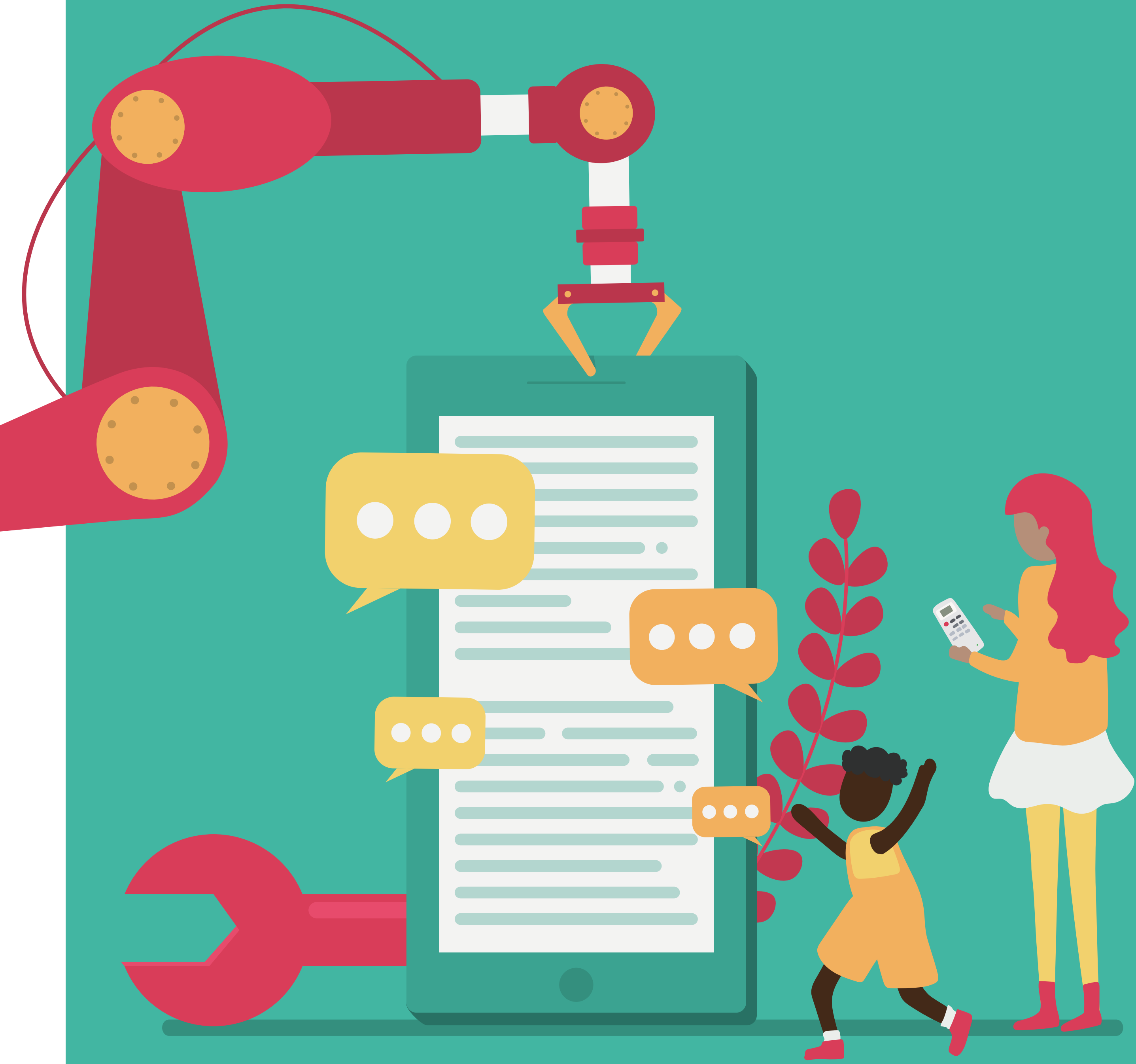
Educational Robotics

eMedia



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INTRODUCTION

Today's world is facing more rapid technological progress than ever and this change continues to accelerate. In this rapidly changing world, adaptation and developing new competences and skills are essential. The development of digital technologies and digitalisation affects all citizens, young and old. Mobile phones, computers, tablets and other technologies that provide both social and entertainment functions are an integral part of everyday life. Everyone must adapt to the changing world, learn and develop their digital competences to be able to interest the digital generation in the educational process. Digital competence involves the confident and critical use of electronic media for work, leisure and communication. Those competences are related to logical and critical thinking, high-level information management skills, and well-developed communication skills (Ranieri, 2009). Digital competence is one of the eight key competences for lifelong learning developed by the European Commission in 2005.

The European Digital Competence Framework (DigComp) offers a matrix to understand the essential competences needed for all citizens to adapt in the digital world. Understanding where one is located on the DigComp index can provide guidance to improve citizen's digital competence and to achieve goals related to work, employability, learning, leisure and participation in society. (European Commission, 2019; European Union, 2016). It describes 21 learning outcomes in 5 areas:

1) Information and data literacy;
2) Communication and collaboration;
3) Digital content creation;
4) Safety;
5) Problem-solving.

Beyond the DigComp framework, there is also a European Framework for Digital Competence of Educators (DigCompEdu). This framework gives guidance to educators and teachers on what it means to be digitally competent. It describes six areas of core digital competences for educators, professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learner's digital competencies. (ec.europa.eu/jrc/digcompedu)

The eMedia project aims to promote education for all by producing educational guidelines related to digital practices which consists of three handbooks. These handbooks support possibilities for a new and innovative way of teaching different subjects at school. They address teachers who are interested in developing their digital competence and improving their understanding of educational robotics as a pedagogical approach in formal or non-formal education.

The handbooks are devoted to three aspects of digital competence:

1) Educational robotics: to develop computational thinking with hands-on activities.
2) Media literacy: to understand the power and the risks of online social media.
3) Online expression: to promote a more responsible use of social media, blogs, web radios and web TVs.

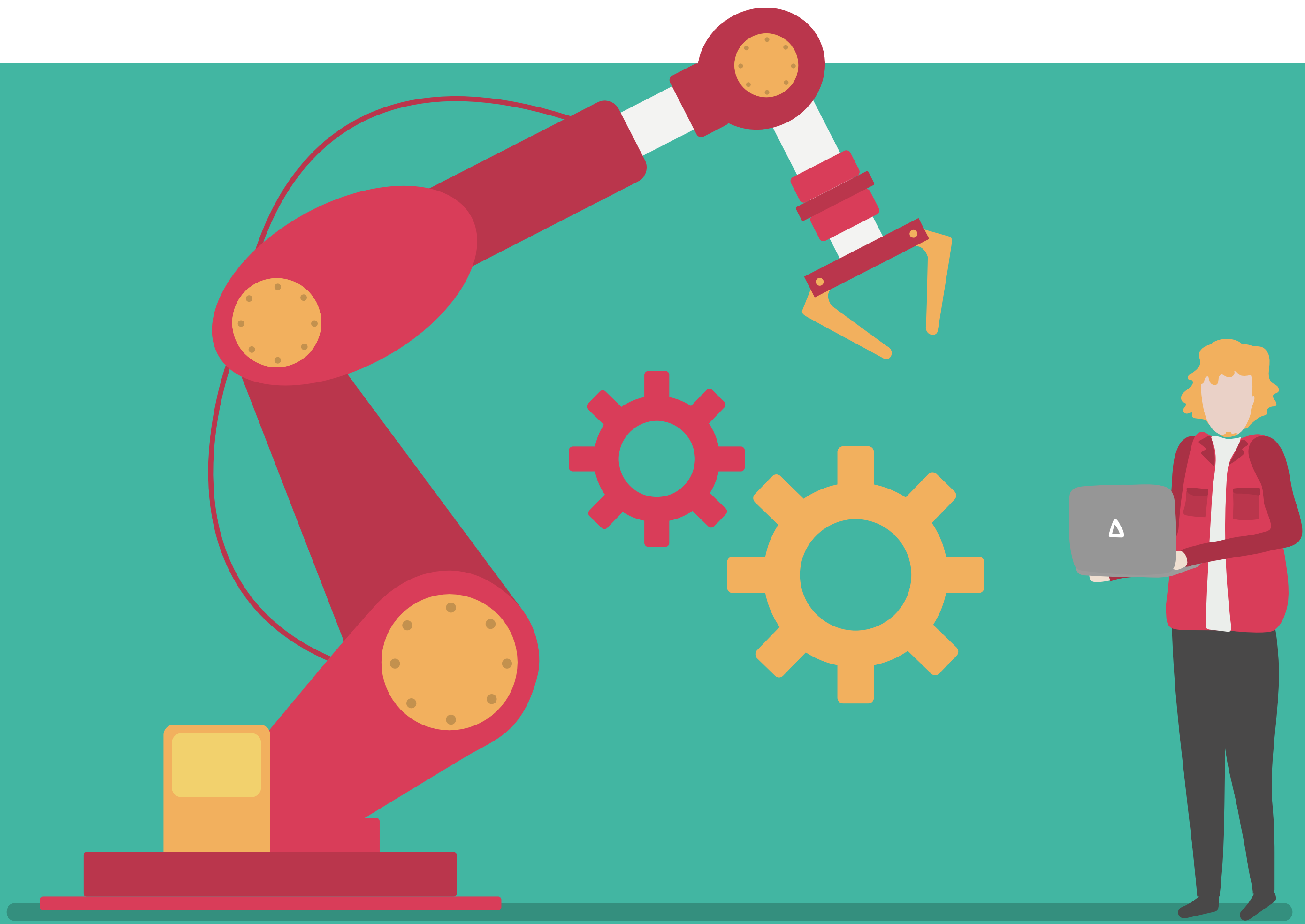
In addition to the printed manuals, their electronic versions are also available, with additional information on the topic in question. Free online courses have been created on a moodle platform. It is free.

WHAT IS ROBOTICS?

It is easy to find a definition of robotics on the internet: "robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electronic engineering, information engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing".
This operational definition allows the reader to see the relationship between robotics and the education of STEM disciplines (Science, Technology, Engineering and Mathematics).

At the moment, there are three possible ways to classify robots depending on the sector of application:
1) industrial robots
2) service robots
3) educational robots, which are divided in two subcategories:
- educational robotics
- robotics for education

This material will be devoted to how educational robotics can be incorporated in the learning process, which competences can be developed, what pedagogical principles should be followed.



Robotics in the history

Robotics is the result of evolution, the curiosity, the efforts and the creativity of human thought on how to create tools and machines able to solve problems and do specific tasks autonomously.
The process of modernisation through technical and material conquests, has made the creation of tools endowed with autonomy and skills possible.

The water clock clepsydra introduced by the Babylonians in 1400 BC was one of the first known automated mechanical artefacts. In the following centuries, human creativity gave rise to a series of mechanical devices such as the automatic theatre of Hero of Alexandria (c. 10 BC – c. 70 BC), the hydroelectric machines for collecting water, the humanoid machines of Al-Jazari (13th century) and the ingenious drawings of Leonardo da Vinci (1452–1519), for instance the flapping ornithopter and the machine with a helical rotor. The development of automatons continued to flourish in the 18th century in both Europe and Asia with the creations of the watchmaker Pierre Jaquet-Droz and the Karakuri-Ningyo mechanical dolls.

Catlin (2019) states that the term "robot" was introduced for the first time in 1920 to refer organisms that perform heavy manual work, entities treated as servants. In the opera RUR (Rossum's Universal Robots), by Karel Capek, robots are not automatic machines but multiple machines made of meat. It was Joseph Capek, the brother of Karel, a painter (who died in the Bergen Belsen concentration camp) who coined the term "robot", for entities more similar to Frankenstein's creature and Philip Dick's replicants than to mechanical robots.

The scientist and writer Isaac Asimov anticipated the ethical and social implications that would arise from the introduction of robots in society. In 1940, he tried to codify the ethics of the interaction between robots and humans by introducing the three basic laws of robotics in the novel Runaroud (for more information refer to the Social considerations chapter of this handbook).

A fast technological progress since the 1950s allowed to start researches into the interactions between human beings and machines.
The virtuous circle triggered by these phenomena over time has produced the knowledge and the understanding necessary to give life to the area of robotics that is "the science and technology of robots".

The first robots made in the '60s were born from the union of different needs that led to the creation of numerical control machines for precision production

and teleoperators for the handling of radioactive materials at a distance.
Subsequently, the development of integrated circuits, digital computers and miniaturized components allowed the design and programming of robots through the use of dedicated software. These robots, called industrial robots, became essential components for the automation of flexible manufacturing systems in the late 1970s.

In the 1980s, robotics was defined as the science that studies the intelligent connection between perception and action. The action of a robotic system is entrusted to a locomotion apparatus to move in the environment, where appropriate actuators animate the mechanical components of the robot. Perception is extracted from sensors that provide information on the state of the robot (position and speed) and the surrounding environment (force and touch, range and vision). The intelligent connection is entrusted to an architecture of programming, planning and control that is based on the perception and available models of the robot and the environment and exploits the learning and acquisition of skills.

In the 1990s, research was driven by the need to use robots to address human safety in hazardous environments, to improve the capabilities of the human operator and reduce fatigue, or by the desire to develop products with large potential markets to improve quality of life. More recently, robots have found new applications outside factories, in areas such as cleaning, search and rescue, underwater, space and medical applications.

