The Contextualization in the Teaching Physics through of instruments of the Educational Robotics: analysis of activities by Verisimilar Praxeology

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Abstract. The idea of a contextualized physics education is increasingly present in the discourse of teachers and educators, reinforced also by the official documents of the Ministry of Education of Brazil. We seek to promote didactic sequences that assist the realization of this process by means of instruments available in the educational robotics. Based on the Anthropological Theory of Didactics is created in the notion of "Verisimilar Praxeology" to analyze in a structured and organized which elements praxeological are in fact operated in such didactic sequences.

Resumen. La idea de una enseñanza la física contextualizado es cada vez más presente en el discurso de los profesores y educadores, reforzada también por los documentos oficiales del Ministerio de Educación de Brasil. Buscamos promover secuencias didácticas que contribuyan a lograr este proceso mediante el uso de las herramientas disponibles en robótica educativa. Basado en la Teoría Antropológica de lo Didáctico se crea la noción de "Verisimilitud Praxeológico" para analizar de una manera estructurada y organizados cuales los elementos praxeológicos realidad son explorados en las secuencias didácticas.

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The Contextualization in the Teaching Physics through of instruments of the Educational Robotics: analysis of activities by Verisimilar Praxeology (pp. 01-14).

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Axe 2. *L'analyse praxéologique comme outil de l'analyse et de l'ingénierie didactiques*

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1. Introduction

The idea of a contextualized physics education is increasingly present in the discourse of teachers and educators, reinforced also by the official documents of the Ministry of Education of Brazil, becoming one of the targets of most curricula (Brasil, 2000, 2002). In general, among the many facets of contextualization discussed this scenario are: the approach of school knowledge to the daily life of students; as motivator of learning; prerequisite for promoting interdisciplinarity; reflection on the transformations undergone by school knowledge (Ricardo, 2010).

One of the questions that arise is how to promote didactic activities that really help to realization of this process? What materials and methodological strategies should be used?

The growing increase of the resources and technological innovations is allowing further situations of teaching and learning and among them should be highlighted the instruments presents at Educational Robotics (ER) (Papert, 1993; Yi et al., 2009; Frangou et al., 2008; Ruiz-del-Solar & Avilés, 2004). The robotics in the educational setting, particularly in the teaching of physics, can be thought of as a set of dynamic tools, capable of positively influencing the learning process in different situations and levels of education. Several studies have shown the possibility to develop abilities such as logical problem solving and mathematicians as well as work creative processes, enrich critical thinking and promote scientific alphabetization (Chalmers et al., 2012; Cabral, 2011; Church et al., 2010; Mitnik et al., 2009; Barak & Zadok, 2009; Lowe et al., 2008; Wang et al, 2004).

Our hypothesis is that materials of this nature potentiates the insertion of a wide range of real contexts in the development of activities and issues, and also at different level of formal education process, from Elementary School to the Technical and Higher Education. Robotics kits may use fitting pieces of hard plastic in the form of girders, full bricks, plates, shafts, pulleys and gears with different dimensions and passive of connections between them, beyond software, processing modules and sensors (e.g.: magnetic field, accelerometer, ultrasonic and rotation (Church et al., 2010; Barak & Zadok, 2009). Thus, it is possible to create several montages (vehicles, androids, houses, drawbridges, freight elevators, machinery so on.), increasing the “mimicry” of a wide range of “real” contexts. We also highlight that all this can be realized by making use of the same set of pieces or kit, reducing the cost of new mountings (Wang et al, 2004).

On the other hand, there is the risk of not knowing pedagogically adapt this material (ER), which can generate activities that reinforce only limited use of techniques to accomplish specific tasks, without actually having a concern with learning conceptual content. As emphasizes Mitnik et al (2009), most of the activities developed with robotics kits are directed to the treatment of contents very intimately related to the robotics, such as programming, construction of robots, artificial intelligence or the construction and development of algorithms. With this, one runs the risk of focusing precisely on the most "controllable" of the innovation, i.e., in its technical dimension, restricting the teaching and learning of the students to the processes involved in the assembly and operation of robots. Or, be based on a situation with pretense of contextualization but at the end, serves merely as an illustration, without didactic purposes-pedagogic deeper.

