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Alice in the country of rocks and what she did not find there*

Alicia en el país de las rocas y lo que no encontró allí

Rosely Aparecida Liguori Imbernon[1,2], Clara Vasconcelos[3], Katia Mansur[4], Pedro Wagner Gonçalves[2,5], Celso Dal Ré Carneiro[2,5]

1 - Universidade de São Paulo, Escola de Artes, Ciências e Humanidades (EACH-USP), São Paulo, SP, Brasil.

2 - Programa de Pós-Graduação em Ensino e História de Ciências da Terra, professor/a Permanente, Campinas, SP, Brasil.

3 - Universidade do Porto, Faculdade de Ciências (FC-UPorto), Porto, Portugal.

4 - Universidade Federal do Rio de Janeiro, Programa de Pós-Graduação em Geologia (PPGG-UFRJ), Rio de Janeiro, RJ, Brasil.

5 - Universidade Estadual de Campinas, Instituto de Geociências (IG-Unicamp), Campinas, SP, Brasil.

E-mail: imbernon@usp.br, csvascon@fc.up.pt, katia.lmansur@gmail.com, pedrog@unicamp.br, cedrec@unicamp.br

Abstract: **Introduction**. This article proposes a reflection about Geology teaching in basic education, using a seminal contribution of the author Conrado Paschoale: *Alice in the Geology land and what she found there*. **Objective**. The objective is to center a reflection on the training of a teacher who never could learn Geology by "doing it" but is obliged to develop related contents in classrooms. **Methodology**. Starting from the "Alice" proposal, we find a professor entering the world of Geology, but finds nothing, because he/she lacks geoscientific knowledge to understand and, therefore, to teach, too. **Results**. Poor teacher training generates cascading problems, especially at a time when new discoveries in Geosciences demand rapid teacher updating. Faced with simplistic representations and models, the teacher needs to develop a high level of conceptual abstraction – such as the conception of Geological Time, among many others – in order to understand how the planet Earth works. **Conclusion**. Aggregating new knowledge and relating it to previous knowledge seems to be a satisfactory way for interrupting a vicious circle in which the poor quality of teaching is due to poor teacher training.

Resumen: **Introducción**. Este artículo propone una reflexión sobre la enseñanza de la Geología en la educación básica, a partir de un aporte seminal del autor Conrado Paschoale: *Alicia en la tierra de la Geología y lo que encontró allí*. **Objetivo**. El objetivo es centrar una reflexión sobre la formación de un docente que nunca podría aprender Geología "haciéndola" sino que se ve obligado a desarrollar contenidos afines en las aulas. **Metodología**. Partiendo de la propuesta de "Alicia", nos encontramos con un profesor que se adentra en el mundo de la Geología, pero no encuentra nada, porque le faltan conocimientos geocientíficos para comprender y, por tanto, para enseñar. **Resultados**. La mala formación de los docentes genera problemas en cascada, especialmente en un momento en que los nuevos descubrimientos en Geociencias exigen una rápida actualización de los docentes. Frente a representaciones y modelos simplistas, el docente necesita desarrollar un alto nivel de abstracción conceptual –como la concepción del Tiempo Geológico, entre muchos otros– para comprender cómo funciona el planeta Tierra. **Conclusión**. Agregar nuevos conocimientos y relacionarlos con los conocimientos previos parece ser una buena forma de romper un círculo vicioso en el que la mala calidad de la enseñanza se debe a la mala formación de los docentes.

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Introduction

If we consider that "to learn Geology is to do Geology" (Figueirôa, 2009) we will find, as well as the cited author, a statement by Paschoale (1984) that makes us reflect on the acts of teaching and learning Geology in basic education.

> (...) to build a learning model that is not only a Geology practice, but also its critique. (...) If the students want to know what a fold is, I will draw a fold on the board for them. Then we will go to the field to see how that diagram is very limited, and discuss its real use. And realizing how, on certain occasions, fixing it on your head can even get in the way. (Paschoale, 1984, p. 5.248).

In Conrado Paschoale's line of thought, we can raise the following question: many times, we only have access to the *representation* of a certain natural phenomenon, such as a package of folded rocks, but we do not ask when was the first time that the same feature was observed and interpreted as evidence of a phenomenon that occurred in the past. In other words, there are two concurrent actions in the didactic communication process: the simple recognition of the phenomenon and its representation. It is necessary to separate the identification of the phenomenon itself from the representation we make of it. The author prioritizes direct observation and proposes to avoid models that offer

simplistic explanations of phenomena, because they can limit the reach of thought.

