

inVISIBILI outreach project

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Summary. — The inVISIBILI project examines the influence of gender stereotypes on the interest in science of children aged 5 to 11, focusing on differences between male and female students. Conducted over the course of one year, the project engaged around 1600 children from schools in Bologna, Italy. Each participating class took part in two outreach sessions designed to introduce fundamental scientific concepts with an inclusive approach. In addition to outreach activities, a survey was conducted as part of the project. The findings suggest that gender-inclusive outreach might help young girls overcome male-dominated biases related to science.

1. – Introduction

It is widely recognised that women are under-represented in STEM subjects [1], particularly in physics, a field still strongly associated with men [2]. The origin of this gap can be traced, along other causes, to the presence of gender stereotypes related to science. For instance, natural intelligence or “brilliance” is often thought to be more characteristic of men than women. The association of mathematics and physics with the concept of “genius” fosters a bias that predisposes men toward STEM fields, often to the disadvantage of women [3]. Although this gender gap is evident at the academic level [2], the stereotype of male students being more intelligent and obtaining better results at STEM subjects than female students [4] appear to start developing as early as 5 years old [5]. This happens despite international proficiency tests revealing that there is no gender disparity in the ability to learn scientific subjects [6]. The goal of this project is to intervene in age groups where gender stereotypes begin to emerge, study the latter’s impact on children’s interest in science, and assess whether a more inclusive approach to scientific education influences their perception of science.

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2. – Outreach events

Two outreach events were organised in schools in Bologna and surrounding areas during which we explained basic concepts of science to children aged 5 to 11. The aim of these events was to spark the curiosity of children for science and the invisible universe (neutrino and dark matter physics). We used an inclusive approach, such as incorporating female role models in the outreach teams and implementing gender-neutral communication. The events were conducted by around 60 physicists; professors and PhD and Master’s students from the University of Bologna and INFN Bologna. The physicists were organized into gender-balanced teams and underwent three hours of training in each of the following areas: neutrino and dark matter physics (by Prof. Silvia Pascoli), the impact of gender stereotypes on individuals and society (Education Department of the University of Bologna), and science outreach for children (Leo Scienza association).

These events took place approximately one month apart, between April and May 2024. The first event introduced the concept of “invisibility”, emphasising phenomena that cannot be directly observed, as well as the scientific method. The second event focused on elementary particles and the invisible universe, and on how scientists infer the existence of these phenomena. After the second event, children received a goodie-bag containing gadgets related to the outreach activities, which included the adventure book *Oscurina e le Avventure Cosmiche* [7] designed by the inVISIBILI team, which presents the journey of a dark matter particle character during the process of galaxy formation. After the end of the project, 67.3% of teachers reported that children mentioned the outreach events afterward, and 80.8% expressed interest in participating again.

3. – Gender stereotype and personal attitude study

Complementing the outreach activities, we conducted a survey to measure the impact of the outreach events and investigate children’s gender biases related to science, as well as their personal attitudes toward science, depending on age and gender.

Before the first outreach event and after the second, each child completed two identical analogue questionnaires. Children were divided in seven age groups: “kindergarten” ($n = 102$, $M^{\text{age}} = 5.27$), “primary 1” ($n = 157$, $M^{\text{age}} = 6.22$), “primary 2” ($n = 255$, $M^{\text{age}} = 7.28$), “primary 3” ($n = 189$, $M^{\text{age}} = 8.28$), “primary 4” ($n = 262$, $M^{\text{age}} = 9.29$), “primary 5” ($n = 184$, $M^{\text{age}} = 10.26$), and “secondary 1” ($n = 67$, $M^{\text{age}} = 11.36$).

The questionnaire design was based on the multidimensional framework introduced in [8] and adjusted for different age groups to ensure clarity. The survey consisted of three questions within the “bias” category, assessing children’s perceptions of whether boys or girls are more suited for science, more talented, and interested in science, and three questions within the category “attitude”, evaluating children’s personal attitude toward science (their interest in science, self-assessment of scientific ability, etc.). Answer options followed the attitudinal gradient scale used in [8], based on a binary conceptualization of gender. Children in the three youngest age groups could choose one of three possible answer options, while the older children could select one of five possible options. Responses were numerically encoded and rescaled to a common $(-1, 1)$ scale. For the “bias” category, the scale spans from maximum male bias (-1) to maximum female bias ($+1$), while for the “attitude” category, it ranges from maximum negative attitude (-1) to maximum positive attitude ($+1$), with 0 representing neutral stance.

