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Chemical Elements of the Periodic Table in Indigenous Language as a Teaching Resource for Contextualized Chemistry/Science Teaching

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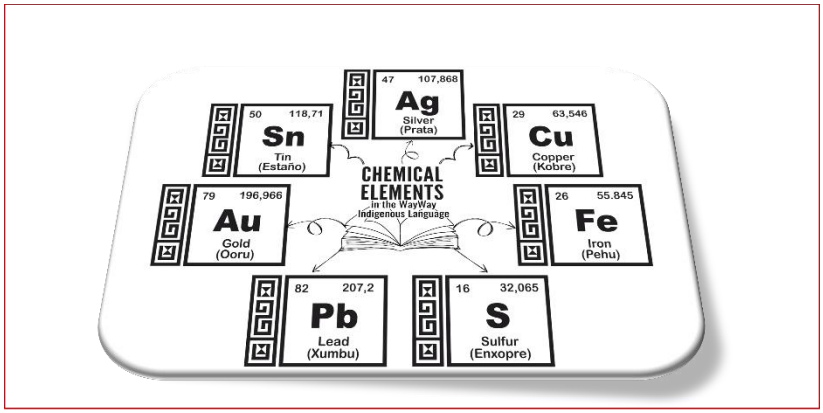
Roraima is the northernmost state in the Legal Amazon and the northernmost part of Brazil. Its population is over 600,000, of which approximately 15% are indigenous populations, the ethnic groups being Macuxi, Wapichana, Taurepang, Ingaricó, Patamona, Yanomami, Ye`kuana, Sapará, Waimiri Atroari and Waiwai. Indigenous populations in Brazil have few teaching materials that value the indigenous language and knowledge, as well as their relationship with science. The aim of this work is to develop contextualized, intercultural and interdisciplinary cards for teaching chemistry/science based on the identification of chemical elements of the Periodic Table found in the Holy Bible in the indigenous Waiwai language. To this end, we used applied research, with inductive reasoning, with exploratory and descriptive objectives for this study, with a qualitative approach using the documentary technique. The selection of documents was based on the Holy Bible translated into the Waiwai indigenous language, which resulted in 14 citations for sulfur (S), 86 for pehu (Fe), 35 for kobre (Cu), 10 for prata (Ag), 7 for estañu (Sn), 182 for ooru (Au) and 9 citations for xumbu (Pb). These were used in the construction of the teaching material. Through categorization, the data were decoded and interpreted. The educational product developed, the cards, is a teaching material for teaching chemistry/sciences that is contextualized and expresses the ethnic group's cultural and identity. In this sense, the production of cards seems to be an effective pedagogical resource for teaching chemistry/sciences in an intercultural context.

Graphical abstract



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1. Introduction

The educational content of chemistry or science has been a challenge in the acquisition of learning. Classes, often without any contextualization and, still, monotonous, can contribute to the lack of active participation of students. The adaptation of these technical-scientific contents to a more didactic form can be inadequately developed by teachers, which makes it difficult to understand these more complex subjects and, thus, reduces students' interest in the subject [1]. This difficulty in understanding the curricular content of chemistry is observed in relation to decontextualization, especially in the relationship between "society, environment, science and technology" [2].

Furthermore, there is a noticeable difficulty in assimilating these topics due to the lack of familiarity with the more fluid scientific language [1]. The aforementioned author's statement converges with Chassot's [3] defense that "being scientifically literate is knowing how to read the language in which nature is written. A scientific illiterate is someone who is incapable of reading the universe."

Teaching chemistry/science requires building pedagogical planning with a good didactic sequence and classes contextualized with the student's daily life [4], as well as using didactic resources to make the teaching and learning process viable, which becomes necessary to produce successful teaching, especially when teaching is intercultural.

Regarding the teaching of chemistry/science and its teaching resources from an intercultural perspective regarding the Periodic Table theme, it can be said that it is still incipient. When conducting an exploratory search, the Web of Science and SciELO databases provided only three articles published between 2021 and 2023 that dialogue with the proposal of this study, they are: Elements of country: a First Nations-first approach to chemistry [5], Adaptación de la Tabla Periódica al náhuatl: una propuesta para la enseñanza e inclusión [6] and Adaptation of the Periodic Table to Kichwa: An Ecuadorian Native Language [7]. The CAPES Theses and Dissertations Catalog and the annals of the Brazilian Association for Research in Science Education (ABRAPEC) did not return any results for the search.

