The use of history of science on physics teaching as a social representation from pre-service teachers

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Abstract. In this work we used the Social Representation theory and one of its methods for investigating social representations of a group of undergrad physics students (N = 77), taking teaching credential, regarding the usage of History of Science as teaching strategy. Our empirical data showed a social representation with a nucleus consisting of elements from History of Science more as a contextualization tool and pragmatics science products than as a human process. The lack of a representation of science as process point out the need of rethinking the undergrad curriculum in order to expand students views on the nature of science.

1. Introduction
History of Science (HoS) plays a major role in understanding the Nature of Science (NoS) and its process. It can be taken both as a field of study, concerning the understanding of how the contemporary science became structured as it can be recognized nowadays or as a discipline itself concerning its usage as a didactic strategy [1]. In this last sense, the use of HoS should appear as part of the curriculum of pre-service teachers in order to be incorporated in their development as prospective science teachers.

Although we don’t mean to imply HoS would be a privileged didactic strategy, its usage is known as an important tool for humanizing sciences and also for bringing science closer to personal, ethical, cultural, and political concerns [2]. But an existent gap between science teaching and science teachers training regarding HoS is reported [3], showing that “the vast majority of newly trained science teachers will go out into schools with unexamined and unclear conceptions of NoS” [3, p 1138].

The importance of HoS as teaching strategy and its lack in the teacher training lead us to our research question: “how do undergrad Physics teaching major students, from a major Brazilian public university, represent the use of HoS as teaching strategy?” In order to achieve our research goal, we adopt a methodological approach from Social Representation [4] to explore emerging consensus among students’ representations when they were asked to freely evoke words on this matter.

2. Theoretical framework
The Social Representations Theory (SRT) [4] is a perspective from social psychology, first proposed by Serge Moscovici. It aims to reveal what a particular social group share about certain topic or event. Moscovici argues that Social Representations builds the social world from a kind of knowledge that turns an unfamiliar content into a familiar one [5]. According to Moscovici, in Social Representation we are “dealing with knowledge whose objective it is to ‘create a reality’” [5, p 229]. Thus, Social representations allow one to shape reality and to form stable consensus about life situations, objects
and events. These consensus emerges as a nucleus of the representation, carrying beliefs and ways of living of a social group.

Through Social Representations we can see at which extension the official norms reified in the undergrad curriculum permeates the student’s universe of ideas. Moreover, looking at the representations we can learn how the training of those futures Physics teachers can be (and must be) adapted.

2.1 Basic foundations of Social Representations Theory

Social Representations (SR) as a research program, has come a long way since Moscovici’s first works. It has been updated and adapted, gathering different methodological approaches. In Brazil, SR has a particular solid ground and it has been used as theoretical/methodological lens for several works in educational research varying from works exploring students’ representation [6, 7] to teachers’ [8, 9] representations.

The SR goes beyond an object to be described. They are happenings of social life. It can be seen in two different categories: representation as concept and representation as phenomena. If representations are considered a concept, it means that would be possible to characterize it by its full description, which would be closer to Durkheim’s proposal of collective representations [10].

Although Moscovici acknowledges he took the notion of representation from sociology, he criticizes Durkheim who saw representations as an element inert to the society. Moscovici argues that in Durkheim, representations would be analogue to atoms in classical Mechanics: nobody would questions that they were there but also no one could question its internal structure or dynamics. Instead, Moscovici’s social psychology took SR as dynamic events which its internal structure would provide ways for knowing and for communicating what we already know. It implies that representations are a kind of consensual knowledge that gives sense to life situations. And it can be seen in both senses of the verb “to represent”: representing like acting (social action or social performance) or representing like transforming an intellectual demand into language.

2.2 Two social universes

The SR theory explores a tension between two ways of sharing truths. One is through the scientific logics, which is acknowledged as positive and valid. But in another way truths could be also built consensually, in a way which each person has equal power for deciding the truth, even without the shield of scientific norms. That’s why Moscovici [10] contrasts the sacred sciences and the secular ones. It criticizes the idea of scientific knowledge as prevailing over daily life knowledge.

