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Physics Teaching for Children: A Bibliographic Review

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ABSTRACT

The perspectives investigated by Physics/Science Teaching researchers in the context of youth and adults are diverse. They research on innovations in the classroom, new technologies, experimental activities, evaluation, among others subjects. In the children context, Physics/ Sciences teaching is poorly explored. This article discusses the results of a bibliographical research on this theme, whose main objective was to gather theoretical and methodological subsidies for the teaching practice in this context. The data sources used were articles, dissertations and theses available in the Capes/ MEC Journal Portal, Scientific Electronic Library Online (SciELO), Bank of Theses and Dissertations and Theses and Dissertations Digital Library (BDTD), as well as papers published and presented at the National Symposium on Physics Teaching (SNEF) and Meeting on Physics Teaching Research (EPEF) among years 2000 and 2017. In this context, the sources were grouped and analyzed from the following categories: level of education, with the possibility of insertion of Physics/Science teaching from the age of 3, in the context of both formal and non-formal education, as long as the scientific activities are appropriate to the children's age group and whose main objective is to motivate their interest in scientific contents; content covered, with works on the various Physics themes, with predominance of Mechanics, Fluids and Astronomy; and methodology, didactic resources and theoretical foundation, where we highlight the occurrence of experimental and ludic activities based predominantly on Piaget, Vygotsky and Ausubel theories. Thus, from this article, the reader will contemplate a general overview about the possibilities and potentialities for the insertion of Physics/Science teaching in children's context, in order to make possible the interest for Science, as well as scientific literacy.

Keywords: Child education. State of art. Scientific Literacy.

O Ensino de Física para Crianças: uma Revisão Bibliográfica

RESUMO

As perspectivas investigadas por pesquisadores da área do ensino de Física/Ciências no contexto de jovens e adultos são diversas. Pesquisa-se sobre inovações em sala de aula, novas tecnologias, atividades experimentais, avaliação, entre outras. Já no contexto infantil, o ensino de

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Física/Ciências é uma temática pouco explorada. O presente artigo discorre sobre os resultados de uma revisão bibliográfica sobre este tema, cujo objetivo principal foi reunir subsídios teóricos e metodológicos para a prática docente neste contexto. As fontes de dados utilizadas foram artigos, dissertações e teses disponíveis no Portal de Periódico Capes/MEC, Scientific Electronic Library Online (SciELO), Banco de Teses e Dissertações e Biblioteca Digital de Teses e Dissertações (BDTD), bem como os trabalhos publicados e apresentados no Simpósio Nacional de Ensino de Física (SNEF) e Encontro de Pesquisa em Ensino de Física (EPEF) entre os anos 2000 e 2017. Nesse contexto, as fontes foram agrupadas e analisadas a partir das seguintes categorias: nível de ensino, com a possibilidade da inserção do ensino de Física/Ciências a partir dos 3 anos de idade, no contexto tanto da educação formal como da não formal, desde que as atividades científicas sejam adequadas à faixa etária das crianças e que tenham como principal objetivo motivar o interesse dos sujeitos por conteúdos científicos; conteúdo abordado, com trabalhos com as diversas temáticas da Física, com a predominância da Mecânica, Fluidos e Astronomia; e metodologia, recursos didáticos e fundamentação teórica, onde destacamos a ocorrência de atividades experimentais e lúdicas fundamentadas, predominantemente, nas teorias de Piaget, Vygotsky e Ausubel. Assim, a partir deste artigo, o leitor contemplará um panorama geral sobre as possibilidades e potencialidades para a inserção do ensino de Física/Ciências no contexto infantil, a fim de viabilizar o interesse pela Ciência, bem como a alfabetização científica.

Palavras-chave: Educação Infantil. Estado da Arte. Alfabetização Científica.

INTRODUCTION: PHYSICS TEACHING FOR CHILDREN

The perspectives investigated by Physics teaching researchers in the context of High School and Higher Education are diverse. For example, discussion about the use of innovative teaching methods in the classroom (Araujo & Mazur, 2013), use of experimental activities (Carvalho, 2010; Galbiatti, Assis, & Camargo, 2015), use of new technologies (Dorneles, Araujo, & Veit, 2012; Yonezawa & Souza, 2015) are performed. However, in the children's context, the Physics and/or Science teaching is still relatively unexplored (Lorenzetti & Delizoicov, 2001). Arce, Silva and Varotto (2011) argue that a possible explanation for this fact is the belief in the impossibility of teaching and learning scientific concepts by children.

