ROSE Project

Robotics Opportunities (to foster) STEM Education

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EDUCATIONAL ROBOTICS IN SCHOOL CURRICULA

By

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PART I

1 - Why putting Educational Robotics in School Curricula?

The ROSE project approach transforms the pupil-teacher relationship and highlights how, once a teaching goal has been chosen, the paths to follow to pursue that specific goal might be different, in a trial-and-error fashion, so as to choose the best solution in a cooperative way. Educational Robotics is interdisciplinary in nature and is well fit for the Vertical Curriculum.

In the ROSE project, particular attention is paid to the programming languages used to try and verify different solutions (to solve the same problem). The mechanisms governing complex systems are analysed in order to implement prototypes and verifying their functionality. Particular emphasis is put on input/output devices and their interfacing, and the control of such input/output devices from the programming environment.

2 - Educational Robotics in the teaching approach of other Disciplines: an Added Value

The interdisciplinary nature of Educational Robotics allows to put together all the involved competencies and exploit/"use" the pupils to perform a technological transfer between "different experiences". The class laboratory group becomes a lively simulation of the working environment / real world where pupils have the possibility to put into practice the team work so as to highlight the its strengths, weaknesses, and necessary requirements to obtain the best results.

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3 - European and National trends, a confirmation

The methodological framework of the proposed work is aligned with several items of the key competencies for lifelong learning as stated in the Recommendation of the European Parliament and the European Council dated 18 December 2016:

- **Communication in the mother tongue** is the ability to express and interpret concepts, thoughts, feelings, facts and opinions in both oral and written form (listening, speaking, reading and writing), and to interact linguistically in an appropriate and creative way in a full range of societal and cultural contexts; in education and training, work, home and leisure.
- **Communication in foreign languages** which also calls for skills such as mediation and intercultural understanding. An individual's level of proficiency will vary between the four dimensions (listening, speaking, reading and writing) and between the different languages, and according to that individual's social and cultural background, environment, needs and/or interests.
- **Mathematical competence** is the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations. Building on a sound mastery of numeracy, the emphasis is on process and activity, as well as knowledge. Mathematical competence involves, to different degrees, the ability and willingness to use mathematical modes of thought (logical and spatial thinking) and presentation (formulas, models, constructs, graphs, charts).
- **Competence in science** refers to the ability and willingness to use the body of knowledge and methodology employed to explain the natural world, in order to identify questions and to draw evidence-based conclusions. Competence in technology is viewed as the application of that knowledge and methodology in response to perceived human wants or needs. Competence in science and technology involves an understanding of the changes caused by human activity and responsibility as an individual citizen.
- **Digital competence** involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet.
- **Social and civic competences** include personal, interpersonal and intercultural competence and cover all forms of behaviour that equip individuals to participate in an effective and constructive way in social and working life, and particularly in increasingly diverse societies, and to resolve conflict where necessary. Civic competence equips individuals to fully participate in civic life, based on

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knowledge of social and political concepts and structures and a commitment to active and democratic participation. The core skills of this competence include the ability to communicate constructively in different environments, to show tolerance, express and understand different viewpoints, to negotiate with the ability to create confidence, and to feel empathy.

- **Learning to learn** is the ability to pursue and persist in learning, to organise one's own learning, including through effective management of time and information, both individually and in groups. This competence includes awareness of one's learning process and needs, identifying available opportunities, and the ability to overcome obstacles in order to learn successfully. This competence means gaining, processing and assimilating new knowledge and skills as well as seeking and making use of guidance. Learning to learn engages learners to build on prior learning and life experiences in order to use and apply knowledge and skills in a variety of contexts.
- **A problem-solving attitude** supports both the learning process itself and an individual's ability to handle obstacles and change. The desire to apply prior learning and life experiences and the curiosity to look for opportunities to learn and apply learning in a variety of life contexts are essential elements of a positive attitude.

Concerning the National Italian context, educational goals to pursue as well as abilities and competences to develop by means of Educational Robotics are supported and confirmed by the Italian regulation concerning National Indications for the Nursery and Primary Schools Curricula (D.M.254/2012), where some methodological principles are defined in order to create a suitable context and effective educational actions.

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PART II – Vertical Curriculum of the “ROSE Project”

The project, designed for pupils from primary school to first and second degree of secondary school, offers structured paths to introduce robotics as a cognitive tool and experiential settings with didactic originality. Through robotics, students learn the basics of programming languages, develop logic, measure, analyze problems, discuss and find solutions. Direct experience enables students to develop their knowledge in a constructive way. Pupils explore the characteristics of the robot, learn how to manage its functionality and to program it for the realization of designed actions. Indeed robotics is used as a multidisciplinary environment that can contaminate various school subjects.

Specific Macro-Competences to reach at the end of **Primary School** (within 11 years old):

1. To be able to use a technical language in order to describe the various robot components;
2. To be able to use a specific iconic coding language
3. To be able to start the robot and make the robot move along predefined trajectories and/or paths realized on grids;
4. To be able to sketch simple geometric elements

Specific Macro-Competences to reach at the end of **1st Degree Secondary School** (within 14 years old):

1. To be able to design and build a robot and to be capable to implement a process devoted to solve problems and/or classes of proposed problems by using both induction and deduction methods;
2. To be able to recognize the “robot” complex system and to identify the functionalities of the various subsystems and the way they interact and communicate among them;
3. To be able to deliver written documentation, graphic representation, flux diagrams, comparative tables showing observed data needed for the representation of the solution process; to be able to use the coding language(s) related to the used robot;
4. To be able to identify the element/agents which influence the robot behaviour;
5. To be able to (self) evaluate the personal competences and to identify the roles which can perform at best in a cooperative framework; to be able to recognize and to compare the effectiveness of methods proposed by companions in the same working group.

