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Impossibility of bijective mapping between indigenous and Eurocentric mathematical knowledge[1]

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Abstract
This article aims to discuss the problem of translating mathematical knowledge in the context of indigenous school education, from three aspects: (i) different languages are based on different reference systems, (ii) the logics of different mathematical knowledges are not equivalent, and (iii) there is an impossibility of bijective mapping between sets of indigenous and Eurocentric mathematical knowledges. In this sense, the idea of isomorphic translation associated with prescribed bilingualism is problematized as a characteristic of indigenous school education in Brazil. The theme is explored theoretically and illustrated with the analysis of textual productions of indigenous students of an intercultural licentiate-degree course in the Amazon. As a result, it is shown that the idea of total translation of Eurocentric mathematical knowledge between Portuguese and indigenous languages, inherent in a colonialist conception of school education for indigenous peoples, needs to be overcome, in order to promote the decoloniality of indigenous school education.

Key-words: Ethnomathematics; Translation; Indigenous; Decoloniality.

Impossibilidade de mapeamentos bijetivos entre saberes matemáticos indígenas e eurocêntricos

Resumo
Este artigo tem por objetivo abordar a problemática da tradução de saberes matemáticos em contextos da educação escolar indígena, a partir de três aspectos: (i) diferentes línguas se baseiam em sistemas de referência distintos, (ii) as lógicas de distintos saberes matemáticos não são equivalentes e (iii) há uma impossibilidade de mapeamentos bijetivos entre conjuntos de saberes matemáticos indígenas e

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eurocêntricos. Nesse sentido, problematiza-se a ideia de tradução isomórfica associada ao bilinguismo prescrito como característica da educação escolar indígena no Brasil. O tema é explorado teoricamente e ilustrado com a análise de produções textuais de estudantes indígenas de um curso de licenciatura intercultural na Amazônia. Como resultado, mostra-se que a ideia de tradução total de saberes matemáticos eurocêntricos entre língua portuguesa e línguas indígenas, inerente a uma concepção colonialista de educação escolar para povos indígenas, precisa ser superada, com vistas à decolonialidade da educação escolar indígena.

Palavras-chave: Etnomatemática; Tradução; Indígena; Decolonialidade.

Imposibilidad del mapeo bijetivo entre conocimientos matemáticos indígenas y eurocéntricos

Resumen
Este trabajo tiene como objetivo abordar el problema de la traducción de conocimientos matemáticos en contextos de educación escolar indígena, desde tres aspectos: (i) los diferentes lenguajes se basan en diferentes sistemas de referencia, (ii) las lógicas de los diferentes conocimientos matemáticos no son equivalentes, y (iii) hay una imposibilidad de mapeos biyectivos entre conjuntos de conocimientos matemáticos indígenas y eurocéntricos. En este sentido, se problematiza la idea de traducción isomórfica asociada al bilingüismo prescrito como característica de la educación escolar indígena en Brasil. El tema es explorado teóricamente e ilustrado con el análisis de producciones textuales de estudiantes indígenas de un curso de formación docente intercultural en la Amazonía. Como resultado, se muestra que la idea de una traducción total del conocimiento matemático eurocéntrico entre el portugués y las lenguas indígenas, inherente a una concepción colonialista de la educación escolar para los pueblos indígenas, debe ser superada, con miras a la descolonialidad de la educación escolar indígena.

Palabras clave: Etnomatemática; Traducción; Indígena; Decolonialidad.

1. Introduction

The demonstration that there are different mathematical knowledges originated and located in different socio-cultural contexts is one of the contributions of ethnomathematics research developed since the end of the 20th century. As one of its developments, this contribution has made possible a questioning of the universal character attributed to mathematics in school curricula, opening space for thought and action towards the valorization of the multiplicity of mathematical knowledges and their respective epistemological matrices (D'AMBROSIO, 1990, 2001; POWELL; FRANKENSTEIN, 1997; KNIJNIK, 1998; FANTINATO; FREITAS, 2018).

The effective deconstruction of a modern conception of mathematics, which attributes to it characteristics of universality, with effects for the official reorientation of public policies of education and school practices, necessarily involves overcoming the condition of subalternity in which the ways of being and knowing of peoples that historically were submitted to European colonial domination are found. In this sense, it involves confronting the Eurocentric colonialist conception that humanity

is composed of inferior and superior, irrational and rational, primitive and civilized, traditional and modern peoples (QUIJANO, 2010).

By Eurocentric colonialist conception, one understands a perspective of knowledge and rationality, originating in Western Europe in the middle of the 17th century, which, although it does not encompass all the ways of knowing all Europeans and in all epochs, has become "worldwide hegemonic, colonizing and superimposing itself on all others, previous or different, and their respective concrete knowledge, both in Europe and in the rest of the world" (QUIJANO, 2005, p. 126). As an effect of the hegemonic character of Eurocentric coloniality, reproduced over time in the different regions under the dominion of modern colonial capitalism, Eurocentrism ceased to be a cognitive perspective exclusive to Europeans and was also reproduced by all those educated under its hegemony (QUIJANO, 2010).

Although it has an ethnocentric dimension, Eurocentrism is not restricted to that dimension, nor is it a question of geography, but of epistemology. Thus, as a concept of knowledge originating in Europe, "it could be found and reproduced in the colonies and ex-colonies, as well as in places that were not directly colonized" (MIGNOLO, 2017, p. 12). Thus, as the epistemic structure of colonial modernity, Eurocentrism systematically disregards the multiplicity of rationalities and epistemologies existing in the world or, at best, conceives them in a hierarchical manner, with Europe at the top of a linear scale of human development.

One of the consequences of the hegemonic perspective of Eurocentrism is the way in which certain knowledges may or may not be recognized as mathematical, so that "the standard treatment of the history of non-European mathematics is a product of a historiographical bias (conscious or otherwise) in the selection and interpretation of facts which, as a consequence, results in ignoring, devaluing or distorting contributions arising outside European mathematical traditions" (JOSEPH, 1987, p. 14). This distortion is reflected in school curricula, reducing and limiting the possibilities of promoting through school education the knowledge of the different lore produced by humanity, but located outside the Eurocentric cultural complex (SWARTZ, 1992; WILLINSKY, 1998).

