IL NUOVO CIMENTO **45 C** (2022) 221
DOI 10.1393/ncc/i2022-22221-6

Communications: SIF Congress 2021

# SVELAMI-B project: Remote physics laboratories at Milan-Bicocca University

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received 31 January 2022

**Summary.** — The SVELAMI-B project offered in-depth activities in STEM fields to primary school children, inspired by the discoveries of famous women scientists. Starting from a shared multidisciplinary design (from physics to mathematics, computer science, geology and education science) the aim was to enhance the learning potential of scientific subjects, while addressing the problem of gender gap in Science. Due to the pandemic situation, all the activities were carried out entirely in distance learning. In this paper, some results and outcomes will be analyzed, as well as possible developments for the design of new school interventions based on a community of practice.

## 1. – Introduction

The SVELAMI-B project was submitted to the "STEM2020" call of the Department of Equal Opportunities, Council of Ministers, a call aimed at increasing the interest of young students —in particular girls— towards Science. A specific requirement of the call was that the percentage of female students should be at least 60% of the total number of students involved in the project. Once selected, SVELAMI-B was carried out from March 16, 2021 to June 15, 2021, only remotely due to the Covid-19 emergency. SVELAMI-B was coordinated by the Department of Physics, with the participation of four other Departments of the University of Milan-Bicocca interested in building up a shared multidisciplinary design. The main purpose was to offer educational actions and activities in schools, addressing topics in Science, Technology, Engineering and Mathematics (STEM). Physics, Earth Sciences, Mathematics and Computer Science were specifically chosen, being subjects where the underrepresentation of the female gender is still a compelling issue [1]. In fact, there are several overlapping factors which limit women participation and career in STEM. Results of the latest Trends in International Mathematics and Science Study (TIMSS [2]) clearly depict the current gap between young men and young women in scientific and technological learning. In Italy the gap is wider than in other Organisation for Economic Co-operation and Development (OECD) countries.

Two primary schools were involved (3rd grade classes of I.C. "A. Faipò" in Gessate, Milan, and 4th grade classes of I.C.S. in Cernobbio, Como,) and 11th and 12th grade

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students of four high schools (ITI LSA “Cartesio” in Cinisello Balsamo, Milan, Liceo “Banfi” in Vimercate, Monza Brianza, L.S.S. “Antonelli” in Novara, L.S.S. “Mascheroni” in Bergamo). There were 73 primary school participants (out of which 44 were girls) and 139 secondary school participants (out of which 92 were girls). In total, the percentage of female pupils was about 64%. In the following, we will focus on the primary schools interventions only.

A remarkable outcome of the project was the establishment of a community of practice within the University of Milan-Bicocca, which can work as a reference for future STEM actions.

## 2. – The formal inquiry-based path

The project was designed for primary schools by following inquiry-based principles (see for example [3], and references therein). For each school, planning included 10 days of at least four hours activities. It was shared and discussed with the teachers of the involved classes before the beginning of the path, in order to adjust the activities to the average level of the classes and figure out the most effective tools/actions. Interactions between the university team and primary school teachers were supported by a dedicated tutor, who also assisted teachers remotely offering them educational advice. All the scientists involved in the project were women scientists, while dedicated tutors supporting students were both men and women.

The scheme, for the 10-day project, was the following: 1) introduction to the project and examples of women in science; 2) forces; 3) mathematics codes; 4) mathematics activities; 5) computer science activities; 6) light; 7) rocks; 8) earthquakes; 9) mysteries of the universe; 10) conclusion of the project. To begin with, the life, work and scientific results of famous female scientists of the past were presented, at different levels. This was an important aspect of the project, given that, as outlined by Irene Biemmi [4], books adopted in schools are often affected by gender stereotypes and rarely acknowledge the discoveries made by women scientists. Successively, STEM labs and discussion activities followed, which were always constructed starting from a research question. The University team designed multidisciplinary activities in order to let pupils explore different fields, always starting from experiments and then trying to explain in simple words the observed phenomena. Scientific experiments were presented in playful formats.

Concerning physical sciences, the selected topics were “forces” and “light”, in agreement with disciplinary core ideas [5]. Exploiting the multidisciplinary feature of the project, these were also related to activities in other disciplines. All the activities were designed so as to present physics as a discipline which not only explains natural phenomena, from infinitely large to infinitely small scales, but also allows for several applications, including the fascinating application to the study of cultural heritage. Within this approach, special attention was given to the role of women physicists, in order to pass the message that physics, and more generally science, can be approached by everybody, independently of gender. In particular, children were stimulated by asking them to pay attention to the stories of women scientists and answer questions like “Who is she and what does she do?”, “Where does she work?”.