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Macro-skills to be attained in the **first two years of secondary school - second degree** (within 16 years old)**,** with respect to advanced robotics/mechatronics:

The student knows:

1. How to use and run a robot within a kit and its programming environment;
2. How to recognize different components of the robot (mechanical, electrical, electronics, informatics);
3. How to use a robot programming language to understand its functionality;
4. How to to identify the basic elements of a robot and the principles of operation of sensors and actuators.

Macro-skills to be attained by the end of **last year of secondary school – second degree** (within 19 years old):

The student knows:

1. How to use a robot in compliance with safety standards;
2. How to recognize different components of the robot (mechanical, electrical, electronics, informatics);
3. How to use different simulation programs and is able to adapt the best tool in different situations;
4. How to exploit the potential of the robot in a working environment in order to operate technical and economic optimization on production and assembly cycles.

All activities are organized in order to measure possible differences in operational processes and learning of female component with respect to the male one. **In the long run we want to check if there is an increase of attitudes of female component toward the STEM area of higher education.**

Following is a vertical curriculum of the first cycle of education (from primary school to the first biennium of secondary school – second degree).

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Below a vertical curriculum of the First Cycle of Education (from Primary School to the first two years of High School)

Expected skills		
Subject / subjects Technology - Mathematics - Science - Italian and Foreign Language		
Primary	***Secondary School***	***High School***
Skills developments goals ***DM 254/2012***	***Skills developments goals*** ***DM 254/2012***	***DM 139/2007*** ***National Highlights for High Schools (D.M.211/2010)*** Guidelines for the first two Years of Technical High Schools (Ministerial Directive 57/2010)
MATHEMATICS - The pupil recognizes and represents forms of plan and space, relationships and structures that are in nature or that have been created by man. - He/she searches data to get information and build representations (tables and charts). - He/she can solve simple problems in all content fields, while maintaining control over both the resolution process and the results. He/she describes the procedure he/she has followed and recognizes different solution strategies.	**MATHEMATICS** - The student analyzes and interprets data representations to get variability measures and make decisions. - He/she recognizes and solves problems in different contexts by evaluating information and their consistency. He/she explains the followed procedure, even in written form, keeping control of both the resolution process and the results. - He/she compares different processes and	**MATHEMATICAL FIELD** -The student uses the techniques and procedures of arithmetic and algebraic calculations, representing them graphically. - He/she finds the appropriate strategies for solving problems. - He/she analyzes data and interprets them by developing deductions and arguments about them, even with the aid of graphic representations, consciously using the computing

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- He/she reads and understands texts that involve logical and mathematical aspects. - He/she reasons by formulating hypotheses, supporting his/her own ideas, and comparing with other's opinions. - He/she can solve easy problems in all content spheres, keeping control of both the resolution process and the results. He/she describes the procedure he/she has followed and recognizes different solution strategies. - He/she develops a positive attitude to mathematics, through significant experiences, which made him realize how the mathematical tools he/she has learned are useful to work in reality.	produces formalizations that allow him to move from a specific problem to a problem class. - He/she supports his opinions, bringing appropriate examples and counter-examples and using linked statements; he/she agrees to change his opinion by recognizing the logical consequences of a correct argument. - In situations of uncertainty (daily life, games ...) he/she is oriented with probability assessments. - He/she has strengthened a positive attitude to mathematics through significant experiences and has understood how the mathematical tools he has learnt are useful in lots of situations to operate in reality.	tools and the potentialities offered by specific computer-based applications.
TECHNOLOGY - He/she knows and uses simple everyday objects and tools and is able to describe their main function and structure and to explain how they work. - He/she produces simple models or graphic representations of his/her work using technical drawing elements or multimedia tools.	**TECHNOLOGY** - He/she can use procedural communications and technical instructions to perform complex operational tasks in a methodical and rational way by collaborating and cooperating with his schoolmates as well. - He/she can speculate on the possible	**SCIENTIFIC - TECHNOLOGICAL FIELD** - The student observes, describes and analyzes phenomena belonging to natural and artificial reality and recognizes in its various forms the concepts of system and complexity. - He/she is aware of the potentialities and limits of technologies in the cultural and social context in which they are applied.

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- He/she begins to recognize critically the features, functions and limits of current technology. **SCIENCE** **-** He/she explores phenomena with a scientific approach; with the help of a teacher, of classmates, independently, he/she observes and describes how facts occur, he/she asks questions, also on the basis of personal hypotheses, he/she proposes and performs simple experiments. - He/she is aware of the structure and development of his/her own body, its various organs and apparatus, he/she recognizes and describes its functioning, using intuitive patterns and he/she takes care of health. - He/she takes care of the school environment that it shares with others; he/she respects and appreciates the value of social and natural	consequences of a decision or of a choice in technology field, recognizing opportunities and risks in each innovation. - He/she knows the properties and characteristics of different media and is able to use them in an effective and responsible way with reference to his study and socialization needs. **SCIENCE** - He/she develops simple schemes and modeling of facts and phenomena by resorting to appropriate measures and simple formalizations if necessary. - He/she is curious and interested in the main problems related to the use of science in the field of scientific and technological development. - He/she also explores the most common phenomena, even in the lab, using the knowledge acquired to give answers, he/she develops patterns and modeling, by using measures and formalizations.	