Is worth mentioning that we are dealing here with a contextualization didactic genuine in the perspective presented by Ricardo (2010). In this perspective the contextualization must not merely "reduce the social aspects of science education on physical on space proximal to the students", but worry about breaking with the traditional practices of teaching, "so that reality is perceived and it becomes object of reflection [...] ", in the expectation that "the knowledge taught have felt to the student, to the extent that can be mobilized in contexts outside the school walls."(Ricardo, 2010, p. 37-38).

So how to analyze activities or didactic sequence that makes use of these instruments to fathom how much them dialoged (or not) with the situation you want to contextualize? This implies also analyze how much is being contemplated (or not) the pretension/ didactic intention in this activity.

For that reason we aim to essentially promote the analysis and development of activities that, minimally, have a resonance between the practice ("do") with the theories and concepts physical treated in the same ("why do"), as well as evaluate the level of contextualization intentioned and/ or achieved.

To achieve these objectives, we based our investigation in the Anthropological Theory of Didactics (ATD) (Chevallard, 1999), which enables you to model the knowledge through a Praxeological Organization (PO).

1.1. Praxeological Organization (PO)

This PO is expressed by the set referenced formally by [T, τ, θ, Θ], where T is the *task type*, which can branch in numerous *tasks* [t], τ represents the *technique*, θ refers to *technology* and Θ to the *theory*. This PO is posited as an "organization" that gives two distinct blocks, but correlated: the *practical-technical block*, which can be understood as the know-how, and *technological-theoretical block*, linked to knowledge, or rather a discourse logic that justifies and understand the practical-technical block (ibid).

In accordance with ATD, all that is required for a person to do mediated verbs can be designated as a *task*. In this sense, *task* evokes an action, a way of doing something, thus making the *practical-technical block* a *Praxeological Organization*. In the context of robotics, understanding the concept of task is very important, since the activities, even if they are dealing with a single physical phenomenon or concept, may require an extensive set of "do", since the assembly of robots to programming and calculation of physical magnitudes into play and appropriate use of sensors and processing modules.

A Praxeology related to T (task) requires a way to do solve $t \in T$. This way is called Technique [τ]. Thus Technique does direct reference to particular way of accomplishing $t \in T$, in the case of a well 'know-do'. A technique τ makes sense only when connected to a task on which it is. For example, to perform the task "*calculate speed of the vehicle in Rectilinear Uniform Motion (RUM)*", one can make use of various techniques to collect the necessary data, since the use of ultrasound sensors or movement until the use of chronometers for obtaining experimental time "spent" to move a specific distance in RUM.

In turn, Technology [θ] is seen as a rational discourse that seeks to explain and clarify determined technique justify its use and/ or efficiency in their assignments has become intelligible τ, ensure their success and promote, where possible, the emergence of new techniques [τ1, τ2, ...]. Thus, θ is aimed at triad: Justification - Explanation - Production of new techniques (ibid.). A Technology in general is always underpinned by a theory [Θ], understood as a broader discourse that serves to interpret and justify the technology.

To the it pertains to contextualization to support the teaching of physics education through robotics, we realize that the notion of Praxeological Organization can help highlight and interconnect the practical-technical block with the technological-theoretical block between didactic activity and social practice reference. Addition to enabling the highlight to that actually from contextualization is worked in the didactic activity.

We are not only interested in the execution of a particular task by itself (an uncompromised make), nor solely focused on the ludic aspect. Our intention is to show that robotics offers a means of producing situations of teaching and learning through tasks much closer to those present in real situations of daily life. For this, we developed the notion of "*Verisimilar Praxeology*" presented to below.

2. *Verisimilar Praxeology (VP)*

Essentially, the concept of *Verisimilar Praxeology* (VP) would refer to the set that contains the constituents praxeological identified in the PO social practice of reference, i.e., a human activity embedded in a real situation (which bases the contextualization), compared with the set containing the constituents praxeological identified in the didactic PO that intends to contextualize that social practice of reference. The illustrations below (**Figure 1** and **Figure 2**) can provide more clarity about this notion.

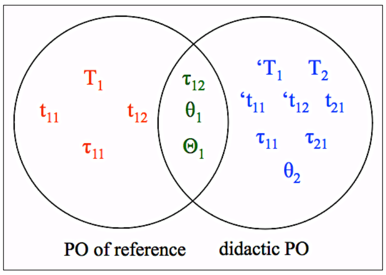

Figure 1. Verisimilar Praxeology by intersection.