With the arrival of the 2000s, robotics underwent a major transformation in scope and size. This expansion was determined by the maturity of the sectors and the progress of related technologies.

Robotics, from a widely dominant industrial perspective, is expanding rapidly towards the new challenges of the human world. The new generation of robots should live safely and reliably with humans in homes, workplaces and communities, providing support in services, entertainment, education, care, production and care.

Ethics for robotics: roboethics

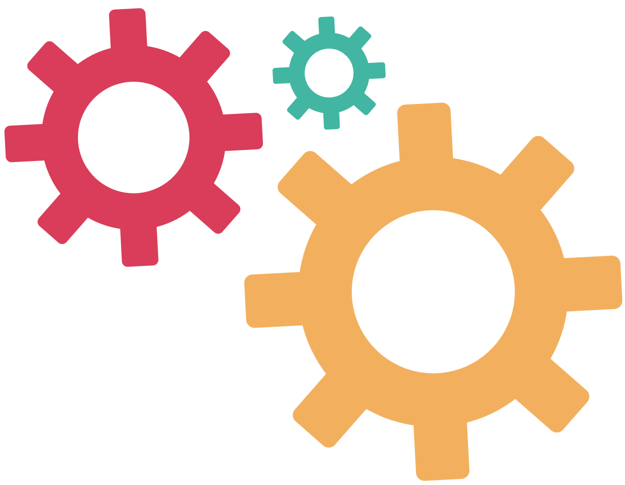
Robots are already assisting humans in various dangerous, difficult, repetitive tasks, and also service tasks such as supporting the professional and care support needed in hospitals, schools, retirement and leisure centres (Siciliano, Khatib, 2016).
Not all of these robotic applications are destined to raise serious ethical, legal and social issues. However, as in any other field of science and technology, the impact that robots will have on our lives will have to be assessed against the recommendations of roboethics developed over several years.

It is the first time in human history that we find ourselves collaborating on different fields with an artificial intelligence (AI). The convergence of robotics, AI, networks and big data, without counting the developments in neurosciences, represent today an extraordinary melting pot, where the synergy between these technologies is giving an exponential rhythm to the technological progress and to the possible applications. (Veruggio, 2018). And with so many opportunities and benefits, all this is raising new ethical issues. Some fields of application of robotics have already posed serious problems in the field of human rights: military robotics, or robotic systems applied to weapon systems (mobile robots and armed drones). And the field of bionics, with the design and use of hybrid systems and Brain-Computer systems. (Tamburrini, 2009).

In addition, the fact that robots can connect to the Internet or other networks, allows the development of distributed robotic systems, aggregates of robots whose connected processors form a parallel processor whose power would allow to address complex problems, process data from the entire network of robots and thus monitor, for example, from the single cell to complex organisms (Dezhen Song, et al, 2016). Sooner or later it will be as common as using a smartphone today to employ a robot. In about ten years we will see people buying robots like today we buy digital gadgets, the market will offer standard robots and the user will customize them with apps, sensors and other digital technologies like today we download apps for our smartphones, updating the "standard format" for the desired functions.
The robots so conformed, equipped with Machine Learning, will coexist with us, and will learn and memorize the patterns of our environments, our profile (health status, habits, preferences, routines) and any other pattern enabled to make them more "intelligent".
In addition to humans, these advanced robots will exchange data and software among themselves, and between databases, without direct human intervention, with the aim of storing, for example, data and solutions already found to complex problems. In these cases, compared to robots with learning capabilities, the problems called Ethical Legal System will be greater, involving issues of privacy, personal identity, dignity, discrimination and accessibility. (Operto, 2008).

In reality, the key element of roboethics is not an artificial ethics, but the discussion and study of the ethical principles of humans, of those who design, produce and employ these machines.
"We must ensure our commitment to raising public awareness about the problems of robotics, so that society can take an active part in the process of creating a collective consciousness, able to detect and prevent misuse of technology. The hope is that we can achieve an ethic shared by all cultures, nations and religions, so that the construction and use of robots against human beings is considered a crime against humanity" (Veruggio, 2011).

As consequence of the robotics technology progress, ethical concerns become more pressing: should robots be programmed to follow a code of ethics, if this is it, how? How might society and ethics change with robotics?



Interactions between humans and robots

Robots will be more and more present in homes, hospitals and schools.
Precisely because we are beginning to see robots operating in our work environments, the discourse on the socio-philosophy of robots and their duplicity as both technological and totemic avatars of humans is shifting to social, relational, ethical and legal aspects.

Robotics is still a new science and it's far from being mature. Preparing for this future is challenging. However, the idea we have of robots is often borrowed from science fiction or industry: the arm that paints the bodies of cars is now in the collective imagination. Even more often we think of anthropomorphic robotics, which is only one part of this science. "In many cases it will not make sense to build humanoids" explains Veruggio. "For an electronic butler, human features can be appropriate, even psychologically. If a robot has to face a hostile environment, such as the depths of the abyss, it will never be an android with mask and fins.

What relationship will we have with these machines? The ability to interact with human beings passes through the intelligence of the robot. But we must understand the meaning of intelligence, which in this field is the ability to synthesize a behaviour favourable for the survival of an individual in the real environment or for the execution of a collective mission. Veruggio marks: "I believe that robotic intelligence is essentially the ability to be useful. It's simple: if robots are easy to use and do what they need to do, they are intelligent, otherwise they won't.

It is a common practice to attribute to Isaac Asimov the merit of having posed the first question of robot-human interaction in a social context. Asimov introduced this set of rules in his 1942 short story "Runaround" (included in the 1950 collection I, Robot), although they had been foreshadowed in a few earlier stories.
The Three Laws, quoted as being from the "Handbook of Robotics, 56th Edition, 2058 A.D.", are:
1) First Law: A robot may not injure a human being or through inaction, allow a human being to be harmed.
2) Second Law: A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.
3) Third Law: A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

About 80 years later after these theoretical laws we live today with more than two million industrial robots, a few million domestic robots (mainly vacuum cleaners and lawnmowers) and specialised robots (surgery, drones), and perhaps twenty thousand humanoid robots (mostly Nao and Pepper robots). Today, in most fields, research in robotics is focussing on finding new forms of complementarity with humans (cobotics) rather than their replacement.

HOW ROBOTICS CAN PLAY AN IMPORTANT ROLE IN EDUCATION?

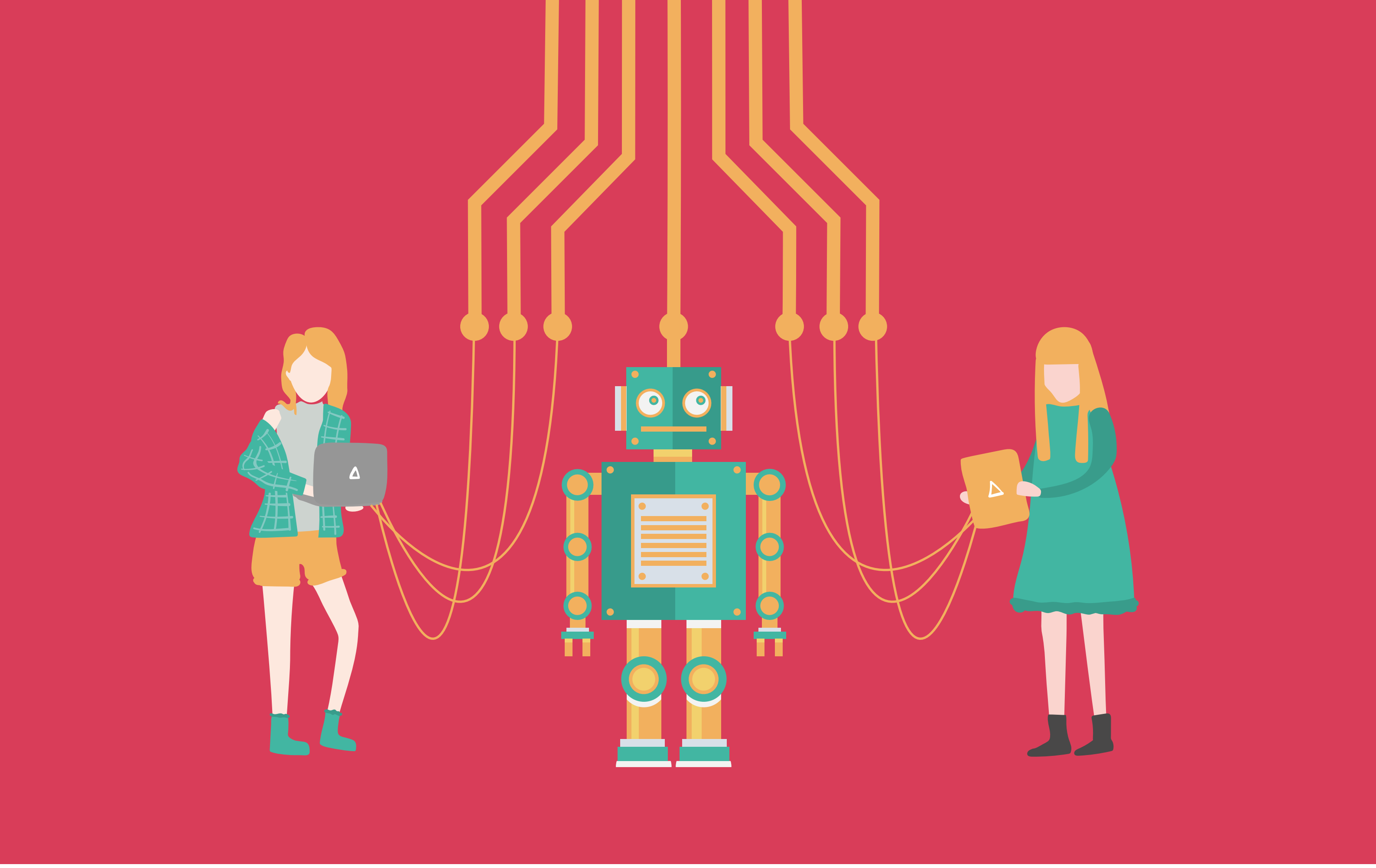
Today robotics is one of the keys to the current industrial and cultural revolution with a strong impact on economics in the near future.
According to the digital economy and society index, 90% of jobs today need some level of digital skills. Not only coding or tech jobs will need them. With Artificial Intelligence and Robotics taking over "simple" tasks, more and more employees will be needed with creative and problem-solving skills (ec.europa.eu/digital-single-market/en/desi).
However, the introduction of robotics in schools cannot only be the result of economic considerations.

Robots as facilitators for learning

Robots are physical three-dimensional objects that move in space and time and that can emulate human/animal behaviour. According to important educational experiences, it has been observed that the use of robots in teaching offers many interesting advantages:

- Young people learn more quickly and easily if they are dealing with concrete and physical objects than only by working on formulas and abstractions, as it would be if young people simply committed themselves to programming a computer.
- To make an intelligent machine work improves motivation during the learning process.