Specifically for indigenous peoples in Brazil, the colonization process initiated by Europeans and conducted internally even after the historical period of colonialism, besides promoting genocide, also represents the epistemicide (SANTOS, 2007a), for denying the rational character to all forms of knowledge that are not guided by the epistemological principles of scientific rationality characteristic of modern thought (SANTOS, 2010).

In that way, the current historical phase of indigenous school education incorporates among its principles the overcoming of paradigms of modern European thought, advocating the recognition, appreciation and promotion of the knowledge proper to each people, their languages, identities,

histories and cultures, thus ensuring a specific and differentiated character to school in indigenous contexts.

Among the resources to provide this specific and differentiated school education in indigenous contexts is bilingualism, with a view to enabling students of each people to study in their own mother tongues, this right being guaranteed by the Brazilian Federal Constitution of 1988 and infra-constitutional legislation. However, even in schools and communities where the dominant language is indigenous, it is common to observe the use of Portuguese to communicate ideas and concepts of school mathematics. D'Angelis[4] (2001 apud NOBRE, 2012) points out three types of bilingualism: transitional bilingualism, maintenance or resistance bilingualism, and immersion bilingualism. In each of these possibilities of bilingualism, it is possible to verify an approximation or a distancing of aspects of coloniality in indigenous school education, making it possible to problematize bilingualism in the case of teaching math in indigenous schools. In this context, there is an interest in the problem of translation as a research topic in ethnomathematics.

Translation has been the subject of interest of ethnomathematics researchers in different contexts. Monteiro (2016), in research with indigenous professors from the Xerente and Karajá peoples, investigated processes of translation and creation of new terms in indigenous languages as attempts to transfer mathematical meanings from the Portuguese language to the indigenous languages, reaching the conclusion that the processes of translation and creation of new terms in the indigenous language do not guarantee the transfer of mathematical meanings between the languages. Eduardo Sebastiani, in an interview granted to Miarka (2011), mentions the challenge of doing ethnographic research in ethnomathematics with indigenous peoples, pointing out cases of impossibility of translation. Gelsa Knijnik, also in an interview with Miarka (2011), mentions translation as a topic of interest in her ethnomathematics research. Millroy (1992), in her well-known criticism, mentions the impossibility of describing different types of mathematics in different cultures without taking the researcher's own mathematics as a reference. Rosa and Orey (2017) present ethnomodeling as a possibility of translating mathematical practices developed by specific socio-cultural groups.

Given these initial considerations, this article aims to discuss the problem of translating mathematical knowledge in the context of indigenous school education, based on three aspects, namely: (i) different languages are based on different reference systems; (ii) the logics of different mathematical knowledges are not equivalent; and, finally, (iii) there is an impossibility of bijective mapping between sets of indigenous and Eurocentric mathematical knowledges.

[4] D'ANGELIS, W. R. **Relatório Curso de Formação de Educadores Kaingang**. Aldeia de Votouro, RS: CGAEI/MEC, 2001. Mimeographed.

2. Different languages are based on different reference systems

The possibility or impossibility of bijective mapping in translations between different languages derive directly from conceptions that are assumed regarding language. There are at least two opposing perspectives in Western thought. On the one hand, we can cite as examples the conceptions of language originated by Descartes (1596 – 1650), Hobbes (1588 – 1679) and Leibniz (1646 – 1716), marked by the search for certainty and objectivity, assuming mathematics as the underlying epistemological model. On the other hand, there are conceptions that consider languages not only as forms of communication of reality, but also as constitutive of reality itself, as assumed by Whorf (1897 – 1941) and Saussure (1857 – 1913).

For Descartes, in order to represent imagination and thoughts well, it would be necessary to express them "by certain signs the briefest possible. In this way I believed that I could borrow all that was best both in geometrical analysis and in algebra, and correct all the defects of the one by help of the other" (DESCARTES, 2003, p. 28). This Cartesian conception is based on a dichotomy between thought and language, assuming a non-discursive nature of thought. In this case, the existence of a system of signs is merely due to the need to communicate thought, and is not a determining factor in it. The accuracy of a good system of signs in this case would be obtained if it were based on a mathematical model, such as geometry and algebra, in order to join "together different words, and thereby constructing a declaration by which to make their thoughts understood" (DESCARTES, 2008, p. 97).

For Hobbes, the understanding of reality would depend on an association of each element of the material world with a name. Names would thus constitute the link between sensation and rational thought, so that the understanding of reality would depend directly on the definition of each word used to represent things and not on the things about which it is spoken, since, for Hobbes, true and false would be attributes of language and not of things. This conception of language also assumes mathematics as a model of precision and objectivity. Thus, Hobbes illustrated his conception of language with an analogy to geometry, in which "men begin by establishing the meanings of their words, and this establishment of meanings they call definitions, and place it at the beginning of their calculation" (HOBBES, 1996, p. 46).

For Leibniz, language would be fundamental to thought, because mental operations or reasoning would not occur directly on the objects and things about which one thinks, but on the symbols and signs that represent such objects. However, Leibniz conceived the possibility of a universal language, taking mathematics as an epistemological model, which would be able to

represent the structure of human reasoning, serving as an instrument for formalizing thought. Therefore, Leibniz states that

> every human reasoning is consumed by certain signs and characters. For not only things themselves, but also the ideas of things, cannot and must not always be observed distinctly by mood, and so, to sum up, signs are employed instead of them. For ... if, during a calculation, an arithmetic continually thought of the values and multiplicity of units of all the notes or ciphers he writes, he would never solve extensive calculations, in the same way as if he wanted to use the same amount of stones (LEIBNIZ[5], 1988 apud MOREIRA, 2005, p. 69-70).

