a survey about geological models to Portuguese science teachers; to analyse data gather with the survey questionnaire;and to do the interpretation of the data collected based upon some scientific literature.

FRAMEWORK

The relationship between theories and models arose in the 1960s as a relevant issue in the context of philosophy of science. Several authors dedicated their work to establish the relationships between scientific theories and models. By definition, a model is an interpretative description of a phenomenon, object or process, which facilitates perceptual and intellectual access to that phenomenon (Franco, 1999). However, it is not a description in the trivial sense of a mere phenomenological explanation to a phenomenon. This description is an interpretation that goes beyond the minimum acceptable knowledge (Bailer-Jones, 2003).

Thomas Kuhn (1970) considers that models are a component of paradigms that are already established. In the educational context, students have to learn scientific paradigms meaningfully, involving the development of meaning-systems (Franco, 1999). However, for science students, models are not established but, as an important feature of the educational process, they have to be built.

Other authors, like Nancy Nersessian (1992), admit that models are important as a starting point of theories development, they are essential during the construction of a theory, but then must be reconstructed when they turn incompatible with the terms of the new theory that they helped to develop. As Kuhn defends, the emergence of a new paradigm includes, therefore, the construction of a new model (Franco, 1999). Theories are about abstract objects and not empirical objects. Models, by their very constitution, are applied to concrete empirical phenomena, whereas theories are not. They can be moulded and adjusted to the address and concrete empirically observed situation. Consequently, a model never is so general like a theory. For many reasons, it is difficult to be so specific to march quite specific empirical situations well (Bailer-Jones, 2003).

In the practice of science education, very often scientific laws are presented without the associated models which provide meaning for them. The biggest concern is to make sense and to practice scientific paradigms, a task which involves model building (Franco, 1999). At school, geoscience teachers use models to help to explain phenomena and, sometimes, students make their own models to display their understanding. Each one constructs his personal mental model for a theory with all knowledge that was developed in the learning process. Thus scientific models are an important way to explain an abstract scientific theory. However, in some schools, scientific models are regarding as concrete replicas of the real target and some students have misconceptions of scientific models that are basically consistent with a naïve realist epistemology (Treagust*et al.*, 2010).

Nowadays it is advocated an active and constructive process of learning. In a constructive process, scientific models are very valuable because they are used to explain an abstract and non-observable science concept. Many often, scientific models are used superficially, making it difficult to understand. In a constructive process it is also assumed that students have their own personal view of scientific models, but these understanding may not always be scientifically correct and may lead to alternative conceptions (Treagust*et al.*, 2010).

The solution for this problem is modelling, an important tool in the construction of geological knowledge, because it promotes the understanding of natural processes' dynamics and their variables (Bolacha*et al.*, 2011).

According to Gilbert (2004), analogue modelling is a simplified version of scientific models. When teachers use modelling to introduce an episode of geology history, it should be clearly presented, because it can play an important role in teaching the evolution of geological thinking, as well as to teach actual scientific concepts (Bolacha*et al.*, 2006).

Dynamics modelling represents phenomena in which one or more elements of a system change over time. If students develop the ability to produce, test and evaluate the models as well as their dynamics, they can improve the interest and have a deeper understanding about the real changes that occurred in the course of Earth's history (Deus *et al.*, 2011). But this might require some degree of abstraction, especially if the studied phenomenon establishes an intricate net of relations with other natural phenomena (Bolacha*et al.*, 2011). Bolacha*et al.* (2006), referring to the work of Dagher(1998), defends that, nowadays learning is an individual process to knowledge construction, and geoscience teachers consider analogue modelling as an important tool to restructure the knowledge assimilation process. Modelling geological phenomena can reduce millions years to some hours or minutes and should require, if possible, the use of materials with a behaviour similar to natural materials (Bolacha*et al.*, 2009; Deus *et al.*, 2011).

However, analogue models may generate misconceptions if students don't make the transference to the targeted scientific phenomena (Deus *et al.*, 2011). To avoid this, the analogue models should be accompanied by other materials, as photos or other models, to ensure the proper relationship between the model and the phenomenon characteristics that is being simulated (Bolacha*et al.*, 2009).