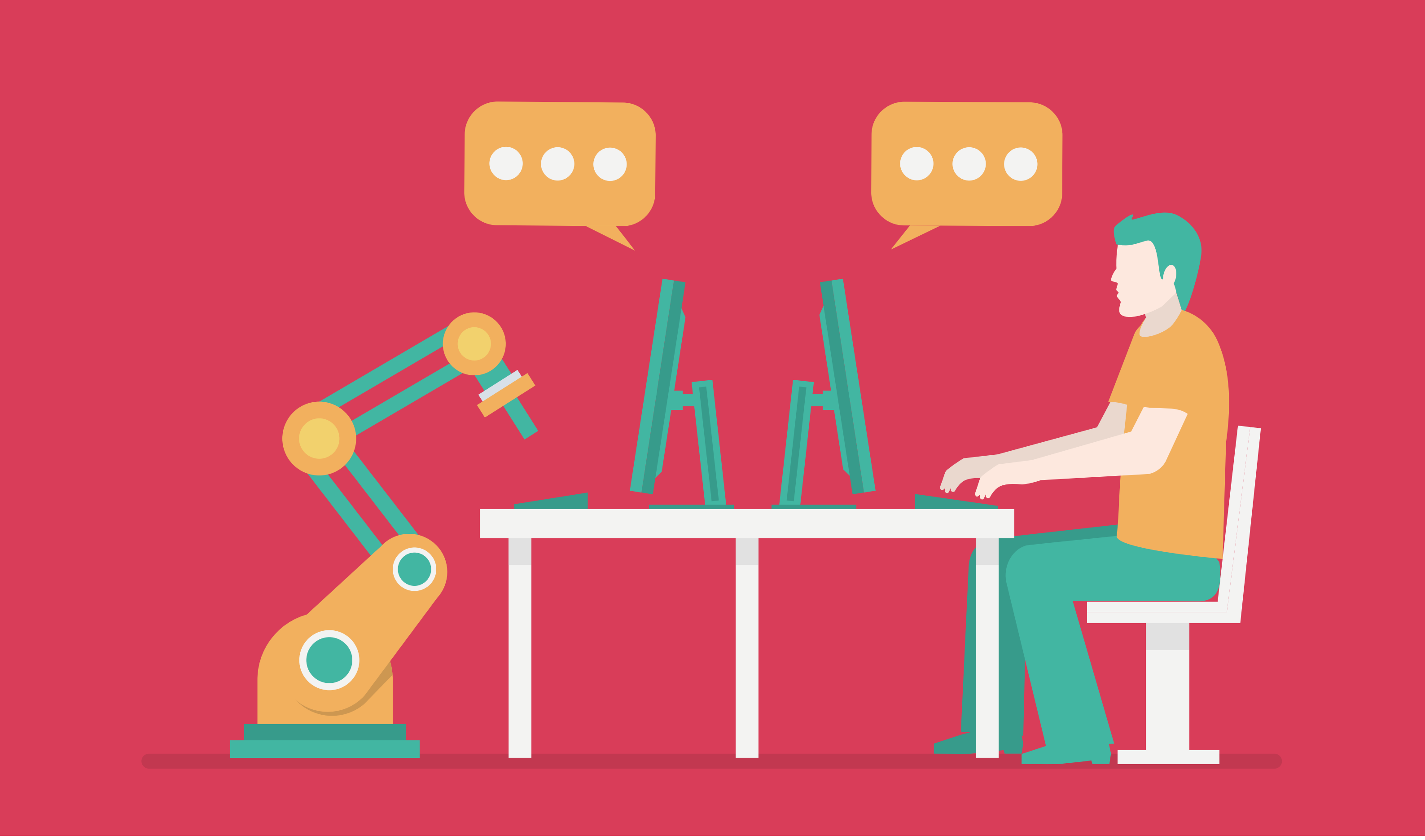
The fascination that robots evoke in children means that even the youngest ones can explore the field of engineering and the exact sciences from an entertaining perspective through these sophisticated intelligent toys. Robots are used quite widely since primary school, with interesting results, to illustrate fundamental concepts of engineering, physics, electronics, programming and automation. In particular, great success has been achieved when robots have been used for teaching in classes composed of young girls or children belonging to cultural minorities or cultural enclaves. According to this research (Mills, 1996, Greenfield, 1997), young girls and students belonging to minorities tend to lose interest in science subjects during middle school: the work on robots, in this case, has kept the scientific interest alive by associating it with a development of manual skills and cooperative work. Moreover, these same students have often developed an interest in subjects such as biology and zoology, through experiments on artificial creatures, an activity that can be compared to the works of synthetic ethology.



The importance of implementing robotics in a classroom

Besides the use of robots in schools, the study of robotics science is a rich experience for children. It is very important to note, before the technical aspects, the interdisciplinary character of robotic science. It is easy to see that to build and program a robot requires several skills and competences coming from different disciplines.

There are multiple benefits of studying robotics in school: the most obvious includes the development of technical skills related to the ICT world and the development of the computational thinking. The new educational approach to STEAM disciplines (Science, Technology, Engineering, Art and Math), where part of creativity is added by adding the concept of Art, allows to use robotics in school as practical activity to encourage the students to learn and apply theoretical knowledge in science, technology, engineering, art (creativity) and mathematics. A combination of robotics using STEAM and DIY (do-it-yourself) approaches can be very effective to help students improve basic skills like logic and communication. A crossed-path can be created through the classical subjects taught in classroom increasing the understanding of the different subjects while decreasing the learning time.



What is Computational Thinking and why is it important?

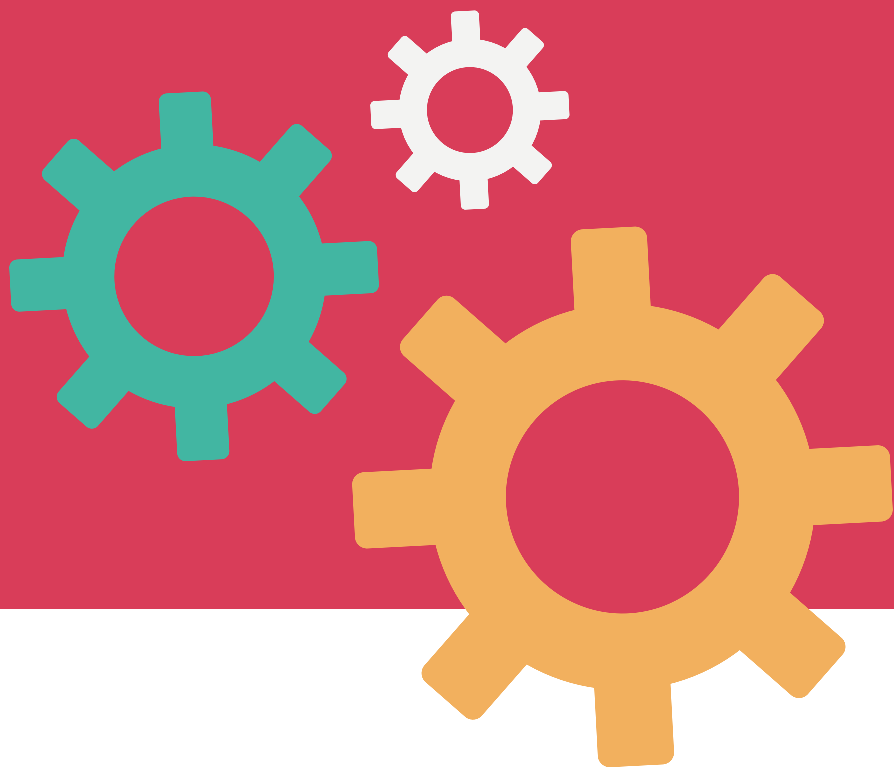
The term was coined by Jeanette Wing in 2006, at the Carnegie Mellon University, to describe an approach to problem solving. "Computational Thinking is an approach to problem solving".

Computational thinking is not a skill, but a range of concepts, applications, tools and thinking strategies that are used to solve problems. You can practice Computational Thinking without using a computer.

Jeannette Wing defines four major facets to computational thinking:
1) Decomposition: breaking a problem down into smaller parts;
2) Pattern recognition: finding similarities and differences between the different parts, to be able to make predictions;
3) Abstraction: the ability to find the general principles behind the parts and patterns in problems;
4) Algorithm Design: developing the step by step instructions to solve different problems.

As technology continues to change our society, it is imperative for pupils and students to learn to think critically as well as to be able to control and create their own digital experience. Rather than be consumers of digital technologies, we want pupils to become the producers of it.

Teaching young people computational thinking and enabling them to understand how digital technologies work, is important to ensure they can become empowered by digital technologies, and not merely be users of digital technologies.



An advantage is that early contact with computational thinking challenges can inspire pupils to choose more STEAM-related fields of study. However, it is important to note that not all the children will become programmers, engineers, architects or experts in other fields where we assume that computational thinking is needed. It is important to support the development of computational thinking to teach how the world is constructed, how digital technologies are working but it shouldn't be narrowed down to programming.

The skill of creative thinking is challenging to define: what is creativity? In the essay on 'Systematic Creativity in the Digital Realm' (Ackermann et al., 2009), being creative is split up into three main activities:

- Combining - coming up with new, surprising and valuable ideas and artefacts through combining existing ideas and objects.
- Exploring - expanding our understanding of an area or creative domain by coming up with new, surprising and valuable ideas and artefacts.
- Transforming - transforming the way we see or understand the world through coming up with new, surprising and valuable ideas and artefacts.

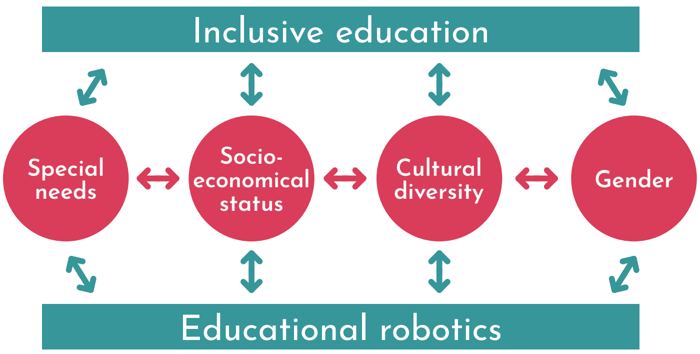
There are many ways to develop 21st century skills; specifically, computational thinking and creativity. However, we believe that teaching pupils and students to code is one of the best paths to follow. This is because it stimulates their capacities to identify, extrapolate and create patterns. Pupils who learn to code have an increased understanding of systems and how they are designed. They continuously analyse problems and come up with novel solutions for them. Coding also offers pupils the tools to start creating on their own.

Instead of consuming technology on a daily basis with an uncritical attitude, pupils can now start building their own digital future. Instead of app-consumers they become app-developers. Whether it is vocational or just for fun, learning to code provides a great advantage.

Inclusive education and educational robotics

Robotics incorporates a range of skills, and thus promotes a learning environment for people with different talents. If properly harnessed, it also promotes a culture of teamwork. It can even be used to help students who might struggle to learn in traditional classroom settings. For example, the ASK NAO robot was developed to help autistic students. Its main goal is to bring everyone on board through modern educational-technology approaches in academia.

The reader can find more information on the following internet links:
- blog.robotiq.com/how-to-get-your-team-on-board-with-robotics
- www.botstem.eu/it/robotics-for-inclusion
- link.springer.com/article/10.1007/s10758-018-9397-5



Graph 1: Concept of interrelations among inclusive education and educational robotics (Daniela, Lytras, 2018).

In an inclusive education system, educational robotics can help provide a better education for all children by interacting on four different levels. These four dimensions are:
It should also be taken in consideration that by ensuring specific support the problems can arise that can lead to social exclusion. This can occur on different levels: exclusion from education systems or from particular fields of education, such as technology.
Some examples on how educational robotic activities can lead to the risks of social exclusion are given below (Daniela, Lytras, 2018):

- Special needs can both reduce access to education in general and limit access to learning in particular areas. For example, children who have colour blindness or discoloration problems can be confronted with the programming of LEGO robots with a high emphasis on colours; therefore, in the context of inclusive education, not only diagnosed and apparent disabilities but also all special needs that can affect learning should be met.
- The SES (Socioeconomic status) can influence access to education if the learning materials, support materials, and the possibility of participating in non-formal activities have to be financed by the student's family. If educational robotics is not used in compulsory education, then families with low SES will not have the possibility to provide these innovative learning activities for their children, and this means that the positive outcomes of educational robotics are unavailable for these students.
- The Cultural diversity dimension includes children of nomadic families, first-generation migrant families, Roma children and so forth. Religious beliefs about innovation, about the involvement of girls in science and so on can also play an important role.
- Gender balance addresses the fact that equal opportunities should be provided for all. In some countries, access to education for girls is still a problem, and in some countries research results show that learning outcomes in particular fields are higher for girls than for boys (for example, reading literacy).

It is important to understand that these dimensions are not separated from each other; for example, a student might be a girl with special needs from a migrant family that has a low socioeconomic background, and this can make the barriers even higher. The dimensions of inclusive education defined in this conceptual model have only illustrative purposes, and other dimensions can be added as well.

Educational robotics (ER) can serve as a tool for knowledge construction and as an assistive tool for students with problems in specific fields; or ER may be used to change students' attitudes to learning – class culture – allowing everyone to be accepted and involved. While analysing the outcomes of such a process, it is often said that educational robotics have not provided much impact on knowledge improvement, but ER can play an important role in other aspects that are important for keeping students engaged and motivated. This, in turn, reduces the risk of social exclusion and dropping out (Daniela & Strods, 2018; Alimisis, 2014; Moro, Agatolio, & Menegatti, 2018; Karkazis et al., 2018; Karampinis, 2018), hence providing inclusive education for everyone.

Educational robotics also shouldn't be taken as providing a panacea for all the problems that exist in education. However, an important principle of inclusive education is 'no child left behind', and everyone should remember the principles of zone, of proximal development (Vygotski, 1978), principles of motivation (Bandura, 1997; Migdley & Urdan, 2001), and previous knowledge. On one hand, educational robotics is a tool to support reaching outcomes, but on the other hand it also brings challenges that can cause opposite effects if the task is too complicated and pedagogical support is not provided. Another challenge is the assumption that ER supports knowledge building, forgetting about other possible outcomes that play an important role in helping students to become active learning actors. Also, challenges can be raised if ER activities are provided as non-formal educational activities that are available for a special group of students – those whose families can pay for these activities or those who are labelled as the focus group of activities (for example, "children at risk", "Muslim girls", etc.). Children don't want to be labelled. If ER activities are provided at a time when the school bus can't take students home, this again provides the possibility to participate for those who live close to the educational setting or whose families can take them home by car. Students who are labelled can feel satisfied and encouraged inside such groups, but they can feel excluded from the compulsory education environment because of feeling "labelled". This risk can be observed not only in countries of low gross private domestic investment (GPDI), where formally the possibility is provided, but hidden factors are not met.

