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## CONSTRUCTION OF INTERCULTURAL DIDACTICAL MATERIAL OF PHYSICS AT THE TINGUI INDIGENOUS SCHOOL OF GUAXUMA

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### ABSTRACT

In Brazil, the teaching of Physics is recognized as deficient, both concerning teacher education as students --- translated into the weak learning of the physical concepts related to its reality ---, and regarding the lack of intercultural educational materials aimed at Indigenous people. In general, the teaching of Physics is characterized by the excess of attention given to repetitive exercises, problems mechanically resolved, memorized in a literal and arbitrary way, to the detriment of a broader analysis that seeks to understand the Physical phenomena involved in Indigenous culture. We would particularly like to emphasize that in the Indigenous schools of the extreme south of Bahia, this fact is no different at all. Because of this problem in the learning process of Physical concepts, this work intends from the constructive criticism of natural language, adopting an alternative methodological approach of teaching intercultural Physics, introducing educational material of intercultural Physics in the class of the first year of the Tingui Indigenous High School in Guaxuma. The didactical operationalization of contents in baptized by the Ausubelian Theory of Learning believed to be the one that best adapts to the teaching of intercultural Physics.

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## INTRODUCTION

In Brazil, where the teaching of Physics and the Indigenous School education have been objects of many kinds of research (LACLAU, 1996; CASTILLO; MALLETT, 1997; FANO, 2001; CASTRO, 2007; TURBINO, 2005; LOPEZ; SICHRA, 2007; ACHMILKES, 2007; WALSH, 2008, CZARRY, 2012; LINS, 2013), its interculturality lacks further investigative insights. This is also mentioned because the scientific-pedagogical knowhow in an intercultural still under construction.

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Intercultural education that takes place in different ways among the people who adopt it in their educational institutes represents an opportunity for the insertion of new knowledge and needs to be analyzed in their conceptions concerning cultural contexts and disciplinary field in which it is held (CANDAUI, 2012). It is likewise a way of giving new answers to the questions of Western science, whose existing methods are ineffective to solve problems highlighted in the educational process of Indigenous schools (FREIRE, 2004). To achieve the goal, the interaction between the intercultural, political and economic aspects is a primordial condition. Because of the occurrence of this issue, this paper intends, based on constructive criticism, to report and promote the sharing of intra-, inter- and transcultural teaching experiences evidenced dialogically between the Indigenous pedagogy and the leaning

of intercultural Physics in the areas of Indigenous primary education. The claims arising from alternative educational projects in Indigenous areas and the growing mobilization of the professionals involved, being Indians or non-Indians, enable a struggle in the construction of educational materials contextualized with the Indigenous daily life (BRASIL, 1988). Through such questions, the study aimed at a critical analysis of the educational content of Physics present in the Indigenous schools, and the production of intercultural material of Physics, with the participation of teachers and Indigenous pupils, from a collaborative research in the Pataxo community. In the context of Indigenous education, the main characteristics are the valorization of the own processes of learning and the practices of each ethnicity, and, *a priori*, the methodology used in the teaching-learning process should be articulated to the context of each Indigenous community (GONÇALVES; MELLO, 2009).