In this sense, it is necessary to reflect on the purposes of the insertion of Physics and/or Science teaching in the children's context. Initially, it was legitimized that teaching and learning of physical concepts for children go beyond **content** approach and **mathematisation** for this area of knowledge. On this aspect, Rodrigues and Mackedanz (2018) rescue the historical principles of Basic School subject Science, with "the understanding of everyday natural processes to students" (p.2). In addition, the authors show that the turn to mathematical approach is linked to Forbes' rise to the position of Natural Philosophy Professor at Cambridge, due to the support of a group of English mathematicians.

Thus, it is essential that the subjects have contact with science from childhood, in order to enable the preliminary contact with scientific literacy.[1] In this context, we agree

[1] We understand that in the children's context the most adequate translation is scientific enculturation.

with Hurd (1998) ideas that scientific literacy must be understood as a social competence required to reflect on the possibilities of science and technology in relation to personal, social, political and economic challenges: issues that will be found in the lives of all citizens. From this perspective, it is possible to form a socially responsible and competent citizen who is able to perceive the contribution of science and technology to public life and welfare. In this perspective, we can affirm that we are experiencing "the transition from laboratory science to the 'real world' and 'real life'" (Hurd, 1998, p.410), since despite the changing character and new demands of society, the Brazilian scientific school curriculum[2] still deals in a fragmented way the contents and approach them in a totally decontextualized way of subjects' experience and need.

It is notorious that achieving scientific literacy (Hurd, 1998) is not an innocent issue and that it will not be fully contemplated in childhood. However, the contact with some of the aforementioned assumptions in childhood is essential, provided that the age group, the development stage and the subjects' specificities would be respected. In this context, it is possible to even use some children characteristics to initiate and encourage the process of scientific literacy, as reported by Lima and Loureiro (2013):

> Children since the beginning of their schooling process have a great interest in natural phenomena and the search for explanations of how and why things are as they are. The schooling main objective at this age group is to cultivate students' natural interest in knowledge, encouraging the reading of varied texts, formulating questions, daring to create or encourage explanations and solutions to presented problems, develop autonomous attitudes, stimulate a taste for science, trying to explain the world around them and proposing solutions for concrete problems. (Lima & Loureiro, 2013, p.15)

Krasilchik and Marandino (2004) also argue that science education enables children development on learning to solve problems, analyze information, make decisions and prepare for life.

In addition to contemplating the possibility of scientific literacy initiation, the insertion of Physics and/or Science teaching for children also facilitates their broad formation and development. This fact occurs because, when the child is in contact with scientific activities (for example, an experiment performed), it is possible to improve four aspects: attention, memory, sensation/perception and speech (Arce, Silva &, Varotto, 2011).

From the above discussions, we highlight some purposes, importance and feasibility of Physics and/or Science teaching to be part of the children's context. Thus, in order to seek support for teaching practice, this article presents the qualitative and

[2] Although the term school curriculum is directly related to formal educational spaces, its impact is not limited to this space. We perceive the same characteristics of this fragmented curriculum, for example, in Science Museums, Science Fairs, Extension Projects etc.

quantitative results of a bibliographical research carried out on Physics teaching for children thematic.

METHODOLOGY

The present article presents the results of a bibliographic type research, which "is developed based on material already elaborated" (Gil, 2002, p.44). This research had as its central theme the Physics teaching for children and its main objective was to gather theoretical and methodological subsidies for the teaching practice in the referred context. Therefore, we seek reflections on the following research problems: Is it possible to insert Physics teaching for children? From what age range are Physics concepts taught? What Physics content is covered with children? Which theoretical references support the Physics teaching for children? What teaching methodologies and resources are used?

For this purpose, we use as data sources articles, dissertations and theses available in the Capes/MEC Journals Portal, Scientific Electronic Library Online (SciELO), Bank of Theses and Dissertations and Theses and Dissertations Digital Library (BDTD), whose publications occurred among years 2000 and 2017 (period that actually occurs the consolidation of academic research in Physics/Sciences teaching). We also resort to papers published and presented at specific scientific events in the field of Physics Teaching: the National Symposium of Physics Teaching (SNEF), between 2005 and 2017,[3] and the Meeting on Teaching Physics Research (EPEF), between 2002 and 2016.[4] In this perspective, the search in all listed repositories was carried out from the following terms: Physics teaching for children, Physics and Elementary Education, Physics and Early Childhood Education, Science and children, Science and Elementary Education and Science and Early Childhood Education.

