PORTUGUESE SCIENCE TEACHERS' VIEWS ABOUTNATURE OF SCIENCE AND SCIENTIFIC MODELS

Joana Torres, Sara Moutinho, António Almeida, Clara Vasconcelos
Centro de Geologia da Universidade do Porto, Portugal

ABSTRACT: Nature of Science (NOS) and Scientific Models are considered to be crucial issues in science education. Thus, and considering that teachers' views strongly influence students' learning experience, our main purpose was to assess Portuguese Science Teachers' (PST) views of NOS and Scientific Models. With this work we also intended to get some information about PST classroom practice when it comes to models.A survey questionnaire was applied to a sample of one hundred and twenty-nine middle and secondary school PST, from different regions of the country. Results reveal some naïve views regarding NOS issues and some inconsistences in the definition of scientific models. Moreover, teachers show that they give more emphasis to the value of models in the learning *of* science over their value in the learning *to do* science and *about* science.

KEY WORDS: Nature of Science; Scientific Models; Teachers' views.

OBJECTIVES

The aim of this work was to diagnose Portuguese science teachers' views ofNature of Science (NOS) and Scientific Models, by applying a questionnaire focusing on this issue.

FRAMEWORK

It has been widely recognized that scientific models have an important role not only in scientific practice but also in science education (Justi& Gilbert, 2002; Halloun, 2007; Oh & Oh, 2011). Although the diversity of models and the inexistence of a unique models' definition(Giere, 2004; Oh & Oh, 2011), we may generally consider that a model is a representation of a target, being a mediator connecting a theory and a phenomenon (Oh & Oh, 2011).Giere (2004) considers that models are the primary representational tools in the sciences, arguing that"scientists use models to represent aspects of the world for various purposes" (p. 747).

Hodson (1998)argues that science education mustimply the learning *of* science -acquiring and developing conceptual and theoretical knowledge, the learning *to do* science – engaging in and developing expertise in scientific inquiry and problem-solving and the learning*about* science - developing an understanding of the nature and methods of science, appreciation of its history and development. In fact, there are many reasons to include Nature of Science (NOS) in science curriculum, as NOS knowledge helps students to enhancethe learning of scientific contents and understanding of science;

it promotes the interest in science and enhances decision making (McComas*et al.*, 1998), as well as it endorses the development of critical thinking (Matthews, 1990).Many studies highlight the importance of understanding that science is a human activity which attemptsto explain natural phenomena(McComas*et al.*, 1998; McComas& Olson, 1998).

Therefore, models are considered to be crucial in science education as students may learn *of*science as they come to know the major models that are the products of science; they may learn how *to do* science by creating and testing their own models and they also may learn *about* scienceby constructing an adequate view of the nature of models and by beingable to appreciate the role of models in the accreditation and dissemination of the products of scientific enquiry (Justi& Gilbert, 2002; Justi& Gilbert, 2003).

Models can be really useful for teachersin classroom to demonstrate how things work and to explain sophisticated knowledge (Oh & Oh, 2011). However, the use of models in classroom should overtake the traditional way that only emphasis thelearning *of* science. Considering that teachers are those who determine a considerable part of students' educational experience, it is important that they have a clear and valid notion of models and their nature in order to use models effectively in science classes (Oh & Oh, 2011).

Considering the importance of teachers' views in students' learning and the importance of NOS and models in science education, it is essential to evaluate teachers' views about these issues.

METHODOLOGY

To evaluate Portuguese Science Teachers' (PST) views about Models and Nature of Science (NOS) we developed a descriptive study. A survey questionnaire was delivered to teachers of middle and secondary school (students' age from 10 to 17) fromdifferent schools of Portugal on paperordigital support. When using the digital one, we also asked teachers to collaborate with us and to request their colleagues to participate in the study. One hundred and twenty-nine Portuguese science teachers (112 females, 15 males), with ages ranging from 23 to 63 (mean= 43,27) answered the questionnaire. The sample included teachers with different qualifications BSc (*n*=78); MSc (*n*=38); PhD (n=1); BSc plus other specialization (n=10) and MSc plus other specialization (n=2);and from different regions of Portugal (Porto, Lisboa,Aveiro, Viseu, Braga, Bragança).