Within this perspective, the teaching of Physics in Indigenous school education should be thought within the contexts and cultures of each community (GRUPIONI, 2008). In fact, the Pataxós indigenous teachers claim the elaboration of new curricular proposals applicable to their schools to replace the overall model of the current educational system. The reason, as recorded by the RCNEI/MEC (2002), is that "such models never corresponded to their political interests and the pedagogies of their cultures". Therefore, we developed Physics workshops with the objective of constructively analyzing the textbook of Physics in the first grade of High School used by Indigenous teachers at the Tingui Indigenous School of Guaxuma. It delimits the Ausubelian Theory of Learning because it considers that the same is the most adaptable to the conception of educational material in Physics because it allows the exploration in a hierarchical way of the cognitive universe in the apprentice and still enables the deliberate manipulation of this universe to provide meaningful learning. Such pieces of evidence justifies the development of the work, since, as a rule, the teaching of Physics in Indigenous schools is still characterized by the excess of attention. It occurs with repetitive exercises, problems mechanically resolved by the use of a succession of formulas, often memorized in a literal or arbitrary way, to the detriment of a broader analysis aimed at understanding the physical phenomena involved (NÉSPOLI, 2007; MOREIRA, 2011). Thus, we propose the necessity of reflecting on the problem in an attempt to seek solutions to translate into new possibilities and strategies for the teaching of physics. This is because such teaching in Indigenous school education aims to provide the Indians with understanding of the logic, concepts and principles of Western science. This way they can dialogue in an isonomic manner with national society and, above all, enable conditions of enjoyment of the current technological resources conquered and available. It is known as opportunity that the knowledge acquired by Indigenous peoples in the teaching of natural sciences is useful to ensure the survival of the Indians in their community, starting from their specific cultural logics (MEC, 1998; BUENO, 2013).

### The teaching of physics in the indigenous school

The teaching of Physics and Indigenous School Education are known conceptions in Brazil, although the scientific-pedagogical approach in an intercultural perspective is still under construction. It happens in most different ways among the traditional peoples in Bahia represent an opportunity for

the insertion of new knowledge (ZANIN, SILVA, CRISTOFOLI, 2018). It is also the moment to offer new responses to questions of Western science in which the current methods are ineffective to solve problems evidenced in the educational process of Indigenous schools. To meet this requirement, the interaction between biosocial-environmental, intercultural, political and economic aspects has been a primordial condition for the construction of our material (SANTANA, 2010). The teaching of Physics in Brazilian schools from the perspective of science, technology, and society is directed at the reconstruction of knowledge and the citizen, pointing ways to construct new rationalities to overcome the paradigm between cognitive and citizen science. It fights significant changes in the curriculum of all Sciences. It is believed that this process is related to the current social matrix and technology of contemporary science (OSTERMANN; MOREIRA, 2001). The teaching-learning of Physics throughout the national territory requires knowledge and understanding of all the actors of the school, especially of the teachers, requiring the meaning of nature of science and its relations amongst Science, Technology, and Society (STS). It has as its goal in Primary Education in every national sphere that scientific and technological literacy is discussed in the school curriculum and the pedagogical teaching praxis (MACIEL *et al.*, 2010). Within the perspective of the teaching of Physics in Indigenous School Education, it should be considered within the contexts and culture of each Indigenous Community (GRUPIONI, 2008).

Indigenous School Education refers to all the educational processes used by each Indigenous people in the teaching of activities, whether they are complex or trivial. For the author, in the Indigenous society, the traditional teachings occur spontaneously, every day, without space and specific subject to teach to learn. It is remarked that the elders have been playing the role of transmitting to the youngest Indigenous culture. However, it was found that the school represents all the physical space in the community. The education of the students is not centered on the figure of the teacher as keeper of knowledge, because several other actors exercise this function, i.e. the mother, the father, the old, the uncle, the elder brother, and the chief are teachers and everyone is a student.

In this respect, it should be noted that Indigenous teachers claim the elaboration of new curricular proposals applicable to their schools to replace the general model of the current educational system. On this basis, it is perceived that the Indians and, in such case, the Pataxós, work for an education that aims at sustainability, to maintain their leadership, their customs, and traditional values. For this purpose, using transversality constitutes a strategy that simplifies the work of the teacher because it helps the discussion of educational and social issues of local and global culture. Moreover, it is a viable proposal in the current context of the classroom, as teachers and students become builders of educational practice for an inclusive and intercultural school (LINS, 2017). To establish a relationship amongst Physics, Culture (COHN, 2001), Territory (ABRÃO, 2010) and Sustainability (PIMENTA, 2004), it is indispensable to understand firstly the concept of each one, given its relevance for the development of the theme. The clarification of these concepts is aimed at the interrelation between them, pointing to the issue of the sustainability of the Indigenous school education of the Pataxós. Therefore, we appropriated the experience experienced in the project and sought to investigate the difficulties that involve the teaching-learning process and the

daily routine of the methodological practices of teaching applied in the classroom, in the Indigenous school. D'Ambrósio (2004) delineates science as a corpus of knowledge, organized and hierarchized according to a degree of complexity and generality, elaborated by the human being in his eagerness to unravel the cosmic and natural order; to clarify the physical, emotional and psychic behavior of the individual and others; to make you know-me and know-you.