In this perspective exemplified by Descartes, Hobbes and Leibniz's conceptions of language, although languages are important, whether for the communication of thought or for the understanding of reality, there would always be the possibility of an objective and universal representation of reality, just by naming things properly or operating the systems of signs properly.

Associated to this perspective of language is the idea of total translation, according to which school mathematics would be universal, thus being possible to be translated into all languages, without changing the meanings of its terms. Thus, it would be appropriate and sufficient for the teaching of school mathematics in indigenous contexts to be based on contextualized examples in local cultures, in order to reach an understanding of what would be universal in it.

Unlike this line of thinking marked by objectivity and the search for certainty, there are conceptions that consider languages not only as forms of communication of reality, but also as constitutive of reality itself. In this regard, one cannot fail to highlight what Feyerabend (2011, p. 215) states:

> I have great sympathy for the idea, clearly and elegantly formulated by Whorf (and anticipated by Bacon), that languages and the reaction patterns they involve are not mere instruments to describe events (facts, states of things), but that they are also modelers of events (facts, states of things), that their "grammar" contains a cosmology, a comprehensive view of the world, society and the situation of the human being, which influences thought, behavior and perception.

For Whorf[6] (1956 apud FEYERABEND, 2011), the language background system, which for the author corresponds to its grammar, is not simply a reproductive system for the purpose of expressing ideas. In fact, this system is an idea modeler, which is a program and a guide for mental activity. In this way, the structure of language influences the thought processes of the individual. In this theoretical perspective, the individual's representation of reality is determined by his or her

[5] LEIBNIZ, G. W. **Opuscules et fragments inédits**: Extraits des manuscrits de la Bibliothèque Royale de Hanovre. Hildesheim: Georg Olms, 1988.
[6] WHORF, B. **Language, Thought and Reality:** selected writings. Cambridge: Technology Press of Massachusetts Institute of Technology, 1956.

mother tongue. Thus, "users of markedly different grammars are led by their grammars to different kinds of observations" (WHORF, 1956 apud FEYERABEND, 2011, p. 215).

Considering this perspective of Whorf (1956), now called "Hypothesis of Linguistic Relativity", Feyerabend (2011, p. 247-248) states that

> only a few philosophers are prepared to concede that the basic structures underlying some newly discovered language may differ radically from the basic structures of the more familiar systems of formal logic, and absolutely no one is prepared to admit that this could be true for science as well. Most of the time, the "logic" [...] of a particular language or theory is immediately identified with the aspects of a particular logical system, without considering the need for an investigation concerning the adequacy of such identification.

In the face of these two conceptions regarding human language, which contrasts the perspectives of Descartes, Hobbes and Leibniz, on the one hand, and Whorf, on the other, it is essential to understand what we call language. For this, we decided to take as a reference the "Course in General Linguistics", by Ferdinand de Saussure, which dates back to the beginning of the 20th century. Its legacy is undoubted, given its founding role of Linguistics as an autonomous science, by forming scientific and epistemological bases for Linguistics, defining sub-areas and delimiting its interface with other sciences.

From this perspective, Linguistics is encompassed by a broader science, Semiology, which, according to Saussure (2006, p. 24), aims to study "the life of signs within society". Furthermore, for Saussure (2006, p. 17), language is "a social product of the faculty of speech and a collection of necessary conventions that have been adopted by a social body to permit individuals to exercise that faculty".

In addition, regarding this inseparable character between language and society, "no society knows or has ever known language other than as a product inherited from preceding generations, and one to be accepted as such" (SAUSSURE, 2006, p. 86). Moreover, the sets of conventions adopted by the social group inseparably act according to time and the weight of the collectivity, which is why Saussure (2006, p. 86) states that "a particular language state is always the product of historical forces, and these forces explain why the sign is unchangeable, i.e. why it resists any arbitrary substitution". Thus, for Saussure (2006, p. 88), "at every moment solidarity with the past checks freedom of choice. We say man and dog because before us they said man and dog".

However, in a paradoxical way, while time ensures the continuity of the sign, preserving the relationship between meaning and signifier, it also allows its mutability, so that there is a displacement of this relationship. The arbitrary nature of the sign is founded there. For this reason, "the social fact alone can create a linguistic system. The community is necessary if values that owe

their existence solely to usage and general acceptance are to be set up […]" (SAUSSURE, 2006, p. 131). This linguistic mutability, therefore, necessarily implies a diversity of languages which has been well noted by Saussure (2006, p. 221), when he states that

> The most striking thing about the study of languages is their diversity, linguistic differences that appear when we pass from one country to another [...]. Divergences in time often escape the observer, but divergences in space immediately force themselves upon him.

Well, if in fact language is a social product of the faculty of language and a set of conventions defined by the social group, as Saussure (2006) states, the greater the differences between languages should be, the greater the other factors that determine it. Thus, language must have a strong link with the experiences of the social group to which it belongs. Each of these particular facts is certainly relevant in providing each language with characteristics that are important to it in terms of the inseparable relationship between the signifier (acoustic image) and the meaning (concept).

When comparing non-genetically related languages, for example, it is very unlikely to identify signs that come close to their signifier, perhaps except in the context of language loans. However, in terms of meaning, this task seems more likely. Otherwise, it is unlikely that we will not find in most languages of the world signs whose meanings are correlated, for example, to "man", "woman", "father", and "mother", since such signs in English seem to denote beings – and relationships between beings – common to all human society. However, the fact that in every human society there is a progenitor does not necessarily mean that all peoples have conventionalized such a relationship in the same way. In Portuguese, *mãe* "mother", in general, is not only the one who has or has had children, but also the one who raises or has raised an individual she has not begotten and with whom she has established maternal bonds and/or is linked by legal ties. The meaning in Portuguese is certainly the result, using Saussure (2006), of conventions adopted as a function of time and the weight of the collectivity and, in view of the arbitrary factor of the sign, it may undergo modifications in the future. For other peoples, it is likely that the sign whose meaning includes that which is progenitor excludes or includes other meanings which do not exist in Portuguese.

