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Educational Robotics: Robotics from fantasy medium to medium for fantasy

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Educational Technologies can be used both as mediators for didactic activities in different specific contexts, and as self-sustaining tools in various settings, acquiring a relevant role in competence building and in developing an attitude to a scientific approach.
In this contribution we propose a systematic overview of theorical assumptions in order to activate some Robotic experiences and didactic paths in which students act as researchers, continuously discovering and verifying if their intuitions are valid. Robotics shows a fantasy dimension which motivate the students and engage them in skill acquisition processes.

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1 Introduction

Robotic experiences in school context are based on Constructivism, in a theoretical path influenced by the contribution of both Papert's "microworlds" and simulations with robots (Parisi, 2001; Lancia & Rubinacci, 2007).

In Papert's perspective of Constructivism, the knowledge building process is fostered by the parallel construction of artifacts, which contribute to a practical knowledge creation. With regard to Information Technologies, the integration between theory and practice realizes in computer artifacts: software applications allow an active use of technological elements, while technology is considered not only as a facilitating tool, but as a medium for learning.

According to the SCOT (Social Construction of Technology) Theory (Feenberg, 2002; Pinch & Bijker, 1984) technology was born without a specific characterization, but it can take different features according to the debate between relevant social groups; these groups set the outcropping of a specific model rather than another one. Computer is a boundary object (Lievrouw & Livingstone, 2007), specializing itself according to the "shapes" it is taking. Therefore, didactics chooses the suitable "dress" according to the contexts of use: first, the boundary object is directed to learning towards a digital medium, then to learning with digital technologies.

Computer artifacts can reproduce specific parts of real worlds (microworlds) and represent personal versions of these worlds; these can be manipulated to become learning environments, so it is possible learning to learn, that is, to create new knowledge by experimenting in a continuous feedback process (Alessandri, 2008). Within microworlds, therefore, it is possible to recreate real worlds in an artificial mode, and to study their characteristics through simulated problems. According to Parisi, there are two kinds of simulations: in a first one, simulations "live" inside the computer and represent a different way to express scientific theories, a sort of virtual labs; in the second kind of simulation, instead, there is a physical model of reality controlled by a software (Parisi, *op. cit.*), and reality is rebuilt through the computer, and not within the computer. These mixed simulations are typical of Robotics.

Differently from simulations which reproduce worlds within the computer, in robotic simulations the computer itself enters the world (Lancia & Rubinacci, *op.cit.*).

2 From Independent Robotics to Educational Robotics

With Independent Robotics we have an innovative view on the computer device: according to this perspective a robot is not used to merely replace the human performance; robots, conversely, are not affected by a unique and specific programming, or able to develop just one task, but they show some characteristics that are typical of human beings, first of all the self-determination (Marocco, 2006).

With regards to its historical background, Independent Robotics was born together with Artificial Intelligence: according to AI the robotic devices hold both the internal representation of the world they act in, and a wide range of possible actions to perform in the same world, with proper combinations according to the context, so they can achieve the solutions to solve problems they were built for. In this way, the solution to a problem is not achieved from the real world in which the robot is acting, but from the world pattern, that is the scheme the robot itself is holding: even a tiny change in the real world will be able to impair the chance for the robot of finding a solution, if the solution is not included in the representation. So the robot both has an intelligence which is symbolically reproducing its context, and interacts with the world itself throughout representations, identifying world parts into its representations and then activating a consequent behaviour (Marocco, *op. cit.*; Nolfi, 2009).

As an alternative to this theory, Brooks (Brooks, 1991) states that a system can be considered intelligent when it activates sensorial behaviours into a real environment, which is dynamic (Marocco, *op. cit.*): a clever system is never completely separated from the physical world but has to be interpreted as a body (embodiment) with a sensorial system (*Ibidem*).

In this perspective we can find a difference between *planning* Robotics (the robot's performance is based on plans resulting from the combination of symbolic actions held by the robot itself) and *behaviour-based* Robotics (the robot is able to react to a behaviour, that is to an obstacle whenever it appears). According to this meaning, robot has to be considered as a machine with a structure that is suitable to the context, and provided of some characteristics: a sensorial system to gather external stimuli; a microcomputer provided with software for developing the robot's behaviours; a structure linking sensors to microcomputer, and microcomputer to devices called actuators, in order to allow the interaction of robot *with* the environment and *into* the environment (Bertacchini, 2006).

