



# Metascience in pre-service primary teacher education

## Enhancing teachers' science conceptions

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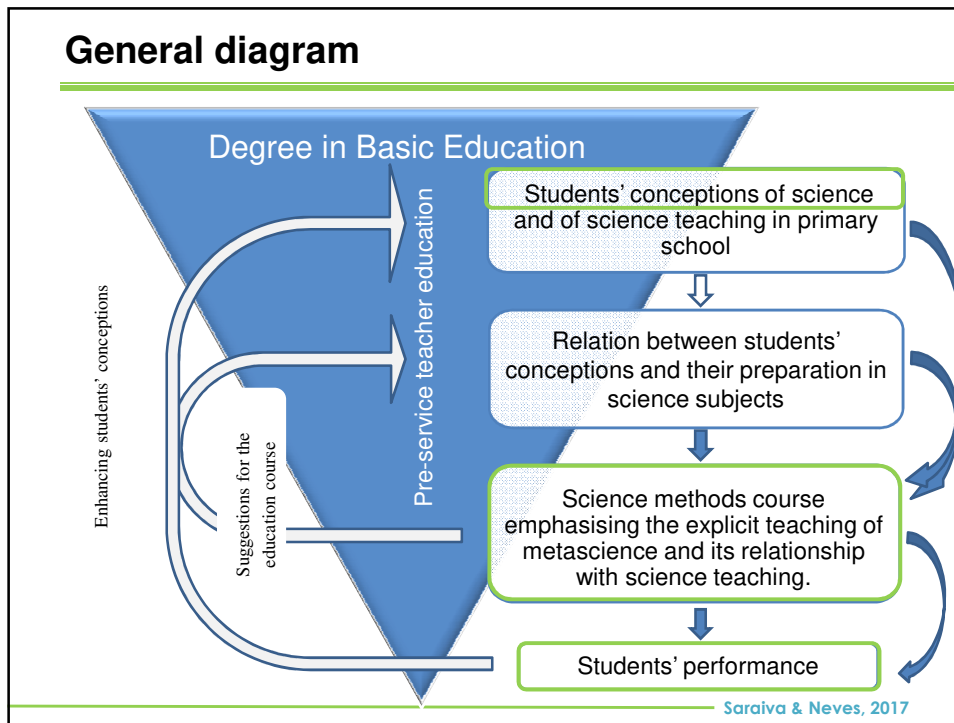
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## Context

- The study of the nature of science (NOS) has been receiving a renewed attention as a major contribution to attain the aim of scientific and technological literacy for all.  
(e.g., Lederman, 2007; McComas, 2014)
- Empirical support has been obtained for the effectiveness of an explicit, reflexive and contextualized approach in enhancing students' understandings of 'how science works' and of the complex nature of scientific knowledge.  
(e.g., Abd-El-Khalick, 2012; Lederman et al., 2012)
- A science methods course, that explicitly focus on a conceptualized view of metascience and its sound relation to science teaching, is a context that may contribute to enhance pre-service primary teachers' science conceptions.

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## Problem

What is the extent to which a teaching context explicitly focused on a conceptualized view of metascience and its sound relation to science teaching may contribute to the development of students' conceptions of science?

## Theoretical framework

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### Epistemological grounds

#### Model of science construction

- . Metascientific dimensions

(philosophical, psychological, historical, sociological internal and external)

(Ziman, 1984, 2000)

### Sociological grounds

#### Model of pedagogic discourse

- . Sociological characteristics of the pedagogical practice

(*the what* and *the how* of PD)

(Bernstein, 1990, 2000)

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## Methods

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### Mixed methodology

(e.g., Creswell & Clark, 2011; Teddlie & Tashakkori, 2009)

### Case study

#### Participants

25 pre-service primary teachers (third year) involved in a science methods course in a Portuguese School of Education

#### Evolution of participants' science conceptions

Questionnaire – 12 items (open and closed)/Model of analysis

#### Analysis of pedagogical practice

Construction of analytical instruments

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## Methods

### Questionnaire structure

#### General data

(e.g., gender, age, academic formation, ...)

#### Participants' science conceptions

**A - Conception about scientific knowledge (ScK)**, taking into account the epistemic values conceptualized by McMullin (1982).

**B - Conception about metascience**, according to Ziman's theorization.

**B1- Metascientific dimensions (MScD)** involved in the construction of scientific knowledge B2 to B5 – Characteristics of each metascientific dimension: **philosophical – PhiD** (B2); **psychological – PsyD** (B3); **internal sociological – ISD** (B4); and **external sociological – ESD** (B5).

