IS THE ATOM REAL OR BUILT? OR IS IT AN INTERMEDIATE BETWEEN THESE TWO? A WITTGENSTEINIAN APPROACH.

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Abstract: The question about whether the atom is real or built is still among us despite the scientific and philosophical efforts already made. In this work we propose a solution to this question based on the philosophy of Wittgenstein, looking on how we use language. Wittgenstein's thought is considered of crucial importance in twenty century philosophy. Despite the importance of his philosophy, which helps us to think about concepts, language and meaning, nowadays there are few contributions of Wittgenstein's ideas in science education. We challenge the idea of asking questions directly about the atom out of a model and try to put real and building in the right place in scientific practice. We discuss about models, data and natural phenomena, and try to understand them in terms of real and built. Instead of trying to answer this question, we *dissolve* it, remembering what exists and what is built in scientific practice. Wittgenstein's philosophy, as an exercise to a closer look on how we use language, is useful to understand philosophical aspects of chemistry and science education. We must not fear or be angry with either existence or building. It is only necessary to put each one of them in their right place. We think it is an interesting educational solution to this problem, as students will start to see that some usual questions may be illusory.

Keywords: Wittgenstein, Science Teaching, realism, constructivism, philosophy of language

INTRODUCTION

It is quite clear by now that Wittgenstein (2001) wrote about philosophy, more specifically the language illusions that philosophers had been chasing for some centuries thinking it were big truths. Wittgenstein's thought is considered of crucial importance in twenty century philosophy. His contribution has influenced the linguistic turn in philosophy and also many other disciplines. These contributions, like his anti-essencialist approach and his methods of pointing to language illusions where philosophers have been trying to find grounds, are still a challenge to those dedicated to an in deep understanding of his thought. His important philosophy helps us to think about concepts, language and meaning, and nowadays the contributions of Wittgenstein's ideas in Science Education research can be found in influential epistemologies inspired on his philosophy (Wickman and Östman, 2004). The questions about the existence of the atom are important in chemistry courses and teacher training courses. Our main focus is to present a contribution on this subject based on Wittgenstein's philosophy. As well as the philosopher, we want to show that some expressions in Chemistry and Science Education are misleading, and have guided us to ask

illusory questions on both fields. In particular, we want to show a philosophical solution, in a wittgensteinian fashion, to the old problem of asking whether atoms are real or built, or even an intermediate between these two positions. We have no intention in finishing this philosophical question, as we are talking to a Science Education community.

It is necessary to observe at first that we, in Science Education research, are not doing any Philosophy of Science research. In fact, in Science Education many historical aspects of Philosophy of Science help us to show the way scientists do science, and these aspects are also interesting to introduce students to important questions in Science Education. Nevertheless, we are always challenged by questions from the Philosophy of Science research field. One of those is the famous question about the existence of the atom. Do atoms exist or are they constructions of our senses? Can we say that atoms are real, for example, in a scientific reality, in opposition to a naïve reality, or the dependence of our senses wouldn't allow us to do such assertions?

The first big congress of chemists took place in Karlsruhe (Nye, 1996). This event gave visibility to Chemistry, and one of the goals was to define general rules to this discipline. One of the main questions was on the divergence of the uses of terms like *atomic weight* and *atomic equivalent*. It was a philosophic question between atomists and anti-atomists, and the background was the existence of the atom. But there was no confrontation between these two groups in that moment, as chemists needed to defend their position against the mecanicist naïve realism of physicists. And this dispute has been renewed in many other flavors, like the dispute between Ostwald's energysm and Boltzmann's realism that ended in 1906 in favor of the late.

More recent disputes on the existence of the atom are about of what representation actually represents, among other topics. Ghins (2010) discusses about the applications that Bas van Fraasen does of Foucault's proposals, when the late challenges the idea that knowledge is representation. Ghins defends a scientific realism, and asserts that models do not represent *completely* natural phenomena. Giere (2006) defends a perspectivist realism, which accord to him would be between realism and constructivism. In his arguments he claims that scientific propositions are neither as objective as objectivist realists want, nor as socially determined as moderate constructivists think. The only fact collectively recognized here is that this surely is a philosophical problem because no more data will solve this old quarrel. In this work we want to analyze the questions, instead of choosing one of the answers.

REAL OR BUILT?

Before our reader accuses us of realism or constructivism, we ask for patience to read our text in full length. We will start with an ordinary question as an example of what we are going to talk, and after that, we will start thinking about our specific subject. Does Santa Claus exist? Of course not, most of human beings would answer. But if we are able to talk about him, so in some sense he exists. Philosophical puzzlement many times starts like this. A wittgensteinian answer to this question would be that we are talking about two similar, but different ways of *existing*. Concepts, models or stories do not exist in the same sense as mountains or natural phenomena. Some philosophers, when asking about this two different existences as if they were one, forget that we, human beings, invented the Santa Claus story, but we did not invent natural phenomena, although we invented ways of thinking and talking about them. And we can use the word *exist* for both, but with different meanings.

