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Educación y Robótica Educativa

Education and Educative Robotics

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Abstract
Educative Robotics (ER) enhances the quality science learning in a playful way and so improves student interest on technology, creative activities and interdisciplinary abilities in problem solving. ER has become a reality in different schools around the world at different education levels. This process, which started with the research development within universities, has made it possible for schools of all educational levels to use robotic to diversifying the process of knowledge construction. In Brazil, through the means of programs of introduction to information and communication technologies, ER has gradually been introduced in both private and public schools. This paper discusses the process of using robotic in elementary school (first nine years of education) in public institutions in which students and teachers have learned how to use the technology and how to integrate it in the school curriculum.

Keywords
Educative Robotics, Elementary School, Technologies in Education.

Resumen
Robótica Educativa (RE) mejora la calidad del aprendizaje de las ciencias de una manera lúdica y así mejora el interés de los estudiantes por la tecnología, las actividades creativas y las habilidades interdisciplinarias en la resolución de problemas. RE se ha convertido en una realidad en diferentes escuelas alrededor del mundo en diferentes niveles de educación. Este proceso, iniciado con el desarrollo de la investigación dentro de las universidades, ha permitido que las escuelas de todos los niveles educativos utilicen la robótica para diversificar el proceso de construcción del conocimiento. En Brasil, a través de los programas de introducción a las tecnologías de la información y la comunicación, se ha introducido gradualmente en las escuelas públicas y privadas. Este artículo analiza el proceso de uso de robótica en la escuela primaria (primeros nueve años de educación) en instituciones públicas en las que los estudiantes y profesores han aprendido a usar la tecnología y cómo integrarla en el currículo escolar.

Palabras clave
Robótica Educativa, Escuela Primaria, Tecnologías en Educación.

1. Introduction

The use of computer controlled robotics devices, or machines controlled by digital technologies, with educational ends is a line of research related to the Educative Robotics(ER) area which has been in crescent growth over the last 3 decades, at least. However, the idea of controlling "robotics" devices which can contribute to the process of carrying out tasks goes back to old age. It came up, for the first time, in Ancient Greece associated to myths of mechanisms that gained life. Noel Sharkey, a British contemporary computer scientist, professor of robotics and artificial intelligence at the University of Sheffield, in England, researched on the origin of the robots and has surprised us with his scientific discoveries. The first automata - machine operated by mechanical or pneumatic means -, dated from the 1st Century A.C, was developed by Heron of Alexandria. There was a "programming" which put into action the cards (strings), that were rolled up in a determined sequence (here we have the early eras of modern programming) around the axis of the front wheels. The role played by wheels was to help in the control of the driving force: at the back of the automata (robot), the string which was wrapped around the axis was tied to a weight. This weight, in turn, was at the top of a tube full of wheat grains. The tube contained a hole through which the wheat grains dropped little by little: Thus, as the weight lowered, it made the axis turn, consequently, the entire robot dislocated itself (LOPES, 2009).

Leonardo da Vinci (1452-1519), on his path of multiple discoveries through his study of the human anatomy, produced advanced inventions equipped with mechanic articulations, deriving, thereof, various inventions, the most known being the "Mechanical Lion", a sketch left by him that was reconstructed 500 years later proved to be able to move head, jaw, tail as well as the whole body.

With the industrial revolution in the 1700's, mechanized work came up: weaving machines for use in industrial textiles, the compass, gun powder which allowed great navigations and the destruction of fortresses feudal castles (ARANHA, 1990). In the 1800's, due to the growing intervention of scientific advances, the manufacturing system of production turned into industry based on machines and the production force stops being exclusively a human force. Man becomes an appendix or accessory of the machine (D'ABREU, 1994). In 1922, the word robot was used for the first time in a theater play created by a Czech named Karnel Capek, but, according to literature, the term might have been coined by Joseph Capek (the brother of the theater man). Finally, in 1942, for the first time the term "robotics" comes up in the world brought by the scientist and writer Isaac Asimov. Since then, it is noted that machines have substituted tasks carried out by man which involve us, voluntary or involuntary, each time more, in the world of the robotics. Therefore, this robotics which is involved in the different means of production has also been penetrating in schools, in the form of educational technology in all levels of schooling.