For further information, refer to: link.springer.com/journal/10758

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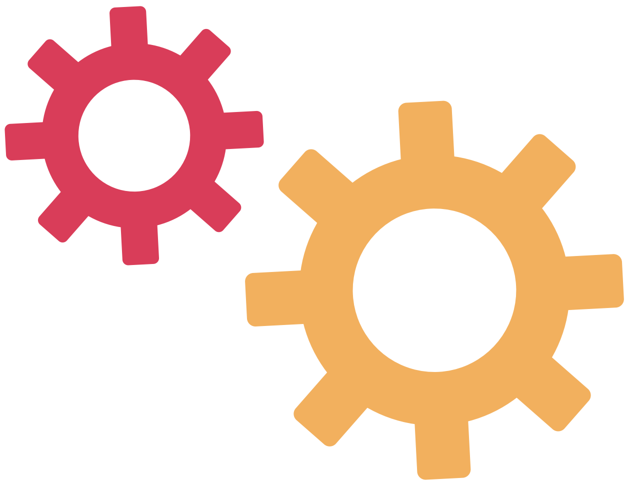


TECHNICAL CONSIDERATIONS

What do you need to start in educational robotics and what you can use?

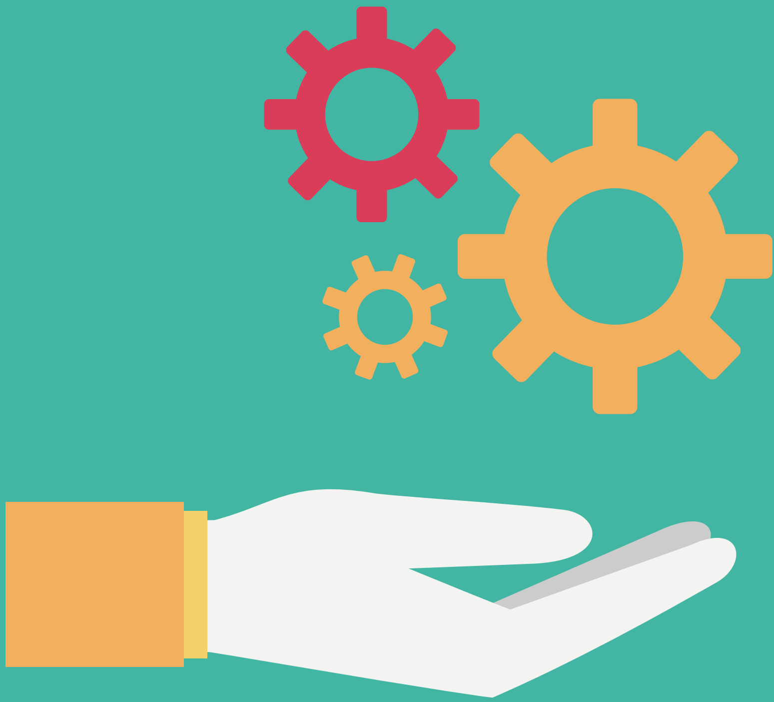
It is possible to start robotics in the classroom in different ways depending primarily on what kind of skills the educators want to teach, how deep in the study and comprehension of these skills they want to go and, of course, what budget they can devote to the project. Many possibilities are available today on the market: from a ready to use robot, to a robotics kit, until the possibility to create a robot from scratch and few components.
What are the differences between these possibilities?

- A robot ready-to-use can be expensive but an "time saving solution". Frequently it is not a scalable solution so it can allow to work on a specific competence but it can be more challenging to apply it in an interdisciplinary project.
- A kit to build a robot is a good solution if you want to realize a workshop with a makers approach. Assembling a robot allows students to apply hands-on work, but also engage in skills such as reading comprehension of technical document and communication. It's an excellent practical exercise with an affordable cost.
- Making a robot from scratch can be an economical but time-consuming solution. Learning how to make a robot is a challenge. It involves several skills, a clear process to choose all components, to design the robot, to code the main program. It can be a great experience if you follow a pedagogical approach based on trials and errors.

Use the following questions to help determine the best fit for introducing robotics in your classroom.
1) How much time do you have for the project?
2) Do you have a specific budget?
3) What do you want to work in terms of skills and competences?

Preliminary knowledge in electronics, like the Ohm law, are suitable but the educator can always include this knowledge as part of educational path. In that case, students will discover the law during the activity. For instance, let's think about the possibility to create their own robot using an open source hardware platform, like Arduino (refer to the next paragraph). In order to understand how this platform works it is a common exercise to use at first the board to control an LED light. This exercise can be used to introduce the Ohm law to students and basic circuit laws, at the same time it allows the students to understand how the Arduino board works, how to connect an external component to the board, how to communicate with the Arduino board through a specific software (please refer to the next paragraph for more information about the Arduino IDE).
In a more advanced workshop the teacher can add to this first experience the study of the Joule effect then to shift to thermodynamics laws and landing on a discussion about energy production, environmental impact of the technology.

Here are some useful links:
- Europe Code Week: codeweek.eu
- klascement: www.klascement.net/?hl=en
- eTwinning: www.etwinning.net/en/pub/index.htm
- Scientix: scientix.eu/live



Some technological solutions available today

What kind of technological solution should be adapted in a robotics project in a classroom? It all depends on the purpose of the project. In order to make the correct technical choice it could be important to answer the following questions:

1) What technical skills should the students learn in the project?
2) How many lesson hours can be devoted to the construction of the robots?
3) Do you want to make the robots evolve?

For instance, an educator would like to realize a basic introductory robotics project. The goals are to focus on computational thinking, on creativity and on the construction of a robot. Finally the educator would like to reuse the robot in other, more advanced, projects. In this case an open source solution it is a good choice.
If the educator wants the students to focus on a specific aspect of computational thinking without spending time in assembly task and without the intention to create a more advanced project, in that case a proprietary solution can be more convenient.

The free software and open source solution

This handbook on Educational Robotics focuses on free software and open source solutions.

Free software is featured by four main qualities:
1) The freedom to run the software
2) The freedom to change it
3) The freedom to redistribute it
4) The freedom to redistribute it with change

Not all four foundational freedoms are granted by all software, some are only granted to a certain degree. For example, you may be able to only run a software on your computer, but not to change it or to redistribute it.

Free software differentiates by open source. Open source refers to ensuring the source code is transparent, allowing it to be seen publicly. Be careful, not all open source codes are free. Many programs are open source, the source code is transparent, but users do not have access to modify the code, redistribute it or change it.

Since the 1990s, the definition of "open source" has become increasingly widespread in the IT context. In the case of open source, the source code is public, encouraging its free study and allowing independent programmers to make changes and extensions.

Closed source or proprietary software experienced its golden age at the turn of the millenium when companies like Microsoft declared themselves "enemies" of open source systems. At that time, the main focus was on computer operating systems such as Windows. Recently, thanks to the introduction of new devices and services such as smartphones, cloud services and service robotics to the market, the trend has been reversed in favour of the free and open source world. The peak of this process was reached with the purchase of GitHub by Microsoft in June 2018 (for more information: news.microsoft.com/2018/06/04/microsoft-to-acquire-github-for-7-5-billion)

GitHub is the world's largest open code sharing platform and location. Within Github there are more than 57 million code repositories, of which 28 million are public, used by more than 40 million users. In addition, over time it has also become an increasingly popular tool for enterprise software development (for more information: www.bloomberg.com/news/articles/2018-06-03/microsoft-is-said-to-have-agreed-to-acquire-coding-site-github).

Over the last decade, other large companies in the industry have also begun to invest in the open source world. Google has developed the operating system for Android smartphones on Linux and Apple has also developed macOS and iOS software on open code. (For more information: www.wired.it/gadget/computer/2018/06/25/microsoft-github-open-source)

The fact that the world's leading proprietary software companies have decided to invest in the Free and open source world demonstrates the potential benefits of this solution in order to develop new opportunities for business and education.

In the context of robotics context it would be more correct to use the term "Open Source Hardware".

Open source hardware platforms

To build a robot using a "maker" and "do-it-yourself" (DYI) approach a mechanical structure, like a chassis or a skeleton, and the electronic components (sensors, actuators, control unit, power supply) are necessary.
The mechanical parts and components can be bought on the market, printed on a 3D printer or they can be developed by using recycled materials. The electronic components have to be bought on the market. The most important electronic component of a robot is the control unit, the microcontroller, the "brain" of the robot. The choice of the microcontroller determines the choice of the other components (sensors, actuators and power supply). The sensors and actuators have to be fully compatible with the microcontroller. In other terms, the microcontroller has to recognize the components and to know how to drive the external component using a specific library. In this section we focus on the most popular open source control units (microcontrollers) available today on the market.

Arduino
Arduino is an italian company that produces an open-source low cost single-board microcontroller family for building digital devices and interactive objects that can sense and control both physically and digitally. Arduino boards are available commercially in preassembled form or as do-it-yourself (DIY) kits or single components.
The board works with a free integrated development environment, called Arduino IDE, that has to be installed on the computer. There is also an online version of the Arduino IDE.
Recently Arduino introduced to the general public Arduino Education, a dedicated team formed by education experts, content developers, engineers and interaction designers from all around the world. Arduino Education is focused on developing the next generation of STEAM systems and supporting the needs of educators and students throughout the educational journey.
Arduino has a large global community of users who share open-source projects, suggestions and tutorials for new and experienced users.
Useful links:
- www.arduino.cc
- www.arduino.cc/en/Main/Education

Elegoo
ELEGOO is a Chinese technology company dedicated to open-source hardware research, development, production, and marketing. Elegoo kits and components are well known to be fully compatible with Arduino platform.
Useful links:
- www.elegoo.com

Makey Makey
MakeyMakey is a device based on simplicity and fun. It allows the user to to connect everyday objects to a computer with the aim of exploiting the electrical conductivity. The kit consists of a few crocodile clips, a USB cable and a printed circuit board.
The card can replace the computer keyboard so when connected through the USB input, the four arrows, the mouse click, the space bar and even some letters respond to the device and, in this way, the user can take advantage of the characteristics of electrical conductivity of many elements such as fruit, vegetables, plasticine, foil, coins, etc.
Fruit is an excellent compromise, as it is very rich in water, so using vegetables for waste can be a good idea. Obviously the user needs to use a graphical interface. For example, can be used Scratch.
Useful links:
- makeymakey.com
- makeymakey.com/pages/educators#resources
- roboable.scuoladirobotica.it/it/newsroboable/1022/Robotica_creativa_e_disabilit____intervista_a_Elena_Parodi.html

Micro:bit

The Micro:bit open source hardware platform is a small device (5 cm by 4 cm) fully equipped for electronics experiences with bluetooth for connectivity, an accelerometer and compass on board.

It was created in 2015 by the British Broadcast Company (BBC) in association with 29 other partners with the aim of donating 1 million devices to students in the United Kingdom.

Useful links:

- www.bbc.co.uk/mediacentre/mediapacks/microbit/specs
- microbit.org/teach
- arstechnica.com/gadgets/2015/07/bbc-microbit-a-free-single-board-pc-for-every-year-7-kid-in-the-uk

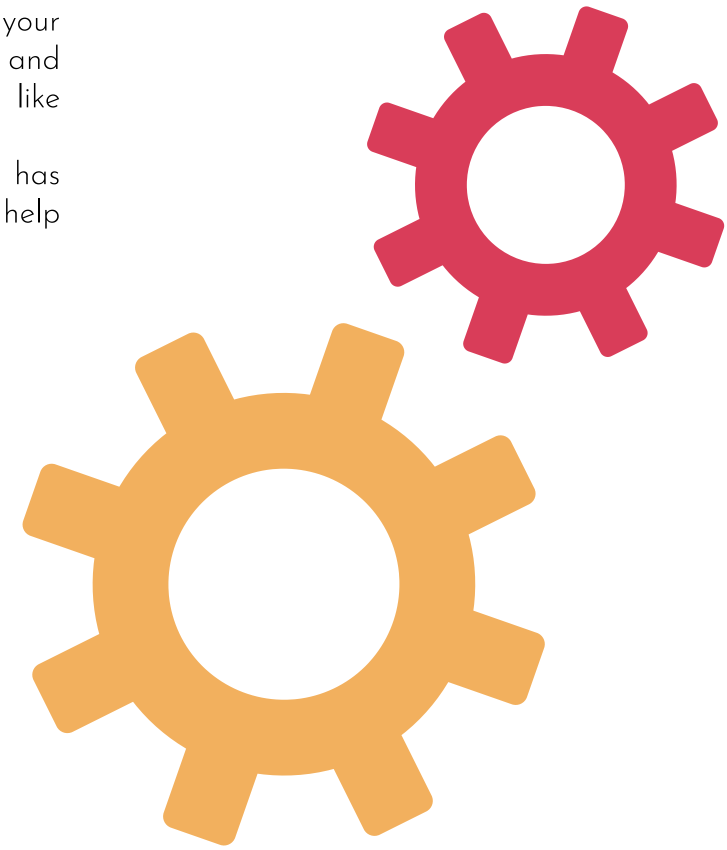
Raspberry Pi

The Raspberry Pi is a British built low cost computer that enables everybody to learn computing, start programming and explore basic electronics and robotics. With Raspberry Pi you install your own operating system, connect all your devices and create your own programs using languages like Scratch and Python.

Like for the Arduino plateform, Raspberry Pi has a large world wide community users ready to help and share very interesting projects.

Useful links:

- www.raspberrypi.org
- projects.raspberrypi.org/en



Open source software and programming environments

A robot is an autonomous electro-mechanical system. The electronic components work together executing a main program installed in the microcontroller's internal memory. In order to create this program and upload it into the robot, a software interface and a programming environment, able to communicate with the microcontroller have to be used. In this section we focus on the most popular open source software platforms that can be used with the microcontrollers presented in the previous section.