This article aims to analyze the teaching of Geology in a playful way, being mainly addressed to teachers who "learned" Geology without having had the opportunity of "doing" Geology. At the same time, we want to explore the ideas of the geologist and professor Conrado Paschoale (1984), who connect Alice's magical world (Fig. 1) to the universe of geological knowledge: a body of knowledge that recognizes and values the internal and external dynamic processes of planet Earth, and which is indispensable for the inhabitants of different territories to understand the negative effects of human intervention in natural processes. On the other hand, the recognition of geological processes also helps in the better occupation and use of land, generating well-being and security.

Commanding nature means respecting its determinations! However, buildings continue to be built in geological risk areas, as well as there is no control over tourism in areas with a high risk of geological events. One of the reasons is that the population has not yet understood that human intervention **cannot** interrupt natural systemic processes that have been operating for millions of years, such as, for example, the flooding of the Tietê river and its tributaries on the marginal avenues of the city of São Paulo. Public policies must be established to prevent the repetition of disasters caused by human action. Nova Friburgo (2011), Petrópolis (2022), Franco da Rocha (2022), Capitólio (2022), São Sebastião (2023), are recent examples, among others, of irresponsible occupation, marked by the lack of geological knowledge capable of subordinating the social dynamics to regional weathering, erosion and climatic patterns. Mariana (2015) and Brumadinho (2019) reveal examples of the dark face of predatory and criminal mining (Petley, 2020); these cases get worse because the population did not realize the dimensions and importance of iron ore in the national territory (Guerra et al., 2007, Dourado et al., 2012, Rocha, 2021, Vieira et al., 2022).

In Brazil we observe great scientific illiteracy, especially in Earth Sciences. Some accuse scientists of dogmatism, isolation and meaninglessness, a restriction that is partially valid if we look at the uninteresting way in which traditional teaching presents science content in schools (Gil-Perez et al., 2005). Although access to scientific knowledge is a citizen's right, it lacks meaningfulness[1]. This is

Figure 1. Alice trying to interpret the origin of a package of weathered metasedimentary strata. Source: the authors

an essential component of the sustainable development goals, especially SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities) defined by the UN's 2030 Agenda.

Earth Sciences "study and explore the Earth system and are therefore highly relevant to understanding and addressing central environmental issues" (Vasconcelos & Orion, 2022). This is pertinent but, when we evaluate the way in which the teaching of Natural Sciences takes place in schools, we verify that Geology is diluted among other contents. In general, the focus is on the origin and evolution of Life, and not on the origin and evolution of planet Earth and Life. After all, first the planet evolved, so that the conditions for life to establish itself were created.

Anthropogenic action contributes to accelerating degradation processes of the various terrestrial subsystems, climate change, soil impoverishment, ecosystem imbalances and many other phenomena that cause strong social, environmental, and economic impacts, often irreversible. Planetary unsustainability, far below the goals of sustainable development of the United Nations 2030 Agenda, can and must be fought with geological education capable of promoting attitudinal changes and generating geoethical behaviors.

Thus, when comparing Alice's world with the world of Geology knowledge, we seek to find, in a playful way, elements that make it possible to reflect on this teaching in teacher training, "Alices" lost in a completely unknown world of knowledge.

But what did Alice not find in the country of geology?

Alice, the girl described by Charles Lutwidge Dodgson – better known by the pseudonym Lewis Carroll – lived oneiric and playful adventures about

1 The term *meaningfulness* applies in the sense of Ausubel's theory of meaningful learning. In this theory, new knowledge needs to be related to the learner's previous knowledge so that the new learning makes sense to him, and can be organized in his cognitive structure, in a non-arbitrary and non-literal way (Gil-Perez et al., 2005)

reality and language. Alice's work explores ideas of how we remember the past and think about the future, namely cognition and cognitive science, the process of acquiring knowledge, exploring the imagination. Well, children who play make-believe and practice believing in the impossible tend to develop more advanced cognition, overcoming barriers imposed by many learning contents that involve abstraction.