That makes school the space of the digital technology insertion, which transforms itself into cultural artifacts of our time, with which teachers and students, alike, cannot leave aside (FARIA, 2016). This paper discusses the process of the insertion of educative robotics in the spheres of the elementary education (first nine years of schooling) which would be the likes of the primary secondary school in Peru. The paper discuss the context

of the educational use of the information and communication technologies (ICT's) in a public school in Campinas, a city in Sao Paulo state, in Brazil, where teachers and students have been part of a project of integrating educative robotics (ER) to the curriculum as a tool to help the learning of concepts in multiple subjects.

The paper is, thus, organized as follows: in section 1, introduction, a historic overview of the robotics is presented leading to (the) Educative Robotics(ER). In section 2, the Educative Robotics(ER) is discussed from the conceptual point of view. In section 3, a brief discussion on the curriculum in the context of Educative Robotics is presented. In section 4, the process of implementing Educative Robotics in a public school is presented. The section 5 deals with the results discussion. And, finally, in the section 6, we present the conclusions.

2. Educative Robotics (ER)

Educative Robotics (ER) may be understood as a process of interaction between an environment, a mechanical electro-mechanical robotic device that, as a rule of thumb, may have sensors which capture information from the environment to the device which change the environment according to the commands of the device as a way of favoring the cognitive processes. Educative Robotics can also be considered as an environment in which the learning process occurs in a growing spiral cycle (RESNICK, 2007). This cycle may occur in the form of projects that involve conception, implementation, construction and automation control of the robotic devices using digital technologies (D'ABREU et al, 2010, 2012, 2016). Once inserted into this process, the student, on each construction of a new robotic device, re-elaborates the previously acquired knowledge and improves it, so the "spiral" is traversed at a superior level, thus allowing for a broaden learning of much more dense scientific concepts. Finally, Educative Robotics (ER) is an environment which can enable a teacher to stimulate the students to reflect upon their own ideas, encouraging them to compare these ideas with the scientific knew knowledge accepted, and to seek to establish the link between these two types of knowledge (JÓFILI, 2002).

This article is also in line with other references that may be cited as: the experience of Maia et al (2009) whose objective is to provide an environment for open source programming by using robotics in education that help students to improve their learning of programming languages software engineering disciplines through a study case using the Lego Mindstorms Educational Kit. Ribeiro et al (2011) proposes a methodology to conduct studies that provide an answer to those questions.

Our proposal has two distinct components: (i) the planning of a set of ER sessions to conduct with the students; (ii) the validation instruments to apply, for quantitative and qualitative evaluation of ER as a pedagogical tool. An example is provided for subjects related to the concepts of multiplication/ division in 4th grade Mathematics. Vollmer et al (2011) present the article in order to enhance the impact factor, the integration of "multipliers", in particular the "educators" in elementary schools, middle schools and high schools - even in the kindergarten - is an important task. They describe a concept

for training teachers on how to implement robotics curriculum into today's classrooms which is currently under development at the University of Stuttgart and the Technische Universität Berlin. Cho (2011) explores ways of introducing hands-on robotic activities not only in extra-curricular programs but also in formal curricula, such as Math, Natural Sciences, Languages and Arts. In this sense, it is also worth highlighting RE activities that in Portuguese we call "mão na massa" in which students learn by doing, or in situations that allow not only knowing the name of things, but also their usefulness and limitations. That is, learning by doing (TRINIDAD, et al, 2015)

The Educative Robotics enhances the quality science learning in a playful way, and so improves student interest on technology, creative activities and interdisciplinary abilities in problem solving (TRENTIN et al, 2013).

Zapata (2015) in his article Computational Thinking: A new Digital Literacy, ponders in its approach to the Sinética theory, that through the understanding of emotional elements of a problem or an idea, a group can be more successful in solving a Problem, emphasizing there, the importance of creative behavior, in reducing the inhibition, and liberation of the creativity inherent to the individuals in the process of group interaction. What we perceive, in RE term of use, this also happens, as the process of conception, implementation, construction, automation and control of robotic devices, involves this delivery and opening of the students for interaction with the technology. In this context, computational thinking is evident in its most expressive form. In this case, as well as in computational thinking, based on scientific ideas, we perceive the RE making it possible to create learning situations to solve a certain problem in a systematic, safe and fun way. This also meets Wing (2006) definition of computational thinking as something that involves problem solving and system design based on fundamental concepts of computer science, as well as the reformulation of a seemingly difficult problem in one whose solution it's known.