Returning to the point of discussion about teaching resources that can help in teaching chemistry/science in a contextualized way is the use of the Periodic Table of chemical elements, especially when it brings the language, the cultural context in which the participants are inserted, such as the Periodic Tables in the indigenous languages Náhuatl [6] and Quechua [7].

Using the Periodic Table to teach chemistry or science in the native language, in this case Quechua, can help teach traditional knowledge, "by promoting Kichwa deep-rooted writing and enhancing an excellent bilingual intercultural education system in Ecuador" [7]. One of the authors of the work cited in the previous paragraph, and a native speaker of the Quechua language, states "we think that science can be part of Quechua and Quechua can be part of science" [8].

When observing the possibilities of adapting the Periodic Table to the indigenous languages of the countries mentioned above, we see that in Brazil there is a great diversity of indigenous populations, with 305 ethnic groups of indigenous peoples and 274 languages [9]. In Roraima, a state with a total of 636,707 inhabitants [10] and around 97.3 thousand indigenous people [11], which represents 15.3% of the population of Roraima, distributed among the Macuxi, Wapichana, Taurepang, Ingaricó, Patamona, Yanomami, Ye`kuana, Sapará, Waimiri Atroari and Wai Wai ethnic groups [12-14].

The number of indigenous peoples in Roraima is significant, but teaching resources focused on formative concepts of chemistry/science contextualized with the indigenous reality and with the Periodic Table theme are incipient. For this reason, this work is the result of a Course Conclusion Work (TCC) of an indigenous teacher training course, whose main aim was to develop contextualized, intercultural and interdisciplinary teaching material for the teaching of chemistry/science based on the identification of chemical elements of the Periodic Table found in the Holy Bible in the indigenous Waiwai language.

Thus, we wanted to identify the record of possible chemical elements of the Periodic Table in the Holy Bible printed in Waiwai and in a smartphone application, characterize the name of the chemical element in Waiwai and in Portuguese, the number of citations observed, its symbol, number and atomic mass and the uses of these elements in general and in common use by the ethnic group (when applicable) and systematize the teaching material produced according to Waiwai indigenous art.

2. Results and Discussion

Using the printed Holy Bible in Waiwai [15] and the Bible in Waiwai via smartphone application [16] as a research source, it enabled a satisfactory documentary analysis, and as a result the identification of seven chemical elements, which are presented in the following Table (Table 1) in the Waiwai, Portuguese and English languages, as well as their references, number of citations observed, their atomic numbers, abridged standard atomic weight and symbols, according to IUPAC [17].

After identifying the chemical elements of the Periodic Table, and a brief review of the literature, it was possible to develop summaries, which were part of the production of contextualized instructional material (when possible), in card format, with Waiwai indigenous graphics as a cultural and identity expression of the ethnic group, the name of the chemical element in Waiwai and in Portuguese (Figure 1).

It is important to emphasize that there is little teaching material aimed at valuing indigenous languages and knowledge, especially for basic education [18]. The situation of the Waiwai indigenous people is no different [19]. Therefore, this material can be printed and used in the classroom for teaching Chemistry or Science in classes in the final years of Elementary School and High School, thus helping to promote the understanding and interpretation of natural phenomena [3] and anthropogenic actions in which the indigenous community is involved.

Chemistry teaching can be more relevant when integrating contextualization and culture, using contextualized instructional materials and, when there is a shortage of resources, improvising them, which improves student learning [20]. Thus, establishing a connection between scientific content, for example: the chemical elements of the Periodic Table, and, in the cultural context, is of great importance, as it favors scientific knowledge for "students of original peoples" [6]. We can find similar work to this being developed by the Natural Sciences and Engineering Research Council of

Canada that connects traditional knowledge with the Periodic Table [21].

Table 1. Seven chemical elements from the Periodic Table and their references.

