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Play INAF for schools: Coding and educational robotics training for teachers

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Abstract. The INAF Play.Coding working group regularly organises teacher training courses about coding and educational robotics, to bring these methodologies into the classroom with astronomy-related applications. This paper presents the in-person training for primary and secondary school teachers held during the science festival Esperienza Insegna 2023 in Palermo, which was also offered through the S.O.F.I.A. platform of the Italian Ministry of Education. The training, taught by researchers and technologists from the Italian National Institute for Astrophysics, was free of charge and consisted of 4 sessions of 3 hours each (12 hours in total). The main focus of the training was to provide skills to effectively bring coding and some educational robotics applications into the classroom. Twelve teachers participated in the training and provided feedback about their experience.

Key words. Astronomy Education – Teacher training – Coding – Educational robotics

1. Introduction

As part of its Third Mission to engage with society, the Italian National Institute for Astrophysics (INAF) fosters the development of social, educational and cultural products to be made readily available to the public. The Play INAF website[1] is an online, multilanguage platform hosting materials and resources to bring astronomical topics into the classroom with the aid of coding, educational robotics, tinkering, hands-on and making, augmented and virtual reality, and game-based learning. In particular, the Play.Coding working group has been supporting the creation of digital resources that disseminate astronomical content while enabling users to practice computational thinking and digital skills (Sandri et al. 2023; Mignone et al. 2022). Computational thinking, defined a practice that "involves solving problems, designing systems, and under-

[1] https://play.inaf.it/en/ (accessed 7 Nov. 2024)

standing human behaviour, by drawing on the concepts fundamental to computer science" (Wing 2006) is an essential ability to make sense of the world, interact with and co-create technology. The objectives of these activities, besides astronomy and physics education, include stimulating curiosity in order to learn while having fun.

In addition to the materials and resources published online, the Play.Coding working group also offers webinars, educational courses, teacher training, workshops and summer camps for schools (see e.g. Sandri & D'Orsi 2022). Since 2018, the team has been organising training for primary and secondary school teachers using coding and educational robotics:

- Coding with Scratch and mblock (15 hours in-person sessions + 13 hours in the classroom), Bologna, 2018-2019;
- Coding with Scratch (10 hours), Monte Rotondo (Rome), 2018-2019;
- Coding with Scratch and mblock, National INAF workshop on innovative education (10 hours), Bologna, 2019;
- Coding with Scratch and mblock, Agenda 2030 delle bambine e dei bambini (6 hours), Bologna, 2021;
- Coding with Scratch and mblock, Agenda 2030 delle bambine e dei bambini (6 hours), Bologna, 2022;
- Coding with Scratch and mblock, (12 hours) @ Esperienza Insegna, Palermo, 2023.

In this paper, we present the most recent of activity in this series, namely the teacher training organised in February 2023 in Palermo, Italy, as part of the Esperienza Insegna science festival.

2. Teacher training

The teacher training, aimed at primary and secondary school teachers, took place from 14 to 17 February 2023 at the University of Palermo. It was free of charge and certified through the S.O.F.I.A. platform[2] of the Italian Ministry of Education. The authors of this paper, who are researchers and technologists from INAF, the Italian National Institute for Astrophysics, acted as trainers and facilitators. The training consisted of 4 sessions of 3 hours each (12 hours in total), alternating frontal lessons with individual and group practical exercises. The main focus was to provide skills to effectively bring coding and some educational robotics applications into the classroom.

2.1. Session 1

The first session covered the following topics:

- Introduction to computational thinking;
- The Scratch[3] programming environment;
- Execution of a single command;
- Sequence of commands;
- Programming: cycles, conditional constructs, variables and lists, operators, messages;
- Use of sounds and costumes;
- The Scratch community;
- Sharing and remixing projects.

After an introduction to the concept and benefits of **computational thinking**, the course covered the basics of **Scratch**, a block-based visual programming language aimed primarily at children (Resnick 2009). Thanks to its visual interface and block-based design, Scratch makes coding accessible to a wide range of students and teachers, allowing them to visualise **key functions** of coding such as cycles, conditional constructs, operators, etc. (see Figure 1). **Sprites** are objects or characters in Scratch that can be programmed to perform actions using block-based scripts. The training introduced teachers to the vibrant online **community** where Scratch users from all over the world interact, work together and share their projects, tips and troubleshooting advice.