From this preliminary search, we found 28 papers: 14 articles, 12 dissertations and 2 theses. In the publications of the SNEF and EPEF, we found, respectively, 75 and 41 papers that related to the central theme: Physics teaching for children.

However, after the papers' "exploratory reading" (GIL, 2002, p.77), we found that some of them escaped this research main thematic, since they made general reflections about the implications of Physics teaching for children, analyzed the conceptions that children had about the relation of some physical concepts to their daily life and/or were directed exclusively to the initial and continued teacher's formation. Therefore, these studies were discarded from the analyzes carried out in this research, since they would not allow inferences about how Physics teaching for children actually occurs, nor would they offer subsidies and reflections on the aforementioned research problems.

[3] The selection of the SNEF works was done from 2005 due to the availability of the complete works on the site of the event to happen from that year.

[4] The selection of the works of EPEF took place from 2002 due to the availability of the complete works in the site of the event to happen from that year.

In this context, 8 articles and 9 dissertations were left for analysis, as well as 32 SNEF papers and 14 EPEF papers. Therefore, the mentioned works constitute the sample data and make possible the problematization and reflections on the research problems mentioned previously.

After the sample constitution, the "selective and analytical reading" (GIL, 2002, p.78) was carried out. Subsequently, a list of selected papers was prepared, in order to enable their identification and registration of published contents. Later, the papers were analyzed and grouped in the following categories: 1) Teaching Level, 2) Content addressed, 3) Teaching methodology, didactic resource and theoretical reference. The analysis results will be made explicit in the next topics.

RESULTS AND DISCUSSIONS

Category: Education Level

In general, the Physics teaching can occur within the scope of formal and non-formal educational spaces. In this context, formal space can be understood as:

> The school space, which is related to the School Institutions of Basic Education and Higher Education, defined in Law 9394/96 of National Education Guidelines and Bases. It is the school, with all its dependencies: classroom, laboratories, sports courts, library, courtyard, canteen, cafeteria. (Jacobucci, 2005, 56)

Non-formal spaces of education are understood as spaces that provide non-sequential, voluntary and flexible learning, that is, it is oriented by the needs and interests of the subjects (Falk, 2001).

In this sense, the result of the analysis showed the possibility of Physics teaching for children in the context of Early Childhood Education, Elementary Education (initial and final years), as well as in museums and extension projects (non-formal education).

In the context of the analysis of articles and dissertations, the didactic experiences of Physics teaching in children's context were limited to the formal space, exclusively in Elementary School (Table 1), occurring the predominance of activities focused on the initial years of such education level.

Table 1

Quantitative analysis of articles and dissertations regarding education level.

Level of education	Prevailing age group	Quantitative of works	Percentage of work
Elementary School – Initial Years	6-10 years	11	64.70%
Elementary School – Final Years	10-14 years	6	35.30%
Total		17	100%

In the context of papers from scientific events (Table 2), the didactic experiences occur in Early Childhood Education (Whitaker, Whitaker, Azevedo, & Santana, 2002; Jango et al., 2011; Borges & Strieder, 2014), Elementary School, Science Museums (Junior & Silva, 2009; Santos, Lima, Mattiuci, Smith, & Sobrinho, 2011) and extension projects (Santos Antunes, Noguez, & Lucchese, 2017; Lucchese, Antunes, Noguez, Cunha, & Santos, 2017). It is again verified the predominance of works carried out for Initial years of Elementary School, corroborating the results obtained in the analysis for articles and dissertations. In relation to Science teaching for children in non-formal educational spaces (Scientific Museums, for example), it is emphasized that they provide motivation for learning and the enrichment of scientific culture (Júnior & Silva, 2009), but is still scarce the number of publications (only 6.40% of the papers analyzed) that discusses the implications of learning Physics contents for children in such spaces.

Table 2

Quantitative analysis of SNEF and EPEF papers, regarding education level.