Accordingly, it is understood that all cultures, societies, professional classes and identifiable groups, in general, possess their science, or rather, their ethnoscience, which according to D'Ambrósio (1990), devotes the study of scientific and, extensively, technological phenomena in a direct relationship with social, economic and cultural formation.

Working playfully, using games as tools in the teaching of Physics, provides the pupil with the pleasure of being active, thinking, questioning and reflective, providing the him with more excellent quality concerning the receptivity of the discipline, as observed by Mendonça (2001, p.14):

Teaching and learning Physics can and must be a happy experience. Interestingly, there is almost no mention of happiness within the educational objectives, but it is quite evident that we can only talk about a teaching job well done when we all achieve a satisfactory degree of happiness.

## MATERIALS AND METHODS

The methodological pathway was a time of many considerations and decisions by the Indigenous school community and the researchers. In this particular case, the path traveled has brought as a result the vision and conceptions of the Indigenous teachers regarding the teaching of Physics and the basic concepts present in educational practices. It also promoted the contribution to the construction of the educational material of intercultural Physics. Yet, due to the specificity of the actions required by the various developmental stages, this research has been divided into three moments:

### Theoretical-Hermeneutical Moment

Systematic bibliographical studies were conducted to characterize the main concepts present in Physics, as well as the detailed study of all the chapters of the textbooks of the High School of Physics used at the Tingui Indigenous School in Guaxuma. To perform the study qualitatively, we used content analysis (BARDIN, 2000; BAUER, 2002; FRANCO, 2008). This option resulted from the possibilities that it brings to produce descriptions of the contents of the messages conveyed in textbooks based on systematic, methodologically explicit and replicable procedures (BAUER, 2002, P. 192), based on characteristics identified in the text.

### Cognitive Exploration Moment

After analyzing the concepts of Physics textbooks, the next phase of the research focused on using Ausubel's Theory of Meaningful Learning (2003) to organize perceptions within a cognitive model. The ideas modeled on the students' characteristics and learning needs are reconciled in a pedagogical way. Therefore, we seek to understand the Ausubelian cognitivism in a situated and final manner, viz. a

specific context of action and geared towards achieving an objective. It aims to analyze the cognitive processes involved in the organization of the contents, comprising these aspects as being constituted of operative modes, sequences of action, a succession of search and information processing. The creation of stages and temporal development of the activities to be proposed and the strategies to be used enabled the articulation of interculturality with Indigenous knowledge. We seek a didactical way for the concepts of each specific domain of Physics to be organized from the following parameters:1. Subsumptions that represent the anchor's concepts necessary to provide meaningful learning;2. The progressive differentiation that corresponds precisely to the principle that the most general and inclusive ideas are presented previously, creating the necessary conditions for the subsequent differentiation thereof, conforming to a natural tendency of Human consciousness when exposed to an entirely new field of knowledge, and ultimately;3. The integrative reconciliation that deals with the way Ausubel also describes relationships, seeking to point out similarities and differences between ideas intending to circumventing real or imaginary discrepancies. From these parameters were constructed conceptual maps of the contents and the production of the educational material differentiated from adequate support to the level of indigenous secondary education.