[2] Sistema Operativo per la Formazione e le Iniziative di Aggiornamento del personale della scuola (accessed 7 Nov. 2024)

[3] scratch.mit.edu (accessed 7 Nov. 2024)

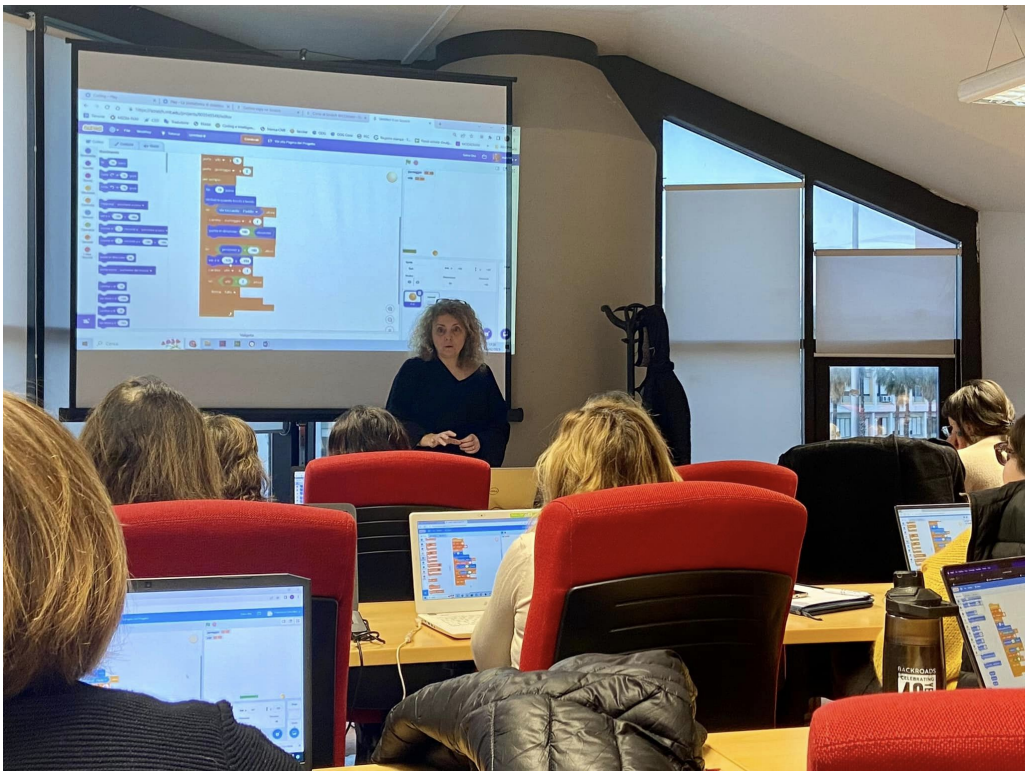

Fig. 1. Session about Scratch during the teacher training.

2.2. Session 2

The second session covered the following topics:

- Use of the Pen tool;
- Cloning sprites;
- Digital storytelling with Scratch.

Having covered the basics of Scratch, the training delved into some tools that can be used to create animations. One of them is the **Pen tool**, which enables sprites to draw lines as it moves. A classical example to apply the Pen tool is the drawing of lines and shapes, especially polygons: starting from a three-sided polygon (triangle) and increasing the number of sides, generalising it to N sides [4]. In this way, coding can be used to practice and test concepts learnt in mathematics (geometry) class or, conversely, the knowledge acquired during geometry class can be used to practice coding skills.

Another key feature in Scratch is **cloning**, which allows a sprite to create a copy of itself while the project is running. An example is the basic exercise in which a single ball bounces off the environment's walls[5], generalised to N balls[6]. This feature can be used, for example, when designing video games by and for children with Scratch (Sandri et al. 2025).

Scratch enables teachers and students to explore stories, combining the power of narrative with images, video, digital devices and web-based technologies. The narrative scheme reflects the human experience of problem-solving: therefore, through **digital**

[4] scratch.mit.edu/projects/262332165 (accessed 7 Nov. 2024)

[5] scratch.mit.edu/projects/816234916 (accessed 7 Nov. 2024)

[6] scratch.mit.edu/projects/838209833 (accessed 7 Nov. 2024)

storytelling, learners can organise, express, remediate, and share ideas and knowledge in a creative, original way (Petrucco & De Rossi 2009). The course presented a Scratch-based activity[7] to create a storyboard, search for images and sounds, and program to produce an animated video inspired by a short story from the Cosmicomics collection by Italo Calvino, celebrating the centenary of the great Italian writer's birth in 1923.