> Learning through play has emerged as an important strategy to promote students' engagement, inclusion, and holistic skill development beyond the preschool years. Policymakers, researchers, and educators have promoted the notion that learning through play is developmentally appropriate because it stimulates the innate curiosity of school-age children and facilitates the often difficult transition from preschool to school (Parker et al., 2022).

Geology, on the contrary, finds in the present the key to the past, because when we observe fossils, minerals, rocks, geological structures, or relief features, we can infer the evolution of the environment, changes in the climate, in the level of the oceans etc.; in short, we have direct access to the records of geological processes.

When visiting places like Morocco today, we can observe a fine reddish sand, with a dull shine, forming the dunes of the Sahara Desert. When we visit locations close to São Pedro, Botucatu and others in the Corumbataí river valley, we observe hills and ravines composed of a rock formed by grains of sand, reddish and with the same matte shine as African sands. Such records allow us to conclude that, tens of millions of years ago, in the interior of South America, there was a vast hot desert. Wherever we can find the same rock, we will find the clue to places where the desert climate prevailed.

As important as knowing the size of the desert is knowing its distribution because the rock, nowadays, is an enormous underground water reservoir (the Guarani Aquifer System), which supplies cities and industries, allows irrigation and the tourist use of thermal waters. On the other hand, the entire area where the rock is exposed on the Earth's surface is where the rainwater that supplies a large part of the underground water infiltrates. At the same time, this region is subject to contamination, which can harm successive generations for many centuries. Knowing how the aquifer works is essential when making decisions about the future of water – a resource that is already scarce for many people today.

The land of rocks and Geology

Alice explored the apparent meaninglessness of the world she found herself in – Wonderland; now he finds himself in the "land of rocks, of geology" and he needs to find answers, or, at least, he needs to know how to formulate questions.

Similarly, let us think of the adventures of a professor when he enters the world of Geology, or faces some learning contents dispersed in the disciplines that make up the curriculum of basic education. The professor is a professional, whose university education often did not include curricular components and learning objects in Geology. It is very likely that he has already manipulated minerals, rocks or fossils, without imagining, however, that they are records of natural processes. In this wonderland, of rocks or geology, Alice and also our teacher find the logic of the absurd and not of understanding.

This teacher often did not have Geology or Paleontology classes. But when he had them, he learned how the Earth works, how rocks, minerals and fossils form, how Plate Tectonics operates and how folds form from the slate and the book. He was limited to the world "on the other side of the looking glass", a world of many shadows but few facts. But it will be the Teachers who will have to develop knowledge and skills with their students, often on topics that they themselves do not understand. After all, we're talking about our planet Earth, which even scientists still don't quite understand how it works, remember?

It is in the classroom that the professor walks between paradoxes and abstractions, and not congruence and wisdom. If this professor was not given training (and information) that would allow him to (re)know the evolutionary processes of the Earth system, over geological time, nor the way to teach his students, how should he proceed? (Carneiro et al., 2004, Compiani, 2005, Toledo, 2005a, 2005b, Santos et al., 2021).

Like Alice, the professor encounters enigmas that are difficult to understand, in which two worlds (do not) combine – that of geological knowledge and that of pedagogical knowledge.

But what did the professor find in the land of rocks and Geology and how can he carry out his teaching and learning plans there? How has children and young people learned Geology in the

classroom, if Geology is not a curricular component in at least one of the grades that make up the 12 years of basic education in Brazil, but only dispersed learning content in the school curriculum?

After all, the same curiosity that made Alice intrigued with the rabbit constantly running against time, also when entering the world of rocks and geology, the professor is intrigued by the knowledge that he should develop in the classroom, as such knowledge involves understanding the planet we inhabit, and whose time is Geological Time, a concept that is difficult to understand and requires a high level of abstraction.

Geology teaching

But how has Geology teaching been in Brazil, since the discipline is not present in basic education curricula?

Until the 1950s, geology content in education remained restricted to Natural History. Within this, Geology, Mineralogy and Petrology together occupied more workload than Zoology and Botany. However, not all secondary school students (approximately our current high school) studied Natural History, only students who opted for the Scientific course had three years of this subject. Educational and professional changes (Lei de Diretrizes e Bases da Educação in 1961 and the creation of Geology courses in 1957) were decisive in the near elimination of school geology in Brazil.