In a parallel way, there are signs whose meaning is definitely not expected to be found in all the languages of the world. The words for "snow" and "hurricane", for example, possibly should not exist in indigenous languages of the Brazilian Amazon, simply because they refer to meteorological phenomena that do not occur in this geographical region. However, nothing prevents the social group, due to some extralinguistic factor, from modifying its set of conventions and incorporating in its vocabulary signs that denote these meanings – whether through loan or neologism, for example.

Another interesting example to illustrate the importance of the conventions adopted by social groups can be found in the color systems available in natural languages. At first, it can be stated that all human beings, except those who present some degree of blindness, including in these groups those who present any of the types of color blindness, for example, are able to see the same spectrum of colors. However, when investigating the signs referring to color in a comparative perspective, we notice that languages differ significantly. In the Xavante language, from the Jê linguistic family, "the word i`udzé seems to cover both the notion of green and also yellow and blue" (BONFIM; QUINTINO, 2013, p. 294). This is not to say that the individuals of this people are unable to distinguish what in Portuguese is defined as *azul* "blue", *verde* "green", and *amarelo* "yellow". In fact, within the framework of the conventions adopted by the Xavante, there must not have been, from the historical and functional point of view of the language up to that moment, sufficient reasons to distinguish these three parts of the spectrum of visible colors.

In fact, the history of colors is very interesting and dates back a few thousand years. For that, it is enough to give due attention to the colors present, for example, in cave paintings (MARSHACK, 1981; BAINES, 1985; CAGE, 1999; SEPÚLVEDA, 2011; among many others). It was, however, possibly from the Industrial Revolution (1760 – 1840) that the production of several colors in large scale began, mainly due to mechanical equipment. Since then, the production of paints of various colors has proliferated significantly. There is no doubt that this scenario poses a new challenge for social groups that need to revisit their previously adopted conventions. One should not be surprised to hear "nude", "marsala", "fuchsia" or "coral" as preferred colors of lipsticks or nail polish. In societies where, by convention, there are not so many distinctions between colors, or where making such distinctions is socially irrelevant, it is unlikely that linguistic signs will be found to cover each of these color frequencies. In Amondawa[7] (Tupí-Guaraní linguistic family), for example, five signs seem to be enough to distinguish the visible colors, namely: *awy* "blue"; *pirawy* "green"; *iwag* "red"; *jupim* "black"; and, finally, *itĩg* "white". It should be noted that there is no sign in Amondawa that corresponds, in terms of meaning, to *amarelo* "yellow" in Portuguese. It is possible that part of the spectrum corresponding to *amarelo* "yellow" in Portuguese is distributed between *iwag* "red" and *pirawy* "green", for example. It may even be that the meaning of *awy* and *azul* "blue", *pirawy* and *verde* "green", *iwag* and *vermelho* "red", for example, are not biunivocal in Amondawa and Portuguese. The strategies to delimit the shades of each color seem to have been conventionalized in different ways as well. While in Portuguese the adjectives *claro* "light" and *escuro* "dark" contribute

[7] The linguistic data of the Amondawa (Tupí-Guraní) and Aikanã (isolated) languages, which are presented in this article, were obtained through the realization of the Project "Estudos morfológicos e sintáticos de predicados verbais nas línguas indígenas Amondawa e Aikanã", coordinated by Professor Quesler Fagundes Camargos, co-author of this article, in the scope of the Programa Institucional de Bolsas de Iniciação Científica (PIBIC/UNIR/CNPq).

to this distinction, in Amondawa there is the suffix {*-arawe*}, which indicates a color approximate to the prototypical color, and may vary in tone (light and dark, for example). Thus, from the basic colors in Amondawa, others are derived: *awyrawe* "almost blue"; *pirawyrawe* "almost green"; *iwararawe* "pink (almost red)"; *jupirarawe* "gray (almost black)"; and finally *itĩrawe* "almost white".

What we have said above regarding words also applies to any other term in the language, including those referring to grammatical entities. The value of the grammatical feature of female gender in Portuguese, for example, does not correspond to the female gender in the Wari' language (Txapakura linguistic family). In Portuguese, the grammatical gender, besides the idiosyncrasies, corresponds in part to flexion that is attributed to word classes (noun and adjective, for example) and essentially, in morphosyntactic terms, to the process of agreement with determinants, quantifiers and adjectives. It is thus known that *caixa* "box" and *armário* "closet" are respectively feminine and masculine nouns, due to the fact that we add to them flexed determinants, as in *a caixa pesada caiu* "the heavy box fell" and *o armário está sujo* "the closet is dirty". From this we have the distinction, for example, between *o menino* "the boy" and *a menina* "the girl", *(a) velha* "the old (woman)" and *(o) velho* "the old (man)", *rápido* "(masculine) fast" and *rápida* "(feminine) fast". There are also names that, although they belong to the group of inanimate beings, also mark the grammatical genres. This is the case, for example, of *a faca* "the knife", *a flecha* "the arrow" and *a mesa* "the table", which mark the female gender, and *o garfo* "the fork", *o arco* "the bow" and *o armário* "the closet", which show the male gender. In fact, the grammatical gender in Portuguese is intrinsic to the name itself and does not necessarily correspond to the biological gender. In the Wari'[8] language, on the other hand, in grammatical terms, instead of two, we have three grammatical genders: female, male and neutral. Human beings, such as *arawet* "child", *trama'* "man" and *narima'* "woman", are morphosyntactically marked with the masculine {*-on*} or feminine {*-am*} genders, depending on the biological gender of the individual. Animated non-human beings and inanimate beings, in turn, present a split behavior. There are those, like *kopakao* "ounce" and *papak* "corn", who receive the masculine marker {*-on*}, and there are others, like *miyak* "peccary" and *pakyn* "stone", who trigger the neutral gender marker {*-ain*}. Thus, the language distinguishes the following three sentences as to gender from what has been seen (*hrik* means "to see" and the gap indicated by "___" refers to what is seen): *hrik non* ___ "I saw someone/something (that belongs to the male gender class)", *hrik nain* ___ "I saw something (that belongs to the neutral gender class) and *hrik nam* ___ "I saw someone (that belongs to the female gender class). It is noted, therefore, that in contradictory terms, in addition

[8] The examples from the Wari' (Txapakura) language in this article are the result of descriptive research carried out under the Project "Documentação, descrição e análise das línguas da família linguística Txapakura", coordinated by Professor Quesler Fagundes Camargos and supported by grants from the Brazilian agencies CNPq (grant number 430275/2018-8) and FAPERO (grant number 01.1331.00032.028/2015).

to many other differences, the Wari' language reserves the female gender {*-am*} exclusively for female human beings. In Portuguese, the female gender is present in names whose referents are animated human beings, non-human and inanimate.