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## Example – Item B2

<b>B.2 PhiD</b>	<b>What are the characteristics of the investigative processes leading to scientific knowledge?</b>
	(a) Check with a circle the statement or statements that can answer to the question.
<b>I</b>	They are procedures based on theories with great explanatory power on natural phenomena and events. <b>[rationalist]</b>
<b>II</b>	They are rigorous observation, measurement and experimentation procedures associated with an interpretation of the results. <b>[empiricist]</b>
<b>III</b>	They are procedures of critical analysis of knowledge, subjecting it to rejection by any new observation or result. <b>[refutation]</b>
<b>IV</b>	They are rigorous and controlled procedures of observation and experimentation designed to obtain data that will allow to describe and explain the reality. <b>[objectivity]</b>
<b>V</b>	They are rigorous procedures that follow precise norms to repeatedly test and validate knowledge. <b>[confirmation]</b>
<b>VI</b>	They are rigorous, imaginative, and critical procedures based on the scientists' ideas and beliefs about the subjects they investigate. <b>[subjectivity]</b>
	(b) Explain the reason (s) of your (s) choice (s).

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## Example of answers to item B2

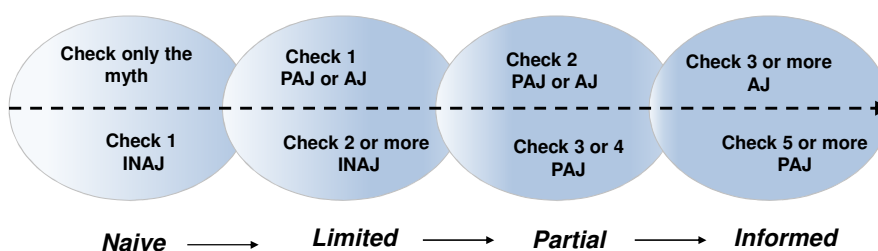
PhiD AJ	<b>Statements checked:</b> II , IV and VI (empiricist, objectivity and subjectivity)  <i>Sara</i>	The investigative processes are <b>rigorous and controlled procedures</b> because only in this way <b>it allows the validation of results</b> . Moreover, they [procedures] must be based in the <b>imagination</b> because only in this way they [scientists] can think of something based on the observations [...] and <b>critical thinking</b> because only in this way they are able to analyse former scientific knowledge and to examine other scientists research.
PhiD PAJ	<b>Statements checked:</b> III and IV (refutation and objectivity)  <i>Clara</i>	... , because in the case of the first hypothesis, the scientists risk, because when they try to discover something important, there can be <b>another point of view and thus overturn the work that was developed by the other</b> . In the case of the second answer, I think that the procedures of observation and experimentation will make a great contribution to discover reality and truth.

*AJ – Appropriate justification; PAJ - Partially appropriate justification*

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## Methods

### Conceptions about science – Model of analysis



Saraiva, 2016 (adapted)

INAJ - inappropriate justification  
 PAJ- partially appropriate justification  
 AJ – appropriate justification

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## Curricular materials

### Teacher guide

General structure	Type of activity	Intended message	PD
Each activity is organized in three topics:  Objectives  Materials (students' worksheets)  Description (teacher' informations/ suggestions)	Learning activities (experimental/ discussion)	Broad conception of MSc (knowledge and skills)	The What
		Strong relation between metascience (MSc) and science (Sc) (Weak classification)	
	Additional readings	Strong relation between metascience (MSc) and science teaching (ScT) (Weak classification)	The How
	Evaluation activities	Strong metascience explicitness (Strong framing)  Strong explicitness of MSc – ScT relation (Strong framing)	

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## Instruments – Pedagogical practice

### Instrument – Metascientific dimensions (excerpt)

Increasing level of conceptualization →

Level 1	Level 2	Level 3	Level 4
The teacher <b>does not refer</b> the metascientific dimension. Or The teacher <b>refers</b> the metascientific dimension <b>in an ambiguous way</b> .	... only refers to knowledge of a general nature, ...  Or ... only refers to skills, ...	... refers to knowledge of a general nature and skills, ...  Or ... only refers to knowledge of a specific nature, ...	The teacher refers to knowledge of a specific nature and skills, related to the metascientific dimension.

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## Instruments – Pedagogical practice

### Instrument – Intradisciplinary relation between MSc-ScT (excerpt)

Increasing degree of relation

C <sup>++</sup>	C <sup>+</sup>	C <sup>-</sup>	C <sup>--</sup>
The teacher <b>only</b> addresses the <b>metascientific knowledge and/or skills</b> included in the activities.	....	....	The teacher <b>addresses, interconnecting them, the relationship between metascientific knowledge and/or skills and knowledge about teaching and learning of the sciences</b> included in the activities.