Level of education	Prevailing age group	Quantitative of works	Percentage of work
Child education	35 years	3	8.50%
Elementary Schoo – Initial Yearsl	6-10 years	22	46.80%
Elementary School – Final Years	10-14 years	18	38.30%
Non-formal spaces	3-12 years	4	6.40%
Total		47	100%

The results presented in this item make it possible to discuss the first research problem addressed in this article: *Is it possible to insert Physics teaching for children?* Based on the results of the analyzed sample, it is possible that children from the age of three years have contact with scientific activities, specifically, aimed at Physics teaching.

For this purpose, we highlight the need and importance that teachers, as well as Scientific Museums and Extension projects mediators, adjust the scientific activities for the age group and the cognitive development of the subjects. In this sense, Carvalho, Vannucchi, Barros, Gonçalves and Rey (1998) point out that:

> [...] we must work with physical problems that students can discuss and propose solutions compatible with their development and their vision of the world, but in a sense that later will lead them to scientific knowledge. [...] First-grade teachers need not be concerned with systematizations beyond the reach of students: as Science has evolved over the centuries, our students will also evolve and reconstruct new meanings for the phenomena studied. [...] During school development, from fifth to eighth grade, these meanings, these 'temporary knowledge', must be reorganized, acquiring new meanings; the relations between the variables, now only pointed out, will later be mathematized and structured in laws and theories. (Carvalho, Vannucchi, Barros, Gonçalves, & Rey, 1998, p.13)

These authors affirm that early contact with scientific activities (from childhood) facilitates the development of scientific knowledge and scientific literacy (HURD, 1998). We thus perceive the possibility of insertion of Physics and/or Science teaching to contemplate the preliminary learning of scientific concepts, as well as to develop skills for the broad formation of the citizen to the present society: critical sense of observation and decision-making, relating science and technology to their experiences, initiative in solving problems (personal, social, economic, scientific, etc.), competence to work in teams, etc.

Therefore, it is important to emphasize the importance of introducing Physics teaching for children in formal education (Child and Elementary Education) and in non-formal educational spaces (museums, teaching and extension projects, etc.) since the scientific knowledge learned in this phase will be previous knowledge and subsidies for future scientific and systematized learning (High School and Higher Education). From a constructivist perspective, previous acquired knowledge and didactic experiences in this age group in the scientific area will be essential for subsequent learning, making possible a significant learning, since it develops the anchor points of David Ausubel's theory.

Another fact worth mentioning is that the insertion of scientific contents from the beginning of the school process can make possible the increase of students' interest and motivation for Science. This fact can have positive consequences for Physics teaching, for example, the reduction of failure rates and the lack of interest, taste and curiosity in such a curricular component when taught in High School and Higher Education – problems pointed out by several researchers (Ricardo & Freire, 2007; Massoni, 2014).

Category: Content Covered

The result from analysis regarding the Physics contents addressed for children evidences the possibility of developing didactic activities in the children's context in different Physics areas: Mechanics, Thermology, Waves, Fluids, Optics, Electricity, Magnetism and Astronomy. However, in the scope of the scientific articles and dissertations, the predominance of Mechanics (occurrence in 8 works) and Fluids (6 works) was verified. In the context of the SNEF and EPEF works, there was a predominance of Fluids (occurrence in 12 works) and Astronomy (11 works).

In this context, the predominance of the subject Mechanics can be explained by the wide range of possibilities that can be explored in the student's daily life (Araújo & Abib, 2003), as well as the possibility of performing several experiments that allow handling by children. Thus, it is possible to explore skills such as children motor development, as well as observation, hypothesis elaboration, contact with measuring instruments, and so on.

The topic Fluids generally addresses activities involving air and water: Physics concepts present in the daily life of all children. Thus, the justifications for their insertion in teaching from childhood cover, for example, historical aspects (sailing at the beginning of civilization, use of the wind as the first motor force, steam engines), ludic (support of a kite), interdisciplinary, environmental, etc. (Gaspar, 2014).

About Astronomy*,* some authors, such as Langhi and Nardi (2014), point out that from this thematic it is possible to insert scientific education in different perspectives, such as from the History and Philosophy of Science, the practice of observing the sky, the development of experimental activities, interdisciplinarity, etc. Such factors stimulate students' motivation and the preliminary development of scientific literacy.

Based on our previous discussions and in a perception of the diversity of topics that can be explored with children from the beginning of their schooling process, Carvalho, Vannucchi, Barros, Gonçalves and Rey (1998) point out that the selection of scientific concepts is extremely important. Such concepts should be part of the physical world in which the child **lives** and **plays**. In this way, it is possible that the child has access to scientific culture, without devaluing childhood (Souza, 2016).

