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# Educational itineraries to promote Gender Equality in STEM

G. MONETTI[1][2] and R. DE LUCA[1]

[1] *Dipartimento di Fisica, Università di Salerno - Fisciano, Salerno, Italy*
[2] *Liceo Statale B. Rescigno di Roccapiemonte - Salerno, Italy*

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**Summary.** — To promote Action-1 in the Italian PLS Project on Gender Equality in STEM, interdisciplinary teaching activities for High School students were developed in the 2019–2021 period. These activities were conceived in such a way that the laboratory practice could be linked not only to technical or scientific contents but also to historical or sociological topics according to the Inquiry methodology. During laboratory sessions, besides carrying out ordinary experimental activities on carefully selected topics, students had the chance to learn about the biography of some female scientists whose research activities were related to these topics. Part of the activities was designed as an *escape room* process: students were guided through the maze by the relation existing between a female scientist and the relevant physics topic.

## 1. – Introduction

In the third article of the Italian Constitution, gender equality is established as one of the key principles in the construction of the Italian Republic. This article was drafted on March 24, 1947, by the Constituent Assembly and voted by a large majority. Since then, a series of legislative acts regarding gender equality has followed (on working mothers (1950), on the abolition of the clauses on maternity in collective labour agreements (1963), on the recognition of domestic work (2011) [1]) but not always the legislative process has been followed by real employment measures, so that Italy still ranks 50 (out of 142 countries) in the gender gap, as in the 2016 Annual Report of the World Economic Forum [2].

Action-1 of the Italian PLS Project (Scientific Degree Project) was introduced in 2010 by MIUR (Italian Ministry of Instruction, University, and Research) [3] to further warrant gender equality through cultural and educational measures. This project aims at addressing the undesirable social aspects related to the lack of women in some areas of training and careers in science. Regarding this aspect, the University of Salerno, like other Italian Universities, set up an Equal Opportunities Committee in 1999. Attention to this particular issue was manifested by the University of Salerno by means of the First Gender Report (2018) [4]. In this report, the will to eliminate disparities between genders in the local academic organization was declared. As a consequence, the whole educational community is now conscious of the fact that gender balance is a desirable objective to pursue, also considering that the percentage of women achieving a technical or scientific university degree is below 30%.

 

To date, the orientation activities of the Italian PLS (Piano Nazionale Lauree Scientifiche) in physics are aimed at stimulating senior high school students to make more informed choices in which gender equality is also guaranteed. In order to identify possible strategies to increase the interest of students in physics and to stimulate their enrolment in physics degree courses, where the presence of women is below 35% [4], the motivations and expectations of senior high school students or freshmen college students in physics were tested. This was done in the training course on Gender Equality in STEM under Action-1 of the PLS project in physics at University of Salerno. Therefore, by relying mainly upon the Inquiry-Based Learning methodology [5], three different series of teaching and learning activities relating to Gender Equality were developed. The aim of these activities was to combine laboratory practice, carried out with the Inquiry method, with historical, sociological, technical, and scientific contents.

The research questions we address in the present work can be finally summarized as: How can gender equality be achieved in our students' future STEM careers? Which knowledge and educational paths must be activated to promote this goal?

A possible answer to these research questions consists in developing interdisciplinary educational itineraries that include the history of female scientific discoveries intertwined with the history of physics and the historical cultural context.

## 2. – Planning the teaching and learning activities

In the three-year period 2019–2021, about 150 students from five high schools and five teachers from the same institutions participated in the Action-1 PLS project. Both *face-to-face* and *distance-learning* teaching methods were adopted. A single thread and the same logic underlie the three educational paths; namely, a combination of laboratory practice (carried out with the Inquiry method) and an interdisciplinary learning path. In more detail, the three educational paths have been designed and implemented with a basic standard structure based on the following three key points:

1) carry out historical surveys on women's careers in the STEM field [6];

2) design lessons to promote learning of specific physics contents that can be related to the biographies discussed in the previous phase;

3) create a "bridge" between social and scientific themes through laboratory lessons.