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environment. **ITALIAN AND FOREIGN LANGUAGE** **-** The pupil participates in communicative exchanges (conversation, class or group discussion) with classmates and teachers respecting the turn and expressing clear and pertinent messages in a register that is as suited as possible to the situation. - He/she reads and includes texts of various kinds, continuous and not-continuous, he/she identifies the global meaning and the main information, using appropriate reading strategies. - He/she uses functional skills to study: he/she identifies in written texts useful information for learning a given topic and links them; he/she synthesizes them, depending also on oral exposure; he/she acquires some basically specific terminology. - He/she carries out assignments according to the instructions given in the foreign language by the teacher, possibly asking explanations.	**ITALIAN AND FOREIGN LANGUAGE** -The student can use handbooks of technical disciplines or dissemination texts (continuous, not-continuous and mixed) in personal and collaborative study activities to search, collect and process data, information and concepts; referring to what he has read the student produces texts or presentations using traditional and computer tools. -He/she reads literary texts of various kinds (narrative, poetic, theatrical) and begins to interpret them, working with schoolmates and teachers. - He/she can use oral communication to collaborate with others, for example in the production of games or other products, in drafting projects and formulating judgments on issues that affect different cultural and social sectors. - He/she produces multimedia texts by effectively combining verbal and iconic or sound language. - He/she recognizes and uses specialized words	**LANGUAGE FIELD** - The student uses a foreign language for the main communicative and operational purposes. - He/she reads, comprehends and interprets written texts of various genre.

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	based on the speech fields; - He/she can speak English in the use of information and communication technologies; - He/she can use English to learn topics from different disciplines as well.	

Learning Objectives V Class	Learning Objectives III Class	Learning Objectives II Class
MATHEMATICS - To perform the four operations safely, assessing the opportunity to calculate mentally, in the written way or by using calculator depending on the situation. - To represent the known numbers on the line and use graduated scales in significant contexts for science and technology. - To draw a shape according to a description, using the appropriate tools (squared paper, ruler and compass, set square, geometry software). To use the cartesian plan to locate points. Scale an assigned figure (using, for example, squared paper). - To represent reports and data and, in significant situations, use representations to obtain information, make judgments, and make	**MATHEMATICS** -The student describes with a numeric expression the sequence of operations that provides a solution to a problem; - He/she represents data sets, even using a spreadsheet. - In significant situations, he/she compares data in order to make decisions, using frequency distributions and relative frequencies. - He/she chooses and uses average values (modal value, median, arithmetic mean) appropriate to the typology and characteristics of the available data. - He/she solves math problems even using the geometric properties of the figures. - He/she describes with a numeric expression the sequence of operations that provides a solution to a problem.	**MATHEMATICAL FIELD** - To solve short expressions in the various numerical sets; to represent the solution of a problem with an expression and calculate its value even by using a calculator. - To translate brief instructions in symbolic sequences (even with tables); to solve sequences of operations and problems by replacing literal variables with numeric values. - To plan a structured solving path in stages. - To formulate the solution path of a problem through algebraic and graphical models. - To collect, organize and represent a set of data.

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decisions. - To describe with a numeric expression the sequence of operations that provides a solution to a problem - In concrete situations, to start arguing what is the most probable of two events, giving first quantification in the simplest cases, or recognizing if it is equally probable events. - To recognize and describe regularity in a sequence of numbers or figures.	- He/she interprets, constructs and transforms formulas that contain letters to express general relationships and properties. - He/she reproduces geometric figures and drawings based on a description and coding made by others. - He/she recognizes pairs of complementary, incompatible, independent events. - In simple random situations, he/she can identify elemental events, assign them a probability, calculate the probability of some event, splitting into disjoined elemental events.	
TECHNOLOGY - To read and obtain useful information from user guides or assembly instructions. - To use some technical drawing rules to represent simple objects. - To plan the making of a simple object by listing the tools and materials you need. To disassemble simple objects and mechanisms, equipment, or other common devices. - To search, select, download and install a common program on your computer. **SCIENCE** - To identify, in the observation of concrete experiences, some scientific concepts such as space dimensions, weight, specific weight, force, movement, pressure, temperature, heat,	**TECHNOLOGY** The student reads and interprets simple technical drawings getting qualitative and quantitative information. He/she uses the technical drawing tools and rules in representing objects or processes. He/she gets in touch with new IT applications by exploring its features and potential; - He/she plans the various stages for the realization of an object; - He/she disassembles and reassembles simple objects, electronic equipment or other common devices; He/she programs computer environments and elaborating simple instructions to control the behavior of a robot; - He/she assesses the consequences of choices and decisions related to problem situations. - He/she uses simple procedures to perform	**SCIENTIFIC - TECHNOLOGICAL FIELD** - To collect data through direct observation of natural phenomena (physical, chemical, biological, geological, etc.). - To organize and represent the collected data. - To understand the concept of system and complexity. - To use classifications, generalizations and/or logic schemes to recognize the reference model. - To recognize the role of technology in everyday life and in the economy of society. - To understand the interactions between life needs and technological processes. - To be able to explain the operating principle and structure of the main physical and software devices.