When Robotics meets Education, it becomes Educational Robotics, namely a research field directed towards the building of artifacts based on educational methodologies, in order to improve learning processes (Lancia & Rubinacci, *op. cit.*). Robots can represent a valid support to new didactic methods, if they are located into contexts they can interact with as well as they can interface with each other.

A model for designing robotic devices is composed of several steps: you have to specify the domain of robot's action (step 1), to set how it is interacting with the world throughout appropriate interfaces or sensors (step 2); to build the most suitable model of robot (step 3); to supply the robot with actions and behaviours fitting to the context (step 4) and realized through specific software (step 5); to transfer these software products to the robot (step 6); to repeatedly check the device and make every needed correction in order to achieve its efficiency (step 7); finally, to have a shoring and a reflection process (step 8).

This design flow can be also considered as a cycle to build a simulation (Landriscina, 2009): the cycle itself shows the didactic and educational potential involved in the creation of robotic devices. First, it is necessary to study the *world* you want to represent, that is the reference *system* in which the robot will act; second, you have to draw a *model* to express the features of the system itself, in order to create the *simulation*. In case of unexpected or unwanted results, it will be possible to retrace each step of the process, to correct any error or to improve the final result.

The use of ready-made simulations in educational contexts can make easier the handling of software they are based on, so allowing the study of simulated systems in different settings. The use of self-created simulations, instead, allows the realization of a continuous passage transfer from reality to formal, and from this one to reality again, through a cycle among research- design - realization – algorithm – trial. Therefore, using ready-made simulations can solve just the problem merging from the simulated context, while using *ex novo* simulations is a process aimed at identifying the formal model of the problem to solve and the algorithms for its solution.

In this kind of activity the student doesn't have to analyse the critical context to draw a solution into a close set of possibilities: the student has to describe formally and to realize the resolving process of a class of problems. Therefore the robot will be able to solve problems using parameters, in order to face up partially or fully predictable events.

3 Creating stories with robots

Robots are often the leading actors in the fantastic and literary production of ever. Between 130 and 180 A.D. Aulo Gellio says that Archita, a 5th century philosopher and mathematician, designed and realized clever mechanical toys; one of these toys, a dove, was able to fly, maybe thanks to a pneumatic system. She was able to fly just for one time (Battaglia, 2006). Somadeva, an Indian writer of the 11th century, in his fairy tales speaks about dolls acting actually like a robot or an automaton (*Ibidem*).

Robots are present not only in tales but also in research activities and projects: in the past, an artifact created by Leonardo Da Vinci, for example, was designed to represent a kind of robot similar to a human being; today, there are several researches about robots and humanoids (*Ibidem*).

Over the time, therefore, storytelling has been the main theme in the developing process of Robotics, bridging across fantasy and reality, dream and fulfilment, drawing a path in which theory and practice are variously combined in order to start new experiences. This path develops into two directions: the dimension of narration, that is the evolution of knowledge building process of Robotics itself, and the dimension of the script, dealing with the realization of robotic devices.

This path also represents the personal walk of everyone having experiences dealing in Educational Robotics: on one hand, narration represents the development of the knowledge building process between Robotics and Didactics, on the other hand the script is given by the reifications proposed to the communities, that are giving their own "what" in the story. The reifications realized through robotic devices determine the storytelling of your own personal experience within the community or the social group.

The combination of the narration and the script can represent a useful input to create personal experiences of Educational Robotics by creating stories in which robots are actors in the plot. The result is a *digital tale*, that is the narration of an event with a specific screenplay also developing into the real world, through the interaction between characters (the robots) and the writer/narrator. At school, students build their own narration through a script, improving and developing skills in communicating, understanding and producing texts, in technological abilities, as far as in an artistic sense.

We can say that Robotics was born and developed *through* fantasy, and it becomes a medium *for* fantasy when, through the narration, stories are created to develop robotic experiences and projects.