### Moment of Ergonomic-Pedagogical Validation

After the differentiated educational material was produced for the indigenous medium level, and the usability test was performed to verify the ease of its use by the peoples. When the tests were conducted with students from the Indigenous school, the pupils were encouraged to use the material in a monitored environment, where their actions were continuously evaluated. The teacher became a facilitator because he was close to the student to guide him through the test and encouraged him to verbalize his problems and discomfort. The students worked with the material over several sessions that lasted approximately one semester. At the end of the analysis, a report was generated containing the problems and possible solutions proposed. The purpose of the usability study was to point out flaws in the design of the material so that they can be solved before the final version of the elements. It will be performed from two parameters:

**Performance:** Measurements and empirical observations focusing on the performance of the proposed activities and quantifying the fulfillment of specific events.

**Attitude:** Subjective views about the students' opinion while operations are carried out to reach conclusions on the issues raised so far.

## RESULTS AND DISCUSSION

In the construction of the material, we care to contemplate the desires of the Indigenous teachers in what inflexibility to their expectations regarding the textbook. After all, to our surprise, in their vast majority, Indigenous teachers and students did not understand what was written in the Handbook of Physics, because they did not perceive the meaning, due to the lack of contextualization of their reality. The care to bring to the daily practice the themes studied in Physics was fundamental for the construction of the educational material. Choosing to attend a Physics class of the first grade of High School, we found that

the teacher asked students to elaborate summaries of the chapters in the classroom, reporting what they had understood from the studied content. After the lesson, when asked if this was his practice when teaching physics, the answer is also surprising:

“I ask someone to write the summary, because, Teacher, I do not understand what the book says! In many cases I read together with them and we discuss what they did not understand.” (14/08/2017, Coroa Vermelha).

After this moan, we noticed again the prominence of the availability of textbooks to the teachers, who in turn usually do not have a specific training in Physics, being these textbooks a unique pedagogical support of the Indigenous teachers, taking into consideration the naked truth. Almost 100% do not have the adequate instruction to administer the discipline and most of them do not have High Education degrees in that area. We need to stress the reports of the Indigenous teachers about the textbooks of Physics not coming to their region, or frequently the coming of only one specimen. When investigating the collection of Physics present in the school, it was noticed that they were restricted to five copies only, which served as a pedagogical support for the educator to teach the classes and as a source of research for the first grade of High School students. When being asked about the book used in the classroom, the teacher reported that he used the book with as many copies as possible in the school, and with this basis, he adopted the textbook: “To be Protagonist, Physics, High School (1<sup>st</sup> Grade)”. Surprisingly in 95% of the examples given, under the perspective of the students of the traditional schools, it does not match the Indigenous relations in their communities.

During the reading process about the introduction of Physics, only one specimen denoted the Indigenous reality: the depiction of an Indian fishing with bow and arrow in a pond at the Xingu Indigenous Reserve, in the state of Mato Grosso, in 2011, inserted in the introductory section under the “vector sum” theme. In the aftermath, we evaluated the themes presented in the three units of the book. The first unit approaches “Kinematics”, divided into three chapters: “Uniform Movement”, “Uniformly Varied Movement”, and “Circular Movement”. The second unit brings the theme “Dynamics”, divided into four chapters: “Forces and Newton's Laws”, “Impulse and Collisions”, “Work-Energy” and “Gravitation”. Finally, the third unit, whose theme is “Statics”, is divided into two chapters: “Balance” and “Study of Fluids”. In conclusion, at the end of each chapter of the book, after the respective explanation of the content, there are sub-chapters with the titles: “Incorporate the Learning”, which is nothing more than multiple-choice exercises related to the content studied: “Physics has History”, sometimes bringing pseudo-stories referring to the content covered in the chapter. Finally, the theme laboratory, which are examples of experiments that can be done in the classroom, although not all chapters are accompanied by this proposal.