2.3. Session 3

The third session covered the following topics:

- Makey Makey[8]: application of interactions between a computer and the outside world;
- Example: exploration of the Solar System;
- mBot and mBlock[9];
- Elements of robot programming;
- Example: mBot goes to Mars.

After the first two days dedicated to coding and its applications, the third day moved to educational robotics. The training introduced teachers to **Makey Makey**, an innovative kit that turns any object into a touchpad. In particular, the course presented an activity to discover the Solar System with Makey Makey and Scratch, creating an interactive panel to introduce the planets, the Sun, the Moon and the asteroid main belt with music and audio recorded by students[10].

Besides, teachers were also introduced to **mBot**, an educational robot designed to make teaching and learning robotics and coding both simple and fun. mBot can be programmed using mBlock, a programming language based on Scratch, which also includes a library of actions that can be performed by the robot. The training included an activity to program mBot as if it were on Mars[11].

[7] Digital storytelling con le Cosmicomiche di Italo Calvino (accessed 7 Nov. 2024)

[8] makeymakey.com (accessed 7 Nov. 2024)

[9] makeblock.com (accessed 7 Nov. 2024)

[10] Discover the Solar System with Makey Makey and Scratch (accessed 7 Nov. 2024)

[11] mBot è su Marte (accessed 7 Nov. 2024)

Fig. 2. Session about Ozobot during the teacher training.

2.4. Session 4

The fourth session covered the following topics:

- Educational robotics for young children;
- Unplugged coding: pixel art, Ozobot[12], BeeBot and BlueBot.

The last day of the training covered **unplugged coding**, i.e. computer science activities that do not include actual programming and can be done offline without a computer (Bell et al. 2009). The course included pixel art, or drawings that emphasise the underlying pixel structure, represented as a run-length encoded sequence to indicate the colour of each pixel and specify how many pixels should be painted in each colour (Bogliolo et al. 2017). In particular, it presented a series of **pixel art** codes for Solar System planets and other astronomical images created by the INAF Play.Coding

[12] ozobot.com (accessed 7 Nov. 2024)

working group[13]. It also included a practical session with **Ozobot** (see Figure 2), one of the smallest programmable robots, which can be instructed to follow a black line and guided towards different directions by applying appropriate colour codes to the empty spaces placed along the maze, presenting astronomical applications to the theme of extrasolar planets (Leonardi et al. 2025). Finally, the training presented activities using **BeeBot** and **BlueBot**, small educational robots that execute simple sequences of commands such as forward, left and right, designed specifically to be used by young children. This included practical exercises to engage with children with storytelling, programming the small robots to create a space-themed adventure such as those involving the fictional alien character, Blu[14] (see Figure 3). The course also presented an astronomy-themed escape room developed by the working group that includes all the above-described unplugged coding and educational robotics activities (Mignone et al. 2025).

3. Feedback from teachers

Twelve teachers from primary and secondary school attended the training, including science and non-science teachers, as well as special-needs educators. Six teachers responded to a final appreciation survey a few weeks after the course. About half of them had already attended similar courses and had already practiced coding and/or educational robotics in the classroom before. In terms of satisfaction, on a scale from 1 (least satisfied) to 5 (most satisfied), four out of six scored 5 and two out of six scored 4, indicating a high degree of appreciation for the training. All respondents indicated that they did not find anything too easy or too difficult; one of them pointed out that they would have enjoyed more time for practical exercises. They found all aspects very useful and highly interesting, especially the robotics sessions "because children are fascinated by these activities".