4 Educational Robotics at school

According to Resnick (Resnick, 2007), learning process is defined as a creative design spiral, in which students are both able to solve a problem, and to make tests, to check relationships, sharing new ideas based on the experiences. This spiral process shows similarities with the conceptualization of *Diagnosticare*, *Relazionarsi* and *Affrontare* dealing with life-skills (Pellerey, 2004; Alessandri & Paciaroni, 2011).

Educational Robotics experiences can be usefully involved both in the field of life-skills, and in the field of cross-disciplinary abilities, when they are part of disciplinary learning path, i.e. in building scientific notions or literary texts.

In primary school you can introduce Robotics through the medium of narration, considered as a tool both for planning and for refining skills connected to learning tasks such as *listening, speaking, reading, writing*.

Jason Ohler (Ohler, 2007) points out two different methods for creating stories: a *green screen-based storytelling* and a *computer-based storytelling* which implies the following steps: the student creates a map of the story; the group gives her/him a feedback, adding new elements if it's necessary; the story is written and recorded; the final step is to listen to the story with adequate revision. If the product doesn't fulfil the expectations, you can adjust the realization process, otherwise the story is digitalized. In this case the story is enriched by the creation of the robot, with the its own planning path. In primary school easy-to-use robotic kits should be proposed, in order to create simple algorithms or hardware.

In secondary school it could be interesting and functional to introduce Educational Robotics experiences in disciplinary contexts, both for scientific and for literary subjects. An example that deals with scientific topics is the one related to programming a 90° right rotation of a robot that is simulating a car movement: in this example it's clear that, you must know the concepts of circumference and diameter; but in a problem solving approach the student is not requested to simply apply his/her competences, but an opportune combination of them to achieve the solution. Unlike the simple solution of an exercise, a context of problem solving involves a really creative activity: according to his/her own abilities, in fact, a student has to arrange them for creating and using a new strategy (D'Amore *et al.*, 2006). With regard to Italian language, students can use a descriptive text to write a description of the robot's programme, an instructional text to number the different steps of the artifact's building, an informative text to share the experience with other group members. Students can usefully write a description of the robot's programme, draw a diary (personal or social, private or public) in the form of a narrative text. Finally, the argumentative text will be a valid support for the final step, when different solutions are compared from different groups of students.

According to Perrenoud, a competence is beyond cognition, it is not based on the assimilation of additional knowledge (general or local), but on building a set of devices and schemes, allowing a conscious fluidity of contextual knowledge (Perrenoud, 2010). Pellerey, on the other hand, has focused on the so called "*pedagogia del progetto*", in the learning process and in the competence shift: working in projects implies the knowledge of a work methodology focused on practice and sensibility in using it in different contexts (Pellerey, *op. cit.*). So it could be very interesting to add Robotics experiences in didactic paths, in order to achieve personal abilities. A workshop is the favoured context to promote school abilities throughout projects (Pellerey, *op. cit.*) The switch from Robotics to Educational Robotics is due to the workshop itself.

According to the "*Indicazioni per il curricolo*" in 2007, as far as the relevance of laboratory experience, it is important to refine the ability of creating stories and models, to develop arguments and topics, to organize the text, paying a special attention to language. It is clear that Robotic experiences are cross-sectional, both as a medium to negotiate meanings into a learning process, and as a practice for learning to learn and tell stories and, thus, learn in the reflection process (Merlo, 2008).

Some experiences, properly described in a recent article (Alessandri & Paciaroni, 2011), have been realized by an informal research group, created in the Faculty of Education Sciences at University of Macerata, involving teachers at different levels, primary and secondary school and university.

Conclusions

The various Robotics experiences, both in primary and in secondary school, are bound by a line, which connects narration to simulation. According to the dimension of narration, a didactic approach to robotic devices allows students to describe their own world, realizing and manipulating robots, who are playing the role of main character in the stories. Simulation, hence, takes part in the process with the practical setting-up of the robotic devices, who are simulating fantastic or real worlds to use in the different disciplines.

So, the traditional way to study is replaced by a new approach to contents and a higher motivation: when creating artificial worlds based on their own representations and trying out real events, students act as researchers, continuously discovering and verifying if their intuitions are valid, according to a coherence between research and trial (*Ibidem*). Throughout storytelling and simulation, Educational Robotics leads Didactics to the integration of real and artificial, through an approach that is functional both to contents and to methodology, promoting the motivation with a positive effect on learning process.

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