From this perspective, the selection of Physics content or concept should be thought in a broader context, as well as, it should ensure:

> [...] the possibility of creating spaces for children to live and experience science, within the child logic, which encompasses creation, imagination, fantasy and desire. It is to think science as a vehicle of power to whet curiosity and new glances into the world, often different from that of the adult. (Souza, 2016, p.50)

Category: Methodology, Didactic Resources and Theoretical Basis

This topic will discuss the main methodologies and didactic resources used in the context of Physics teaching for children. It is emphasized that, generally, the choice of a methodology and didactic resources is based on learning theories. Then, the main aspects of teaching resources, teaching methods and theoretical foundations will be approached from a descriptive analysis.

When referring to the didactic methodologies for Physics teaching, it is observed the occurrence of **experimentation** in several educational researches. This is not different in the children's context. Several authors inserted Physics teaching for children from an experimental approach. As a result, we highlight that the experiment is the didactic resource predominantly and used (12 articles and dissertations and 35 scientific events papers) to discuss physical knowledge with the children.

Given this result, we ask What are the justifications for teachers to use, predominantly, experiments in the context of Physics teaching for children?

Schroeder (2004, 2007) argues that the main function of this didactic resource is familiarization with lab experimental work and with results discussions (for 7-8 years old); as well as the exploration of phenomena and the proposition of theories based on observations (for 9-10 years old). For example, Silva, Assis and Carvalho (2010) argue that the experimental demonstration for children, in a dialogic approach, is essential, since it is possible to motivate the exploration of students' previous knowledge.

Corroborating these ideas, Moro (2013) points out that:

> [...] the worked experimental activities can favor **meaningful learning**, since such activities establish relationship with students' daily life and instigate the development of some cognitive abilities: Ability of abstraction; establishing relationships between what they knew and what was presented to them, allowing construction and restructuring some concepts; ability to interact with colleagues and the teacher (create collective working conditions); troubleshooting; creation of explanatory models. (Moro, 2013, p.86 – our emphasis)

Thus, it is noticed that some researchers ground the insertion of the experimental activities in child context from David Ausubel's **Meaningful Learning Theory**. In this context:

> For Ausubel, meaningful learning is a process whereby new information relates to a specifically relevant aspect of the individual's knowledge structure, that is, this process involves the interaction of new information with a specific knowledge structure, which Ausubel defines as subsumption concept, or simply subsumption, existing in the individual cognitive structure. Meaningful learning occurs when

> new information is anchored in relevant preexisting concepts or propositions in the learner's cognitive structure. (Moreira, 1999, p.153)

In this sense, according to the authors of the works in the analyzed sample, the main justification to support the insertion of Physics and/or Science teaching in the children's context in Ausubel 's Meaningful Learning Theory is that preliminary contact with scientific concepts may enable the elaboration of subsumption concepts in child's cognitive structure. This fact may influence the development of the subject during the course of his/her schooling process, in order to institute a meaningful learning, since such subsumption concepts will anchor new scientific concepts learned.

The **research-based methodology** is also inserted in children's context. In this case, Schroeder (2004, 2007) points out that the experimental activities can follow the following steps: i) Teacher oral explanation, discussing the main procedures for conducting the experiment; ii) Delivery of written material on the practice and accomplishment of the same; iii) Group discussion of the results obtained; iv) Drafting the report, in written or drawing form. An inference that the researcher makes in relation to Physics teaching for children is that the activities should be worked out so that the steps do not last more than ten minutes, "because children up to ten years lose interest if they need to dedicate themselves to an experiment for more time"(Schroeder, 2004, p.51). Besides that:

> During the activities, the teacher should move among students' desks to help the children, avoiding giving direct answers to the questions; it should, above all, propose questions that might guide them to find their own answers. The same should be done during the time reserved for group discussions. The report, whether in drawing or writing form, is the only individual part. (Schroeder, 2004, p 51)

The **research-based Physics teaching** is also used in Kroth (2011). In this case, the author used the following methodological sequence in her Learning Unit: i) Survey of students' prior knowledge; ii) Application of diversified activities: experimentation, reading, research, ludic and artistic activities and iii) Evaluation and presentation of activities developed by the children. In this context, we noticed that the use of the experiments incorporated in the research-based methodology has characteristics very close to the experimental activities traditionally used in the academic environment (Higher Education). That is, such activities are focused on the assembly of the experiment, observation and synthesis (report). Thus, we observe the predominance of experimental mechanical and methodical investigations, leaving aside the intuitive characteristic, which is necessary for the first contacts of children with scientific concepts. We believe that the intuitive characteristic should not be excluded from scientific activities for children, as it will allow the development of autonomy, perception and decision making, as well as the beginning of the construction of scientific literacy.