Each activity was conducted remotely, through a platform previously used by the classes involved (Google Meet). Pupils, due to the pandemic, were very familiar with distance learning activities (*i.e.*, DAD) and this facilitated the whole process. Every experiment was proposed by the University team, during a live meeting (in streaming). The teachers had already the necessary materials, and all the class could perform the "experiment" guided by the University team and the teachers. Examples of the activities regarded: the phenomenon of birefringence in calcite crystals; experiences with magnetic forces (using small magnets) and with electrical forces (for example due to electrification by rubbing); exploration of the Universe through the observation of pictures sent by satellites and virtual reconstruction of cosmological and astrophysical events.

Since the whole project was carried out remotely, it was also possible to exploit well-established resources in virtual laboratories. One of them is the PhET lab (interactive simulations for Science and Mathematics at the University of Colorado, Boulder([1])). Although participants could not grasp all the aspects, they got fascinated for example by refraction of light, by playing with the dispersion of "white" light and the appearance of "different colors", or by "visualizing" light as a wave.

Another way of involving the participants in the project was to assign them manual activities, such as experimenting with the effects of electrification by rubbing a trickle of water coming down from the tap, or going on a rainbow hunt, or making drawings of what they had learned about the universe. The level of involvement of the pupils and the success of the project are certified by the large amount of material —pictures, drawings, and texts— that has been collected, also thanks to the great work of the teachers.

At the end of each meeting, we proposed a simple survey made by only two questions: "What did you learn today?" and "What doubts remain with you?"

## 3. – Results and conclusions

The effectiveness and the results of the project can be primarily inferred from the answers to the survey. Some general, but meaningful answers, are those to the question: "What did you learn today"? Sample answers are: "So many wonderful things I didn't know". "I learned that there were female scientists".

Concerning the experience on the light, some significant comments were: "Today I learned how a rainbow gets formed". "I learned that if you look at colored lights you see white and that you can find double rainbows". "I learned that white light "contains" the colors of the rainbow".

As for the activity about the universe, some significant comments were: "Today I learned how the universe looks like, how a black hole gets formed, that the universe keeps growing, that there could be other universes". "I managed to learn more information about the universe, galaxies, space, and black holes. For example, I learned that the universe is expanding *i.e.*, it is getting bigger". "We learned something about the universe and the celestial bodies that inhabit it (stars, planets, satellites, galaxies, black holes$\cdots$). We realized that the distances in space are so great that it's even hard to imagine them! Thinking about light years made us realize that much information from space has not reached us yet, because it is still "on the way". We were so intrigued by black holes, because they are so mysterious... but we discovered that for scientists themselves many things remain hard to understand!"

Among the many positive effects of this project we can mention: 1) the great involvement of children, who were always active and curious, and participated with keen interest and numerous questions; 2) the involvement of teachers, who appreciated having

([1]) PhET resources (University of Colorado, Boulder), for interactive simulations for Science and Math, are available also in Italian at the following link: `phet.colorado.edu/it/`, last accessed on 31st of March, 2022.

a real opportunity to learn and deepen their knowledge of various STEM subjects; 3) the effectiveness of the "role model" played by women scientists who carried out the project, in gaining attention to the gender gap in Science and better engaging girls and boys. An interesting manifestation of unconscious gender bias emerged during the first meeting, when some male pupils asked "where are the scientists?", clearly expecting male figures to conduct the activities.

Curiosity of the pupils was testified also by many further questions, such as: "What made you decide to become a scientist? What are you passionate about? What is the most beautiful thing?" "How do you become a scientist? Have you ever made an important discovery?" "But have you always loved science? Why are there so few female scientists? What tools do you use to analyze objects? Which women scientists have you met? Why did you choose the job of scientist and not another job?" And finally: "If Covid-19 ends, can we come to one of your laboratories?"

As a perspective, we plan to replicate the SVELAMI-B project in different schools (hopefully in presence in the next future). We also plan to go deeper in the analysis of the answers to the surveys. We would like to enhance scientific and operational stimuli from an educational point of view to transform them into a driving force for teachers (autonomy for the design of new educational experiences with children and/or young people), and to strengthen our community of practice at Milano-Bicocca University. One of the topics to be added to the path in 2022 will be physics laboratories and activities concerning archaeological glasses [6], to celebrate the "United Nations International Year Of Glass" [7]. Finally, we would like to deeply investigate the importance of gender matching, through new initiatives devoted to increase interest in STEM disciplines, in particular among girls, also targeted for parents and others who have interpersonal relationships with the pupils, as suggested by Sjastaad [8].

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We thank the Department of Equal Opportunity for funding the SVELAMI-B project under the STEM2020 call for proposals, and the entire team of SVELAMI-B —tutors and faculties— who contributed to the project.

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