# From school to research: a problem-solving activity to engage high school students in STEM

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**Abstract.** Results in Physics Education Research suggest that cooperative problem-solving (CPS) pedagogy enhances students' creativity and motivation toward STEM. Researchers in the Aria Project, a project aimed at the cryogenic distillation of stable isotope, designed the "Aria Masterclass", an educational program devoted to high school students (fourth and fifth classes), to improve scientific awareness and bolstering motivation on contemporary physics. Students solved a contextualized exercise based on Aria research topics by using a CPS-inspired methodology to size a distillation column. We discuss the design of the activity and results on students' learning and STEM engagement of a 2023-2024 Italian experimentation.

## Introduction

Results in Physics Education Research (PER) suggest that implementing active learning strategies within the formal high school curricula enhances students' creativity, helping them develop the skills that increasingly determine their future employability and personal development and increasing their STEM performances [1]. The active learning strategies based on the Inquiry Based Science Education (IBSE) pedagogy are promising in this direction [2]. In IBSE, knowledge is constructed by an individual through active thinking [3]. Implementing inquiry-based methodologies is beneficial in training students to learn science through activities that reflect the authenticity of science as practiced by professional scientists and in presenting practical and manageable content within the school context [2,3].

## Theoretical Framework

Satisfying students' curiosities regarding the application of chemistry and physics concepts learned at school in research also helps engage them in STEM. The Cooperative Problem-Solving (CPS) pedagogy was demonstrated to be very effective in reaching this goal [1,4,5]. Problem-solving (PS) is the ability of one person to cope with a problem, the latter being a new situation that requires elaborating previous knowledge and experience to achieve the solution [6]. Teaching PS strategies is very effective in improving their performances in physics and their professional and personal skills [7]. Implementing the solving strategy in cooperative grouping and with an IBSE pedagogy was successful at high school and college levels in improving students' achievements and teaching approaches, developing more effective learning [1,5,8].

## Research

Inspired by PER results, researchers involved in the Aria Project, a research project of the National Institute of Nuclear Physics in Italy aimed at the cryogenic distillation of stable isotopes, designed a specific educational program denoted as "Aria Masterclass." The aim was to improve scientific awareness and literacy on contemporary physics subjects, bolstering motivation to learn science and physics. Moreover, the intent was also to help students give meaning to notions and concepts they learn at school, making them live a concrete physical situation, possibly derived from researchers' experiences in research. Our research was also on studying how the activity influences students' PS attitude.

## Methods

The activity was held in Sardinia and Campania, Italy, from September 2023 to February 2024 and more the 800 students (fourth and fifth year, 17-19 years old) were involved. The methodology relied on CPS [1]. Students solved a contextualized exercise based on Aria research topics by applying their physics, chemistry, and mathematics knowledge for the sizing of a distillation column. Through a research questionnaire (pre and post-tests), we measured the efficacy of our methodology on the investigated domains. We collected 600 answers. We illustrate and discuss the design of the activity and results on student's PS attitude, as well as on their learning and engagement.

## Conclusions

Students appreciated the activity and reported a positive influence on their learning and career aspirations. They found the activity and the collaborative task of solving the problem engaging, fostering their learning. They felt motivated, curious, and interested in attending the activity. Most of them correctly solved the problem, representing and analyzing the proposed distillation process. Concerning problem-solving attitude, results are encouraging. Comparing pre-and post-tests, the means related to self-efficacy and auto-efficacy are higher in the post-test, suggesting a positive influence of the activity on these domains. They affirmed that text-enriched problems made them live a real-like research experience, appreciating it. Students also expressed an interest in pursuing STEM careers, and the masterclass motivated them. Our findings suggest that implementing active learning strategies such as the CPS in high school seems promising in giving students a sense of concreteness in their learning, connecting the latter with current trends in research, engaging them in STEM.

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