Roboticsness—*Gymnasium Mentis*

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**Abstract** *Roboticsness* is an innovative teaching/learning approach based on the European Digital Agenda. The Lego robotics classroom is a living lab where students and teachers work together and share the enthusiasm of finding solutions thanks to new technologies. Project work and prototypes are produced, but the main objective is to train new prosumers to anticipate and prepare for the needs of a complex world.

**Keywords** Arduino · Coding · Creativity · Coworking · Problem-solving · Competences

1 The Project: LEIS Classroom

1.1 Goals

The Lego Education Innovation Studio (LEIS) robotics classroom was founded in 2014 at the Pepe Scientific High School in Ostuni (Puglia, Italy), where the Roboticsness [1] project (based on the Lego curriculum) has been conducted for five years. Here, a new philosophy of education is practiced: students are taught to think with machines. *Roboticsness* is an innovative teaching/learning approach based on the European Digital Agenda and civil law rules on robotics. The different manifestations of artificial intelligence have initiated a new industrial revolution and their diffusion has prompted the European Parliament to express itself on the matter through the Resolution of 16 February 2017 “Civil law rules on robotics”. Rules to regulate the development of these technologies without conditioning the innovation process are necessary. The European document draws attention to the shortage of ICT professionals in education and in the workforce (no. 41) [2]. The growth in robotics requires Member States to develop more flexible education and training

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systems, so as to ensure that the knowledge strategies for women match the needs of the robot economy (no. 42) [2]. Our goal is to move past the traditional concept of school as a system of linear transmission of knowledge from teacher to learner. Our school is based on learning by doing and on prototype construction.

Revolutions are made by people. Schools are made up of people: teachers and students.

How much distance is there between digital natives and teachers? Can schools take this route? Can we reach them, meet them?

1.2 Teaching Methods and Strategies

The main point of this experience is to learn in cooperative teams, where each member brings her individual skills to a project to build a new idea and a sense of community. Active learning, peer collaboration, personalized learning, learning by doing, and learning by mistake are the teaching practices of the robotics classroom. Teachers implement a process-driven approach, based on IBL (inquiry-based learning) and PBL (problem-based learning). This means starting with an analysis of (one or more) real problems (e.g., data log of acceleration in uniformly accelerated motion) and working backwards to an ideal model, in order to appreciate how it differs from reality. This approach leads students to analyze the whole problem, drawing on skills in mathematics, physics, engineering and technology.

1.3 Cooperative Learning and Cooperative Teaching

The teacher acts as a coach to support learning. No one is excluded during robotics activities: everyone works in groups, learning to interact with others. Building and programming a robot is the best way to promote digital culture, information technology, critical thinking, creativity [3], curiosity, initiative, persistence, and the value of error (Fig. 1).

2 Experiences

2.1 Curricular Robotics for First-Year Students (Aged 14–15, Science-Based High School)

The kinematics teaching unit (six hours) is led by two co-teachers in the robotics classroom and the physics laboratory. Students work in groups: each group builds a
robot (Lego Ev3) and programs it for an experiment in uniform linear motion. The activity consists of several steps:

- How to write a physics report
- What a Lego robot kit contains
- Let’s make a robot
- How to program an Ev3
- Let’s experiment: is uniform linear motion really uniform? Let’s write a report.

2.2 **STEM**

The Lego environment provides an innovative learning and teaching approach to STEM (Science Technology Engineering Mathematic) subjects. The number of female students enrolled in the project has increased in five years. Girls find it hard to take the initiative; gender-based teams form and exclude girls; boys are reluctant to accept girls in a context where there are machines. Girls are autonomous in programming; their attitudes and qualities are different from those of male students; they are resilient; they know how to solve problems; they recognize strengths; they disassemble and reassemble robots; they program and reprogram machines; they reach objectives [4].

2.3 **Participation in Exhibitions and Fairs**

The project involves developing robotic applications and/or using robots for learning and for creating activities in which they are used. This has enabled students to take an active part in some of the most important exhibitions and fairs in Italy and Europe. Groups of students have attended:

- Maker Faire Rome, Europe’s largest event on innovation (2015 and 2017)
• RomeCup, the event organized and managed by Fondazione Mondo Digitale, which offers an extraordinary immersive experience on the present and future (2014, 2015, 2017).

3 Results and Conclusions

During the 2014/2019 five-year period, the project showed significant results in terms of frequency, educational outcomes and overcoming the gender gap.

The indicators for identifying outcomes were:

• Improvement in school performance;
• Improvement in study method;
• Strengthening STEM skills in female students.

Throughout the project, the average attendance of enrolled students was around 98%.

The percentage of female students enrolled in the project grew exponentially (by up to 75%), fully in line with PNSD (National Plan for Digital Education) action #20 “Girls in tech and science” (reducing the gender gap) (Figs. 2 and 3).

Furthermore, the impact was positive on the subject performances of both male and female students. Performance in science subjects (particularly physics) improved for 70% of students compared to results in the first four months and the previous year.

![Number of students during the 5-year project](Fig. 2)
The aim of the project is not to replace “obsolete” content and knowledge with something that is “fun and modern,” but rather to make the transmission of “knowledge” more effective and to ensure that school can be closer to the everyday reality of digital natives, who are surrounded by captivating digital tools and robotics.

In keeping with the goals of the project and of several international ICT frameworks, the activities develop the following competences:

- Digital literacy (Recommendation 2006/962/EC, updated on 22 May 2018)
- Knowing how to deal with reality as compared with a theoretical reference model
- Knowing how to design strategies for solving problems through programming (DigComp 2.1, programming and problem-solving)
- Knowing how to make decisions consistent with goals and strategies
- Knowing how to handle errors
- Knowing how to process results and apply the necessary corrective measures
- Knowing how to develop simple prototype robot applications
- Knowing how to organize, analyze, summarize, infer, abstract and process
- Correlate, contextualize and generalize learned knowledge.

References

1. Roboticsness Homepage. http://www.liceopepe.wixsite.com/roboticsness
2. The European Parliament’s “Civil law rules on robotics” document (European Parliament resolution of 16 February 2017 with recommendations to the Commission concerning civil law rules on robotics 2015/2103 INL), is available at the link URL: https://www.europarl.europa.eu/doceo/document/TA-8-2017-0051_IT.pdf. In particular “General principles concerning the development of robotics and artificial intelligence for civil use civil use”, “Education and Work” n. 41 and n. 42
3. Gardner, H.: Five Minds for the Future. Boston: Harvard Business School Press, tr. it. di E. Dornetti (2007), Cinque chiavi per il futuro. Milano: Giangiacomo Feltrinelli Editore, p.164:
Creative intelligence goes beyond existing knowledge and syntheses to pose new questions, offer new solutions, and shape works that push the boundaries of genres or shape new ones. Creativity is based on one or more recognised disciplines and requires judgements of quality or acceptability to be made by an informed environment (2006).

4. Campustore.: #womeninstem education edition, Paola Lisimberti, Girls do it better. (2017) https://youtu.be/SpkimcCWXGU