After the analysis of all chapters and sub-chapters, we noted that in their proposal there is no concern of the authors in contextualizing the issues approached in the Indigenous culture, neither in a general manner, as in general textbooks do, neither in a specific manner referring to a given community. It is worth endorsing that our analysis in the pursuit of application of the contents in the Indigenous reality, but in relation to a vision of the so-called dominant culture, the

textbook of Physics studied in traditional schools fits satisfactorily the contemporary patterns. We also believe that it is not enough, once this is the active model of preparation of pupils to the ENEM, being a repeater of ideas, encompassing a mechanical learning of concepts, i.e., that unfortunately it is not studied the meaningful education of pupils, making them critical, reflective and active in society. Based on these assumptions, we corroborate the necessity of producing alternative textbook on Physics, in a way that reflect as a significant production of knowledge, contemplating in an intercultural way the themes studied in Physics in an Indigenous context. Thus, the Indigenous teachers and students, as well as the whole community throughout the process, should create epistemological bases for all its reasoning. In contemplating the participation of the Indigenous people throughout the construction process, it was introduced to us that the Indigenous culture is guided by the knowledge given by the elders of the villages, building at several moments the bridge between knowledge configured by the common sense and scientific knowledge. This is the theory that most harmonize in the sense of valuing previous expertise associated with the Indigenous reality, supporting the dialogue between knowledge of Physics and David Ausubel's Theory of Meaningful Learning.

That is a prominent ideology in the Indigenous school context because of a cultural appreciation presented in the Indigenous communities so that the book meets intercultural demands of teaching in a contextualized and interdisciplinary way in the current education. Hence, it is seen the relevance of the role of the textbook, since pedagogically it is often the only resource available to the Indigenous teacher. Therefore, the Indigenous teachers who teach the disciplines of natural sciences. For example, Physics have the complex task of understanding and transiting in the relations of their culture with other cultures said to be the dominant considered inferior by contemporary society. This is why it is neglected by textbooks and force itself to assimilate ideas and concepts that do not match the dynamics of the community. We believe that, for the textbook to be well used in Indigenous schools, besides meeting common recommendations in different curricular proposals prevailing, it is prevalent in order to add an intercultural motion, valuing the Indigenous culture of community to which it is inserted. Therefore, the presence of the Indigenous teacher during the pedagogical process involving the discussion and analysis of the contextualized didactic book is essential.

## Conclusions

The results revealed that this new teaching proposal contributed significantly to the greater participation of pupils in the classroom during Physics classes by bringing it close the material produced to the reality of the Indigenous pupil, thus promoting the interaction between the Indigenous knowledge and traditional western acquaintance, including the increase in the approval rate compared to previous years. Furthermore, it was seen that the textbook on Physics constructed with the participation of Indigenous teachers and students with an intercultural epistemological proposal and with a didactical operationalization of contents delimited by the Ausubelian Theory of Learning allowed the exploration in a hierarchical manner of the cognitive universe of the Indigenous teacher and student. It has also enabled the deliberated manipulation of this universe to propitiate a significant apprenticeship. This study

shows the tremendous didactical-conceptual advantage of the use the ethno-physical knowledge to exemplify or forge the core concepts of Physics. Extensively it is due to the capability of the existing dialogue between the general aspects of the Indigenous culture and the natural phenomena studied by the Physics. The relationship of the cultural valuation in the Indigenous context was fundamental to construct the educational material and its acceptance by the educational community, as well. We believe that the local conceptions, allied to the pedagogical practices and exchange of knowledge within the process, were essential to obtain a significant response from the students. Accordingly, it is herein ratified in the process the compatibility between the educational materials produced from the proposal of cultural valuation of the Indigenous considered herein and the study of Physics, making them fundamental for meaningful learning of Physical processes focused on the First Grade of High School. Simultaneously, the relation between teacher, pupil, and the community configured a differential in the methodology of intercultural education applied in the Indigenous educational system. Based on the above premises, the project contributed in the learning-education process of Physics. Accordingly, it is expected that this work becomes the initial milestones for the inclusion of this material in the prototype that inserts physical concepts in the student's reality. Thus, we suggest the continuousness and the broadening of the theme, exploring and associating the two exceptional school circumstances: Indigenous and non-Indigenous.

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