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## Instruments – Pedagogical practice

### Instrument – Explicitness of the relationship between MSc-ScT (excerpt)

Decreasing degree of explicitness

F <sup>++</sup>	F <sup>+</sup>	F <sup>-</sup>	F <sup>--</sup>
The teacher <b>addresses very explicitly the meaning of metascientific knowledge and/or skills</b> in the teaching / learning of sciences, and/or their importance for the success of learning.	.....	.....	The teacher <b>does not address or does it with confusing / incorrect ideas about the meaning of metascientific knowledge and/or skills</b> in the teaching/learning.....

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## Discourse in the classroom – Example (PhiD)

Level MScK	Explic. MSc	
		<p><i>Professor</i>- [Scientific laws] They should have unifying capacity.  <i>Student</i>- Capacity what?  <i>Clara</i> - Unifying! As in Lavoisier's law.  <i>Professor</i> - We saw this in the last class. Lavoisier unified the concepts of oxidation, rust and respiration, in addition to enunciating the Law of Conservation of Mass.  <i>Sofia</i> - Teacher, are there laws usually associated with formulas? [...] For example. Newton's 1st law. I do not know...  <i>Professor</i> - The first law and the others that Newton enunciated can be expressed with formulas that relate the variables under study.  <i>Rui</i> - All laws related to quantitative problems have formulas. [...]  <i>Student</i> - I do not remember any that is not represented ... {by formula}!  <i>Professor</i> - Rui is right: in many cases laws ... can be represented by mathematical expressions. [Lesson 6, UA 71]</p>

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## Discourse in the classroom – Example (ESD)

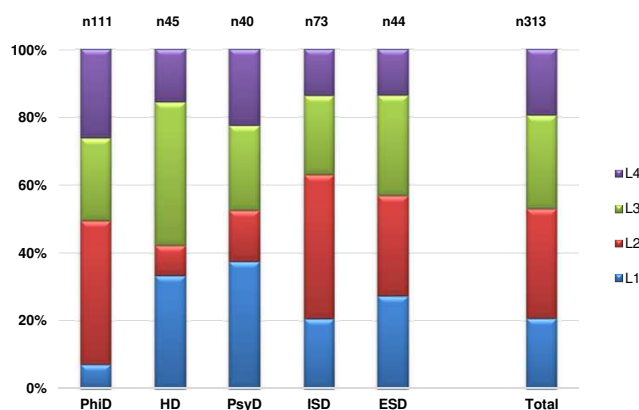
Relation MSc-ScT	Explicit. Relation MSc-ScT	
		<p><i>Professor</i> -[...] this debate about science education and about the scientific learning that children are supposed to carry out at the level of basic schooling ... is long overdue .... As we saw earlier, [...] we should contribute to the education of participatory citizens who have a word to say when asked to speak on certain socioscientific issues and to understand the importance of the relations that are established between science, technology and society. [Lesson 10, UA 114].</p>

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## Results – Modality of pedagogical practice

### Conceptualization level of metascience – *The what*



In the pedagogical practice, the metascientific knowledge of a generic nature or skills related to metascientific dimensions were more present.