It should be emphasized, therefore, that from the examples presented in this section, in fact, it seems that languages vary from one to another also because they are based on different systems of references, which is the basis, for example, of the perception of Saussure (2006) and his predecessors regarding the constitution of human language, which certainly has repercussions, as will be better explored in the next sections, on the impossibility of total translation as a bijective mapping.

3. The logics of different mathematical knowledges are not equivalent

Mathematical knowledge originated and located in different socio-cultural contexts is based on different logical systems that necessarily do not identify with the particular Eurocentric and hegemonic logical system that has been established from modernity by coloniality. The model of rationality that characterizes modernity is based on a mathematics whose logical system presupposes ideas of objectivity, precision, rigor and universality. Due to these characteristics, this mathematics has assumed a prominent role in modern science, providing it with "not only the privileged instrument of analysis, but also the logic of research, as well as the model of representation of the very structure of matter" (SANTOS, 2011, p. 63).

Were it not for the abyssal character of modern Western thought, which produces "two incommunicable sides, so that 'the other side of the line' is considered nonexistent, not credible" (SANTOS, 2007b, p. 71), it could have been long since verified and recognized, with all the effects that this could cause to overcome the idea of a general epistemology, moving from the paradigm of universality to that of pluriversality (MIGNOLO, 2017), the false aspect of universality attributed to the Eurocentric logical system.

Ethnographic research has already produced significant examples of mathematical knowledge whose logics differ from the logic of Eurocentric mathematics. Among the Xinguan peoples Juruna, Kayabi and Suyá, it can be stated that, according to Ferreira (1994), the concepts of "more" and "less" do not necessarily correspond to those conventionalized in the arithmetic of Eurocentric mathematics, so that the logic of giving or winning as less or more is replaced by the logic of the principle of reciprocity, according to which, the less of school mathematics can mean more in some situations of exchange in the cultural context of these peoples. Vilaça (2019) identifies among the Wari' a moral and relational character of quantities, in a way opposed to the idea present in school mathematics that conceives a world made up of objective quantities extrinsic to subjects and their relationships. Still among the Wari', Leite (2012) points out the variation of meaning of numerical terms from one to

ten, so that the same terms can designate exact quantities, when orality is associated with the indication of fingers, or indefinite quantities, meaning many. Lévi-Strauss (2006) cites "aberrant derivations" in the formation of numbers in some indigenous languages of North American peoples, in whose arithmetic system, for example, 7 would derive from 6 + 2. Pica et al. (2004) show that although there are no words for numbers beyond 5 in the Munduruku language lexicon, they are able to compare and add large numbers that are far beyond this range by means of an inaccurate arithmetic in a non-verbal system, distinct from the school arithmetic system. In turn, Suruí and Leite (2013) describe the incompleteness of meaning generated by the writing of the numerical term *xakalar amakap om* "three" in the language of the Paiter people, exemplifying that in cultures of oral tradition, such as those of indigenous peoples, the writing of language may not be sufficient to encompass the significant contexts of mathematical knowledge, because it does not have, for example, the complementarity of sign language.

Specifically with regard to linguistically expressed mathematical concepts, it is interesting for us to identify what could be considered in a given society as basic geometric forms that originate from specific logics of each language. In Aikanã (a genetically isolated language spoken in the state of Rondônia), there is an extremely rich Nominal Classification System that has morphemes that are carried out in names, adjectives and verbs to denote animacity, physical properties (liquid, mass, powder), physical forms (round, cylindrical, long, short), for example. In descriptive terms, in this language there are suffixes which, when realized in a transitive verb predicate, for example, denote some property of the syntactic object of this verb. In the sentence *hisa dukuka**pe**pateẽ*, which literally means "I touched something round", the highlighted verb suffix {*-pe*} is responsible for denoting the spherical geometric shape of the thing touched. By saying *hisa dukuka**ta**pateẽ*, now with the suffix {*-ta*}, the thing touched has a cylindrical shape, as is the case with a can of oil, for example. Finally, it can be said that in Aikanã a sophisticated grammatical system for Nominal Classification was developed, which codifies, besides other properties, geometric formats, based on the logic of an epistemology of this people.

The examples discussed above provide us with clues as to which methodological procedures could be implemented to identify, through natural languages, the set of conventions adopted by a given group to allow their exercise of the faculty of language, since, for Saussure (2006), language is a social product of this faculty of language. For some reason, the Aikanã language has developed a rich Nominal Classification System, which encodes numerous properties, including those contained in the semantic field of mathematics. The existence of such systems reveals a certain sophistication that is certainly not found in every language of the world. Likewise, there are still concepts and conventions in other languages that do not find space in Juruna, Kayabi, Suyá, Wari' and Aikanã.

One should not be surprised to find, for example, the absence of the pyramid or rhombus concepts in certain societies. While such concepts may prove to be elementary to some people, it does not mean they are for others.

Such facts demonstrate that linguistic differences between culturally distinct peoples are reflected in logical constituents of mathematical knowledges that are not necessarily equivalent to the model of rationality that characterizes modernity and which is based on a Eurocentric mathematics whose logical system presupposes universality.