Based on these definitions, the conclusion is that Educative Robotics (ER) is an environment of learning in which we reconcile the concrete and the abstract in problem solving tasks which solution may require knowledge from diverse scientific areas. That is, in the school context, depending on the project to be developed, it may end up in valuable pedagogical gains as much as in broadening the horizons of the possibilities of the tools resources (available) to develop teaching and learning.

In the Brazilian context, based on the ideas of Papert (1985), the activities in the area of Educative Robotics (ER) started in 1987, at the Nucleus (center) of Information Applied to Education-NIED, at University of Campinas (Unicamp), in Campinas (SP), together with the learning of the programming language LOGO. To Papert (1994), an ER environment should bring up, in the context of school learning teaching, powerful technological ideas that allow kids to appropriating themselves of such ideas. In that manner, at NIED, it was sought to develop ER in a context that presupposed the existence of a teacher, student and the tools which allowed assembling, automation and control of robotic devices. Or rather, students and teachers interacting and producing new knowledge (D'ABREU et al, 2012). At NIED, the first projects directed at the use of the

computer to control robotic devices were the Educational Chart and the Soil Mechanical Turtle that, when equipped with a pen, reproduced on paper or on the ground, respectively, the movements of a virtual turtle from the computer screen. These devices were built from a mixture of commercial standard of alternative materials ("scrap" metal). With the upcoming of the first kits of the LEGO Technic, which had electric components (such as engine, sensor light) that could be controlled by a computer, NIED developed the LEGO-Logo environment. This environment consists of a set of LEGO components that allows the assembly of automated mechanical devices and a set of programming language commands Logo.

In 1989, NIED carried out the first workshop of Educative Robotics (ER), conducted by a researcher from the Massachusetts Institute of Technology (MIT), with the aim of qualifying the researchers at the center to enable them to use robotics in the educational context. Since then, the activities in ER area at the center have been carried out associating research and teacher training. An example of the teacher training in ER area involved developing activities in teacher training at Centers of Informatics in Education (CIED's) around the Brazil. At this occasion, through an agreement signed with the Danish Company LEGO, NIED carried out actions to implant ER in some strategic regions of the country.

Therefore, originally at NIED and today developed throughout other institutions of learning research, both public and private, ER has become a reality incorporated as a pedagogic practice in many schools in Brazil.

For a school to develop activities in this area it is necessary to provide conditions for its implementation, such as investments in teacher training, creating proper space for the development of such activities as well as the acquisition of the necessary material: assembling kits, basic electronic components, the acquisition of specific software for the ER area, among other requirements (VENANCIO, et al, 2013; D'ABREU et al, 2012).

In this sense, we present and discuss in this article the specific work, the use of the ER integrated into the curriculum developed in a Brazilian public school involving teachers, students in fifth grade (classes A and B) - in average, there were 25 students per room-, and a group of 10 monitors. The monitors were students of different age groups, who during the period they were not having classes helped the teachers in the tasks of appropriating the use of computers in the class. Next, we present is a brief discussion on the curriculum with focus in the ER.

3. Brief discussion on the curriculum in the context of Educative Robotics

School curriculum is constituted by school subjects which in their origin have a resemblance with subjects of scientific nature, also known as subjects of reference. To exemplify, we can cite Mathematics, Biology, Chemistry, History and Geography as scientific subjects. School curriculum has in these subjects its main reference as regards to concepts taught to kids in elementary education. The curriculum is made from choices, but also from practices that underlie them, implicit or explicitly, presumptive, formal or problematical.