IDE-Arduino

The Arduino integrated development environment (IDE) is an application for Windows, macOS and Linux. It allows communication with your Arduino board. It includes a code editor and a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. It also includes general libraries to drive different kind of sensors and actuators.
The Arduino IDE supports the languages C and C++ using special rules of code structuring.
Some useful links:

- www.arduino.cc/en/Main/Software

Open Roberta

The programming environment "Open Roberta Lab" developed by Frauenhofer IAIS enables children and adolescents to program robots. A variety of different programming blocks are provided to program the motors and sensors of the robot. Open Roberta Lab uses an approach of graphical programming so that beginners can seamlessly start coding.
Some useful links:

- lab.open-roberta.org
- github.com/OpenRoberta

Scratch 3

Scratch is the most popular block-based visual programming language environnement developed by the Lifelong Kindergarten Group at the MIT Media Lab.
It allows the users to create interactive stories, games, and animations, to learn to think creatively, reason systematically, and work collaboratively through an online and offline plateforme.
Specific plugins can be created and added to Scratch 3 in order to allow the platform to communicate with a specific microcontroller. That's the case, for Makey Makey or Raspberry Pi.
Some useful links:

- scratch.mit.edu
- scratch.mit.edu/educators

Snap4Arduino

Snap4Arduino is a modification of Snap!, a visual programming language that allows to interact with almost all versions of the Arduino/Elegoo boards. Snap4Arduino is an offline platform, so the user needs to install it on his or her computer.
To start working with Snap4Arduino environment, a firmware (Firmata) has to be uploaded in the Arduino/Elegoo microcontroller. Firmata allows the microcontroller to communicate with the different sensors and actuators. Once this firmware has been installed in the Arduino Snap4arduino, it is possible to code the robot as in Scratch. Please note: to install the Firmata on the Arduino board, you need IDE Arduino.
Useful links:

- snap4arduino.rocks

PRACTICAL EXAMPLES OF ROBOTICS ACTIVITIES IN CLASSROOMS

This chapter includes 10 time-based activities to work on educational robotics in classrooms. They are activities meant to challenge the students with a time-based approach and "makers" projects oriented to study robotics principles and to develop technical and soft skills. The activities are proposed in a progressive order, from easy to more challenging. The discussion on social and environmental impacts of robotics and technology is part of all the activities, as well as the consideration on the ethical aspect.

A time based activity pushes the student to focus on the subject in order to quickly find a first solution. Following an agile development approach, a solution can then improve and evolve into a second or third release, allowing a deeper study of the topic. Finally and hopefully, the curiosity will motivate the students to search for more information outside the classroom context to improve stronger knowledge on the subject.

In the classroom, every solution proposed by the students should be evaluated positively. The main goal remains the development of the computational and critical thinking.

According to the DigComp 2.0 (The Digital Competence Framework for Citizens) the activities proposed below will allow students to develop competences like:

- Browsing, searching and filtering data, information and digital content
- Evaluating data, information and digital content
- Managing data, information and digital content
- Interacting through digital technologies
- Collaborating through digital technologies
- Programming
- Protecting health and well-being
- Protecting the environment
- Solving technical problems
- Identifying needs and technological responses
- Creatively using digital technologies
- Identifying digital competence gaps

The role of the educator shifts from teacher to project manager and moderator, helping the students to organize the work and to stay focused on the objective of the project. The educator will guide students in the learning process, and learn about it himself /herself about it at the same time.

According to the European Framework for the Digital Competence of Educators (DigComEdu), through these activities the educator can work on:

- Organisational communication improving his/her professional engagement
- Collaborative and self-regulated learning
- Actively engaging learners
- Facilitating learners' digital competence

Activity 1
Robotics without robots

Activity duration
30 to 45 minutes

What do you need?
A few sheets of paper, post-it, pens or pencils.

Introduction
A robot is an autonomous machine able to interact with the external environment in order to accomplish a specific task by executing a program. A program, an algorithm, is a clear and unambiguous sequence of instructions used to solve a specific problem.

A common misconception is that robotics is difficult to explain, hard to understand and an expansive activity. As multidisciplinary science, robotics needs the use of a technical terminology and specific knowledge. Sooner or later, it will include some expenses, such as a robot ready to use, or a kit to build a robot, or singles components to make it. However, first concepts can be easily introduced with some unplugged "icebreaker" activities, used to bypass formal theory and definitions and to motivate students.

"Robots and me" and "Harold the Robot" are two simple unplugged activities teachers can use in classrooms to give an introduction on what is a robot (with its main components such as the control unit, the sensors and the actuators) and how it works (with some principles of coding), introducing at the same time specific terminology and a first definition of robot.
These activities can also be used to establish a discussion with the students in order to clarify some stereotypes about robotics and coding or to introduce the ethical in robotics and in technology.

Activity progress
Robots and me
• Divide the class in groups of 2 or 3 students. Each group elects a group leader in charge of writing and speaking on behalf of the group. The groups will have 5 minutes to write on a paper a short definition of what a robot is (3-4 lines max) and 3 examples of robots they can see every day. Internet access is not allowed during this task. Then leaders of every group stick their definition on the blackboard.
• The teacher provides a general definition of the main components of a robot.
- Based on this previous definition, the students will have 5 minutes to draw on a paper a functional schema of a robot. Internet access is not allowed during this task. The group leaders stick the schemas on the blackboard.
• The teacher finally provides a formal definition of a robot and a formal schema then he/she starts the discussion:
- What are the 3 definitions closest to the formal one? Why?
- What are the 3 definitions furthest from the formal one? Why?

Harold the Robot
What can a robot do? Is it intelligent?
The previous activity the students started to familiarize with a first definition of robot and its main components. This second activity is intended to give them the idea that a robot, just like a computer, follows the instructions received in a program.
• The activity can be done as a challenge between the two groups. Group 1 creates a path in the classroom, like a labyrinth or a path with obstacles. Then it defines an instruction set (for instance, step forward, turn right on place, turn left on place...) provided to group 2. Meanwhile, the leader of the Group 2 is placed in the middle of the labyrinth.
• Group 2 now has 3 minutes to write a program based on the instructions set received, then communicate it to their leader who has to memorize it and then follow it in order to escape from the labyrinth, exactly as a robot would do.
Note: in this version the robot doesn't have any sensors, he just executes the program. How to modify the experience in order to allow the robot student to find automatically the exit way?
At the end of the activity the teacher moderates a short discussion with the students: Is it possible to compare the human body to a robot? What is the definition of intelligence? What is the difference between the intelligence and artificial intelligence.
This activity also raises the general issue surrounding communication. How to choose an instructions set: is it better to have a large basic instruction set, or a small efficient and complex set?

Some useful links
- d-clicsnumeriques.org - Parcours "Robotique"
- classic.csunplugged.org/harold-the-robot-2

Activity 2
The rocket on the moon

Activity duration
1 hour

What do you need?
An open source microcontroller like Arduino or Elegoo, a breadboard, a 100 Ohm resistor, a 3 V and 5 V LED, a button switch module, a computer with an Internet connection, a few sheets of paper, post-it, pens or pencils.

Introduction
A robot interacts with the external environment through its sensors. Sensors cap a specific information that they then translate in an electrical signal to transfer to the robot control unit. Through the main program, the control unit (the microcontroller) processes this information and then drives the actuators in a specific way.

The goal of this activity is to simulate a robot behaviour with an easy program and to understand the role of the sensors in a robot. The robot, the rocket, is simulated with a program using Snap4Arduino. The button switch module allows the robot to interact with the external environment.

Activity progress
- The students download and install the program Arduino IDE, then they download the Standard Firmata on the Arduino board. The use of the Internet to find procedure and information is allowed. The students have 10 minutes to complete the task.
- The students download and install Snap4Arduino on their computer, then they create a short program that simulate the behaviour of a rocket. The rocket has to interact with the button switch module. The students can choose the action that the rocket can do by pushing the button. The students have 40 minutes to complete the task.

One idea for an alternative task: it is possible to replicate the experience using different types of sensors. It can be interesting, for example, to use a humidity or temperature sensor to discuss, for example, security systems at home.

Activity 3
Basic electronics concepts

Activity duration
1 hour

What do you need?
An open source robot already built and fully operational (as Arduino or Raspberry based robot), some resistors, some LED, a mini speaker or headphones (optional), a breadboard (optional). A few sheets of paper, post-it, pens or pencils.

Introduction
A robot is an autonomous electro-mechanic system able to receive information from the external environment, to process it in order to realize autonomously a predefined task through its actuators.
4 main subsystems or units can be isolated in a robot: the power supply unit, the control unit, the sensors and actuators. Every unit accomplishes a specific task and it cooperates with other units in a synchronized way.

Every unit, as a subsystem, has at least two ports to receive and to transfer the information (one input and one output). Depending on the complexity, every subsystem can be able to process the information received in input to allow this information to be transferred to another unit.

Starting with the above definition, the goals of this activity are:
- To observe and to isolate the components of the robot shown in the classroom defined as subsystems, to understand how they work separately and how they work together in the specific robot.
- To reproduce a simple input-output process by programming an open source microcontroller (for instance an Arduino or Raspberry) to light on a LED or to reproduce a sound automatically when an input is given by keyboard or other input devices.
- To introduce some basics safety procedure in electronics by blowing up a LED or a resistor.

Activity progress
- The teacher shows the robot to the students divided into small groups.
- The students observe the robot in action, then they have 15 minutes to describe on paper the behaviour of the robot and to identify the main components or subsystems. For every subsystem identified, students have to write a short definition and how it works deducted from the observation. Internet access is not allowed during this task.
- The groups have now 30 minutes to build a cardboard robot with a real flashing LED antenna, and use a block program language to create a robot twin that beeps. The teacher will allow using Internet access in order to find suggestions after 5 minutes from the start of the activity.
- The students have 15 minutes to modify the program or the circuit already created in order to blow blow up a LED or a resistor. Basic safety procedures are then discussed.

Some useful links
- projects.raspberrypi.org/en/projects/robot-antenna
- d-clicsnumeriques.org - Robotics educational path - Parcours Robotique

Activity 4
The brain impact simulator

Activity duration
2 hours

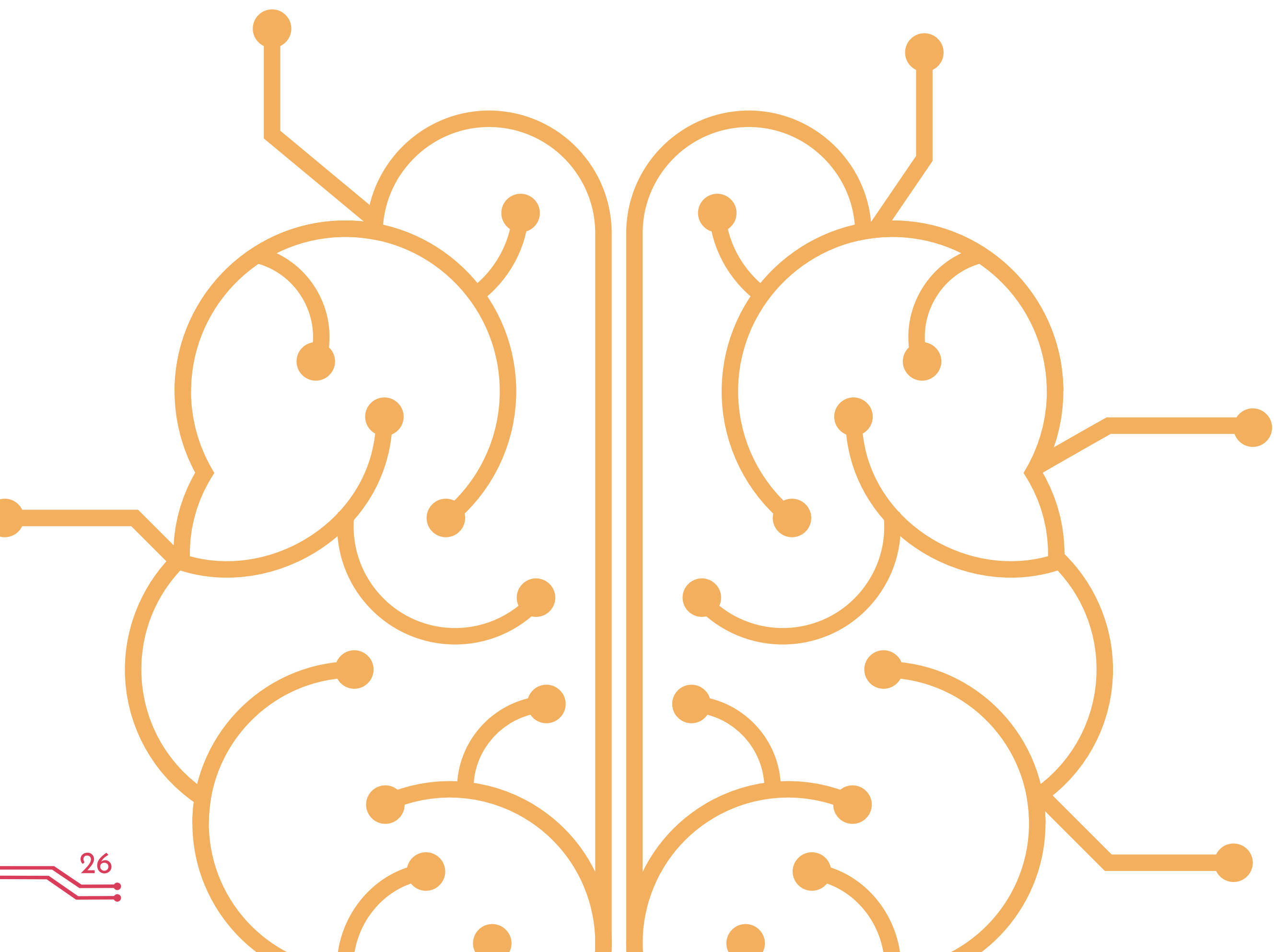
What do you need?
1 printed brain hat template; 5 strips of cardstock 3 cm x 12 cm; 10 strips of copper tape 2.5 cm x 5.5 cm; 10 strips of Velostat 3 cm x 6 cm; 17 male-to-male jumper wires; 10 female-to-female jumper wires; 5 100-ohm resistors; 1 tennis ball; 50+ metal washers string paper plate; 1 30,5 cm (12 in) balloon.
Reusables: 1 microcontroller (Arduino or micro:bit); 1 edge connector if you are using micro:bit; 1 USB cable A-to-B for Arduino; 1 USB cable micro for micro:bit; 1 breadboard

Introduction
A robot interacts with the external environment through its sensors. The role of the sensors is to catch a specific information from the environment, to translate it into an electrical signal and to transfer it to the control unit. The control unit (the microcontroller) processes this information and then drives the actuators to solve a task.