Atomic number	Atomic weight	Symbol	Chemical Elements and the citation of a text as an example			Quotes of chemical elements in Waiwai indigenous language
			English	Portuguese	Waiwai	
16	32.06	S	Sulfur (Revelation 20:10)	Enxofre (Apocalipse 20:10)	Enxopre (Xesus Nenpotho 20:10)	14
26	55.84	Fe	Iron (Proverbs 27:17)	Ferro (Provérbios 27:17)	Pehu (Kakihretopo 27:17)	86
29	63.55	Cu	Copper (Job 28:2)	Cobre (Jó 28:2)	Kobre (Xoo 28:2)	35
47	107.87	Ag	Silver (Proverbs 17:3)	Prata (Provérbios 17:3)	Prata (Kakihretopo 17:3)	10
50	118.71	Sn	Tin (Ezekiel 27:12)	Estanho (Ezequiel 27:12)	Estañu (Esekiyew 27:12)	7
79	196.97	Au	Gold (Exodus 32:2)	Ouro (Êxodo 32:2)	Ooru (Towtoponhiri 32:2)	182
82	207.20	Pb	Lead (Zechariah 5:7-8)	Chumbo (Zacarias 5:7-8)	Xumbu (Xakarias 5:7-8)	9

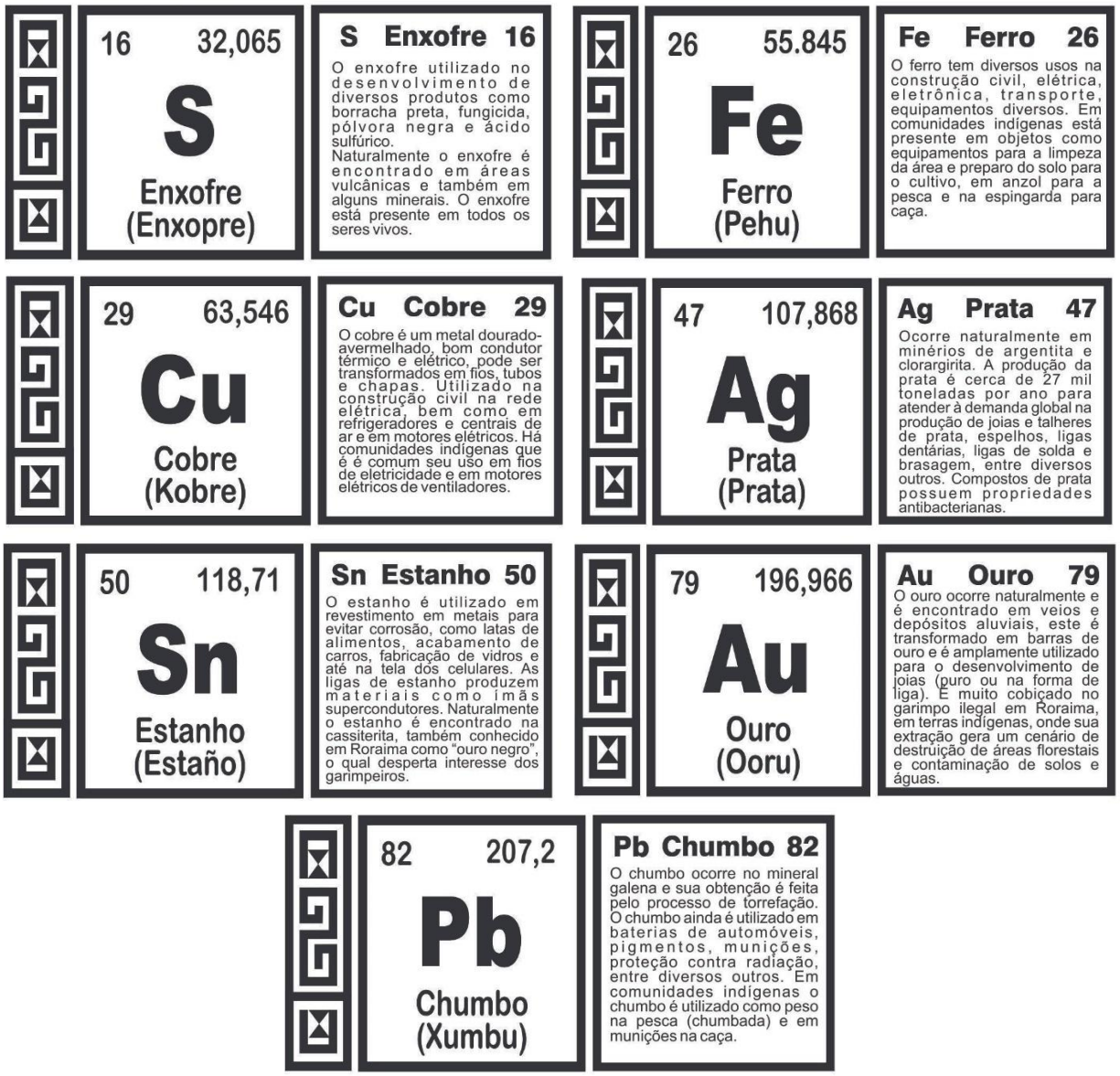

Fig. 1. Chemical elements of the Periodic Table in the Waiwai indigenous language.

The content on the cards brings a relationship between science and everyday life, therefore, contextualized science can make theoretical knowledge more understandable [2] and help in the development of the ability to think scientifically, as pointed out by Ardyansyah e Rahayu [22] "Scientific literacy supports the development of scientific thinking that supports the application of knowledge in everyday life."

3. Material and Methods

This study was developed using inductive reasoning, whose research nature is applied, with exploratory and descriptive objectives and with a qualitative approach and making use of the documentary analysis technique [23].

Document analysis is important because it allows us to know and name the 'document' understood as that artifact capable of "adding the dimension of time to the understanding of the social" [24]. Furthermore, according to this author, it is necessary to experience five steps to use this technique, which are: understanding the context of the document that will be used as a primary source, knowing the writer of the document that will serve as the basis for the research, being aware of the veracity and credibility of the manuscript to be analyzed, the characteristics and finally, the key concepts that will be sought in the archive.

Therefore, considering Cellard's (2012) guidelines [24], we defined the Holy Bible in Waiwai as the search basis for selecting primary documents. The Waiwai indigenous ethnic group has an estimated general population of 2,861, with 2,691 in the states of Pará, Amazonas and Roraima and 170 in Guyana. The ethnic group has a relationship with the Christian religion, due to the presence of American missionaries since the 1950s through the Unevangelized Fields Mission (UFM) and, as a result of this interaction, the Holy Bible was translated into the mother tongue, Waiwai. The language is part of the Karib linguistic family [14, 19, 25].