4. There is an impossibility of bijective mapping between sets of indigenous and Eurocentric mathematical knowledge

Considering that different languages are based on different reference systems and that the logics of different mathematical knowledges are not equivalent, it is possible to extract as a consequence of these two aspects, that although the modern colonial conception of mathematics presupposes its universality, and by this way attempts are made to impose a model of Eurocentric rationality as an effect of coloniality, there is in fact an impossibility of bijective mapping between sets of socioculturally distinct mathematical knowledges, such as indigenous and Eurocentric knowledges.

By bijective mapping one can understand the biunivocal correspondence between elements of two sets or of two distinct structures. In this case, it is said that the structures are isomorphic. Examples of bijective mapping in mathematics are the group and ring isomorphisms. According to Domingues and Iezzi (2003, p. 161), the idea behind the concept of group isomorphism in algebra "is to separate the groups into disjoined classes such that the properties deduced for a particular group in a given class can be transferred to all the groups in that class". In the case of a ring isomorphism, it is assumed

> a biunivocal correspondence between all the rings of the same class [...] in such a way that the properties pertinent to the ring structure deduced for one of the representatives of one of the classes can be extended to all the other rings of the same class, only the notations of the elements and operations being conveniently changed. Or, put another way, that a ring of a given class may eventually replace, in all that concerns the ring structure, any other of that class. [...] It reflects well this situation to imagine the rings of the same class as "copies" of each other (DOMINGUES; IEZZI, 2003, p. 232).

The concept of isomorphism is also presented in other areas of knowledge. For example, in Mineralogy, isomorphism occurs between two chemically distinct substances when they have the same crystalline structure. In Administration Theory, there is isomorphism between two distinct organizations when they adopt identical administrative practices in their field of action. In Gestalt

Psychology, there would be an isomorphism between the physical systems and the nervous system, that is, "the phenomenological Gestalten of the consciousness would have the same form or would follow the same topological mathematics as the physical structures" (ENGELMANN, 2002, p. 5).

From this idea of isomorphism, it is possible to verify that the modern conception of mathematics, which attempts to attribute to Eurocentric mathematical knowledges a character of universality, presupposes the possibility of translation as a bijective mapping between sets of socioculturally distinct mathematical knowledges. As argued in this article, however, it is possible to demonstrate from the examples of indigenous languages that isomorphic translations of mathematical ideas are unlikely among languages that are based on different reference systems, either because of the absence of corresponding lexical terms or because of the logical difference between different mathematical knowledges. It is even due to all these differences between languages and cultures that some authors, from a more extremist perspective, deny the possibility of translation. By way of example, the adherents of linguistic relativity, also known as the Sapir-Whorf Hypothesis, assume the impossibility of translation, since each particular language constitutes a singular worldview, so that it can only be accessed through this same language. Regarding this Hypothesis, Crystal (2008, p. 411) states that relativity is

> A term used to identify an influential view of the relationship between LANGUAGE and thought, generally known as linguistic relativity, which asserts, in its strongest form, that language determines the way people perceive and organize their worlds. This view (of 'linguistic determinism') was first expounded by the German ethnologist Wilhelm von Humboldt (1767–1835): in the twentieth century it came to be known as the SAPIR–WHORF HYPOTHESIS.

It is quite possible that individuals from different peoples may think and interpret the world differently because of the language they speak, since it is through it that the facts of the world are interpreted (cf. WHORF, 1956). The opposite could also be said. To a certain extent, languages may vary to suit the way a certain people think and interpret the world. However, there are still countless other sets of linguistic facts that bring all these languages together in such a way that not only communication but also translation is possible.

In the field of literature, there are many voices opposed to possible translations of poetic texts, for example. Using metaphorical strategies, the philosopher Voltaire (1694 – 1778) illustrates this concept well: "Pardon the blemishes of the translation for the sake of the original; and remember always that when you see a version, you see merely a faint print of a beautiful picture" (VOLTAIRE, 1973, p. 40). Jakobson (1971, p. 72) also stated that "poetry by definition is untranslatable". Nevertheless, translation, it seems, exists from the moment the human being saw the need to

communicate with individuals speaking other languages. Not only that, but there is no lack of works that propose translation methodologies, as is the case of Haroldo de Campos, who explores, in an analogous way, articulated resources in the source language (mainly in what concerns form) to reproduce them in the target language, what he designated as transcreation.

In any case, it should be emphasized that, in fact, there should not be absolute or total translation, since this possibility becomes unattainable as the very act of communicating, even intralinguistically, is not absolute either. This imprecision is perhaps based on the very nature of human language. During the act of communication, wouldn't language, in its most intrinsic sense, already be a translation of thoughts and facts of the real world? For Sapir and Whorf, language translates the world and reality. Thus, if at this level of translation there is already imprecision, partiality and limitation, even more will so will exist when the act of translating involves two languages.

In another perspective, one can cite Jakobson (2001), who, when conceiving in typological terms three types of translation, namely: intralingual or reformulation, interlingual or translation proper and, finally, intersemiotic translation or transmutation, stated that "the meaning of any linguistic sign is its translation into some further, alternative sign, especially a sign 'in which it is more fully developed,' as Peirce, the deepest inquirer into the essence of signs, insistently stated" (JAKOBSON, 2001, p. 64).

In view of these considerations, translation is possible as language is understood as a communication system. If this were not true, communication between speakers of distant languages would not be possible, which is made possible through translation. Obviously, the correspondence is not always exact between languages. Returning to Saussure (2006), we will hardly find a considerable set of signs in different languages that present an exact correspondence of meaning. This fact, however, does not preclude the work of translation, since, according to Jakobson (2001, p. 66), "all cognitive experience and its classification is conveyable in any existing language. Whenever there is a deficiency, terminology can be qualified and amplified by loanwords or loan translations, by neologisms or semantic shifts, and, finally, by circumlocutions". It is because of this, for example, that after contact with non-indigenous society, the Guajajára people (speaking a language of the Tupí-Guaraní linguistic family) began to use the expression *karaiw àkàgwer*, which literally means "the former head (skull) of the non-indigenous" to refer to the radio set, possibly because the older electronic equipment has a format similar to the "skull" and it broadcasts ("speaks") in the language of the non-indigenous.