That difference would emerge from two different social universes: in one hand the reified universe, where the society is made of solid entities, where the science prevails over individual experience and the possibility of each individual decide what is or not true is suppressed. In the other hand the consensual universe where society is seen as a group of individuals free to speak for themselves and for the group, truths are built individually and life experience validates what is true.

Bring this view to our research question, the teacher training takes place in the reified universe, that is, by its turn, materialized in the curriculum and in the university norms. HoS is part of the curriculum. But the prospective physics teachers are living in both universes. They are under the university norms but they also must deal with life situations, in a consensual universe. The students’ consensual knowledge is the one they validate for themselves and it would be what they carry for their lives as physics teachers in action. And that is why we take the SR approach in this study. We are interested in what they, consensually, represent regarding using HoS as a didactic strategy.

2.3 Nuclear and peripheral systems of a SR

When we explore a SR we must to deal with an inherent contradiction: representations are rigid and static enough to allow the emergency of consensus, creating a stable system of values. But at the same time they are fluid and dynamic, constantly changing. In another way, representations are ways for building consensus but they are deeply influenced by an enormous set of fuzzy idiosyncrasies. The theoretical solution for this contradiction was proposed, splitting a representation in two regions. In one of that the collective memory, the values and historical conditions would determine the rigid part
of the representation. That would be the central core of the representation. The central core does not depend on the immediate social and material contexts. In the other part of the representation, a periphery would accommodate the dynamic and the fuzziness and there would be a strong dependency of immediate social and material context [11].

Those two sets would operate under different specific functions. While the central core has a consensual function, the periphery acts as an interface between the concrete world and the core. In order to look at these two source of information (core and periphery of a representation) an experimental adaptation was proposed: the linguistic structure could reveal core elements and peripheral ones [12]. Also, by looking at the connectivity of elements, the relations among them could be seen and the SR could be explicitly shown.

3. Methodology
The research was proceed using a free word evoking as the survey method in order to identify the core and the periphery of the students’ representation. The subjects were 77 undergrad students, taking physics teaching credentials in a public university in the state of São Paulo, Brazil. The students were in different stages and their admission years vary from 2007 to 2017. The data was collected between October and December 2017.

3.1 Data collection and analysis techniques
In this survey, the subjects were asked to write down in a form the five first words that came to their minds about the trigger phrase “use of history of science in physics teaching”. Evoking words freely, we could take a snapshot of their representation on HoS as teaching strategy.

The analysis was proceeded using the Free Words Association Technique [13]. The advantage of using this methodological approach is its quick data gathering process and its potentiality for express explicitly the elements of the SR and the relations among them. This structural approach of SR can inform us about the internal structure of the SR.

As the central core carries symbolic value, its elements would be salient in the group’s discourse by consistency of certain words and of certain relations between the words. According to Moliner, “[…] the items more connected in a semantic network are better memorized than the others” [13, p 94] This memory is related to stability and therefore it can point out the most likely core elements in the representation.

Another advantage of the methodological approach is that as we asked subjects all over the campus and in some cases, interrupting some professor’s classes, it would be wise to use a form that could be quickly answered.

After having all the evoked words, they were lematized in order to reduce the variations to a fewer lexemes. Then, we proceed a similarity analysis for building a semantic network which would give us a structure that could inform core and periphery of the SR. In the network, each vertex is a lexeme with the diameter proportional to its frequency and each edge is a similarity relation with its edge thickness proportional to the computed value of similarity, as detailed in the Figure 01 later. The analysis was proceed using the free software IraMuTeQ [14]. In order to deeply understand the analysis process, we provide a thorough example of the similarity analysis with a hypothetic situation: consider we ask three subjects to evoke the three first words coming to their mind when we say “fruit”. The first step of the analysis is to table all the words by subject (Figure 1, A). Then an occurrence boolean matrix is set with “0” for non evoked and “1” for evoked in each term by each subject (Figure 1, B). After this, a 2x2 contingency matrix is set for each pair of words (Figure 1, C) and the next step is to compute the similarity between two words by its co-occurrence, using the Jaccard’s method [15] (Figure 1, D). We computed the similarity between “apple” and “papaya” as exemple (Figure 1, E). Then, computing the similarity between every pair of words we set a matrix of similarity (Figure 1, F) and that matrix was used as an adjacency matrix for drawing the weighted
network (Figure 1, G) and then the Pons algorithm [16] was used for detecting clusters in the network, which helps us to see subgroups of words by its similarity. With the similarity network built we could interpret the elements and the relations shown.