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etc. - To observe, use and, where possible, build simple measuring instruments: volume / capacity measurements, spring scales, etc.) by learning to use conventional units. - To start identifying regularity in phenomena and conceiving energy in an elementary way.	experimental tests in various technology fields. **SCIENCES** - To use fundamental physical concepts such as: pressure, volume, speed, weight, specific weight, strength, etc., in various experience situations; in some cases to collect data on relevant variables of different phenomena, finding quantitative relationships and expressing them with formal representations of a different type. - To fulfil experiences such as: inclined plane, movement on a trajectory, centrifugal force action and centripetal in a non-straight motion. - To contextualize the physical phenomena of everyday life, also to develop social and civic skills and critical thinking. - To observe, describe, collect data, and interpret the results. - To make simple experiences and represent them. - To use appropriate tools and units of measurement for the situations under consideration, to measure and use the known math to handle the data.	- To be able to use the basic and most common software to produce multimedia texts and media, to calculate and represent data, to draw, to catalogue information, to search for information, and to communicate over the network.
ITALIAN AND FOREIGN LANGUAGE - Collaborative interaction in a conversation, in a discussion, in a dialogue on topics of direct experience, asking questions, giving answers and providing explanations and examples. - To search for information in texts of different genre and origin (including modules,	**ITALIAN AND FOREIGN LANGUAGE** - To understand and use appropriately the basic specialized terms related to the various disciplines. - To be involved in a class or group conversation with pertinence and consistency while respecting times and shifts of speech and providing a positive personal	**LANGUAGE FIELD** - To understand a message and its logical links. - To search, get and select general and specific information. - To look for information in short texts.

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timetables, charts, maps etc.) for practical or cognitive purposes by applying comprehension support techniques (such as, for example, highlighting, writing down information, building maps and charts etc..). - To follow written instructions in order to make products, to regulate behaviors, to carry out an activity, to carry out a process. - To find the specific meaning of a word in a text. - To understand and use specific words and terms related to studied subjects. - To understand English words, instructions, expressions and sentences linked to known contexts, clearly and slowly pronounced. - To communicate in a foreign language in a comprehensible way with a classmate or an adult you are familiar with, using expressions and sentences suited to the situation.	contribution. -To discuss his/her own thesis on a topic dealt with in the study and in the classroom dialogue with relevant data and valid motivations. - To read literary texts of various kinds and forms (stories, novels, novels, poems, comedies) by identifying the author's main theme and intentions, characters, their characteristics, roles, relationships and reasons of their actions; spatial and temporal setting; genre. - To formulate hypotheses based on the text together with classmates. - To write texts of a different form (eg user's instructions, private and public letters, personal and on-board diaries, dialogues, news articles, reviews, comments, arguments) based on experimented models, adapting them to situation, topic , purpose, recipient, and selecting the most appropriate registry. - To discuss his/her own thesis on a topic dealt with in the study and in the classroom dialogue with relevant data and valid motivations. - To understand words, instructions, expressions and phrases related to specific contexts, spoken clearly and slowly in English.	

Links with other disciplines / fields of	Being (Educational Robotics) a tool capable of stimulating pupils to actively study non only the scientific disciplines but all of them and given the learning method based on projects, Educational Robotics can stimulate the pupils to actively approach whatever class of problems in every day life. In addition, the method foresees an active and self-conscious collaboration with other people as an

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experience	effective tool to achieve the problem solution. This kind of learning, strongly linked to practical problems and related to a specific project to realize allows to measure own abilities and vocations with more effectiveness and gratification.
Link with other goals for the development of competence(s)	**PHYSICAL EDUCATION:** The pupils acquires self-consciousness by dominating motor/postural schemes with continuous adaptation to spatial and temporal variables at hand; her/he experience, first in a simplified manner and then in a more and more complex manner, different technical gestures. **MUSIC** The pupil explores, discriminates, and elaborates sonorous events from different viewpoints: qualitative, spatial, and related to their source. **GEOGRAPHY** The pupil is able to spatially self-orient and to use maps with different scales, based on cardinal directions and geographical coordinates; her/he suitably uses digital elaborations, maps, geographical information systems in order to communicate spatial information. **HISTORY AND LAW** The pupil uses her/his knowledge and abilities in order to self-orient in the present complexity; her/he understands different opinions and cultures as well the fundamental problems of the contemporary world. Her/he knows fundamental processes of world history, from Neolithic civilization to industrial revolution to globalization. Her/he knows the fundamental laws of educational robotics in order to acquire self-consciousness and critical spirit towards technology.

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PRIMARY SCHOOL				
Axis	***Goals for the development of competences***	***Learning goals***		***Topics***
		Abilities	***Knowledge***	
Math	**MATHEMATICS** - The pupil recognizes and represents planar and spatial shapes as well as their relationships and structures. She/he describes names and classifies geometrical entities based on their geometrical features, derives dimensions, designs and builds models. - The pupil searches for data in order to extract information, and builds visual representations (tables and graphs) - The pupil recognizes and solves problems in different contexts maintaining the control both on the solution	- The pupil is able to describe, to name, and to reproduce geometrical entities - The pupil is able to search data and to build visual representations. - The pupil is able to reproduce a scaled version of a given geometrical entity/shape. - The pupil is able to solve problems seeking for suitable strategies - The pupil is able to orient her/himself in space	- To know geometrical entities and their representations - To know different strategies to solve problems	- Geometrical concepts (straight line, half-line, segment, angles and their amplitudes, meridian, parallels), geometrical entities and shapes, fractions

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	process and the results. - The pupil develops a positive attitude towards mathematics, and foresee the usefulness of the studied mathematical tools in order to address real – world problems.			
Scientific – technological disciplines	**TECHNOLOGY** - The pupil recognizes and identifies, in the surrounding environment, artificial elements and phenomena. - The pupil begins to recognize, in a critical fashion, features, functions, and limits of state of the art technology. - The pupil derives useful information by using procedures and technical instructions.	- The pupil is able to use drawing tools - The pupil is able to build simple object by following suitable instructions - The pupil is able to plan the fabrication of a simple object by listing and (check – listing) the necessary tools and materials - The pupil is able to mount/dismount simple objects and mechanisms - The pupil is able to read and derive useful information from user guides and/or mounting instructions	- To know the structure of objects and tools - To know the functions and limits of state of the art technology - To know and use every day objects and to be able to describe and explain how they work - To know how Beebots and Probots work - To know sensors and actuators of Beebots and Probots	- Materials - Functions and features of an artefact and of a simple machine - Natural and artificial elements of the environment