The questionnaire focused essentially PST views about Models and NOSand has 7 closed questions and 3semi-open questions. The questionnaire was validated by 2 experts in didactics and science education.To analyze the answers of the teachers, a descriptive statistic was made using the SPSS 20. Some content analysis had to be previously made in semi-open questions- number 8,9 and 10.

RESULTS

The answers given to the 7 closed questions are presented in the table below (table 1).As shown, when asked about scientific knowledge, all teachers assumed that scientific knowledge is not definite. However, most of them (55,8%) believed that scientific knowledge only change with new information and technology, showing a naïve perspective about this aspect. Regarding creativity and imagination in science, the majority of teachers considered that they are needed in the development of scientific knowledge. Still, a considerable percentage (24%) referred that creativity should not be used in the data collection stage. Concerning the relationship between theories and laws, a high number of teachers held the naïve conception that theories evolve to laws. In question 4, almost all teachers (79,8%) had a correct perception about the relation between theories, phenomena and models.In question 5,

the majority of respondents reveal that they know that models result from inference. However, by analyzing the answers given in question 6, we may consider that teachers do not have a clear definition of models.

Table 1.
Category and rate of responses regarding NOS aspects and Scientific Models.

Evaluation Issue	Question	Answer options	Category of answer	%	Authors of reference
Tentativeness of scientific knowledge.	Q1 – Regarding scientific knowledge, you consider that …	Scientific knowledge is definite and correct, being a proven truth.	Wrong	0	Liu & Lederman (2007)
		Scientific knowledge, although reliable, is tentative and never certain.	Correct	31	
		Scientific knowledge change solely with new information and advanced technology.	Naïve	55,8	
		Scientific knowledge is tentative due to insufficientevidence for proving their validity.	Naïve	5,4	
		I do notunderstand.		0	
		I do not have knowledge to do a choice.		0	
		None of the options reflects my point of view.		7,8	
Creativity and imagination in Science.	Q2 – Relating to creativity and imagination, you think that…	They are not necessary in the construction of scientific knowledge.	Wrong	1,6	
		Only make sense in planning and design stage.	Naïve	7	
		They are needed in the development of scientific knowledge.	Correct	67,4	
		They are needed during all the research except in the data collection stage.	Naïve	24	
		I do notunderstand.		0	
		I do not have knowledge to do a choice.		0	
		None of the options reflects my point of view.		0	
Scientific theories and laws.	Q3 – Regarding theories and laws, you consider that…	Theories and laws are different kinds of knowledge and one cannot become the other.	Correct	8,5	Liu & Lederman (2007); McComas (1998)
		Theories evolve to laws with the evidence accumulation.	Naïve	39,5	
		Laws reflect a proven knowledge and so they are more certain than theories.	Naïve	9,3	
		Laws are the explanations of phenomena and theories constitute descriptions of patterns related to observational phenomena.	Wrong	34,1	
		I do not understand.		0,8	
		I do not have knowledge to do a choice.		2,3	
		None of the options reflects my point of view.		5,4	