From the 1960s onwards, driven by the NASA space programs and man's trip to the moon, Astronomy contents presented a more expressive approach in education; therefore, the other contents were reduced. During the 1970s, Geology occupies a large part of school content, reversing what happened in the 1960s. We emphasize that in the early 1970s, educational materials in Brazil began to focus on geosciences, having been largely inspired by the *Investigando a Terra* book/project (Funbec/AGI 1973) – largely the change in curriculum policy was motivated by the legislation that created the First Degree (Law 5692 of 1971). The book, an adaptation of the "Earth Science Curriculum Project", initially aimed at the equivalent of our high school in the United States, had an influence in Brazil on the teaching of Introductory Geology, therefore, on the training of Teachers, with repercussions in the following decade.

This fact shows the importance of universities in teacher training, as well as the importance of didactic material to support the classroom and its positive effects on education. Nowadays, we find unacceptable errors in textbooks used by our children and young people, which involve Geology content. Mistakes are repeated and multiplied in the media in general, even in ENEM tests. Did you know that?

The professor, like Alice in Wonderland, finds himself in the unknown world of Geology, a world that is not part of his daily life. How to turn the ordinary facts of everyday life into extraordinary and rich facts of terrestrial processes? How to explain the embedded valley of the Atibaia River and the abrupt changes in the direction of its course? This important tributary of the Tietê River has its secrets, as much as the Tietê itself (which flows inland, unlike almost all rivers that flow directly to the sea). The wide course of the São Francisco River reveals billions of years of history on the South American continent. Rocks from the touristic Lagos Region of the state of Rio de Janeiro are similar to African rocks, demonstrating that they are part of the same evolutionary history. The biggest challenge is: how to establish elements that allow the construction of geological knowledge by the child, the young person and the citizen from the observation of extraordinary things that are around us?

Why, after all, does geological knowledge interest the citizen?

By making use of the Alice metaphor, we really want to show the problem of representation and teaching, as we cannot accept, for example, conceptions linked to flat-Earth in the second decade of the 21st century. Another central point of the argument is that in the "country of teaching" *facts are not described, but representations are produced and exchanged*. In the "land of rocks, Geology" we question whether representations express the reality of geological facts and phenomena. Just as Alice observed Wonderland to understand it, we need to know how to observe our planet Earth to understand it, too. In Geology, the role of direct observation to build geological knowledge is fundamental. The target message (or reflection effect) is a very simple matter: geological processes are poorly understood by the majority of the population. Thus, teaching must return to dealing with facts in order to build representations (concepts, explanations, theories) afterwards. We live in an era permeated by successive discoveries of Geosciences, which demand rapid and continuous

teaching updating. On the other hand, poor teacher training introduces barriers and creates cascading problems because, in order to understand how the planet Earth works, the teacher must develop a high level of conceptual abstraction – such as the conception of Geological Time, among many others. When presented with simplistic representations and incomplete models, teachers often feel like they are facing the sphinx: "decipher me or I will devour you" ..., because they lack the bases to refute or circumscribe incomplete or false examples.

In Brazil, the expression of the scientific "deficit model" (Lewenstein, 2003) was revealed during the Covid-19 pandemic, in the face of a disproportionately high number of deaths compared to the Brazilian population. Scientific ignorance, driven by quackery and lies with a clear political orientation, has generated death, denialism and fostered an authentic fake news industry. People and authorities pursued, without stopping to reflect, a non-existent fantasy world. Scientific and technological advances were ignored and depreciated – as is still the case today – mainly by denying children the right to receive vaccines. There are serious problems in the interaction between science and society.

Final remarks

In Conrado Paschoale's line of thought, the identification of a certain natural phenomenon implies a coexistence of two concurrent actions: recognition and representation of the phenomenon. The author prioritizes direct observation and proposes that one should avoid simplistic explanations of phenomena and, in parallel, explore in greater depth the models that were constructed and propagated to explain the phenomenon in question. A good strategy to break a vicious circle in which the poor quality of teaching is caused by poor teacher training seems to be the adoption of a constructive alignment, in which new knowledge is added and related to previous knowledge that the teacher already has.

The main issue is: if we fully understand that planet Earth is a large system, which integrates different spheres (hydrosphere, atmosphere, pedosphere, biosphere, asthenosphere etc.), which interact and produce natural phenomena, often of gigantic magnitude and dimension, and that human intervention accelerates or alters such phenomena, causing much destruction, would knowledge of the "land of rocks, geology" not change society's behavior and attitude with regard to acts of "using, consuming and occupying" ?

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