METHODOLOGY

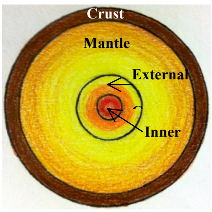
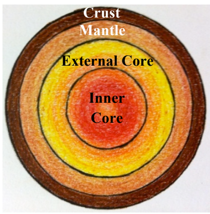
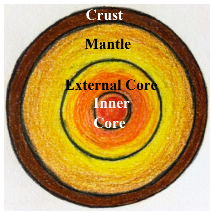
According to research aim, a survey study was developed and data were collected from a questionnaire about geosciences models. The questionnaire was applied to teachers from different schools and from diverse Portugal regions (Aveiro, Porto, Viseu, Braga, Lisboa, Bragança). Questionnaires could be fulfilled on paper or in digital form.

The questionnaire had four closed questions, each one about a different geoscience model, such as, the internal structure of the Earth, the solar system, the continental drift and plate tectonic theory, and the mountain chain formation. Before being applied, the questionnaire was validated by two experts in geoscience education. After collecting the questionnaires, teachers' answers were analysed using SPSS 20 version. The questionnaire was answered by a convenient sample of 129 Portuguese science teachers from middle and secondary schools. The majority of the sample were females (112 females, 15 males), and the mean age was 43,3 years old (ranging from 23 to 63). The teachers had different qualifications like, BSc (n=78); MSc (n=38); PhD (n=1); BSc plus other specialization (n=10) and, MSc plus other specialization (n=2).

RESULTS

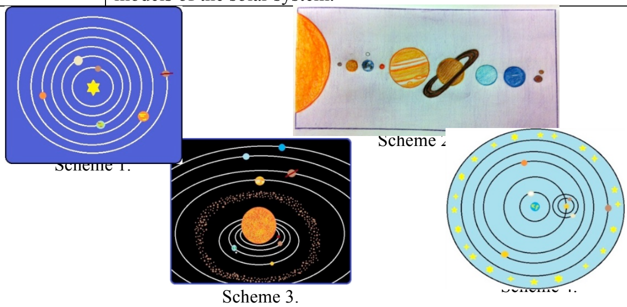
After collecting the questionnaires, introducing the data in appropriate statistic software and considering the objectives of the study, the following results were obtained.

Table 1
Rate of teachers' responses about model of internal structure of Earth.

Question 1	Considering the images, what is the scheme that represents the model of the internal structure of Earth?	**Answers (%)**	
 Scheme 1.  Scheme2.  Scheme 3.		a	8,5
a. Scheme 1. c. Scheme 3. e. I don't know.		b	2,3
		c	63,6
		d	14,0
		e	4,7
		na	4,7
		nc	2,3
na – no answer; nc – not considered (two options selected)			

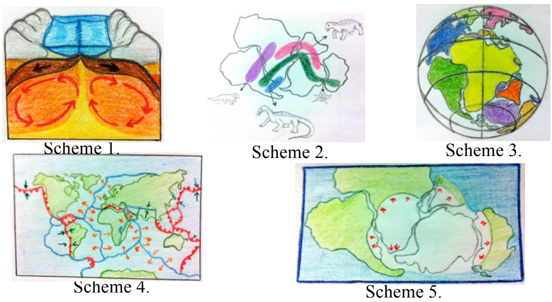
The answer to question 1 (table 1) showed that the majority of teachers (c=63,6%) recognized the correct model of the internal structure of the Earth. However, some teachers considered that all schemes were incorrect (d=14,0%). The answers make us believe that science teachers are generally familiarized with the accepted model of the internal structure of Earth, probably because this is a subject frequently discussed in school since classes.

Table 2.
Rate of teachers' answers regarding solar system model.

<table>
<tr><td>Question 2</td><td>Sort the schemes to obtain the historical sequence of different models of the solar system.</td><td colspan="2">Answers (%)</td></tr>
<tr><td colspan="2" rowspan="7">
Scheme 1. Scheme 2. Scheme 3. Scheme 4.
a. 1 – 2 – 3 – 4. c. 1 – 4 – 2 – 3.
e.I don't know.</td><td>a</td><td>0</td></tr>
<tr><td>b</td><td>20,9</td></tr>
<tr><td>c</td><td>4,7</td></tr>
<tr><td>d</td><td>65,9</td></tr>
<tr><td>e</td><td>3,9</td></tr>
<tr><td>na</td><td>4,7</td></tr>
<tr><td>nc</td><td>0</td></tr>
<tr><td colspan="4">na – no answer; nc – not considered (two options selected)</td></tr>
</table>

According to the results to the question 2 (table 2), 65,9% of the teachers knew the correct historical sequence of the solar system models (option d). In spite of that, many teachers still selected the wrong option (b = 20,9%).