For the final years of Elementary School, Oliveira (2011) discusses the possibility of **teaching by projects**. Thus, the researcher emphasizes methodological procedures as: presentation of topics for the students; project planning (questions, hypotheses); preparation of logbook; research on the topic; teacher orientation to groups; experimentation, simulation and modeling; preparation of poster and models and presentation of results.

In this sense, it is emphasized that the research-based methodologies and projects were based on the **Vygotsky's theory**. The most mentioned assumption is the social interaction for the development and learning of the child. Thus, Moreira (1999) argues that according to Vygotsky, "higher mental processes (thought, language, volitional behavior) originate in social processes; the cognitive development of the human being cannot be understood without reference to the social environment" (p.110). In this context, it is emphasized *that* "social interaction is, therefore, in Vygotsky perspective, the fundamental vehicle for the dynamic transmission (from inter to intrapersonal) of social knowledge, historically and culturally constructed" (p 112). Therefore, in this perspective, two levels of mediation, child-child and child- adult (teacher, for example) are necessary for scientific learning occurrence.

Another methodology based on the use of experiments is **the activity of physical knowledge**. In this case, Padilha and Carvalho (2005, 2007) and Monteiro and Teixeira (2007) discuss the four procedural steps for the insertion of this methodology in the children's context: i) Knowing the object: understanding how the object reacts to different manipulations; ii) Acting on the object: performing various actions on the object in order to achieve the desired effect; iii) Being Aware of the actions: describing the action on the object and iv) Establishing causal relations: giving explanations that answer because the object had certain effect after the accomplishment of certain actions. For this methodological strategy development, Monteiro and Teixeira (2007) emphasize that "if the activity does not offer different possibilities of interaction between students and the object of knowledge, they will not have evidence to construct arguments and/or refutations about the phenomenon studied" (p.81).

In the aforementioned context, the authors used Piaget's theory as a foundation. Its main assumption is the period of individuals' mental development. Moreira (1999) argues that: "Piaget distinguishes four general periods of cognitive development: sensorimotor, preoperative, operational-concrete, operational-formal. Each of these periods, in turn, is subdivided into stages or levels" (p.96). In order to analyze the context of Physics teaching for children, we highlight the importance of the characteristics of the subjects in the preoperative periods (approximate age range: two to six years) and operational-concrete (approximate age range: seven to twelve years).

One of the characteristics of the preoperative period is that the child begins to make use of language, symbols and mental images, essential factors for the development of learning scientific concepts. Another important characteristic is that the child's thinking begins to organize, however, it is not reversible. In addition, the child attention "turns to the most attractive aspects of events and their conclusions are also more attractive in percentage [...] their explanations are given in function of their experiences, and may or may not be consistent with the reality" (Ibid., p.97). The cited characteristics are essential for planning the teaching practice for Physics teaching for children. For example, the possibility of using scientific activities as a resource to stimulate the development and use of children's language, symbols and mental images is emphasized. As well as selecting strategies and didactic resources that attract children to interact with scientific concepts and give explanations for such phenomena (even if they are not scientifically correct).

In the operational-concrete period, the child's thinking "has characteristics of a logic of reversible operations" (Ibid., p.98). In addition, their operations are concrete, that is, they depend on interaction with real objects, and then go towards the absent. These characteristics also have implications for the Physics teaching in children's context: in this period it is possible, for example, approach real physical concepts that depend on more than one variable – since their thinking is reversible. In addition, it is already possible to stimulate the child to elaborate hypotheses and explanations when in contact with a concrete physical phenomenon (an experiment, for example).