Evaluation Issue	Question	Answer options	Category of answer	%	Authors of reference
Theories, phenomena and models.	Q4 – Concerning the relation between theories, phenomena and models, you believe that…	A model is a representation of phenomena or processes and serves as a 'bridge' connecting a theory and a phenomenon.	Correct	79,8	Oh & Oh (2011)
		A model is a fundamental theory to understand a phenomenon and to formulate future theories.	Wrong	10,9	
		A phenomenon can be represented only by a unique model.	Naïve	0,8	
		A model represents all the aspects of a phenomenon.	Naïve	1,6	
		I do not understand.		1,6	
		I do not have knowledge to do a choice.		3,1	
		None of the options reflects my point of view.		2,3	
Scientific models.	Q5 – Relating to models, you think that…	Scientific models are a copy of reality.	Wrong	6,2	Abd-El-Khalick et al. (1998)
		Scientific models are immutable.	Naïve	1,6	
		Scientific models result from inference.	Correct	66,7	
		Models created by scientists are all proven.	Naïve	3,1	
		I do not understand.		1,6	
		I do not have knowledge to do a choice.		0	
		None of the options reflects my point of view.		19,4	
		No answer.		1,6	
Scientific models.	Q6 – Do you consider a scientific model as…	A reference to which a phenomenon has to be compared to help understanding it scientifically.	Wrong	11,6	Danusso et al. (2010)
		An abstract representation which reproduces the behaviour of a phenomenon using suitable parameters.	Correct	30,2	
		The set of rules and schemes which identify a given phenomenon and allow understanding it.	Naïve	34,1	
		An abstract tool to analyse reality designed from the observation of that reality.	Naïve	14,7	
		I do not understand.		0	
		I do not have knowledge to do a choice.		2,3	
		None of the options reflects my point of view.		3,1	
		No answer.		3,1	
		No meaning.		0,8	
Scientific models in science classes	Q7 – The use of models in the classroom…	Only contributes to the understanding of complex natural phenomena.	Naïve	7,8	Justi& Gilbert (2002)
		Contributes to a better learning *of* science, *about* science and *to do* science.	Correct	87,6	
		Requires more traditional teaching methodologies.	Naïve	3,1	
		Does not contribute to the understanding of the Nature of Science.	Wrong	0	
		I do not understand.		0	
		I do not have knowledge to do a choice.		0	
		None of the options reflects my point of view.		0,8	
		No answer.		0,8	

About models in science classes, almost all teachers (87,6%) recognized that models contribute to a better learning *of* science, *about* science and *to do*science.However, when asked about their teaching practices, only 1 teacher justifies the use of scientific models in class by pointing this last reason. In fact, the majority of teachers reveal that they use modelsand analoguemodelling in class because it helps in the understanding of phenomena and processes (52,3%) and it leads to a better knowledgeof the evolution of natural phenomena(38%), respectively (Table 2).

Table 2.
Responses regarding teaching practices about the use of scientific models and analogue models.

Question	Answer Options	%	Mains Justifications	%
How often do you use scientific models in Science Classes?	Never	3,1	It is not suitable for students' level.	100
	Sometimes	96,9	It helps in the understanding of phenomena and processes.	52,3
How often do you use analogue models in Science Classes?	Never	7	It is not suitable for students' level.	60
	Sometimes	93	It leads to a better understanding of the evolution of natural phenomena.	38
In science classes, how do you mostly use models?	You present the models that you have.	27	Conditioned by time.	43,7
			Conditioned by students' age.	25
	You suggest students to construct their own models.	4,8	Students learn more.	50
	Both options.	68,2	Limited by time.	25

When asked about the way teachers use models, the majority (68,2%) refer that they present models and suggest students to construct models, giving students an active role.This student-centred approach "can be used to help students gain insight into the activities of scientists" (Henze et al., 2007, p. 104).

CONCLUSIONS

We may conclude that Portuguesescience teachers, in general, held naïve views about NOS aspects, especially those concerning with the tentativeness of scientific knowledge and with the relation between theories and laws. Although they believe that models result from inference, they do not reveal a consistent knowledge of what a model is. Teachers assume that models are important to the learning *of* science, *about* science and *to do*science. However, when asked about their practices teachers only emphasize the significance of models as facilitators of learning *of* science. Giving the importance of this issue the authors think that itwill be important to improve teachers' knowledge about NOS and models in a collaborative work with science education researchers.

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