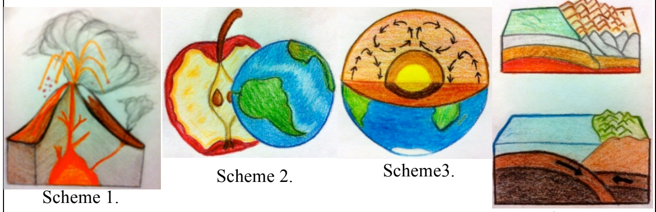
Table 3.
Teachers' answers about model of continental drift and tectonic plates.

<table>
<tr><td>Question 3.</td><td>Look at the schemes and identify the arguments to the continental drift and the model of plate tectonic.</td><td colspan="2">Answers (%)</td></tr>
<tr><td colspan="2" rowspan="7">
Scheme 1. Scheme 2. Scheme 3. Scheme 4. Scheme 5.
a. The schemes 1 and 4 represent the arguments to the model of plate tectonic and, schemes 2, 3 and 5 are arguments to continental drift.
b. The schemes 1 and 4 represent the arguments to the continental drift and, schemes 2, 3 and 5 are arguments to model of plate tectonic.
c. All the schemes represent the arguments to the model of continental drift.
d. All the schemes represent the arguments to the model of plate tectonic.</td><td>a</td><td>81,4</td></tr>
<tr><td>b</td><td>2,3</td></tr>
<tr><td>c</td><td>0</td></tr>
<tr><td>d</td><td>3,9</td></tr>
<tr><td>e</td><td>7,0</td></tr>
<tr><td>na</td><td>3,9</td></tr>
<tr><td>nc</td><td>1, 6</td></tr>
<tr><td colspan="4">na – no answer; nc – not considered (two options selected)</td></tr>
</table>

On question 3 (table 3), the results showed that the majority of teachers (a = 81,4%) identified correctly the arguments in favour of the continental drift and the arguments for the theory of plate tectonic. The fact that in Portuguese science curriculum this subject is taught through an historical-based perspective may help to understand this result.

Meanwhile, 7,0% of the teachers that didn't recognize the models choose the answer *e)I don't know*. This probably occurred because teachers may not have correctly related images with the arguments that each model represents.

Table 4.
Teachers' answers frequencies
regarding model of mountain chain formation.

Question 4.	Identify the scheme that does not represent a model to the mountain chain formation.	Answers (%)	
 Scheme 1. Scheme 2. Scheme3. Scheme 4		a	9,3
		b	64,3
		c	7,8
		d	8,5
		e	5,4
a. Scheme 1. c. Scheme 3. e. I don't know.		na	4,7
		nc	0
na – no answer; nc – not considered (two options selected)			

The results for the question 4 (table 4) showed that 64,3% of the teachers thought that the scheme 2 didn't represent a model for the mountain formation. Moreover, 9,3% of teachers thought that the wrong scheme was the first one represented. In fact, both schemes (1 and 2) represented two different models for the mountain formation, both proposed in 19th century. Only 7,8% of the teachers selected the right option (c = scheme 3). Although this scheme represents the convection currents which are indeed an argument for the plate tectonic, they don't have a directly relation with mountain formation.

However, the fourth scheme showed two types of convergent boundaries (continental plate – continental plate and ocean plate – continental plate), which is the accepted model to explain the mountain formation. According to data, only 8,5% of teachers considered that was the wrong scheme.

CONCLUSIONS

With this research we have realized that Portuguese science teachers recognize the majority of geosciences models which they usually teach in school. It also showed that teachers have more difficulty in recognising models that are not covered in the science curriculum, probably because they don't teach them frequently.

In fact, a model-based approach is important in geoscience classrooms, but for its success it's necessary that teachers have knowledge regarding scientific models and modelling strategy. Without that knowledge they can't mediate a meaningful learning process. Portuguese geoscience teachers have demonstrated to have knowledge of the geological models which they are required to teach. This factor may contribute to the good performance of the teachers when promoting a successful cognitive development based in geoscience modelling.

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