[13] https://play.inaf.it/tag/pixel-art/ (accessed 7 Nov. 2024)

[14] https://play.inaf.it/en/the-adventures-of-blu/ (accessed 7 Nov. 2024)

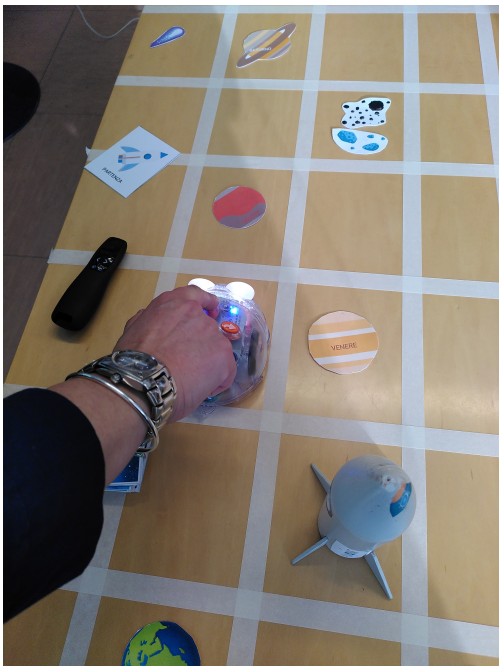

Fig. 3. Creating stories of space adventures using BlueBot and unplugged coding.

4. Conclusion

Teacher feedback, collected both formally via an online survey and informally, via direct comments at the end of the course, demonstrates that the training organised in Palermo as part of the Esperienza Insegna 2023 science festival was a very successful activity. The INAF Play.Coding working group continues to develop new activities and educational resources, which are readily available online, as well as organising teacher training, upon request, to disseminate this material that combines science and astronomy education with coding and robotics to practice computational thinking and digital skills.

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References

Bell, T., Alexander, J., Freeman, I., & Grimley, E. 2009, Computer science unplugged: School students doing real computing without computers, New Zealand Journal of Applied Computing and Information Technology, 13(1), 20-29

Bogliolo, A. 2017. Pixel art, coding e immagini digitali. https://codemooc.org/pixel-art/

Leonardi, L., Sandri, M., Daricello, L. & Mignone, C. 2025 (in press). Developing autonomous learning processes in Astrophysics programming with Ozobot. Proceedings of CRI23, International Conference on Child-Robot Interaction, June 23–25, 2023, University of Milano-Bicocca, Milan, Italy

Mignone, C., Sandri, M., Bandiera, R., Bogliolo, A., Casu, S., Fulco, M. T., Giobbi, G., Klopfenstein, L. C., Leonardi, L., Malaspina, M., Toniolo, R. & Trinchieri, G. 2022, The first international online Astrophysical Code Hunting Game. GARR Conference Proceedings 13

Mignone, C., Galleti, S., Leonardi, L., Di Giacomo, F., Fulco, M. T., Sandri, M. 2025 (in press). "On board a photon": an educational escape room based on robotics and unplugged coding to discover the journey of light across the Solar System. Proceedings of CRI23, International Conference on Child-Robot Interaction, June 23–25, 2023, University of Milano-Bicocca, Milan, Italy

Petrucco, C., & De Rossi, M. 2009. Narrare con il digital storytelling a scuola e nelle organizzazioni. Carocci Editore, Roma

Resnick, M., Maloney, J., Monroy-Hernandez, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B. & Kafai, Y. 2009, Scratch: programming for all, Communications of the ACM, 52, 11

Sandri, M., Mignone, C., Bogliolo, A., Bandiera, R., Coero Borga, D., Casu, S., Fulco, M. T., Giobbi, G., Klopfenstein, L. C., Galleti, S., Leonardi, L., Malaspina, M., Ricciardi, S., Toniolo, R. & Trinchieri, G. 2023. The International Astrophysical Online Code Hunting Game and the Astrophysical Cody Maze. Two innovative resources to promote computational thinking, digital skills and astronomy dissemination, Memorie della Società Astronomica Italiana, Vol. 94, p. 128

Sandri, M., & D'Orsi, G. 2022. An inclusive summer camp based on coding and educational robotics to discover the planet Mars through digital storytelling with Scratch, Inclusive Science Education and Robotic, pp. 185–198, Franco Angeli

Sandri, M., Bandiera, R., Olmi, B., Mignone, C., Di Giacomo, F., Cassaro, P., Falco, M., Fulco, M. T., Galleti, S., Leonardi, L., Malaspina, M. & Trinchieri, G. 2025. Astro Arcade: the videogames in eighties style ad the Time Machine exhibition, Memorie della Società Astronomica Italiana, this volume

Wing, J. M. 2006. Computational thinking. Communications of the ACM, 49(3), pp. 33–35