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	SCIENCE - The pupil recognizes the main features of animal and vegetal organisms - The pupil develops curiosity – driven behaviours and explores phenomena with scientific approach	- The pupil is able to describe features of the environment as well as features of living and non – living beings - The pupil is able to observe and interpret the various transformations of the environment - The pupil is able to identify some scientific concepts after observation: spatial dimensions, weight, motion, temperature…	- To know the features of the environment - To know the main terms of the specific (scientific) language - To know the human kind in relationship with the environment	- Living and non living beings - Atmospheric transformations and transformations of the environment - The human body
Linguistic disciplines	**ITALIAN LANGUAGE** - The pupil formulates clear and relevant messages with a choice of terms as adequate as possible with respect to the situation at hand - The pupil reads and understands various kinds of texts (including technical ones) by using suitable reading strategies - The pupil acquires a first	- The pupil is able to tell stories in chronological sequence - The pupil is able to invent and represent, individually and collectively, stories, even in graphical form - The pupil is able to verbally recap phases of lived (past) experiences - The pupil is able to read	- To know the different kind of texts - To know the structure of the sentence and of the period - To know the main spatial – temporal and logical connectors (in the text) - To know the elementary kernels of specific terminology for the various kinds of texts	- Tell tales, stories, comics, videos, and movies with robots as characters - Narrative, descriptive, and injunctive text

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	kernel of specific terminology	texts and to extract the topic at hand, identifying the main information and the main relationships - The pupil is able to follow written instructions to realize products and procedures		
	ENGLISH LANGUAGE - The pupil understands short messages, both written and oral ones	- The pupil is able to describe a robot - The pupil is able to read and understand short texts in English	- To know English terms devoted to describe spatial entities and relationships - To know terms devoted to describe a robot	- Short stories and audio – visual sequences with robots as characters

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The same job has been performed also for 1st degree secondary school, see the table below

SECONDARY – II degree				
Subject	***Disciplinary goals***	***Skills***	***Knowledge***	***Contents***
Mathematical	**MATHEMATICAL** The student: - understands robots as real three-dimensional objects; - understands robots as emulators of human/animal behavior; - develops movement schematizations in space and time; - understands how mathematical tools are useful in many situations to operate in reality.	The student: - knows how to use techniques and procedures of arithmetic and algebraic calculus, compares and analyzes geometric figures and identifies appropriate strategies; - knows how to analyze data and interpret them developing deductions, even with the help of graphic interpretations or using computational tools of computer applications; - knows how to use the 3D geometry knowledge to design the movement of mechanical structures in	The student: - knows techniques and procedures of the arithmetic algebraic calculus and geometric figures; - knows data calculation tools, graphics and computing applications; - knows matrix algebra; - knows rules to interpret data and graphs; - knows elements of 3D geometry.	- The logical-operative meaning of numbers belonging to different numerical systems, techniques and procedures of arithmetic and algebraic calculus and geometric figures. - The systems of linear equations and matrix calculus. - Freedom degrees in algebraic structures.

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		space.		
Scientific - Technological	**GRAPHIC** The student knows graphical environment designs.	The student: - knows how to graph objects and components of robotic systems; - creates objects and components of robotic systems using 3D printer.	The student knows reference standards of the graphic representations, orthogonal and isometric projections.	- Graphic representations, axonometric, dimensioning and representations with components of robotic systems. - Basic components of robotic systems.

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	SCIENCE & TECHNOLOGY The student: - knows basic elements of simulators; - knows proper programming environments; - knows appropriate hardware platforms.	The student: - knows how to assemble hardware components; - knows how to use and modify supplied software to perform simple movements along defined trajectories; - unserstands signals from the sensors; - knows how to change the behavior of the objects created in both hardware and software; - knows how to realize simple projects of mechanical organs, to be connected to the robot; - knows how to realize physical connections of Arduino board, powering it, identificating inputs and outputs and interpretating signals coming from sensors.	The student: - knows procedures and techniques to find effective and efficient solutions in relation to simple problems in robotic field; - analyzes, designs and realizes simple devices and robotic systems with the use of educational modules.	- Torque, moment of forces. - Electricity, resistors, capacitors, inductors, electromagnetism, principle of operation of electric motors and their control components for robotics applications. - Sensors, actuators, safety devices used in an industrial robot. - Structure and basic syntax of microprocessor commands.

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Linguistic	**LINGUISTIC** - Ability to comunicate in Italian and/or in English languages the relationship that human beings have had with "machines" and in particular with industrial and service robots. - Understanding of technical documentation in Italian and/or English.	- The student is able to describe aspects and functions of robotics and use a specific vocabulary in Italian and English.	- The student knows robotic function applications in industrial and service robotics.	- The robot in literature and in movie productions. - Texts and movies in Italian and English.
	HISTORICAL AND CIVIC - Ability to track, as part of a historical period, the relationship that human beings have had with "machines" and in particular, with industrial and service robots. - Ability to be aware and critical with regard to technology.	The student: - knows how to explain the basic laws related to robotics; - can describe a historical path and express assumptions.	The student: - knows laws and regulations governing the use of robots in society; - knows current robotic functions and possible future developments.	- History of robotics. - The existing industrial and service robots, and their impact on socio-economic sphere. - Laws and regulations governing the use of robots in society.