The first of the above points was "visible" to students while the second was not. During the "invisible" lab activities, students were asked to look for a relation between the experiment carried out and the scientist who inspired it. In practice, the "invisible" part of the learning process was a treasure hunt, by which students went through a playful dimension of learning. At the same time, students were also accompanied, by means of laboratory practice on specific physics topics, in a historical and scientific itinerary through the last two centuries. In this way, the entire learning process could be thought to be constructed as an *escape room* with social and scientific themes. The common part of the three sections of the educational itinerary devised for the Action-1 PLS project is a review of the biography of the female Nobel laureates (nowadays four in physics) and of those female scientists who missed the Nobel prize because of historical and sociological reasons. During this part, students were asked to take David Chambers' test ("Draw a scientist" test) [7]. This test may be used to know the conception that students have of the scientist's gender. In subsequent lessons, the career of three different female scientists were analysed: Lise Meitner [6] and her contribution to modern physics [8]; Maria Telkes [6] and her contribution to the use of the solar energy [9]; Amelia Earhart [10] and the understanding of the physics of flight [11]. To these scientists, a specific topic

in physics was associated and related laboratory activities were carried out following the Inquiry Based Science Education instructional model.

## 3. – Developing the activities

The activities were designed by following the logic of an *escape room* (or treasure hunt) according to which clues are given to students who independently select the significant information for proceeding in their itinerary. The clues were of historical, cultural, sociological and scientific nature.

At the beginning the biographies of the four Nobel and no-Nobel female scientists (who have not received any recognition in the more general context of STEM) were illustrated with the description of the historical age in which the events took place and in which the research was carried out. This first part was useful to make students understand the issue of gender equality in the STEM field.

Next, the draw-a-scientist test was illustrated. This part was useful for making students aware of how ingrained some stereotypes may still be in our society. The results of the survey, designed by David W. Chambers for children of the preschool and elementary age classes, were shown. According to Chambers, the opinions of our society about the figure of the scientist belonging to a specific gender (male or female, white or black) could emerge in this survey, where a simple pictorial representation of a scientist was requested. We need to notice that the noun "scientist" is neutral in English. In this way, the expression "draw a scientist" was left unaltered in the second phase.

As a third phase, following the "learning by doing" or "learning by investigating" principles, the laboratory activities were carried out the measurement of: the Planck's constant with a photodiode [8]; the efficiency of a photovoltaic cell [9]; the lift in airplanes and the evidence of the Coanda effect [11].

Finally, all the previous phases were integrated into an *escape room* (or treasure hunt) itinerary. Students at this stage had sufficient knowledge to carry out their investigation into the research life of female scientists at the center of each PLS annual session (in sequence: Lise Meitner, Maria Telkes, and Amelia Earhart). Thus, the contents of the laboratory sessions together with historical and scientific clues were used to construct the identikits of the scientists and to exit the labyrinth through the circular educational itineraries shown in fig. 1.

## 4. – Conclusions

The teaching and learning process illustrated in the present work represents a way to achieve a rather ambitious goal, such as identifying socially induced attitudes of distrust

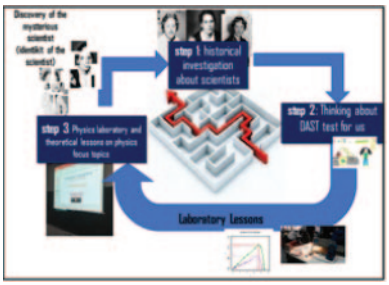


Fig. 1. – A schematic view of the circular educational itineraries of the physics lessons carried out in the PLS Action 1 Project from 2019 to 2021.

toward female scientists. Of course, laboratory activities are central in this educational path. In order to compensate the complexity of the physics topics, the latter can be broken into small sub-topics addressed from time to time either in the laboratory or in the classroom. This cycle of lessons can be modeled according to the needs of the students (face-to-face or distance lessons).

In the framework of the Model of Educational Reconstruction [12], a qualitative assessment process was carried out through observation of social and emotive skills [13] activated by the students while following scientific educational paths in gender equality. The systematic observation of simple phenomena led to the production of useful material which was used both for self-assessment purposes (students monitoring their progress), and as evidence of the work done within this particular learning path.

Students also reproposed the didactic material in oral exams or in the final exam (*Esame di Stato*) at school and presented their work at the annual "PLS Conference" in September 2020 in Fisciano at the University of Salerno.

All the material produced by the students (incoming and outgoing satisfaction interviews, entry tests on content and exit tests on skills) is still being analyzed. Nevertheless, it was observed that all groups developed (or tried to develop) a greater familiarity in dealing with interdisciplinary issues ranging from historical to scientific studies.

In the future it could be opportune to stimulate a discussion in the community of high-school teachers on how to deal with the thorny issue of gender equality, in order to collect criticisms, exchanges of experiences and suggestions on modeling the educational paths traced and implemented in the Action-1 PLS project. Furthermore, it could also be useful to present an organic collection of this teaching project, accompanied by worksheets that can guide teachers step by step through the various phases.

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