The goal of this activity is to understand the role of the sensors in a robot and more generally in an electronic system. Following the instructions available on the link below, the students will build pressure sensors by using simple materials. Then they will connect them to Arduino or a Micro:bit board. Finally, they will simulate the sensors through a ready to use graphical model (what happens the brain collides with the skull).
This activity allows also to work on: Physical science, Life science, Health, Engineering and Data science.

Activity progress
- The students are divided in small groups.
- They have 1 hour and 30 minutes to complete the experience. Using the internet to search for information is allowed. The students can follow the procedure described at the link below.
- The last 30 minutes are dedicated to writing a short report on the experience.

Some useful links
www.microsoft.com/en-us/education/education-workshop/brain-impact-simulator.aspx



Activity 5
Tangible computing with Makey Makey

Activity duration
60 minutes

What do you need?
Computers/laptops; Makey Makey kits; Assortment of materials that conduct electricity, for example: bananas, apples, oranges...; Tin foil, aluminium or copper tape; Plasticine or modelling clay; Metal spoons and forks.

Introduction
Makey Makey ignites curiosity, challenges problem-solving ability, and fosters creativity. With this device everyday objects are transformed into touchpads empowering students to interact with computers as creative tools. The computer becomes an extension of their creativity, fostering imaginative play and discovery.

This activity allows to interact with innovative game controllers out of fruits, cutlery, tin foil and so on. For instance, it will be possible to play the classic Pac-Man with a set of spoons or a piano made out of bananas and apples. This exercise will help teachers to introduce the principles of electrical conductivity and is a good example that can help understanding the connection between reality and the digital coding world.

Activity progress
- Introduce MakeyMakey controller with a short video. A well explained video on YouTube is proposed at this link: bit.ly/intro-makey
- Set up your computers, each with a (different) app on it that is compatible with the Makey Makey. You can also use retro games, that you can find online, such as PacMan or Super Mario, or most Scratch games.
With each computer, there is a Makey Makey set (not yet connected), an instruction sheet on how to connect it and some objects that conduct electricity.
- The students split up, spreading out across the different computers, so they can set up the Makey Makey devices and test the first game or application. After about 15 minutes, they rotate to the next game. From now on, every 10 minutes, they move up again one activity.

Here, you can see the classic "Banana Piano", but there are many more ideas and existing games. Take a look at https://labz.makeymakey.com/d/ for inspiration and choose the ones you like best.

Warning: the game will only work if the player is holding the grounding cable (and touching the metal end). This is because Makey Makey uses an "electrical" circuit for transferring information and those circuits always need to be closed. Don't tell your students in advance: let them figure it out while experimenting.

Further information
- More extensive videos, explaining how to use a Makey Makey, are available at this link here: www.youtube.com/watch?v=-X3hb__YynM
- For tools and resources for teachers, such as their Educators Guide (makeymakey.com/education) and Lesson Plans (makeymakey.com/lessons/lesson-plans.pdf)
- Looking for more inspiration? Take a look here labz.makeymakey.com.

Activity 6
Build a driverless car robot

Activity duration
1 hour and 30 minutes + 1 hour and 30 minutes for the bonus activity.

What do you need?
A kit to build the ROSA or BYOR robot, a set of screwdrivers, a computer with an Internet connection, recycling materials (plastic bottles, cardboard), glue, papers and pencils.

Introduction
A robot is an autonomous system programmed to accomplish a specific task by interacting with the external environment. Actuators are the subsystems the robot uses to accomplish its task.

An open source robot, like ROSA robot, is simple to manufacture and scalable. It allows to introduce open source robotics and basic knowledge in robotics to young people and general citizens. ROSA is the acronym of Robot Open Source Arduino. This robot has been designed by the french non profit organisation Maison du Libre for the French project "D-Clics Numériques". ROSA is composed by a microcontroller Arduino One, a single sensor (ultrasonic sensor), two motors and a motor controller unit. All these components can be assembled to create a driverless car that can avoid obstacles.
A similar robot is proposed by Scuola di Robotica and it is called BYOR robot which is the acronym of Build Your Own Robot.

In this activity the students will face the task of assembling a simple driverless robot/car, coding the main program that allows the robot to move and to avoid obstacles using an ultrasonic sensor. Because of the choice to use an open source robot mixed with the DIY approach, the students will face some mechanical, electrical and software issues to solve. This activity emphasizes the approach "situated learning" and the "trial and error" problem solving method.

Activity progress
- The students will build the entire robot ROSA in 30 minutes without the instruction manual but starting with the simple observation of a photo of the robot already assembled.
- They will simulate the ROSA behaviour with OpenRoberta Simulator.
- They will code ROSA main program to avoid obstacles OpenRoberta then with Snap4Arduino.

Activities bonus to go forward
- Modify the chassis of the robot ROSA by using recycling materials and to create the "ECO-ROSA" or modify the chassis in a funny way in order to create the "UGLY-ROSA".
- Discover Arduino IDE and improve knowledge in coding by modifying the main program already created.

Some useful links
- d-clicsnumeriques.org - Parcours "Robotique"
- byor.scuoladirobotica.it

Activity 7
The underwater robots

Activity duration
2 hours

What do you need?
To create the robot, students are provided with the necessary kit that consists of pipes and connectors for gardening in reused PVC, cable ties readjusted by the electrician, parts of floating pipe, propellers printed in 3D with recycled plastic, motors and controllers. It is possible to reuse the ROSA or BYOR kit for electronic components.

Introduction
This activity's aim is to realize an underwater mini robot, using recovered materials.
This activity allow to introduce the students to
- the marine ecosystem and its plastic pollution
- the importance of recycling and reusing plastic materials.

Activity progress
• To simplify the activity and to encourage group work, students are divided into groups of 2 or 3 participants.
• The project begins with the drawing of an idea for a robot that each group wants to create on paper, which is the result of each group's creativity. After first creating the robot's skeleton, then the mini-rov equipped with motors and controllers, the students move on to the practical test in water.
• Each group will try the mini robot in a large tank full of water and will be able to see the hydrodynamics of the robot and if it has reached a neutral attitude (principle of Archimedes). Once they have reached their ideal shape and performance, they will tele-drive their robot in the water.

The pedagogical objectives of this activity are the transmission of love and respect for the environment and the sea, the communication of the important extent of plastic pollution and teaching of the concept of recycling and reuse of materials. The activity also explains and demonstrates to children the principle of Archimedes and hydrodynamics.

Activity 8
Robotics arm: toward the humanoid robots

Activity duration
1 hour + 30 minutes extra if the students need to assemble the robot

What do you need?
A Poppy Ergo Jr kit, a computer with an internet connection, some paper sheets and pencils.

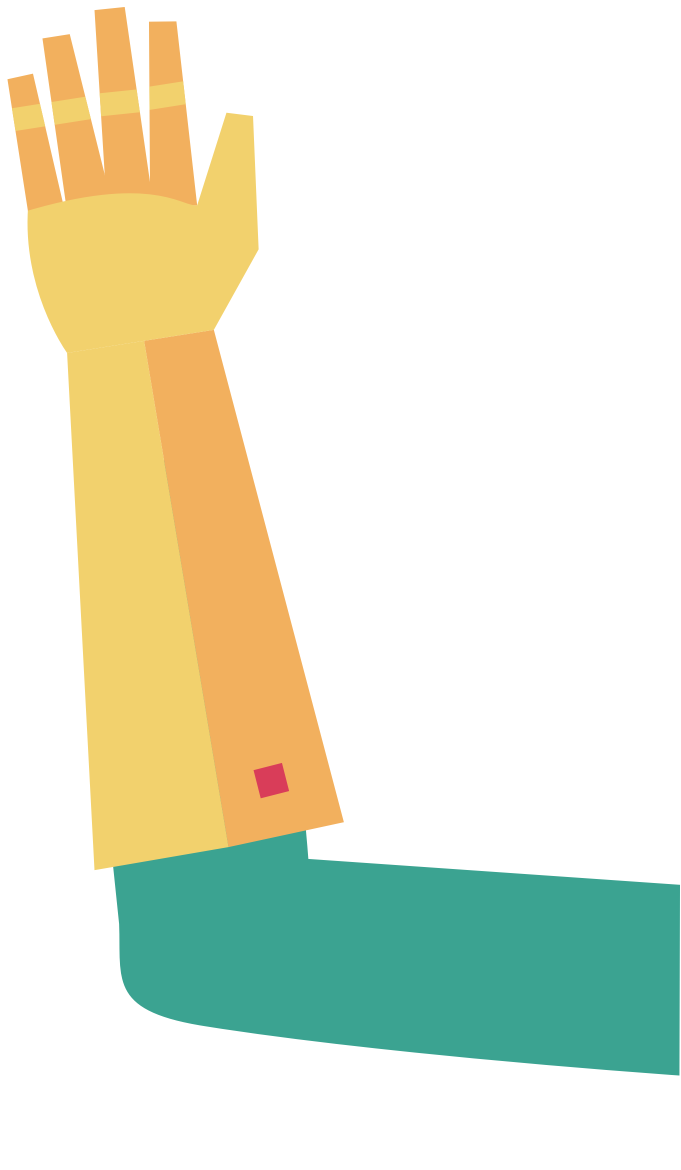
Introduction
A robot is able of performing a specific task with unimaginable precision and without ever getting tired.

Robotics has multiple applications in several sectors. In automotive and healthcare industries robotic arms are used to build cars in an assembly chain or to assist a doctor during a surgery. Precision and accuracy in time are essentials skills to avoid accidents for humans.

This activity allows the students to start to familiarize with robotic arms using the Poppy Ergo Jr robot by testing and modifying the demo programs.
Ergo Jr is a robotic arm, controlled with a Raspberry Pi board. It consists of 6 motors allowing life-like movements and 3D printed elements. A camera can be integrated to help the robot to interact with the world.
Ergo Jr is used to promote an educative approach, an interactive technology and as introduction to humanoid robots.

Activity progress
- The students work in teams.
- Using the demo programs already existing, the students will have 1 hour to create a program that allows the robotic arm to throw a ball.

Some useful links
- www.poppy-project.org/en/robots/poppy-ergo-jr
- drive.google.com/uc?export=download&id=0B-2jV8VX-lQHwTUxXZjF3OGxHVGM
- www.generationrobots.com



Activity 9
Artificial Intelligence and robotics

Activity duration
1 hour + 45 minutes extra if the students need to assembly the robot and install the software to drive the robot

What do you need?
A Poppy robot kit with a set of screwdrivers. A computer with Internet connection. A router to create a Wifi Lan. Paper and pencil.

Introduction
According to A. Kaplan and M. Haenlein, Artificial Intelligence (AI) is defined as a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals.

Robotics and artificial intelligence are deeply connected. Artificial intelligence is a highly sensitive subject nowadays. It's important to start a pragmatic discussion on this subject in schools in order to push the students to learn more about it and to think more deeply on the social impact of technology and its responsible use in daily life.

The purpose of this experience is to familiarize the students with the concept of AI and its social impact. How does a robot distinguish between objects and then takes a decision?
The object detection algorithm used is both AI and machine learning. Machine learning is a subset of AI that involves statistical learning, which is the case here. The algorithm was learned using hand-annotated "reference" data. The even more specific term here would be deep learning applied to the vision (deep learning is a particular type of statistical learning and very fashionable at the moment).

The students have to test all the demo programs created for the robot and deduct what programs use an algorithm close to an AI algorithm. The students will list 5 points for and 5 points against AI in daily life starting from what they learned during the demo with the robot, than they will discuss about the social impact of AI in our daily life.