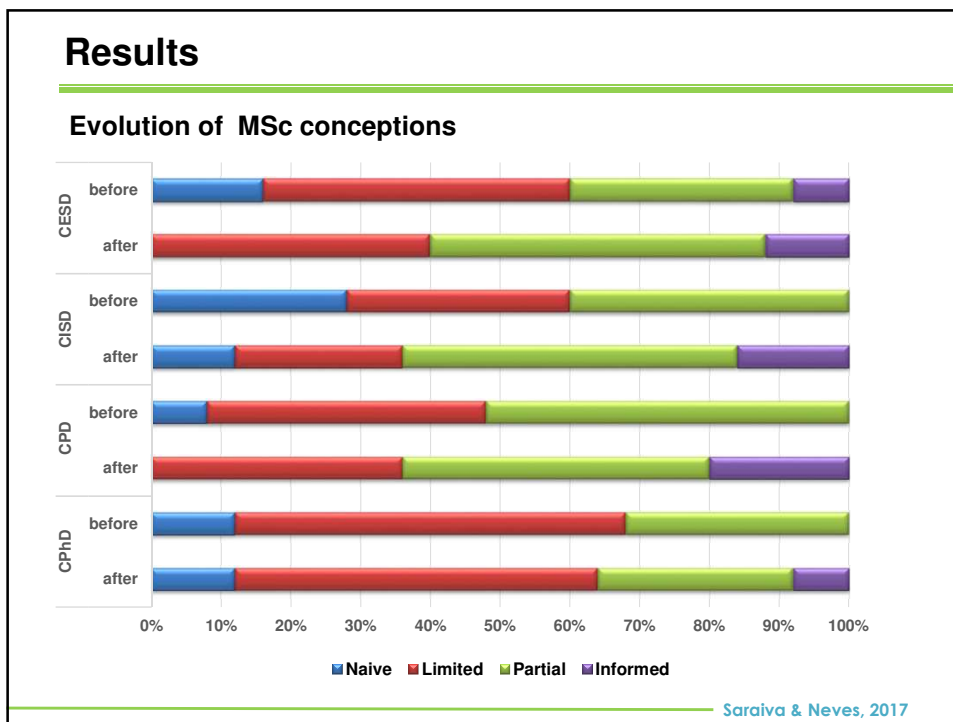
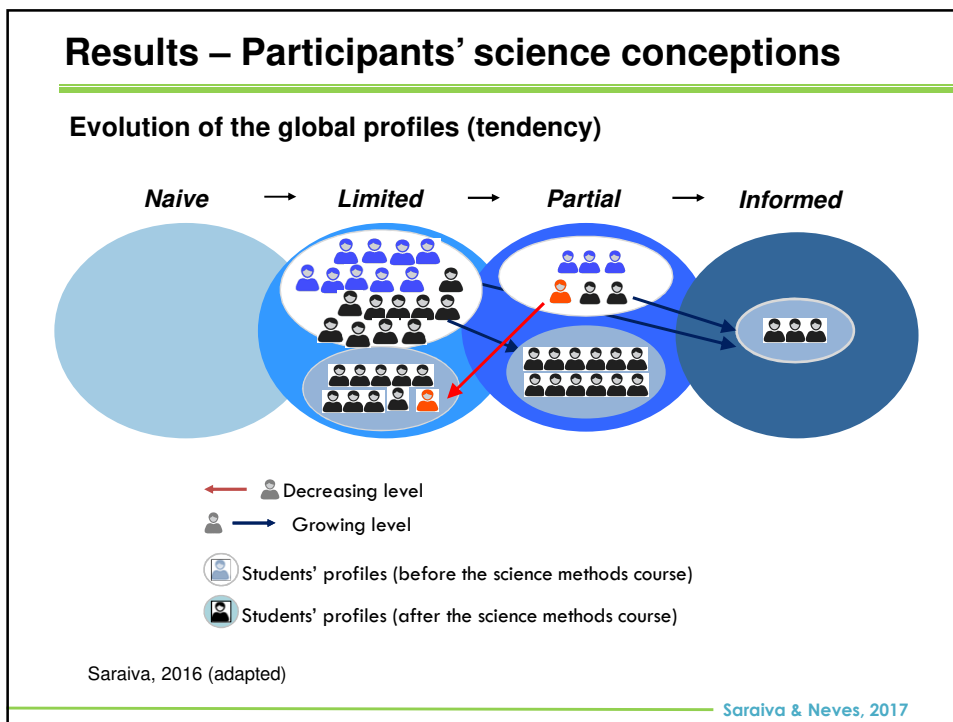
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## Results – Modality of pedagogical practice

### Sociological relations – *The how*

Characteristics studied			Curricular materials	P Practice
<i>The how</i>	Relation between discourses	Intradisciplinarity	MSc-ScT	C <sup>-</sup> C <sup>+</sup> (PhiD, ESD)
	Relation professor-students	Discursive rules	MSc Explicitness	F <sup>+</sup> F <sup>-</sup> (PhiD)
		Evaluation criteria	Explicitness of MSC-ScT relationship	F <sup>+</sup> F <sup>-/</sup> (PhiD)

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## Conclusions

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- The pre-service primary teachers' global profiles of conceptions about science, showed a differential tendency of evolution towards the conceptual profiles of greater comprehensiveness, according to the metascientific dimension under analysis.
- The teacher education course focused on metascience and on its relation to science teaching and directed to pre-service primary teachers showed to have potential for promoting a broad conceptualization of science.

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## Conclusions

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- The research points out to some difficulties of the teacher to implement the message contained in the curricular materials. He moved away from this message with regard to some sociological relations, in particular, the weak relation between MSc and ScT and the weak explicitness of the text to be learned.
- The research raises questions about the importance of teacher education institutions in promoting the learning of a metascientific component in science education, in order to achieve scientific literacy for all.

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## Contributions of the study

- The study provides elements for reflection on the inclusion of metascience in pre-service teacher education courses and in science teaching-learning in primary school contexts.
- It allows, also, a reasoned reflection on the issue of the academic preparation of science teachers' educators.
- The study gives a methodological contribution to the design and analysis of curricular materials centered on metascience and on its relation to science teaching, based on a sound theoretical framework that combines epistemological and sociological aspects of science education.

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