According to the Brazilian Bible Society, the Holy Bible in the Waiwai indigenous language was the first complete translation into an indigenous language in 2002, containing both the Old Testament and the New Testament [25-27]. With technological advancement, this Bible was also developed as a smartphone app. Thus, both printed and as an app, it makes it possible to conduct religious and academic research.

We then conducted a documentary survey of the chemical elements in Waiwai from the books of the Old Testament and New Testament, which served as a documentary source for the construction of the teaching material. To operationalize the research, we cited only one source as an example and presented the number of sources found.

We began the process of selecting the information by organizing the estimated number of citations of chemical elements in a table and, as an example, we highlighted just one book with its chapter and verse, respectively, as well as a brief description of these elements in their general uses and by the Waiwai ethnic group.

4. Conclusions

The use of the Holy Bible in the Waiwai indigenous language, printed or in a smartphone application, as a source of documentary research, made it possible to identify seven chemical elements, organized in ascending order of atomic number: sulfur (S), pehu (Fe), kobre (Cu), prata (Ag), estañu (Sn), ooru (Au) and xumbu (Pb). From this identification, cards were created with the symbols of the chemical elements, atomic numbers, atomic masses, the name of the chemical element in Waiwai and a brief summary of these elements in terms of their general use and also their use in the indigenous community. This teaching resource can be used as an aid in chemistry or science classes, strengthening more contextualized teaching, valuing the language and knowledge of indigenous peoples.

For future work, we point out as a possibility the inclusion of more chemical elements in the Waiwai indigenous language and the construction of a complete Periodic Table in that language.

Author Contributions

Tewton Wai Wai and Kelly Carlos Castello: Formal Analysis, Investigation, Writing – Original Draft. Ricardo Carvalho dos Santos, Virgínia Marne da Silva Araújo dos Santos and Hosana Carolina dos Santos Barreto: Conceptualization, Methodology, Investigation, Writing – Original Draft, Writing – Review & Editing.

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