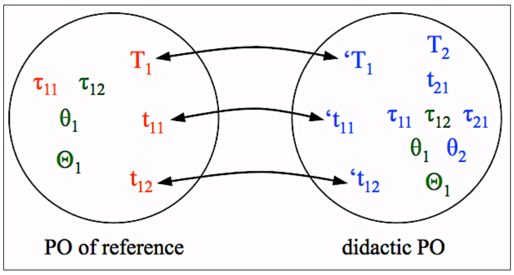

Figure 2. Verisimilar Praxeology by correspondence.

The **Figure 1** presents a situation of Verisimilar Praxeology when occurs the existence of an intersection of two sets. In this case, we note the existence of a theory, a technology and technique contained both in the PO of reference how much in the didactic PO. However, if a particular element praxeological, a task or task type, for example, is not identical to the two sets but has one similarity, we can say it is a Verisimilar Praxeology by correspondence (**Figure 2**).

Thus, one can fathom in a structured and organized which elements praxeological are in fact exploited in the didactic sequence that aims to deal with a contextualization in the school. In other words, one can fathom what tasks, techniques, technology and/ or theories identified in the social practice of reference that support the contextualization is perpetuated in the didactic sequence.

We seek to so evaluate the degree of Verisimilar Praxeology (VP) contained in a didactic sequence that makes use of instruments from Educational Robotics and that intends contextualize a particular social practice of reference.

2.1. Methodological aspects

The investigated context refers to the transport of loads making use of forklift small, common in supermarkets wholesalers and of construction materials stores. The didactic sequence relating to that framework in this is fascicle paradidactic developed by the *Center for Research on Curriculum Innovation* (NUPIC[1]) in partnership with *Lego Education of Brazil* (Lego ZOOM[2]) (Pietrocola et al, 2009). For construction of the forklift in didactic situation, is used the kit of robotics *Lego Mindstorms NXT*[3].

Both the analysis of the social practice of reference (in this case, transporting cargo through a forklift) and from the didactic activity (Forklift) require a systematic and organization to expose in order minimally organized and structured, the main constituents praxeological (T, τ, θ and Θ) identified and / or most relevant in each. For this, we developed a conceptual map (Novak & Cañas, 2008), which allowed a more profound and subtle for the determination of these constituents praxeological.

> Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts. We define concept as a perceived regularity in events or objects, or records of events or objects, designated by a label. The label for most concepts is a word, although sometimes we use symbols such as + or %, and sometimes more than one word is used. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units of meaning. (Ibid, p.1).

[1] http://www.nupic.fe.usp.br. Accessed on December 1, 2012.
[2] http://www.legozoom.com. Accessed on December 1, 2012.
[3] http://mindstorms.lego.com/en-us/default.aspx. Accessed on December 1, 2012.

This graphical tool was originally developed to analyze the conceptual representations established by students about topics in primary school science (Novak & Musonda, 1991). However, today its use is varied and used in several sectors (Novak & Cañas, 2010), since computing and software engineering to "in corporations to help teams clarify and articulate the knowledge needed to solve problems ranging from the design of new products to marketing to administrative problem resolution." (Novak & Cañas, 2008, p.16).

The **Figure 3** presents a conceptual map developed with the aim of answering *what are the main components and physical principles governing the operation of an electric forklift and how is the cargo transportation?* Already the concept map shown in **Figure 4** indicates *how the didactic activity (Forklift) is structured in relation the assembly and to the main physical concepts dealt?*