Another methodological possibility for experimental activities is to relate them to children's everyday knowledge. Thus, Gehlen, Auth and Albrecht (2005) and Rosa, Rosa and Pecatti (2007) point out that it is essential to analyze physical phenomena from their identification in everyday situations, since there is the rescue of children's prior knowledge as it makes possible the proposition of questions. Experimental activity is important because it enables children to interact with phenomena in a practical way, develop the ability to manipulate laboratory instruments, develop hypotheses, and solve problems.

The experiments are also addressed in the Three Pedagogical Moments methodology. Thus, Gomes and Dickman (2007) and Moro (2013) are based on the studies of Delizoicov, Angotti and Pernambuco (2007) to discuss the phases of such didactic methodology. The first phase is called initial problematization and its function is to present real questions or situations known and experienced by the students. The second phase is called the organization of knowledge, from which research and study (from experiments, for example) of specific concepts to understand the topic discussed in the initial problematization takes place – under the guidance of the responsible teacher. Finally, the last step is the application of knowledge, whose objective is to use systematized knowledge to analyze and interpret the initial situations, as well as other phenomena related to the scientific concepts learned.

Experimentation is also inserted in the context of interdisciplinarity. In this case, Pauli (2015) uses an interdisciplinary methodology to insert physical concepts in Elementary School. The researcher approaches Physics concepts in soccer, from a sequence of Didactic Activities based on **experimentation, problem solving, reading and use of simulations**. Varela (2016), on turn, deals with the interdisciplinarity between Physics and Biology for teaching and learning concepts related to vision, from a didactic sequence based on educational resources such as **experiments, poster, mockups and videos** to approach the knowledge of the two curricular components.

The Science Fair is also a didactic strategy used for the insertion of experimental activities for children. Thus, for the preparation of such activity, Boss, Mianutti, Souza Filho and Caluzi (2008) and Boss, Souza Filho, Mianutti and Caluzi (2010) used the following methodological procedures: i) Initial discussion about the activity and concepts addressed, in order to verify and systematize the children's prior knowledge, to promote motivation for participation, discussion of safety rules, etc. ii) Carrying out experiments in groups, based on a script with a problem situation; as well as space for registration of the solution, explanations and design of the experiment, and iii) Final discussion with all groups on the experiments performed and presentations.

Thus, in the context of the use of experimental activities for children, we highlight the occurrence of eight methodological possibilities: demonstration, research-based experiments, experiments from teaching by projects, experimental activities with focus on physical knowledge, experimental investigations for daily phenomena study, use of experiments in the Three Pedagogical Moments, development of experiments in interdisciplinary activities and conducting experiments in Science Fair. In this sense, we emphasize the importance of experimental activities beyond the familiarization of children with academic work in the laboratory. That is, it is essential that the ludic and intuitive character be part of such practice. In this way, the accomplishment of experiments with children will go beyond the (usually mechanical) learning of physical concepts, allowing the contemplation of scientific literacy knowledge and personal skills improvement, such as autonomy, creativity, decision making, work in groups etc.

Besides the experiments, other didactic resources are cited and used in Physics teaching for children. In this context, Lima and Carvalho (2002, 2003) present a methodology from the individual **reading** of **children's books**, group discussion and resolution of **reasoning exercises** (similar to open problems), presentation of the synthesis discussed in group and individual reporting (writing or drawing) of the activity. This methodology can be used to "teach Physics topics to students of the initial schooling series as a complement to the experiments traditionally employed" (Lima & Carvalho, 2002, p.82).

The potential of **reading** for Physics teaching is also explored by Montenegro and Almeida (2004), who discuss the experiences of reading and interpreting portions of Faraday's diary for the understanding of electromagnetic induction. The authors point out that from this activity the students felt motivated and understood the *historical construction* of scientific development. In this perspective, Assis, Assis and Campos (2008) also used a reading, however, of **para-didactic** texts for the insertion of Physics teaching in the Elementary School Final Years. The authors emphasize the importance of reading, as well as open spaces for discussion and reflection on the physical concepts involved.

Still in the context of reading, the use of **comics** is discussed by Soares and Furtado (2009) as didactic strategy for the Physics teaching for children. According to the authors, such use by Elementary School students constitutes a differentiated approach, since "it can play an important role in the explanation of certain natural phenomena of everyday life" (p.3), because it brings a language and a presentation that approach to learning ludic character, making activity more enjoyable.