Activity progress
- Assemble the robot.
- Install the Python environment (Anaconda) on the computer in order to communicate with the robot
- Configure the robot in order to recognize the LAN and to communicate with the computer.
- Find and test all the demo programs. Deduct the goals of each program observing the behaviour of the robot. Select the programs that use an algorithm close to an AI algorithm.
- List 5 points for and 5 points against AI in daily life inspired by the observation of the robot.
- Start a discussion about AI moderated by the teacher.

Some useful links
- github.com/pollen-robotics/rosa

Activity 10
Humanoid robots

Activity duration
1 hour and 30 minutes + 1 hour and 30 minutes for the bonus activity

What do you need?
NAO robot

Introduction
Nao Actor Studio is a teaching activity that can last from one and a half to three hours. The duration depends on the complexity of the exercises the teacher proposes his or her students.
The teaching activity involves the use of at least one Nao humanoid robot present in the classroom and aims to introduce humanoid robotics as a tool.

One of the most important teaching phases aims to teach the importance of relationships through the use of humanoid robotics. Thanks to humanoid robots it is possible to create a "relationship" or "engagement" using the movements of the robot and put them in relation with the human being.

Activity progress
Nao Actor Studio aims to synchronize the movements of the humanoid robot to an audio file with the aim of replicating a scene from a film chosen by the students. To teach how to develop movements with humanoid robots it is important to get inspiration and the best method is to already have an example of movement.
The world of cinema offers a lot of inspiration for this work, in fact it is possible to have dialogues, soundtracks and movements without the need to invent them.
There are many films that lend themselves to this purpose: Rocky, Titanic, Superman, 007, Indiana Jones, Harry Potter, Star Wars etc.

- Ideally, groups of 3-4 people should be formed, but you can also work with just one humanoid robot per class.
- The goal of the unit is to make the humanoid robot Nao move by replicating the movements and sounds of a given scene, so each working group will have to choose one. After that they will have to create a storyboard to decide which are the movements to reproduce with the robot.

At this point the robot Nao comes into play. You can work with two different methodologies:
- Without the robot using the simulation software Coregraphe to move the joints;
- With the robot showing the class the movements;

- After having realized the scheme of the movements, the groupswill go to program the robot to reproduce them, using one of the two methods described above. In addition, the teacher can develop parallel skills such as multimedia using software for editing audio files to be used in the replication of the scene.

At the end of the activity there will be a moment of sharing of the work done and each working group will show the chosen film and the representation with the robot.

Further information
www.softbankrobotics.com
www.naochallenge.it

Bonus • Robotics contests to challenge and to motivate the students

Nao Challenge NAO

The Nao Challenge is an annual contest organized by Scuola di Robotica, in collaboration with SoftBank Robotics, launched for the first time in France in 2014 and in Italy in 2015.

The main objective of the competition is to raise students' awareness, motivate them and train them in the use of humanoid robotics through the development of multi-technological and innovative projects. This competition is one of the educational activities aimed at developing the spirit of initiative and innovation in the students, as well as scientific and technological skills.

The tests are changed at each edition with the aim of stimulating students to explore the potential of humanoid robots in different areas of everyday life.

First contest

The FIRST® LEGO® League is a worldwide robotics and science competition for 9-16 year olds. It was created in 1998 as a result of a synergy between FIRST® (For Inspiration and Recognition of Science and Technology), a US association that promotes science and technology, and LEGO. From 2015, the FIRST® LEGO® League Junior was added, reserved for children aged 6 to 10 years. Operational partner for Italy, national referent, is since 2012 the Fondazione Museo Civico di Rovereto.

Each year the theme changes, and remains the same throughout the world during the season. The teams that qualify for the regional stages, arrive at the event of the national final. Once this phase is over, they are projected into a reality that sees them competing with other teams from around the world in different international events.

Robocup

RoboCup is an annual international competition with the goal to promote robotics and AI research, by offering a publicly appealing, but formidable challenge. The contest currently has six major competition domains (RoboCup Soccer, RoboCup Rescue Leagues Homepage, RoboCup@Home, RoboCup@Work, RoboCup Logistics League and RoboCup Junior). For further information:
www.robocup.org/

Schools can participate in the competition by enrolling groups of students in the RoboCup Junior. RoboCupJunior is a project-oriented educational initiative that sponsors local, regional and international robotic events for young students. It is designed to introduce RoboCup to primary and secondary school children, as well as undergraduates who do not have the resources to get involved in the senior leagues yet.

For further information: junior.robocup.org

SOME EUROPEAN GOOD PRACTICES

Coding for Inclusion

Belgium
Coding for Inclusion is a peer-to-peer methodology. Teenagers in schools are trained in a 15 hour methodology based on computational thinking, Scratch, Makey makey, Micro: bit and robotics. The teenagers than go on to teach their young peers, kids in elementary schools the methodology. The coding project thus empowers the older students to see themselves as teachers and offers them their first working opportunity. The methodology is very good for promoting inclusion for schools in disadvantaged areas to adopt.
For further information: robohub.lv

D-clics numériques: robotics educational path

France
D-Clics numériques is a French project lead by La Ligue de l'enseignement. It aims to help young people to become actors of the digital revolution by promoting and developing digital culture and critical thinking. Robotic education path propose an initiation to the robotic science through the discovery of a ROSA (robot open source Arduino). A ready to use education path divided in 12 lessons with several offline education games proposed. All technical files and documents are available under Creative Commons license (BY-NC-SA).
For further information: d-clicsnumeriques.org

Digital Welcome

Belgium
The Digital Welcome program aims to mentor young people, particularly from refugee or third country backgrounds, to be empowered and educated with digital and soft skills to be better integrated into society and have more capacity to be employed in the long term. The programme involved a peer-to-peer mentoring methodology. The core programme is based on four modules on: coding with scratch, digital storytelling, digital journalism, and soft skills.
For further information: digitalwelcome.eu

Driverless car

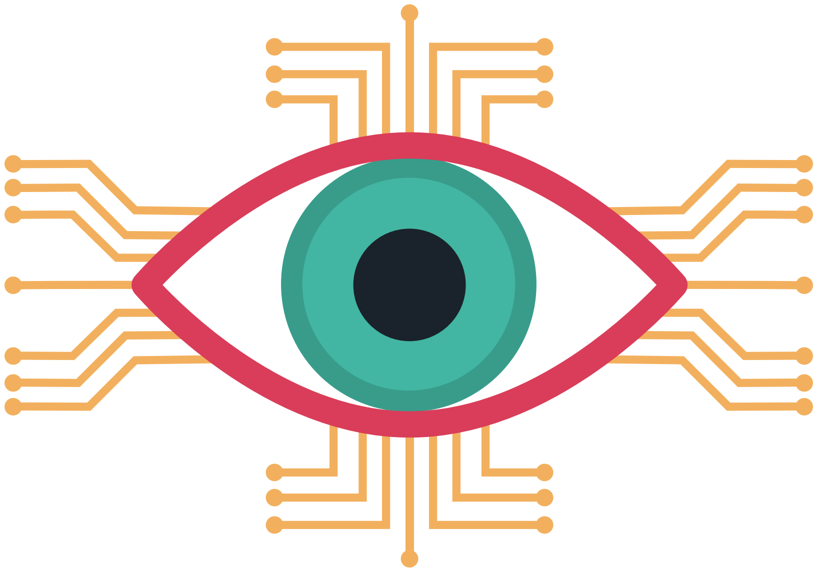
Italy
This activity is focused on the ethical issues linked to the rise of driverless car. During the lesson, students can build a mobile robot that can avoid obstacles with the help of a robotic platform. After that, they can understand some ethical issues with practice examples. This activity offers the possibility to translate ethical issues into "action". Scuola di Robotica used this lesson on different school levels: from 12 to 30 years old.
For further information: byor.scuoladirobotica.it

Erasmus+ project RoboESL

Latvia
10 projects on robotic activities were developed (using Lego Mindstorm platform) for students who are at risk of early school leaving.
For further information: roboesl.eu

Litera-robot: blending robot and literature

Italy
A seven-lesson program dedicated to boosting appreciation in young people and high school students for international literature throughout the use of robots. The program will incorporate certain pertinent texts, combining them with the introduction of simple robotics using the Lego Ev3 educational kits. The didactic approach adopted will enable participants to develop a strong appreciation for literature and master the basics of educational robotics and the related ethical aspects. This activity allows to boost the student's capacity to interpret and appreciate literature and the ethical consequences of using robots and new technologies, and rise awareness for the importance of educational robotics in the society of both today and tomorrow. In spite of learning difficulties of many participants as well as being culturally disadvantaged, all students succeeded in obtaining satisfactory results and thoroughly enjoyed the innovative didactic approach and tools utilized throughout the course.



Poppy Station

France

Poppy Station is the result of a transfer of Inria research from its open-source Poppy robot ecosystem to a multi-partner external structure. The Poppy ecosystem includes software and hardware tools for creating and programming robots, as well as educational content for education and training, and a large interdisciplinary community of users. This ecosystem was created and developed by the Inria Flowers team, with the aim of facilitating experimentation and the creation of innovative robotic tools in the fields of education, research and the arts.
Poppy Station is dedicated to the development and preservation of robotics ecosystems and associated open source or free technologies, in all areas where their use can allow this development and preservation, in a spirit of transparency and openness.
For further information: www.poppystation.org

Robo Hub

Latvia

It is a robotics training for 3 to 12 year old children after a training program developed by Lego Education. Robo Hub in the form of games provides knowledge of the technique. By modelling and constructing, children learn to think logically and creatively. Basic programming knowledge provides confidence in the ability to solve problems without adult help. Robotics training is integrated into curricula for preschools, schools and youth centres on initiative of these educational institutions.
For further information: robohub.lv

CONCLUSION

Mobile phones, computers, tablets and other technologies provide both social and entertainment functions for people of the digital era, especially for the younger generation. It is wrong to assume that using different technologies is harmful for the development of a person and that those technologies have to be taken away. The thoughtful use of technologies can enhance the learning in the classroom, develop learning motivation, support the development of computational thinking, support new generations by preparing them for the interaction with different technologies, not only as the users of the possibilities provided by technologies, but also as the creators of new, innovative solutions.

At the moment the use of technological solutions in educational settings can be described as "fear and fascination". In some cases technologies are left out of educational setting and only basic knowledge on the use of computers are accepted. This supports the idea that we should keep children safe from harm caused by technologies. On the other hand, the belief that new technologies will help all children to engage with the learning process and make them enthusiastic about it creates a kind of fascination. Both of the concepts are inacceptable. We should support the new generation's interest in digital world and support their learning.

This handbook on Educational Robotics gives an insight in robotics and its implementation in education. It be used as a guideline and source for inspiration for teachers that are willing to expand their knowledge and skills and learn together with children in creative environment.

Appendix 1
Pedagogical concept of digital skills

People cannot ignore the impact of technological development on every aspect of their lives. The rapid growth of technologies has provided different conditions of growing up for new generations from those generations before the digital era. That has an impact on people's interests, values, needs and world perception because technologies are an integral part of their lives that provide both social and entertainment functions.

In 1999 Edgar Morin wrote that the task of education is to prepare an individual to be a part of society and to prepare individuals for the future (Morin, 1999). This hasn't changed, the task of education is not only to educate the students. An essential purpose of education in the 21 century is lifelong learning through voluntary and self-motivated acquisition of knowledge. As mentioned before, one of the essential skills today is digital competence. The process of teaching and learning is a form of mutual understanding through communication by sharing the same specific knowledge and language system (Fernandes, et.al., 2018). Therefore, for teachers development of digital competence it's essential to find common ground with their students and be able to implement these skills into the educational process.

As well as the world and society are continuously changing, pedagogy as a science is constantly evolving as well and looking for new and better ways to teach and involve students in the educational process. In 1956, there was a significant turning point in pedagogical science when the first educational taxonomy, known as Bloom's Taxonomy, was developed under the leadership of educational psychologist Benjamin Bloom (Bloom et al., 1956). It determines not just remembering facts, but ways to promote higher forms of thinking. The original Bloom's Taxonomy explains educational objectives and cognitive processes starting with knowledge, followed by comprehension, application, analysis, synthesis and, finally, evaluation. But in 2001 scientists developed a revised Bloom's Taxonomy that was based on years of research. The revised taxonomy is widely known as Anderson's Taxonomy and was categorized as follows: remembering, understanding, applying, analysing, evaluating and creating new knowledge (Anderson et al., 2001).

Today, for the digital generation, a highly modified version of the original Bloom's Taxonomy is developed as a model for digital literacy skills (Phuapan, et.at., 2016). All six categories form Anderson's Taxonomy in 2007 were adapted to the development of digital skills accordingly from lowest to the highest level and called Bloom's Digital Taxonomy (Churches, 2007). Bloom's Digital Taxonomy explains activities with digital tools as shown in Figure 2.