In another perspective, given the impossibility of isomorphic translation by bijective mapping, where there is a one-to-one correspondence between languages, translation can be conceived as a

fundamentally creative process of meaning production. The "translation" formulated in these terms is well explored in Catford (1965, p. 48), according to which

> […] it should be clear that a restricted kind of 'transference of meaning' from one language to another is possible; but it is equally clear that this is not what is normally meant by 'translation'. In translation, there is substitution of TL [Target Language] meanings for SL [Source Language] meanings: not transference of SL meanings into the TL. In transference there is an implantation of SL meanings into the TL text. These two processes must be clearly differentiated in any theory of translation.

Therefore, for Catford (1965, p. 20), in a translation theory, one does not necessarily expect a process of "transfer" of meanings – although it may occur, but "the replacement of textual material in one language (SL) by equivalent textual material in another language (TL)". In this sense, the translator will have the task, in a first moment, to adequately interpret the text of the source language and, from its comprehension, to produce a new text in the target language, so that the final result comprises an equivalent textual material in the first language. It may be that, in some contexts, the equivalence between the texts in the two languages is to a greater or lesser degree, obviously depending on various linguistic and non-linguistic factors. It is possibly at this point that Haroldo de Campos claims the translator's authorial role. Amaral (2013, p. 265-266) also understands this when he states that

> For Haroldo de Campos, translation is only possible with recreation, hence the option for the word transcreation. When recreating, the translator invests himself in the role of author and, although he has a score in his hands and must be faithful to it, he interprets it as a new creator, in full exercise of his synchronic instruments. Author and transcreator are joined by the synchronous bias of the same aesthetic light.

Research produced by indigenous students of an intercultural licentiate-degree course in the Amazon illustrates cases of non-isomorphic translations of mathematical ideas and the impossibility of translation via bijective mapping. For example, Cacami Cao Orowaje, in his final undergraduate paper, reports:

> During my research for the construction of my final undergraduation paper I realized that there are several concepts and names of school mathematics in Portuguese that have no equal in the language and culture of my people. For example, the term "pyramid" and its concept are taught in school mathematics in the content of spatial geometry, but I did not identify in the language of my people an equivalent term or even the idea of a geometric object similar or similar to a pyramid. This is an example of a challenge for the bilingual teaching of mathematics in the indigenous school. What is necessary to do when names do not have an equal in the culture and language of each people? The concepts that I could not identify the names in the mother tongue, I will invite the elders together with the community for us to discuss together to create the name for each of them, after we create the names for each of them, they will enter in the content of the school to work bilingually with the students. This will not be difficult to create because we have already created several names for other

> objects that did not exist in the culture of the people. For example, shoe (kayikatim), pants (mao mao at). The name will not be the same, but it will have the same meaning. These concepts that I didn't find in my mother tongue, the boys already know the name in Portuguese because they are learning at school (OROWAJE, 2015, p. 29).

In turn, in his final undergraduate paper, the indigenous researcher Adriano Pawah Suruí also makes the following report:

> Throughout the data collection for the construction of my final undergraduation paper, it became apparent that there are several concepts of school mathematics that may not have equivalents in the language and traditional mathematics of the Paiter people. This information was found, according to the speech of the wisest or most experienced people in the Paiter language of the community. And yet, they do not have a certain definition in the language and culture of the Paiter people; even because the Paiter knowledge did not allow them to perceive that solid geometries existed. For that, some names were found according to the reality and knowledge that older people have in themselves. For example, the terms sphere (Penẽm-ah), cylinder (makor ahp) and cone (Iboɠahp apeh), this nomenclature was given according to the knowledge that older people have by identical objects similar to them. The term Penẽm-ah means "object that rolls without direction". The term makor ahp means "part of the bamboo trunk", which is similar to a cylinder. The term Iboɠahp apeh means "thorn of the maracatiara tree", which is similar to the cone. Other terms of spatial geometry have not been identified in their form defined in Paiter, such as the terms pyramid, cube and parallelepiped. There are no such concepts in the Paiter language. Just as there are concepts and ideas of the Paiter people's mathematics that have no equivalent in school mathematics, especially when the meaning of terms, concepts and words are related to context. Therefore, some contents existing in school mathematics do not exist in the traditional mathematics of the Paiter Suruí people and vice versa. In this case, there is a challenge in Paiter schools regarding bilingual teaching of mathematics (SURUÍ, 2015, p. 46).

It should be highlighted the interesting process that led Suruí (2015) to propose the expressions *penẽm-ah*, *makor ahp* and *iboɠahp apeh* to refer, respectively, to the concepts of sphere, cylinder and cone of the spatial geometry of Eurocentric mathematics. This is because the Paiter's concept of curvilinearity, which finds its foundations in this spatial geometry, seems to be linguistically grammatically grounded in the language, which means that it is not just an item listed in the vocabulary as it is in the Portuguese language, but is present in the grammar of the language. Cabral et al. (2014, p. 166) state that the names in Paiter are subdivided into two Nominal Classes. There are the names that "are perceived or considered as round, circular, curvilinear, spherical or circumscribed". In these must emerge the enclitical *ah*, whose grammatical function is to indicate this physical form, according to the following examples: *ɠor ah pep ah* "large intestine"; *walet nom ah* "breast (woman)"; *ɠonio ah* "navel"; *ikahp beti ah* "molar teeth"; *ikahp sak ah* "wisdom teeth"; *ɠopam ah* "porakê"; *nambe ah* "tucunaré (peacock bass)"; *bokop ah* "banana"; *akop ah* "cocoa"

(CABRAL et al., 2014, p. 167-168); among many others. Note that the expression *penẽm-ah*, which was created to designate the concept of sphere, displays this same enclitical *ah*. In fact, such a conception is present in the interpretation that Suruí (2015, p. 46) attributes to neologism: "object that rolls without direction". All these signs, in turn, differ from those in which the enclitical *ah* does not manifest, since they correspond to references that "are not conceived as holders of these properties" (CABRAL et al., 2014, p. 166).