From this perspective, an alternative to reading texts is **storytelling**. Such a didactic resource is used by Damasio (2007) and Damasio and Steffani (2008) for the contextualization of physical phenomena and the history of science. In this sense, it is important to make explicit the level of attention and interest aroused in children (especially those in Early Childhood Education and Elementary School Early Years) when they participate in **ludic activities** such as storytelling. Therefore, Jango et al. (2011) affirm the potential of such didactic resources, when verifying that "the child, when fascinated by the ludic nature of a proposed activity, is highly stimulated to apprehend it and is not intimidated by the need to explain it" (p.3). In addition, children "calmly accept arguments contained in fables or fantasies" (Lopes, Tavares, Ustra & Ustra, 2015, p.2). In this way, the motivation for scientific learning is made possible.

Another recurring recreational resource in the context of Physics teaching for children is the board and/or digital **game**. In this perspective, Melo (2011) emphasizes that the use of this didactic resource for the teaching and learning of physical concepts allows "to the students a moment of involvement and collective work, trying to overcome the individualism perceived through a ludic moment" (p.68). In addition, the inclusion of games in the school context provides a "pleasant and enthusiastic atmosphere, in which the student has assumed the main role in the teaching-learning process, being the key element and the teacher, an advisor of activities" (p.69).

The **new information and communication technologies** (internet, videos, simulations, modeling, etc.) are also used as didactic resources for the Physics teaching-learning process for children (Ferreira, 2005; Oliveira, 2011; Pauli, 2015). The researchers argue that such tools bring scientific concepts to everyday life of the native digital[5] student, enable interaction with content as well as visual stimulation.

Based on what we have presented so far, it is possible to infer some results regarding the methodologies, didactic resources and theoretical basis explored in the children's context to enable Physics teaching. Initially, it is emphasized that didactic methodologies, in general, distanced themselves from the so-called traditional methodologies. That is, for Physics teaching in children's context, teachers sought innovative and diversified methodologies, from which the students could develop their active participation, their autonomy, the interaction with the physical concept addressed and with the other subjects. A similar result occurred in relation to the use of didactic resources: despite the predominance of the use of the experiment, the possibilities and potentialities of different didactic materials were cataloged to enable the insertion of scientific concepts for children. Finally, in relation to the theoretical framework, we highlight the predominance of works based on Piaget, Vygotsky and Ausubel theories, which have implications for Physics teaching in the context of children and in later school years.

FINAL CONSIDERATIONS

From the bibliographic survey presented in this article, it was possible to make some reflections and discussions about Physics teaching in children's context. It is in the child's nature to be curious, therefore, teachers and mediators can use this characteristic, in order

[5] Term created by Marc Prensky.

to make possible the interest and taste for science, the development of the subjects, as well as the beginning of the process of scientific literacy.

As a result, we emphasize that in relation to the education level, there is the possibility of insertion of Physics/Science teaching from the age of 3, in context of both formal and non-formal education, provided that scientific activities are appropriate to the children's age group and whose main objective is to motivate the subjects' interest in scientific content. Regarding the content, it is possible that children interact with scientific activities in the different areas of Physics, despite the predominance of activities for teaching and learning in Mechanics, Fluids and Astronomy. Finally, regarding methodology, didactic resources and theoretical framework, we highlight the occurrence of experimental and ludic activities based, predominantly, on Piaget, Vygotsky and Ausubel theories.

We emphasize that there are several possibilities for scientific concepts to be addressed with children. However, any didactic activity that exploits such concepts in the children's context must be properly adapted to age, daily life and specificity. In addition, it is essential to use didactic resources that allow the subjects' interaction with the concepts in question, as well as the development of their autonomy and broad training.

Thus, it is expected that this article will be useful to offer teachers and mediators an initial and general discussion about Physics teaching for children, as well as some paths that can be traced by those who wish to dare and insert scientific content in their teaching practices with kids.

As a work perspective, after this bibliographical survey, we intend to analyze in depth the way children interact with scientific concepts in formal and non-formal learning spaces. In addition, we aim to explore the use of ludic resources, such as toys, games and storytelling, in order to develop strategies for teaching and learning Physics for children.

AUTHORS CONTRIBUTIONS STATEMENTS

LFM supervised the research. LFM and RCMS conceived of the present idea. LFM and RCMS developed the theory and methodology. RCM implemented the methodology, realized the bibliographic review, collected the data and organized the categories. LFM and RCMS realized the discussion of results and wrote the final version of the paper. LFM wrote the English version of the paper.

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