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Above table, which refers to the second degree of Secondary School, may subsequently be declined for both a type of educational institution which provides robotics within the curricular path (for example Industrial Technical Institutes) both for a type of educational institution providing robotics in an extracurricular path (for example Liceo, etc). In the first case it will be necessary to specify in which disciplines such subjects will be teached, and the temporal chronograms and hourly quantifications of such content. In PART III, at pag. 30, an example of “Robotics Bending” is reported.

Methods and tools:

The use of robotics as a troubleshooting tool allows the teacher to use a variety of teaching methodologies: cooperative learning, flipped class, peer learning, problem solving, gamification. Particular attention should be paid to the latter method which, referring to instinctive behaviors of pupils, leads to an effective increase in motivation and performance since it reproduces patterns of play and competitions that promote collaboration and the creation of group dynamics. Moreover the active learning achieved using robots changes the meaning of mistake. It becomes important because it provides feedback directly interpretable by pupil which is autonomous in managing his own learning. This self-assessment procedures, the greater awareness and autonomy thus acquired, promote the inclusion of all pupils, especially those with behavioral disorders. Also the position of teacher changes, thus becoming a reference figure, facilitator of solving processes and not the depositary of absolute and indisputable knowledge.

In addition to the mounting kit for the construction of the robot, instruments used are those of a laboratory equipped with computers for programming, projector and interactive whiteboard.

For illustration, it is reported in the following table a non-exhaustive list of robotic platforms and related programming environments that you can use in different types of schools:

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School degree	***Suggested platforms List***	***Programming Environment***
Primary	Beebot	The controls are located on the robot itself
	Probot	
Secondary - first degree	Lego EV3	iconographic programming environment
	Lego NXT	
First biennium of Secondary - second degree	Lego NXT	iconographic programming environmen
	Lego EV3	
	MBot	iconographic Environment MBOT
Second biennium/last year of Secondary - second degree	Arduino BYOR, Arduino SPIDER ROBOT KIT , Arduino PARALLAX SHIELD ROBOT , Arduino KIT CRAWLER FOR BOE-BOT , Arduino TINKERKIT BRACCIO	IDE Arduino (C++)
	Lego EV3	Robot C
	Rasberry	Python IDEs

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Verification mode:

Verification is related to the work process realized by individual pupils and therefore observation grids are used, in operational context which take into account the behavior of the pupil within the group, the degree of expressed autonomy and creativity and his technical/scientific capacity. Attached there are evaluation grid patterns for the three types of schools (Annexes C, D, E).

PART III - Bending towards Robotics / Home Automation from"ICT " Expertise

The "Informatics and Telecommunication" expertise aims at enabling the student, at the end of the five-year course, to acquire specific competences in the life cycle of the software product and the telecommunications infrastructure, in terms of ability to concept, design, produce and market industry components and services. The student's preparation is complemented by cross-disciplinary skills that let him read the issues across the entire product chain.

From the analysis of the sector companies demands, humanistic, mathematical and statistical, science and technology, design and management training needs emerged to respond innovatively to market demands and to contribute to the development of a high cultural level in support of ideative and creative capacity.

The "Informatics and Telecommunication" expertise includes the "Informatics" and "Telecommunication" expertises .

In the "Informatica"expertise , skills are acquired that characterize the professional profile in relation to processes, products, services with particular reference to innovative aspects and applied research, to the creation of IT solutions to support companies operating in a market internally and internationally. The professional profile of the expertise allows entry into business processes, with precise functional roles that are consistent with the company's goals.

In the "Telecommunication" articulation, skills are acquired that characterize the professional profile in relation to communication infrastructures and processes to realize them, with particular reference to innovative aspects and applied research. The professional profile of the address allows for effective insertion into a variety of business contexts, with the possibility to deepen the competences related to the characteristics of the different territorial realities.

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Large space is reserved for the development of organizational, managerial and market competencies that allow, thanks to the use of school-work turnover, to realize projects related to the real product development processes and services that characterize the companies in the industry.
The fifth year, devoted to the elaboration of specific sectoral themes, is aimed at favoring young people's choices with respect to their rapid integration into the world of work or the subsequent training opportunities: obtaining a higher technical specialization, pursuing university-level studies .
For some years, Robotics has been part of the didactic programming in the three years of theInformatic and Telecommunications expertise.
Since the school year 2014-2015, the "Robotic Curvature" has been activated, which employs both 20% of school autonomy and the hourly flexibility provided by the law, to change the curriculum and to study robotics and computer science .

The curriculum structure consists of three levels:
1) a prescriptive part, with the core activities and disciplines, the annual hourly dedication, the objectives and the learning standards determined at national level;
2) an optional part that integrates the curriculum left to the schools autonomy with a variety of formative offers among which the pupils have the opportunity to choose;
3) an optional part with the enrichment of the curriculum through additional activities and disciplines, planned and realized with the agreement of subjects outside the school (local authorities and / or training agencies).

Depending on the autonomy, an hourly part of the study plan is entrusted directly to the individual school institutions.
With this quota you can:
- to strengthen compulsory teaching for all students, with particular reference to laboratory activities
- activate further lessons aimed at achieving the objectives set out in the training plan.

In addition provision is made for the possibility of allocating an enhanced staffing quota to individual school institutions and / or making it available through network agreements.
However, there are constraints in the use of the autonomy quota:
- it must not lead to personnel surplus
- it may not exceed 20% of the total hours of the lessons scheduled for the first two years and for last three years of ICT expertise.

The above changes therefore lead to a variation within the disciplines and the relative time distribution of the ICT expertise.