To Lopes and Machado (2011), curriculum refers to cultural production which is part of the struggle for the production of meaning, legitimatizing itself. To Silva (2000), besides the question of knowledge, curriculum also brings along the question of identity and subjectivity. At the early stages of the introduction of Robotics in Education this was worked on more at a technical context than pedagogical. In this manner, the approach to robotics in courses such as Electromechanical Engineer as well as Mechatronics Engineering, it ended up having a great acceptance for showing itself useful towards learning the theories studied in these courses. However, when robotics went beyond the limits of the universities and began to be taught in secondary schools, teachers found it difficult to adapt it to the contents of the school curriculums. That happened in many schools, but especially in the private schools, robotics was introduced as an extracurricular activity to a few students, mostly during the second shift or after classes and usually taught by technicians in science information instead of teachers from the respective curriculum components. Zilli (2004), in his master's degree dissertation, analyses the use of ER in fundamental education schools from 6th to 9th grade in Curitiba, Parana state of Brazil, as a pedagogical resource. The research results indicate that the technology in question is still a challenge to the school reality, in regard to its implementation in the school curriculum. Campos (2011), whose work sought to identify the characteristics (native) of the integration of robotics as a technological resource in the curriculum, shows that this integration poses complex aspects such as the time-space relation and the unpreparedness of the pedagogical team to deal with the relationship between robotics and the areas of knowledge. That is, a project of the integration of robotics as a technology to the curriculum needs to take into account, in a much broader sense, also the knowledge referring to robotics as well as to technology, with the aim of allowing the learners-students to establish a much more complex relation with technology on his own process of learning. Therefore, the challenge to integrate robotics to the curriculum persists; there is a need for a qualifying process of training teachers towards the complexities that come up in using ER. Another similar experience that we described in this article, even developed in another Latin America country, Uruguay, is the application of RE as a resource for the integration of technology in education. In this country, the experience that began with the use of the home computer in education, reached the model of one computer per student and later the stage in which they are analyzing the use of RE as a way of working to support the development of computational thinking in children and young people in general education, in addition to programming, and professional guidelines for those involved in the future (Garcia, 2015).

In Brazil, the discussion about the diffusion and implantation of computational thinking in basic education is now beginning in the academic and scientific circles. In the following section we discuss the process implementation of ER in a public school in Brazil.

4. Implementing Educative Robotics (ER) in school

From the point of view of implementation of robotics in school, the study/paper presented here refers to an extract which seeks to explain, in a brief manner, the process that was developed or carried out, in a Brazilian public elementary school, in which the teachers training of robotics use in classes took place first, and then, after that, the use of

robotics by those teachers and their students was implemented in the classrooms. In this context, the research developed had the objective of training teachers to use pedagogic robotics integrated into the curriculum. It was, therefore, an educational research-action in which we sought to help those teachers to improve their teaching skills with ER and, as a result, collaborating to the learning of their students. (Tripp, 2005). The methodology used focused on qualitative research, using as instruments for data collection filming, photographs and written reports. The school in question is ELZA MARIA PELLEGRINI DE AGUIAR, a public school of Elementary Education, in Campinas, a city in São Paulo state, Brazil. The teacher training process was divided in two distinct phases.

4.1-First phase

The first phase was subdivided into two steps, which will briefly be described next.

4.1.1- Step 1: Carrying out pilot workshops by the university researchers to all teachers of the school administration.

This step took five months. During this period, initial interactions with the school were carried out, through demo pilot workshops, video presentations, lectures and discussions with the aim of raising awareness in the school to the use of the ER. What we sought was, in fact, to find a voluntary among the teachers who was interested in working with robotics. At this step, the school administration invited not only 10 teachers but also some student monitors to take part. The student monitors were of different age groups, who, during the time out of classes helped the teachers in the task of assimilating the use of computers in the classroom. With the group formed by teachers student monitors the workshops have started. They consisted of two hours weekly workshops, carried out in the information technology labs of the school.

The workshops were on:

1- Conception and construction of robotic devices;
2- Programs elaboration using the programming language SCRATCH;
3- Teaching of the basic principles of controlling electronic components via computer;
4- Teaching mechanics principles of the machines which are of ordinary daily use to people.

Along with this process, teachers and student monitors showed themselves extremely receptive and engaged in implementing ER in the school. However, at the end of the process, only two teachers from the fifth grade remained effectively interested in working with robotics and it was by these two professionals that the activities were carried out.