From this point we remember a curious fact about the questions of the atom existence: We don't remember someone has ever asked us about the existence of Rutherford's atom, or

Sommerfeld's atom, or any other model's atom. The question about the atom existence is always made as if it was possible to talk seriously about it out of a given model. We forget that it is not possible to ask anything about the atom out of a model. Lets us try, for example, to ask something about the relationship between electrons and the nucleus in an atom. One would immediately ask: in what atomic model? This would be so because, if we think about Dalton's atom, there is no such a relationship, once there is no electron. And these relationships would differ enormously from model to model. It is not possible to ask if the atom, out of a model, is real or built, just because there is no atom out a model. As chemists and physicists most of us keep talking about atoms without specifying a model, just because it is *implicit* in the properties that are on the subject. This leads us to the illusion that it is possible to ask questions directly about the atom.

What is built in science?

We believe no serious researcher think that any atomic model was not built. So, the atom of Rutherford is a model built by us, as well as any other atomic model. We built these models from the data available in the circumstances, and also from any other historic and scientific circumstances. These models were built to explain data, and also to understand better natural phenomena and some of its properties. So, it is an illusion to ask about the existence of the atom, out of a model, because no one doubts that all models were built. It follows that *atoms, in a given model, are built*. We must not feel that scientific knowledge is threatened because we use models as constructions. We just have to put it in the right place.

What is real in science?

At this point maybe the reader is thinking we are going to defend a constructivist approach, but this is not the case. Someone would be inclined to think like this so far in this text because, at the end, we work with science, and there is plenty evidence about the properties of the models we have built. So, something *must* exist! It is not correct to say that atoms exist, because there is no atoms out of a model, but as practitioners of experimental sciences we also don't believe that the world that surrounds us is a mere convention. So, is it possible to speak that something exists? If so, what is this? Is it a reality behind or beyond our senses?

First, is it possible to speak that the data we collect exist, in a strict sense? We don't think so. The data we collect depend upon methods of collecting data, knowledge of how to deal with numbers, charts and other way of representing, and many times it is possible to collect different sets of data from the same natural phenomenon. Our data are also built, in the sense we have to collect them, as well as we have to arrange them in a proper way of representation.

So, are our data mere conventions? Here we have to remember that there are at least two aspects of data. The first one is about the constructs and representations we invented to deal with quantities, and upon what we take data. The second is that when we take data, it is a way to represent some aspects of a phenomenon that exists without human interference. So, about the question of our data being a convention, the answer is *yes* in the sense about the way we write it, and *no* in the sense they mirror some aspects of natural phenomena. These are two different aspects, and sometimes we treat them as if they were just one. We are not defending that data are conventions, but that its representation is a convention. And we are not defending that data is real, but that it represents some aspects of a real phenomenon. The data may be seen as a mirror of some aspects of natural phenomena, but cannot be considered real in a strict sense, like the natural phenomena itself. In any case, we can say that our data is built.

But, does *anything* exist anyway? To understand better about the existence of the world that surrounds us, we have also to remember from what point most of scientific discourse has emerged: understanding natural phenomena. Natural phenomena are the only thing we can say to exist, in a straight sense. No one should doubt about the existence of natural phenomena, as well as no one usually doubts about the existence of the front door of his or her house. It is senseless to believe the existence behind or beyond our senses both to natural phenomena and our door. It is also senseless to doubt their existence. They just exist. So, it should not be necessary to ask if either of them exist. We think, thought, it is important to stress that *the only existence we can talk about, is of natural phenomena*. But the existence of natural phenomena in atomic and molecular level and the evidences about the laws of matter do not give us the right to state that the models we invented exist. Models and data are built. We must not feel that scientific knowledge is threatened because models and data are not real in a strict sense. We just have to put real in the right place, and this place, we believe, are natural phenomena, although data mirrors some aspects of it.

The illusory question

So, the question about the existence or building of atoms is put as if it was two conflicting positions, and you had to commit yourself with one of them. Or worse, maybe there should be an exhaustive mental exercise to find an intermediate position between these two, or even to find a third way of explaining the fact that we build models and are able to talk about natural phenomena. We hold that none of these positions are satisfactory, because in all of them we just forget how we use the words *real* and *built* in everyday life. And if we want to give them new meaning, let us say clearly what meaning is this. It is philosophically misleading to ask a question in a broad sense, e.g. if something is real or built, and expect a specific sense. All we need to do is to remember what is real and what is built in scientific practice, and that it is not possible to talk seriously about atoms without specifying a model.

Conclusions

The question about whether the atom exists or is built is a double illusion. What is built is the atom of a given model and data, and what exists are natural phenomena. So, the atom of, say, Rutherford's model, is built, although the natural phenomena in atomic and molecular scale, from where both data and model were obtained, is real. The question put forth in the title cannot be answered because it is philosophically misleading and senseless. Instead of trying to answer this question, we tried, in this short work, to *dissolve* it, remembering what exists and what is built in scientific practice. Wittgenstein's philosophy, as an exercise to a closer look on how we use language, is useful to understand philosophical aspects of chemistry and science education. We must not fear or be angry with either existence or building. It is only necessary to put each one of them in their right place. We think it is an interesting educational solution to this problem, as students will start to see that some usual questions may be illusory.

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PART 5: NATURE OF SCIENCE, HISTORY, PHILOSOPHY, SOCIOLOGY OF SCIENCE

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The implications of nature of science, its history, philosophy, sociology and epistemology, for science education. The significance of models and modelling for science education as reflected in the particular importance attached to the use of metaphors, analogy, visualization, simulations and animations in science.

This part corresponds to strand 5. It contains 24 papers.