Below is the "traditional" timeframe of the second biennium and the last year of the Informatics expertise:

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Subjects	Second Biennium		5th school year
	III°	IV°	V°
Italian language and literature	4	4	4
English language	3	3	3
History	2	2	2
Mathematics	3	3	3
Physical education and Sports	2	2	2
Religion / Alternative Activities	1	1	1
Complementary Mathematics	1	1	-
Sistemi e RetiSystem and Networks	4 (2)	4 (2)	4 (2)
Technologies and design of computer and telecommunication systems	3 (1)	3 (2)	4 (2)
Gestione progetto, organizzazione d'impresaProject management, business organization	-	-	3
Information technology	6 (3)	6 (3)	6
Telecommunications	3 (2)	3 (2)	-
Laboratory triennial hours	8	9	10
Total weekly hours	32	32	32 (10)

With the modifications shown above, the new time frame of the Robotics Curvature becomes the following (in bold the "curved" disciplines):

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Subjects	Second Biennium		5th school year
	III°	IV°	V°
Italian language and literature	4	4	4
English language	3	3	3
History	2	2	2
Mathematics	3	3	3
Physical education and Sports	2	2	2
Religion / Alternative Activities	1	1	1
Complementary Mathematics	1	1	-
Sistemi e RetiSystem and Networks	4 (2)	4 (2)	4 (2)
Technologies and design of computer and telecommunication systems	3 (1)	3 (2)	**3 (2)**
Gestione progetto, organizzazione d'impresaProject management, business organization	-	-	3(2)
Information technology	6 (3)	**5 (3)**	**5 (4)**
Telecommunications	3 (2)	**4 (2)**	**2**
Laboratory triennial hours	8	9	10
Total weekly hours	32	32	32 (10)

With the introduction of Robotic Curvature we try to get the following benefits:

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1. gather all the skills necessary for the construction of machines (mechanical, electrical engineering, electronics), computers, programs, communication systems, networks;

2. the particular profile of this new science promotes creative attitudes to students, as well as their communication, cooperation and teamwork skills;

3. the study and the application of robotics favor students in an attitude of interest and openness towards the scientific subjects, and this in many cases allows the student's motivational recovery.

By entering into the living the skills that the robotics students should acquire at the end of the course, four are the

Specifics Macro-Competences that they should possess:

1. Know how to use a robot in compliance with safety rules;

2. Know the different components of the robot (mechanical, electrical, electronics, IT)

3. Know how to use different simulation programs to define the features, dimensions and construction / modeling of different tools;

4. Ability to exploit the potential of the robot in a work environment

And two Cross Macro-Competences:

1. English;

2. Security

These were dealt with in a series of specific skills dealt with each in a specific discipline of the Triennium. Below is a non-exhaustive proposal for a educational path that also draws on the experience of other school institutes.

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III YEAR- SPECIFIC COMPETENCES

Specific competence	Knowledge	Skill	Contents	Resources and facilities needed	Methodology	Discipline	Verification mode
1.1 **The robot** It uses algorithmic abstraction in order to use the constituent elements of a demonstration robot. **10 HOUR**	Concept of Algorithm. Flowcharts. Functional block diagrams.	- Know as modeling / schematizing a problem to deal with - Represent the algorithms for the robot's operation through the iconic language before and through a textual language then (C for robot NXT / EV3).	Development of the block diagram of the NXT robot identification of the main features of the constructive and functional features.	Class 3.0 (Connetivity, Lim or screen projection system with screen mirroring, PC / tablet) .. Lego robotic kits.	Frontal lessons Inductive method Practise: - direct use of the robot; - construction of the robot through specific configurations.	Information Tecnology	Operational context observation, assessment section for specific competence, semestructured and / or structured tests
1.2 **Programming:** Represent the flow diagram NXT / EV3 robot. Transduces the flowchart in programming language. 25 HOURS	Functional block diagrams. Flowchart. Language of Iconic robotization of Lego robots.		Flowcharts Languages of programming for icons in robot programming C ++ elements.		Frontal lessons Inductive method Practise: -realization of programs for specific purposes with the built robots		Observation in an operative context, compilation of specific programs, evaluation section for specific competence.

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Specific competence	Knowledge	Skill	Contents	Resources and facilities needed	Methodology	Discipline	Verification mode
1.1 **The robot** It uses algorithmic abstraction in order to use the constituent elements of a demonstration robot. **10 HOUR**	Concept of Algorithm. Flowcharts. Functional block diagrams.	- Know as modeling / schematizing a problem to deal with - Represent the algorithms for the robot's operation through the iconic language before and through a	Development of the block diagram of the NXT robot identification of the main features of the constructive and functional features.	Class 3.0 (Connetivity, Lim or screen projection system with screen mirroring, PC / tablet) .. Lego robotic kits.	Frontal lessons Inductive method Practise: - direct use of the robot; - construction of the robot through specific configurations.	Information Tecnology	Operational context observation, assessment section for specific competence, semestructured and / or structured tests
1.3 **Recognize the different types of robots;** Apply, given a robot and an external environment, the skills acquired in order to operate a robot. **8 HOURS**	Overview of all different types of existing robots: service robots, industrial robots, medical robots, robots for exploration and security	Calculate, given the physical characteristics, the size of the robot; simple constituent geometries.	Robot: - how it's done - as a work-execution of elementary movements	Classroom 3.0 (Connetivity, Lim or screen projection system with screen mirroring, PC / tablet) Lego robotic kits	-frontal lessons Inductive method Practise: simple execution -programs with robotic kits adopted	TPSI (Technology and design of IT and telecommunications systems).	Observation in operational context; semi-structured and / or structured tests assessment section for specific competence

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Specific competence	Knowledge	Skill	Contents	Resources and facilities needed	Methodology	Discipline	Verification mode
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1.4 **Space Movements:** correctly position objects in the space and detect position and movement. 15 HOURS	Vectors Static. Kinematics. Dynamics.	Apply the knowledge of mechanics to the specificity of Robot.	Static, cinematic and dynamic applied from a positioning, movement and forces associated with the operation of a robot.	Classroom3.0 (Connetivity, Lim or screen projection system with screen mirroring, PC / tablet) Lego robotic kits.	Frontal lessons Inductive method Practise: running simple programs with the robotic kits adopted	System and Networks.	Observation in operational context; semi-structured and / or structured tests, assessment section for specific competence.