The other two expressions, *makor ahp* and *ibogãhp apeh*, used by Suruí (2015) to designate the "cylinder" and the "cone", should also be highlighted. It should be noted that these two expressions already belong to the Paiter lexicon to refer, respectively, to (i) a piece of bamboo cut in such a way that it can be used as an instrument to drink chicha (traditional drink) and (ii) the thorn of the maracatiara tree. Taking up again Saussure's (2006) sign concept, which is formed by the signified and signifier, we note that Suruí (2015), from signifiers already existing in Paiter, attributed to them the meanings of cylinder and cone defined according to concepts of the spatial geometry of Eurocentric mathematics, which illustrates the possibility of coloniality of knowledge in translations of mathematical ideas between different languages, prevailing in the end the knowledge of Eurocentric mathematics. In typological terms, we could classify the process presented here as semantic neologism (cf. BOULANGER, 1979), since Suruí (2015) expands the meaning (in the terms of SAUSSURE, 2006) of *makor ahp* and *ibogãhp apeh*. It is true that this amplification was not random, but it followed metaphorical and iconic principles, as the cylindrical shape of the instrument to take chicha and the conical shape of the maracatiara thorn were relevant to establish this metaphorical relationship.

These results of ethnomathematics research carried out by indigenous students of Rondonia's peoples, besides representing the important manifestation of the voices of subalternized peoples by colonialism regarding their own knowledge and languages, illustrate how the differences between mathematical knowledges, which are based on languages with different reference systems, opportune the problematization of the translation conception that presupposes the bijective mapping between different knowledges and languages and is associated with the idea of universality of Eurocentric mathematics.

From such problematization, it is possible to rethink the idea of bilingualism in the teaching of mathematics in indigenous schools, in the search to overcome aspects of coloniality of knowledge that are still present in this space. Thus, the type of bilingualism in the teaching of mathematics that aims at the decoloniality of indigenous knowledge in school necessarily needs to dissociate itself from modern conceptions of mathematical knowledge and total translation that, under the pretext of valuing local knowledge, can make translation possible of such knowledge in terms of Western

knowledge and thought. In this sense, the coloniality of knowledge can be reproduced, since "there is an epistemological legacy of Eurocentrism that prevents us from understanding the world from the very world in which we live and from the epistemes that are their own" (LANDER, 2005, p. 3).

The case of the translation of "cone" and "cylinder" as "thorn of maracatiara" and "instrument to drink chicha", in the referred research of Suruí (2015), illustrates this risk of the coloniality of knowledge as, locally, there would be no purpose, for example, to calculate the surface area or volume of the thorn of a tree or of a cup of chicha among the Paiter. Thus, the terms "cone" and "cylinder" contain a set of ideas and concepts of Eurocentric mathematics that may not have biunivocal equivalents in Paiter. In this case, in the absence of a biunivocity of meanings between languages, whose reference systems are distinct, the isomorphic translation imposes on the concept of "maracatiara thorn" and "instrument to drink chicha" of Paiter culture the meanings of the spatial geometry of Eurocentric mathematics, constituting a typical example of coloniality of knowledge that, if not properly problematized, could be reproduced at school.

Obviously, in the field of indigenous school education, the Paiter cannot be denied the knowledge, for example, of Eurocentric mathematics, if this is their choice, and neither can an educational system be institutionalized in which, deliberately, it supplants the episteme of the Paiter with the Eurocentric episteme of mathematical knowledge. Furthermore, some implications for ethnomathematics research in indigenous school contexts are also drawn from this discussion, which, by advancing the possibility of teaching mathematics already institutionalized in the curriculum from local knowledge as a beginning, but with Eurocentric mathematics as an end, or by translating concepts between Portuguese and indigenous languages, even if unintentionally, may be contributing to the promotion of paradigms of modernity, including the exclusionary Eurocentric universalism, as opposed to an epistemic pluriversality.

5. Final remarks

This article aimed to problematize the idea of translating mathematical knowledge in indigenous school education contexts, considering that different languages are based on different reference systems, that the logics of different mathematical knowledges are not equivalent, and that, therefore, there is an impossibility of bijective mapping between sets of indigenous and Eurocentric mathematical knowledges.

It has been found that the idea of isomorphic translation of mathematical knowledges in indigenous contexts is close to a conception of language and mathematics characteristic of modernity, so that the translation of mathematical knowledges in indigenous school education needs to be problematized with a view to overcoming colonialist perspectives which, under the aspect of certain

types of bilingualism, may also promote the socio-cultural imposition of Eurocentric mathematics to the detriment of local knowledges, promoting the coloniality of knowledge.

In other words, if not problematized, the practice of certain types of translation of mathematical knowledge in indigenous contexts can transform indigenous teachers themselves into reproducers of the coloniality of knowledge in the schools of their communities, especially when trying to translate local mathematical knowledge in terms of Eurocentric mathematics, based on the idea of bijective mapping and isomorphic translations, or when proposing the "contextualization" of Eurocentric mathematics in local realities, or when proposing to use local mathematical knowledge to "understand" Eurocentric mathematical knowledge.

Based on the present article, it is proposed to think of indigenous mathematical knowledge from its own logic and from the reference systems proper to each language, so that the translation between local and Western knowledge takes place from other perspectives than that of bijective mapping. Thus, faced with the risks of a total and isomorphic attempt at translation, translation can be conceived as a fundamentally creative process of meaning production, in which there is a certain equivalence between the versions in the two languages, without any obvious process of meaning transfer occurring. As Mignolo (2004) points out, this is not a defense or celebration of non-Western knowledge to the detriment of Western knowledge, but the necessary criticism of the hegemonic character of Western thought.

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