4.1.2Step 2: Carrying out the workshops in the classroom with the groups of students from fifth grade (A and B)

This step took eight months. The activities were first carried out with the teacher of the fifth grade of group A and her students. Then after, with the teacher of the fifth

grade of the group B and her students. Both groups had an average of 25 students each. The workshop at this stage also had two hours of duration, which were carried out weekly in the classrooms by the university researchers with the participation of all students of the class along with their teacher. The students (of each class) were divided in groups in a manner that permitted them to have access to all activities of the ER environment (conception, construction, automation, programming control of the robotic devices). During the performance of this step, for each workshop taught, the teachers and the students had, as homework, to elaborate a personal report of what had been worked on that day. In short, the first phase of the teacher and students training process, with the aim of integrating ER to the curriculum, was much more of systematic acting of the university researchers in that school, together with teachers and students, seeking to create conditions that would allow the realization of the second phase, in sequence.

At this stage, different robotic devices were developed and the implementation process allowed to work concepts inherent to the curriculum. Among these devices developed stands out a "robot car" used to teach concepts of Units of Measure. To construct the "robot car" mechanical parts were used to assemble chassis, wheel and two motors. It was a robust structure that could be handled by students without being easily disassembled.

4.2 Second phase

The second phase consisted of the preparation of the teachers to carry out, autonomously, the regular ER activities integrated to the curriculum without the systematic presence of the university researchers at the school. However, although the researchers were not constantly present physically at the school as had happened during the first phase, a permanent channel of virtual communication between them and the teachers was established. The discussion orientations as regards to the development of the activities was fundamentally carried out via e-mails. At this stage, sporadic visits of researchers to the schools were carried out in situations that involved more complex actions such as changing the operating system for controlling of the electronic interface of the robotic kits, teaching of the use of new electronic components, carrying out meetings called up by the school on by the project activities. For this phase, basic support material was elaborated to describe in detail the inputs and outputs of the electronic interface that control the electronic components via computer. This support material contains examples such as designs, motor engine connections, sensors bulbs at the electronic interface, example of programs in Scratch for activating the control of the components, among others, which could help the teacher to solve eventual problems of technical-pedagogical order during the class. Besides that, still with the aim of preparing the teachers to work on their own, some further meetings were carried out at the school which helped to update the contents which had been worked on up to then.

5. Results discussion

The "robot car" constructed at the school served to study Units of Measure, a curricular content that was being worked on at that time. The mediator object "robot car" enabled the students to formulate problems related to the study of the concepts of space, time, speed, distance and power, inherent to the movements of a car. The evidence of this

is in the nature of the problems formulated by the students, whose statements evoked the use of the four mathematical operations: addition, subtraction, multiplication and division, and, moreover, complex mathematical percentages and formulations that could only be proven from an experimental point of view. That is, manipulating such concepts through the object they have built "the robot car". One of the problems formulated by the students had to do with calculating the engine power, a mathematical abstraction involving, for example, the electric current (in Ampere) and the motor supply voltage (in Volts). This type of mathematical formulation had not yet been taught at the school to these students, however, using the "robot car" helped to experimentally understand this concept, as the "robot car" moved faster or slower depending on the variation of its power in the Scratch program. What was important in this case was to understand the 'Pedagogical Robotics' mediation role by enabling the student to explain and test their scholastic knowledge. Space, time, speed, distance, power, percentage, for each of these scientific concepts there is a Unit of Measure (e.g. hours in relation to time, meters in relation to space; watts in relation to power, etc.).

When the training activities started, teachers and students alike had no understanding of the ER environment as a whole, that it would involve conception, construction, automation/programming or automated control of the robot. The tendency was to build something isolated and then only realizing how that did not work at the time they integrated the isolated parts and activated them. The lack of functioning of the robots, in some cases, was important because it involved/required testing/debugging the device under construction the software which was used to control it. In most cases, it was noted that the failure/mistake was in both. So, the testing/debugging process consisted of an action of high relevance as it permitted to resort different strategic abilities to solve what was wrong. During the process of training teachers as well as students, they showed themselves extremely receptive and engaged in implementing ER in school. In short, the methodology carried out in this training process consisted of realizing pilot workshops, video presentations, lectures discussions, motivating teachers, students and the school administration to engage in activities, the training two teachers, and, finally, follow up of the activities at the school by the university researchers on site and virtually.