Specific competence	Knowledge	Skill	Contents	Resources and facilities needed	Methodology	Discipline	Verification mode
2.1 **Recognize and run electronic connections** You can use appropriate	Robot control, boards and cabling. Knowledge of transducers and sensors Communication protocols Hardware: ARDUINO UNO REV 3;	Mount and configure the cards and connect the connectors. Know how to choose	Mount and configure the cards and connect the connectors. Know how to choose the appropriate sensors	- Class 3.0 (Connetivity, Lim or screen projection system with screen mirroring, PC /	Frontal lessons. Inductive method. Testing Robot NXT Lego.	Telecomm unications.	Observation in operational context; semi-structured and / or structured tests

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protocols and communications for robot management. 20 HOURS	programming language C. Knowledge and control of Arduino robotic kits.	the appropriate sensors / actuators Recognize the control and communication system with the robot Implementing semidoff function in the Arduino IDE.	/ actuators Recognize the control and communication system with the robot Implementing semidoff function in the Arduino IDE.Components of the communication system	tablet) Robotic Arduino kits.	Execution and simple operating system commands.		assessment section for specific competence

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Specific competence	Knowledge	Skill	Contents	Resources and facilities needed	Methodology	Discipline	Verification mode
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3.1 **Use different simulation programs** It defines the bulk,functionality and construction / modeling of the different tools. 12 HOURS	PC-assisted drawing programs.	Use solid modeling programs to establish appropriate, intuitive relations between space-object-position.	Solid format open source products (LEGO Digital Designer 4.3).	- Class 3.0 (Connetivity, Lim or screen projection system with screen mirroring, PC / tablet) Lego Robotic Kit LDD Program.	Frontal lessons Inductive method Practise: Use of LDD software (LEGO Digital Designer 4.3).	TPSI (Technology and Design of Computer and Telecommunication Systems).	Observation in operational context, semi-structured and / or structured tests, assessment section for specific competence.
4.1 **Potential of the robot;** exploits the potential of the robot in a work environment.	he use of the robot.	Recognize the right robot to use depending on your needs.	View robots of robots.	Video projector.	Practise: Given a context create the design of robots (discursively).	System and Networks.	semi-structured and / or structured tests.

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10 HOURS							

In the same way we scheduled the specific competences for the 4th e 5th year.This is the summary of didactic programming

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Timetable / skills / classes / disciplines - Matrix skills / classes + disciplines / hours

Specific Competences / Class	1a: You can use and operate a robot in compliance with safety rules.	2a: He knows the different components of the robot (mechanical, electrical, electronics, computer).	3a: You can use the different simulation programs to define the features, the bullet and the construction / modeling of the different tools.	4a: Ability to exploit the potentials of the robot in a work environment.	**TOTAL HOURS: 300**
III **SIST: 25** **INF: 35** **TPSI: 20** **TELEC: 20**	**1.1 [INF] (10h)** **1.2 [INF] (25h)** **1.3 [TPSI] (8h)** **1.4 [SIST] (15h)**	**2.1 [TELEC] (20h)**	**3.1 [TPSI] (12h)**	**4.1 [SIST] (10h)**	**100**
IV **SIST: 20** **INF: 35** **TPSI: 15** **TELEC: 25**		**2.2 [SIST] (25h)2.4 [INF] (40h)** **2.5 [TELEC] (20h)**	**3.1 [TPSI] (20h)**		**95**
V **SIST: 15** **INF: 30** **TPSI: 10** **TELEC: 50**	**1.4 [INF] (15h)** **1.5 [SIST] (15h)** **1.6 [TELEC] (15h)**	**2.3 [TELEC] (35h)** **2.4 [TPSI] (10h)** **2.6 [INF] (15h)**			**105**

Map Legend
SIST : System and networks

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INF : Information Tecnology
TPSI : Technology and Design of Computer and Telecommunication Systems
TELEC : Telecommunication
The educational path experienced in these three years is giving tangible results.
1. Increase of entries in the ICT expertise (we have gone from about 60-70 students in the academic years 2012/13 and 2013/14 to an average of over 100 in the last few years);
2. Raising skills such as teamwork, problem solving, etc;
3. Increase of specialized cross-media skills such as audio-video editing, creation of social channels for the dissemination of projects or activities carried out (eg: http://pentol-ino.co.nf/, https: // www .youtube.com / channel / UCPopzALJRAiz-_kk6CRrRVQ)
4. increased self-esteem and self-efficacy;
5. decreased dispersion;
6. Decrease of non-promoted and pupils with suspended judgment.

This, coupled with the ever-improved results obtained by students and students in national competitions and / or demonstrations such as RoboCup JR or MakerFaire, has convinced us to take a step further with the formal introduction from the next school year of the discipline of Robotics.
The new time frame adopted from next a.s. will therefore be as follows:

ROBOTIC CURVATURE			
	III	IV	V
Technologies and design of computer and telecommunication systems	3	3	3
Telecomunication	3	3	-
System and Networks	3	3	4
Information technology	5	5	5
ROBOTICA	**2**	**2**	**2**

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ANNEXES

Project fiche (A)

Rubric for group project assessment– Lower Secondary School (B)

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