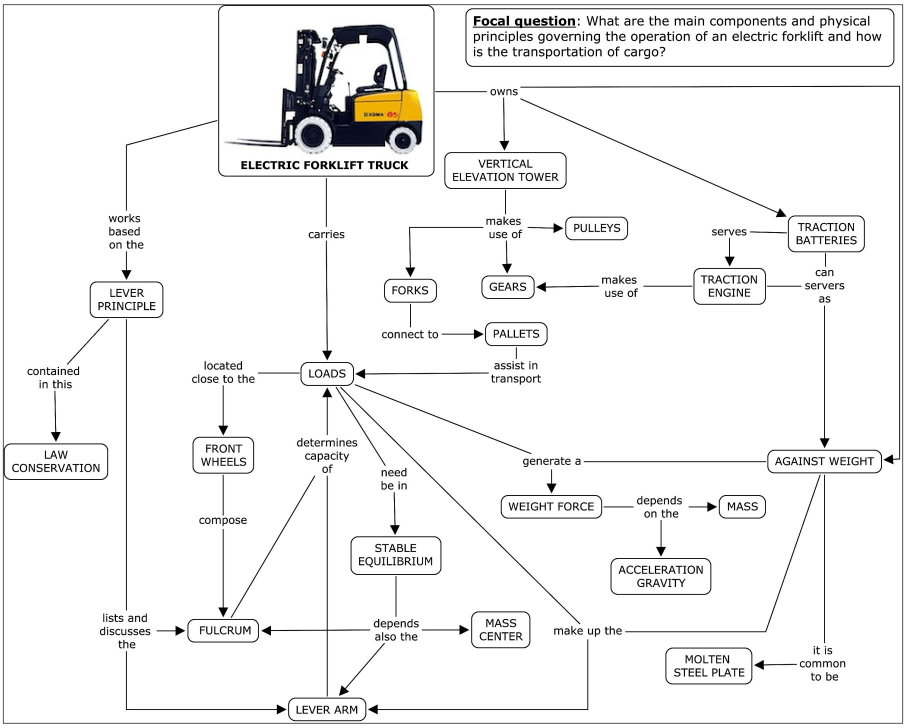

Figure 3. Conceptual map relating the main structural and conceptual aspects from PO of the social practice of reference.

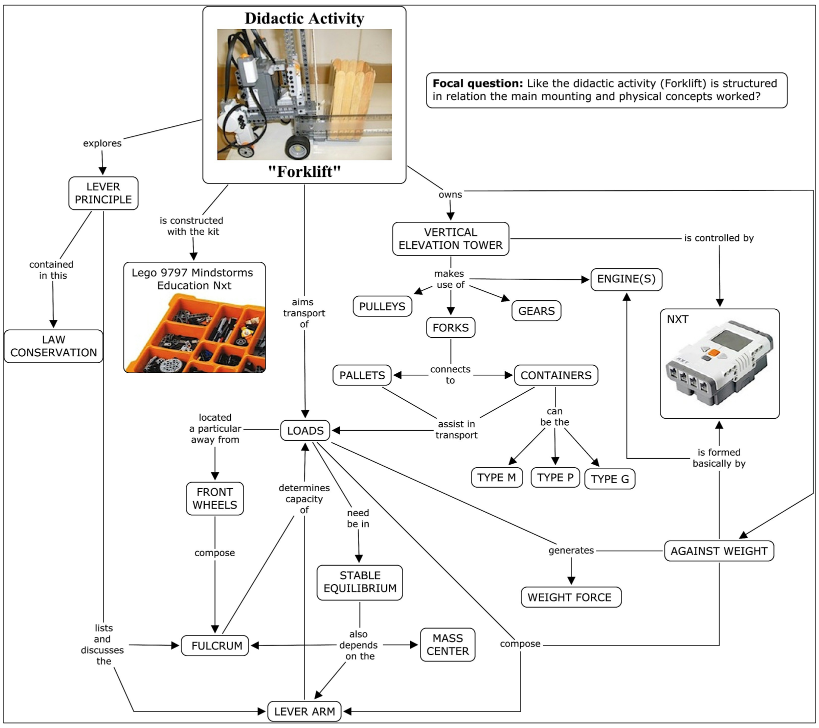

Figure 4. Conceptual map relating the main structural and conceptual aspects identified in didactic PO.

3. Results and Discussion

The two conceptual maps developed (Figures 2 and 3) can indicate some praxeological elements common to both situations, pointing to aspects of verisimilitude. For example: it is clear the need for a support point (fulcrum) and a counter weight (composed of the motors and batteries) positioned at a certain distance from the fulcrum (located on the axis that makes the front wheels) for the correct operation of the forklift and safe transport of the cargo. This is identified both in the PO of the social practice of reference (**Figure 3**) how much in the didactic PO (**Figure 4**).

With this, we can identify the existence of a single technique (τ) to accomplish the same task type (T) (transport of the cargo). The comprehension of this technique, technology (θ), involves understanding the concept *moment of a force* by means of the *lever principle*. Identifies then a Verisimilar Praxeology by intersection, with task type, technique and technology common in both POs. On the other hand, despite having the same type of task (T_3, see **Table 1**), the didactic PO also contains tasks and techniques which have only one similarity with PO of reference, for example the own development and construction of forklift by making use of robotics kit, thus corresponding to what are called VP by correspondence.