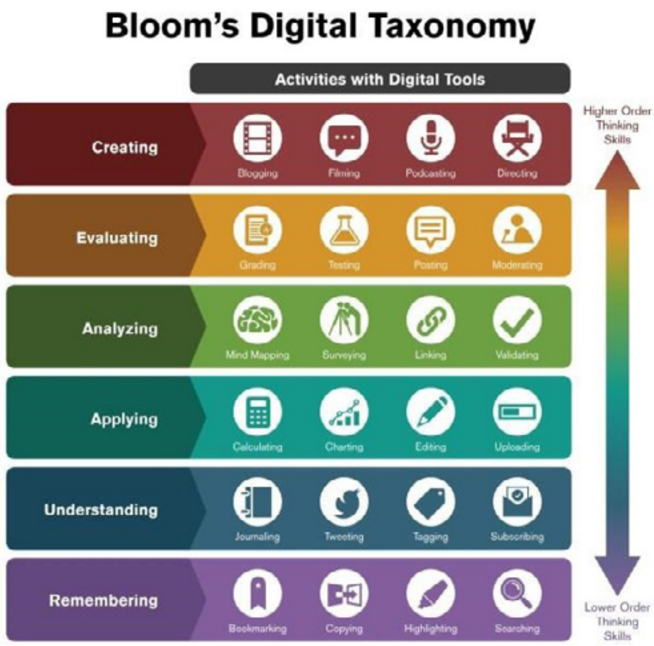
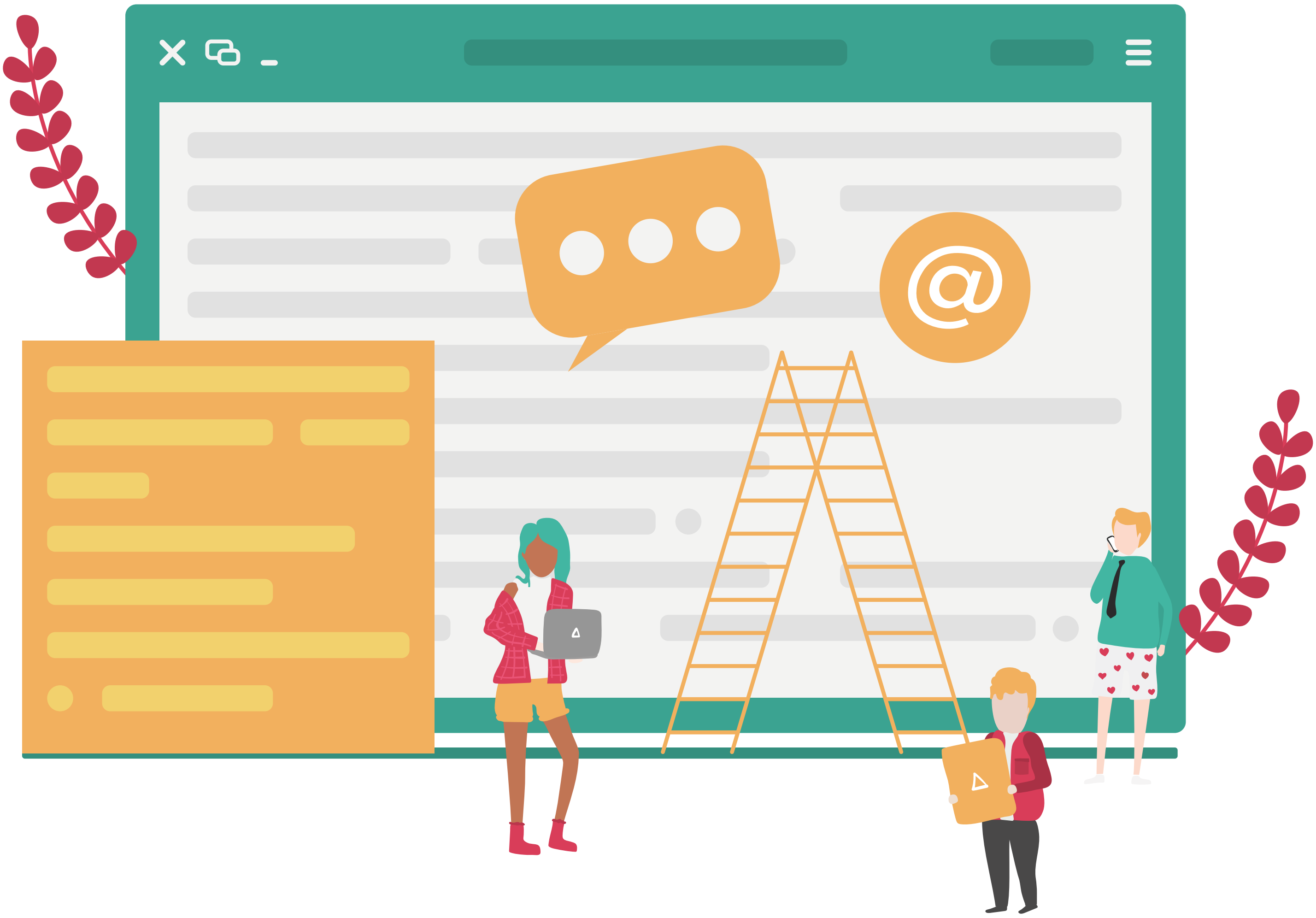


Figure 2. Bloom's Digital Taxonomy (Churches, 2007)

Developing digital skills is important for teachers to be able to implement the use of technologies in the educational process because it is significant to motivate students. The use of technologies or methods that could seem interesting and exciting for digital generation students is essential to increase the persistence of attention. One more important statement is that learning is an active process and the learner is an explorer, maker, creator (Saltmarsh, 1996, P.15). That correlates with John Dewey's idea of learning by doing. To develop a higher level of digital skills or to develop cognitive processes, practical experience and understanding of practical applications of knowledge is important. Educational robotics provide both, evolve digital competences for the students and also for teachers, and motivate students to get involved in any subject taught by a teacher with robotics.

A useful URL

The Erasmus+ MENTEP project developed the tool TET-SAT, an online assessment to evaluate teachers pedagogical skills with regards to introducing technology in classrooms: mentep.eun.org



Appendix 2
The constructivism of Seymour Papert

The researcher interested in this way of conceiving digital technology in education is Seymour Papert, who has taken up Piaget's "constructivist" thesis, according to which knowledge cannot be transmitted ready from one person to another. According to the scholar, conceptual construction is more effective if it is supported by the construction of concrete objects.

Papert worked for a long time at the Piaget Institute of Genetic Epistemology, so when he joined the Massachusetts Institute of Technology in 1964 he was greatly influenced by Piaget's theories of learning. He succeeded in developing computer languages that were easy to use even for very young children, and was responsible for the project in which the Logo language was born, considered the most famous programming language for educational purposes. In addition, Papert is the founder of the working group on epistemology and learning at the MIT Media Laboratory. Papert then extended the Logo language to a set of robotics, so as to offer children not only tools to concretize abstract thinking, but also to create artificial creatures.

In 1980, he published the book "Mindstorms", in which he dealt with the relationship between children and computers, which changed a lot the pedagogical culture and the way of thinking about new technologies for education. Every time a new technology is invented, says Papert, its use changes the lives of those who use it, but it takes time for a new culture of this technology to be established and for the whole community concerned to adapt (Papert, 1980).

The onboarding of new technologies in the educational system lags behind the development and creation of new technologies. As a consequence, children attending schools often find themselves in schools not learning valuable skills with the new technologies which they have been using from an increasingly younger age.

"In general, education is considered to be a cyclic process, where the learning process provides the inclusion of new innovations, modifying the content of teaching, changing teaching strategies, developing new teaching materials, planning what competencies will be needed in the future, which occupations will be required in the labour market, and so on. However, technological progress, which is becoming more rapid with the possibilities provided by digitization, pose a risk of centrifugal effects in the educational process making it fragmented, where actors of educational processes operate independently, and the role of pedagogy is diminishing, which also affects the quality of education. This is due to several possible causes, and one of them that the possibilities which are provided by technology are interesting and exciting and can redirect students' attention away from the educational process, where these interesting and exciting technologies are not included. The reason why they are often excluded is because quite often technology is considered useless for promoting students' cognitive development, since there must be taken in account the regularities of student development and the need to support the development of the attention span. It is undoubtable that it is necessary to let students acquire the needed knowledge to analyse information, make informed decisions, and promote the development of higher-level cognitive processes in order to create new innovations. The fact that the learning process should be interesting and exciting is not new for educators.
However, the fascination of technology makes it necessary to analyse the risks which can be caused by the concept "interesting", as students are constantly shifting their attention to interesting technologies. This attention shifting process can lead to the situation where long-term attention is not developed which means that fragments of different pieces of information are stored in memory, but do not allow being analysed as a whole picture of information, with the new information synthesised and new knowledge being constructed. This may endanger

metacognitive development. This does not mean that to support the development of metacognition what should be provided is a technology-free learning environment. On the contrary, it brings a focus on the pedagogical work, which is where to find the answers for how to incorporate technology in the educational process to use the driving force of the concept of the "interesting" in such a way as to direct the students' attention to reach higher levels of cognitive development."(Linda Daniela, Smart Pedagogy, 2019).

Papert has developed a fundamental concept: the "micro-world". He realized that while in the preschool period everyone acquires the language skills of their own cultural environment, in a formal context not everyone is able to acquire new skills. Therefore, he proposes a school environment in which learning situations that replicate a natural learning can be realized. And it is with this aim in mind that the importance of the robot is underlined as a tool that allows learning to be carried out free from the rigid rules imposed by schools. On the basis of all this, the project "Connected Mathematics" has been realized, which through the constructivist approach tries to change the way in which mathematics is considered and taught. In this project we try to replace the idea of mathematics as an activity of "problem solving" with that of "construction" in the sense that through new technologies it is possible to make concrete abstract mathematical concepts.
These elements have increased the interest for cooperative activities and therefore also for cooperative learning, which has its roots in constructivism.
For further information: connectedmath.msu.edu

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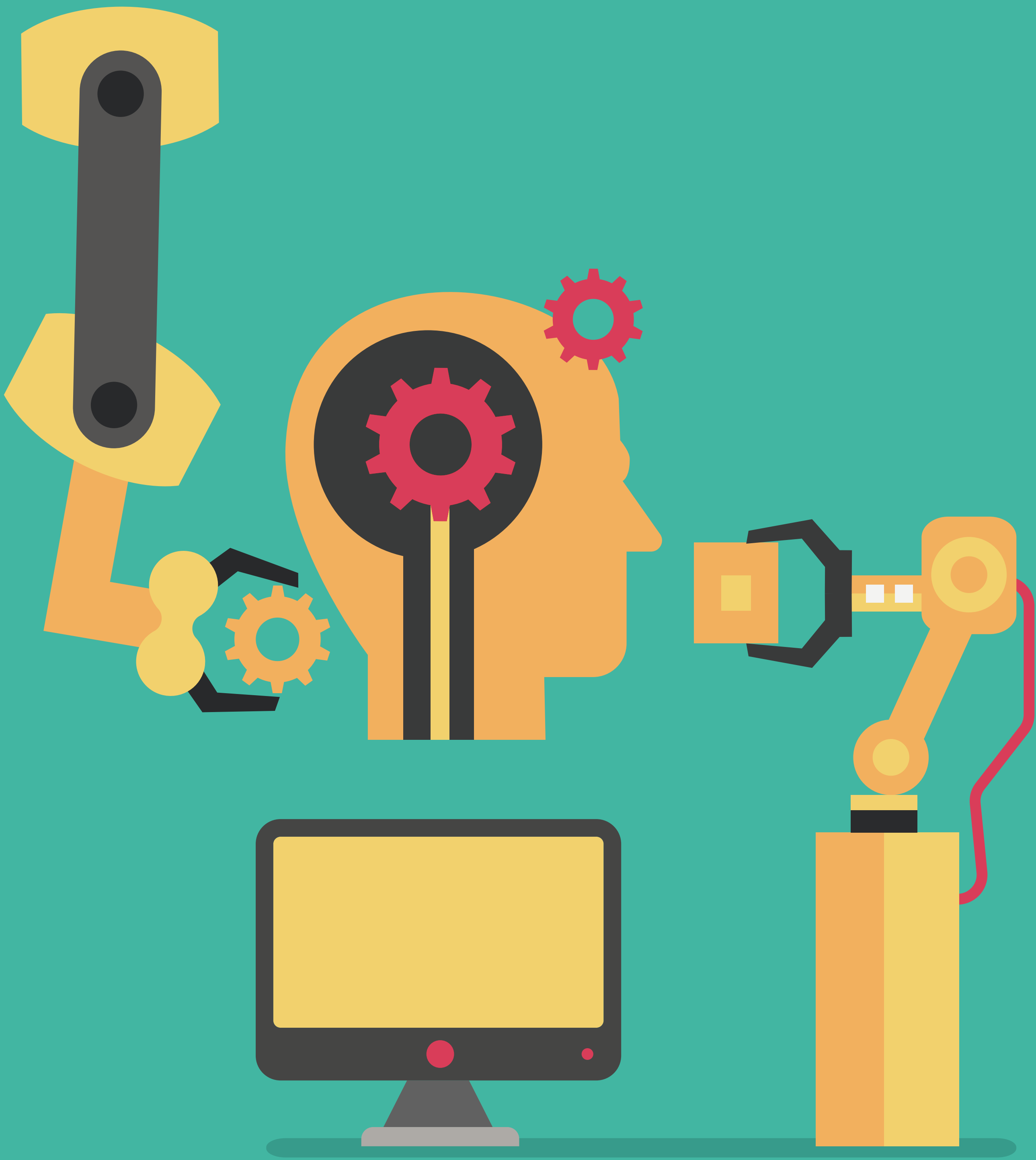
Educational Robotics

eMedia



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