Figure 1 (“bias” category) and fig. 2 (“attitude” category) show the overall mean responses before and after the outreach events. The uncertainty is estimated as the

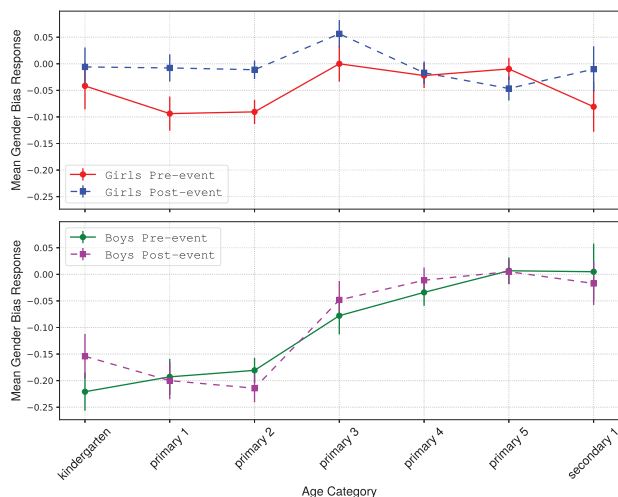


Fig. 1. – Mean responses to the “bias” category questions before and after the events.

standard error of the mean (SEM) which is calculated as $SEM = \frac{\sigma}{\sqrt{n}}$, where σ is the standard deviation of children’s individual mean answers across the category and n is the size of the sample. Figure 1 indicates that children of both genders exhibit a bias toward male-dominated stereotypes about science across all ages, with boys being stronger male-biased than girls. Figure 2 suggests that, overall, children have a positive attitude toward science, though this attitude declines with age, particularly among girls.

To estimate the impact of the outreach activities, individual responses before and after the events were analysed using a paired t -test. These differences are nearly normally distributed across all age groups and genders. Notable changes in responses were observed only among girls in the “primary 1” (with p -values of 0.004 and 0.001 for “bias” and “attitude”, respectively) and “primary 2” (with p -values of 0.002 and 0.018 for “bias”

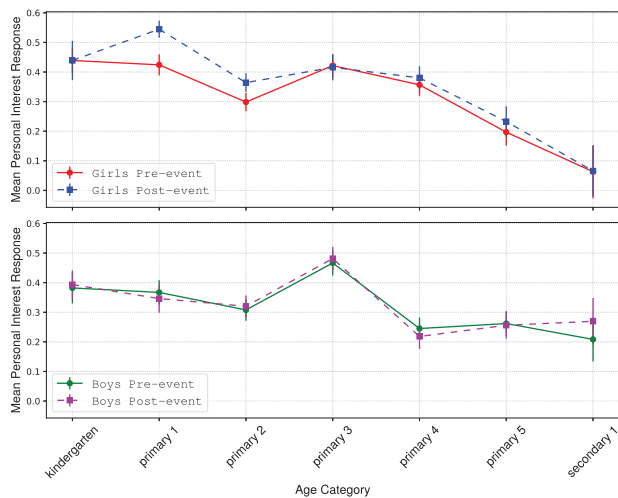


Fig. 2. – Mean responses to the “attitude” category questions before and after the events.

and “attitude”, respectively) groups. The male-dominated gender bias was reduced by 5.7% for girls in “primary 1” and 5.3% for girls in “primary 2”, while the personal attitude increased by 6.0% and 3.3%, respectively. These results suggest that inclusive outreach might be particularly impactful for girls aged 6 to 8, improving their attitude toward science and potentially helping overcome male gender biases about science.

4. – Conclusion

Our results indicate that while young children show interest in science, this interest declines more significantly in girls than in boys with age. Girls aged 6 to 8 were notably impacted by the two outreach events, showing an improvement of up to ca. 6% in both a reduced male-dominated bias related to science and a more positive personal attitude toward it. These results suggest that inclusive outreach might help young girls overcome male-dominated biases about science and, in the long term, reduce the gender gap in science, ensuring equal opportunities for all genders and expanding the talent pool.

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