4. Results and discussion
A total of 376 words was evoked on the trigger phrase. The analysis was proceed using only words evoked by the frequency of three or more. The remaining were 148 evoked words from a 29 different lexemes. In the similarity network 4 different subsets emerged as clusters in the SR, as shown in Figure 02 below.

The overall interpretation for the similarity network indicates that the group see, consensually, the usage of HoS as a tool for contextualization in physics teaching. This core of the SR anchor teaching products. The HoS concerning the historical process of science development appears to lack in the SR. The central core is surrounded by elements concerning the goals of teaching such as understanding, comprehension and culture. A bit far away from the core, a possible periphery includes discovery, basis and interdisciplinary. These elements compound the main cluster (A) in the network.

The second cluster (B) aggregate controversial elements in this representation: the usage of HoS as teaching strategy is, at the same time, innovative, stimulant, necessary and useful but related to difficulty. This controversy is a inherent property of the SR’s periphery, where the core of the representation and the real life are interfacing. It means that students can recognize some value in using HoS but the ways of doing so can be not clear to them. It can be considered as a teaching strategy they think it could be good but it could also be hard to implement. Naturally, we are not advocating pro one or another strategy, bus it’s a consensus that HoS is a contextualization tool, which should make the teaching process easy, but this easiness is not bought along with the tool.
The cluster C is another candidate to a periphery of the SR but what catch our eyes was the systematics of the teaching pragmatics elements, such as movies and books. Also a tautological answer “history” is present. But in this cluster, the elements are less dramatic than the strongest similarity in the network (teacher – book). Even though it’s not a core, the students in this survey recall a strong association between the person who is teaching and the main source of information. This relation address to two epistemic authorities in the classroom: both the teacher and the textbook. But again, the lack of its usage can be seen in the association between teacher and little, regarding the usage of HoS, what endorse previous research in the field [9].

![Figure 2. The similarity networks showing evoked lexemes with frequency ≥3.](image)

The fourth cluster (D) shows elements including remarkable personalities and places in the HoS, specially in physics. It shows that when asked to think about the usage of HoS, the subjects recalled facts, places and people as some sort of flags that can, somehow, been used in the classroom. Both of Moscovici’s process [5] for a SR can be recognized in the present results. HoS is anchored in the contextualization which is orbited by less dramatic elements of the representation. Also, the HoS is objectified in the pragmatics elements of teaching, such as locations, persons and traditional didactic tools like textbook and movies. The presence of both process (anchoring and objectifying) is a hint of a larger SR, traced, at least in part, by the salients words shown in the similarity network.

5. Conclusion
It has been shown some elements and relations among them, considering what is represented in the didactic usage of HoS by a group of undergrads students taking physics teaching credentials, as we were searching in our research question. But we were also impressed by the absence of some views on HoS we consider very structural in physics teaching. The SR on the usage of HoS did not show science as a human development process. That would recall the ways of validating the knowledge in physics, the academic conflicts between different ways of think natural phenomena and its technological implications (e.g. the industrial revolution and/or the communication system we all use nowadays). In a meta utilization of Moscovici’s words, there were points in history when consensual knowledge became reified by the social validation of laws and norms. That is, in our view, one of the deepest influence of HoS as a process that shaped the physics seen in textbooks and taught in classrooms. Naturally, we are aware that any object can be complemented by what it isn’t. But in this case, we are concerning, ultimately, with changes in the reified universe of the college curriculum. So it is not just bringing the consensual view to the reified world. But is more about how to adjust the reified world of physics teacher training in order to provide a broader consensual view on the HoS. A consensual view that could be carried through life, in a way that HoS could be represented beyond merely a contextualization tool. Instead, a consensual view that considers HoS regarding science and knowledge building process and its influence in the actual structure of the contemporary world.

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