6. Conclusions

We presented in this study a brief overview of the use of robotics as a learning tool, from its upcoming through the development of robotics in Brazil until its insertion in schools. However, its implementation is still an ongoing process. The different understandings of the Educative Robotics (ER) that denote how diverse this interdisciplinary area may be perceived were described. The use of robotics in the fundamental school curriculum (first nine years of schooling) allows curriculum contents to be taught in practical manners, arousing curiosity and promoting a scientific methodology of construction of knowledge by students, having in mind that the knowledge acquired at this level of school shall be useful for the whole life. For the training activities, it was necessary to, firstly, carry out introductory workshops to teachers, students and school administration. Secondly, it was offered training to teachers interested in working with this theme; thirdly, we carried out workshops with the

teachers inside the classroom. Fourthly, it was offered virtual follow up sections with teachers to discuss the progress of project, by the university researchers, via e-mail.

With the methodology described in this paper, we implemented a project which objective was the training of teachers for acquiring knowledge in robotics as a resource integrated to the curriculum in the sphere of the use of ICT's in education. It is worth pointing out the fact that the teachers, after acquiring knowledge in the ER, tend to become more autonomous in working with their students without the need of the presence of the university researchers. That, in a way, is perceived as a guarantee of the continuity of the robotics activities at the school. The activities developed at the school had as consequence two interesting facts worth highlighting: the first is the student's participation, presenting projects in academic events in the area. This was an important moment for the school which could show itself to the public presenting something different from the traditional use of ICT's. Second, with the repercussion of the robotics project in the school within the community, the school administration has found more power to raising resources for the acquisition of the material needed to carry out robotics activities at the school. Up to that time, they had been relying on the material lent by the university.

In summary, this article has presented the process of implementing a project for the educational use of ICT's in a public school in Brazil. The activities involved the construction of a robotic device using digital technologies and through this process the students have built up knowledge on concepts of space, time, speed, distance and power, inherent to the movements of a car. At the school, the systematization of knowledge occurred through the curriculum. In order to work on this curriculum, as a way of social construction of knowledge, the research carried out demonstrated that training teachers is a necessary step.

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References

Aranha, M. L.(1990). *A História da Educação*. Editora Moderna, São Paulo.

Campos, F.R. (2011). *Currículo, Tecnologias e Robótica na Educação*. Tese de Doutorado, Pontifícia Universidade Católica de São Paulo – PUCSP, São Paulo.

D'Abreu, J.V.V. (1994). *Construção de um Traçador Gráfico para fins educacionais*. Dissertação de Mestrado. Faculdade de Engenharia Elétrica e de Computação da Universidade Estadual de Campinas Educação, FEEC-UNICAMP, Campinas, São Paulo,187.

D'Abreu, J.V.V. e Garcia, M.F. (2010). *Robótica Pedagógica e Currículo.* In: Workshop de Robótica Educacional WRE, São Bernardo do Campo.Anais de Joint Conference 2010 - SBIA-SBRN-JRI, Workshops. 01 – 06.

D'Abreu, J.V.V, Bastos, B.L e Giachetto, G. F. A. (2012). *Educational Robotics in One Laptop per Student-UCA Project*. In: Constructionism 2012_proceedings. v.01. Athenas.575 – 579.

D'Abreu, J.V.V.e Garcia, M. F. (2016). *Robótica Pedagógica no Currículo Escolar: Uma Experiência de Transposição Didática*. In: IV Conferência Ibérica Inovação na Educação com TIC. De Facto Editores, v.01, Bragança. 83 – 97.

Faria, A. (2016). Sentido(s) Emergente*(s) das Tecnologias Digitais no Jardim de Infância*. In: Silva, S., Monteiro, A., Moreira J. A (Orgs). Ensinar e Aprender com Tecnologias na Era Digital Um Script de aportes teórico-práticos. Editora. Whitebooks, Santo Tirso.