Depending on the didactic intention of the teacher to explore that context through the educational robotics, it is still possible to discuss conservation laws, i.e., treat of the Theory (Θ) that enables better understand and justify the technology (lever principle). However, to the analyze the didactic PO (Figure 4) identified that the same as does not advance in terms of deepening the discussion of the technological-theoretical block, leaving out the element Θ (theory), in other words, does not discuss the conservation law despite this energy is contained in lever principle.

Through the law of conservation of energy we can identify the element Θ, because while counterweight of the forklift performs work (be in social practice of reference in the didactic activity), applying a force weight over one end of the lever arm responsible for potency, the other end performs work on the cargo, maintaining the forklift in stable equilibrium.

Despite the lack of a deepening of discussion concerning the theory Θ, identifies that the contextualization did not reduce the social aspects of science education to the physical space proximal the students, in fact, she introduced elements that were explored in the didactic activity within a Verisimilar Praxeology. The greater the amount of these elements praxeological similar between the context and the didactic activity, the greater the degree of verisimilitude.

The educational robotics in that case favored control and change variables to discuss the lever principle, for example, changing the distance between the center of mass of the load and the fulcrum and increase the load capacity to be transported. Interesting to note that the activity thus can have a character more investigative, and the challenge proposed happens to be in reduced scale, is now in safely transporting boxes of different sizes containing small glass balls. Beyond the cargo transportation, the didactic PO still involves other task types, as well as their techniques and technologies (see **Table 1** and **Table 2**).

Task Type (T)	Task (t)
T_1 – Construct a Forklift.	t_1 – Construct a forklift with tower of elevation to carry a given load (small glass balls).
T_2 – Programming the processing module.	t_2 – Program the processing module to activate the movement of the of elevation tower and forklift.
T_3 – Transporting cargo.	t_3 – Transporting a certain amount of balls with the Forklift in three different situations: with container type P, M and G.
T_4 – Analyze the maximum load supported by the forklift.	t_{41} – Verify experimentally that the maximum load to be transported by container type M and G.
	t_{42} – Investigate the relationship between cargo capacity and cargo center.

Table 1. Activity "forklift" in terms of task types and tasks.

Task (t)	Technique (τ)	Technology (θ)
t_1	τ_1 – It is used the kit from Lego Mindstorms NXT following the manual mounting which, in turn, presents step-by-step the schemas of installation and fittings. Used motors, battery and NXT own to serve as counterweight.	θ_1 – *Moment of a Force*.
t_2	τ_2 – Software is used *NXT Mindstorms 2.0* to development of programming, which, in turn, is previously provided by the instructor, the student leaving only enter the program in NXT composing the structure of the forklift.	θ_2 - Computational Logic Programming
t_3	τ_3 – Supporting the container in "fork" of the forklift, varying the distance between the fulcrum (support point) the center of mass of the load (determined by the container size and distribution of the load), thus configuring the *lever arm*.	θ_3 - Adoption of the *lever principle.*
t_{41}		
t_{42}	τ_4 – Construction of a graph “Cardo Capacity X Cargo Center”, based on the data from t_3 and t_{41}.	θ_4 - Mathematical Functions and Graphs.

Table 2. Activity "forklift" in terms of techniques and technologies.

4. Final considerations

The Anthropological Theory of Didactics proved a strong ally in the initiative to better show the structure and dynamics of activities contained in Educational Robotics. This was made in terms of tasks, techniques, technologies and theory.

The educational robotics, especially when facing the teaching of physics, allows in fact a broad approach that can encompass all constituents that comprise praxeological, however, warned that just is not enough. It is necessary to pay attention to the know-do without forgetting the logical discourse that permeates and helps in understanding this know-do, plus of course the appropriate times and specific approach and study. Thus, the context is not lost in an activity empty and "alienated", with no direct correlation with that phenomenology to be contextualized.

Our research involves analyzes that are yet in development of other activities and contexts, such as electricity generation, Barcode and Radar. However, preliminary studies offer good clues to guide the next steps. Summarized, we find that the ATD, especially with respect to its structural component (Praxeology), shows up as a potentially appropriate tool theory to understand the limits and possibilities of robotics in situations involving tasks that require specific knowledge of physics, especially to highlight praxeological elements that actually are explored in PO teaching that seeks to contextualize a given phenomenology and/ or human activity.

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