García, M. J. (2015) *Robótica Educativa. La programación como parte de un proceso educativo.* RED. Revista de Educación a Distancia. Número 46, setembro de 2015. DOI: 10.6018/red/46/5. Retrieved on 06/21/2017. http://www.um.es/ead/red/46/garcia.pdf

Hye-Kyung Cho (2011) *On the Use of Robot-Enhanced Learning Activities across Formal and Informal K-12 Curricula*. In: 11th International Conference on Control, Automation and Systems Oct. 26-29, 2011 in KINTEX, Gyeonggi-do, Korea. Retrieved on 06/11/2017 http://ieeexplore.ieee.org/document/6106315/?reload=true

Jófili,Z. (2002). *Piaget, Vygotsky, Freire e a Construção do Conhecimento na Escola*. In: Educação: Teorias e Práticas, Ano 2, nº, dezembro de 2002. Rio de Janeiro.

Lopes, R. J. (2009). *Robô da Grécia Antiga era movido a trigo*. http://roboticagrupo4.blogspot.com.br/2009/05/historia-da-robotica.html (Acessado em 10/03/2016).

Lopes, A.C. e Macedo, E. (2011). *Teorias de Currículo*. Editora Cortez. São Paulo. 95-96.

Maia, O. D. L et al (2009) *An experience to use Robotics to improve Computer Science Learning*. In: 39th ASEE/IEEE Frontiers in Education Conference. Retrieved on 06/11/2017
http://ieeexplore.ieee.org/document/5350417/

Papert, S. (1994). *A Máquina das Crianças: Repenso a Escola na Era da Informática*. Porto Alegre, Artes Médicas, Rio Grande do Sul.

Papert, S. (1985). *Logo: Computadores e Educação*. Editora Brasiliense, São Paulo.

Resnick, M. (2007). *All I Really need to know(about creative thinking) I Learned (by studying how children learn) in kindergarten*. In: Proceedings of the 2007 ConferenceonCreativityCognition. 1-6, Washington DC.

Ribeiro, et al (2011). *A Proposal for the Evaluation of Educational Robotics in Basic Schools*. Retrieved on 06/11/2017
https://www.researchgate.net/publication/268188460_28_-

Silva, T.T. (2000). *Documentos de Identidade: Uma Introdução às Teorias do Currículo*. Editora Autêntica, Belo Horizonte.

Trentin M.A.S, Pérez CAS e Teixeira, A.C. (2013). *A robótica livre no auxílio da aprendizagem do movimento retilíneo*. In: XIX Workshop de Informática na Educação (WIE), .51-59, Campinas, São Paulo.

Trinidad, G. Aguirre. A, et al (2015). *Sensores Tortuga 2.0: Cómo el hardware y software abiertos pueden empoderar a las comunidades de aprendizaje*. RED. Revista de Educación a Distancia. Número 46, setembro de 2015.
DOI: 10.6018/red/46/5. Retrieved on 06/21/2017.
http://www.um.es/ead/red/46/guzman_et_al.pdf

Tripp. D. (2005). *Pesquisa-ação: uma introdução metodológica*. In: Educação e Pesquisa, v. 31, n. 3, 443-466. São Paulo.

Venancio, V, Irene K. e Lopes, R.D. (2013). *Reflexões sobre interdisciplinaridade e multidisciplinaridade na formação de professores em ambiente de m-learninng*. In: Workshop do Congresso Brasileiro de Informática na Educação (WCBIE). Campinas, 582-591, São Paulo.

Vollmer et al (2011). *Teachers need robotics-training, too*. In Springer-Verlag Berlin Heidelberg. Retrieved on 06/11/2017.
https://link.springer.com/chapter/10.1007/978-3-642-16208-4_32

Zapata, M. R. (2015) *Pensamiento Computacional: Uma nueva alfabetización digital*. RED. Revista de Educación a Distancia. Número 46, setembro de 2015. DOI: 10.6018/red/46/5. Retrieved on 06/21/2017 http://www.um.es/ead/red/46/zapata.pdf

Zilli, S.R. (2004). *A Robótica Educacional no Ensino Fundamental: Perspectivas e Prática*. Dissertação de Mestrado Programa de Pós-Graduação em Engenharia de Produção da Universidade Federal de Santa Catarina, UFSC, Florianópolis (SC).

Wing, M. J. (2006) *Computational thinking*. Communications of the ACM, 33-35, vol. 49, no. 3.