PROCEEDINGS OF SCIENCE

Creativity at its best: making science by making art

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Creativity and vision capability are common to many disciplines and are involved in artistic and scientific thinking and activities. Scientists and artists are often asked to see and think beyond the perceivable reality, to imagine aspects of things and events, which can be better seen from an unusual perspective. Developing such a open-wide perspective to foster the spread of scientific knowledge in high-school is one of the key ingredient of "Art & Science across Italy", a European science communication project led by the Italian National Institute for Nuclear Physics (INFN) in collaboration with CERN. The main idea is to put in practice the basic concept of the STEAM field in which neither STEM nor arts are privileged over the other, but both are equally in play and engaging high school students with science using artistic languages, regardless of student's specific skills or level of knowledge. During the project, high-school students attend scientific seminars and then, inspired by science, create their own artworks. The latter are shown in local and national art shows. The project is now running the third edition (2020 2022). Here we will describe the project and the methodology used, and some results obtained in the first two editions in which more than 7.500 students coming from about 200 Italian high schools participated.

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1. Introduction

In recent years, the attention toward the benefits of arts-based approaches in inquiry science teaching and learning has grown. Integrating the arts and STEM (Science, Technology, Engineering, and Mathematics) is suggested to make school science subjects more appealing to a wider variety of learners including the non-STEM inclined [1].

A central role to the increasing shift from STEM to STEAM (Science, Technology, Engineering, Arts, and Mathematics) education is played by the notion of creativity. According to a recent position paper of the Organisation for Economic Co-operation and Development (OECD), creativity and creative thinking are considered among the most important skills for 2030's learners and, as such, their development is recommended to be a curriculum priority in schools [2]. Arts-based projects may constitute a suitable approach towards integrating creativity, imagination, and science in school settings. Inheriting the peculiar feature of scientific collaborations, also promoting collaboration and working in team suggests a positive influence on students attitude towards science.

To put in practice the basic concept of the STEAM field in which neither STEM nor arts are privileged over the other, but both are equally in play and engaging high school students with science using artistic languages, regardless of student's specific skills or level of knowledge, new scientific and outreach projects devoted to students are needed. All of these elements led to the birth of "Art & Science Across Italy (A&S)", a project organized and funded by the Italian National Institute for Nuclear Physics (INFN) and by CERN.

Now in its third edition, one of its peculiar feature is to promote the use of art as a universal language to address all students to science, regardless of their knowledge and initial attitude towards scientific subjects, engaging and challenging them to represent scientific ideas and research topics through artworks. The main goal of the project is to bring science and high school students closer together and the methodology used is founded on five key points: creativity; science communication; work in team; conceive; design and create a project; interdisciplinarity [3]. In order to do so, activities to learn how conceive, design a project based on the creativity and realize it are implemented. Inclusion and collaboration are promoted by teaching students how to work in group and with colleagues coming from different cultures and experiences.

In the following, we will describe the project and its innovative features in the STEAM area. Then we will present the methodologies used to investigate students' feedback participating at the first two editions (2016-2018 and 2018-2020) about some of the outcomes of the project. We will discuss the results of the analysis and then we will draw our conclusions.

2. Description of the project

The Art&Science project (A&S) was born in 2015 from an idea of P. Paolucci (INFN Naples), M. Hoch (Wien) and A. Alexopoulos (CERN) [4]. Initially, it was developed in the framework of the European network CREATIONS (H2020) [5] and it is inspired by the STEAM [6–8] educational frame work which brings Science, Technology, Engineering and Mathematics together with Art, with the goal of being more engaging, creative and naturally successful for all members of any educational system.

The A&S project takes place in many Italian Regions and it is addressed to high school students in the third and fourth year of their studies (15-18 years old) [9]. It is supervised by the INFN national scientific committee and organized by a coordination committee, composed by scientists from the regions where the project takes place. In each city the local coordinators keep the contacts with the high school institutes wishing to participate. A close collaboration with school institutes is of primary importance for the successful development of the program, which lasts 2 years and can be chronologically divided into the following phases:

- *Education phase*: students take part in out of school activities and are invited to attend scientific outreach seminars, to visit laboratories, Universities, scientific and art centers, art museums and local events. During this phase students meet and interact with scientists, science educators and communicators, as well as professional artists and art educators, and get exposed to out of school inspiring and interdisciplinary settings. Students are then encouraged and stimulated to ask questions and are also engaged in dialogues to help them in conceptualizing similarities and differences among science and art. During these activities, particular attention is given to the role of creativity in science and art.
- *Creative phase*: the second phase follows the lines of strategies coming from project based learning methodologies [10, 11]. Students are invited to form teams of three, then they work to conceive, design and create an artwork inspired by a scientific topic of their choice. Any artistic technique is welcome: pictures, sculpture, jewel, photo, animation/movie, music, book, electronics and more. There are no restrictions or boundaries to their creativity.
- *Exhibition*: the third phase consists in the organization of local exhibitions in collaboration with INFN institutes, local educational authorities and other stakeholders such as municipalities. During the art show, the dissemination of students' artwork is promoted. The inclusion of a competition element is supported by evidence suggesting a positive association between student participation in STEM competitions. All the artworks are exhibited in the regional exhibition, and the first seven ranked access to the National competition. An international jury of experts, selected from both art and science world, selects the best ten artworks and their authors are awarded with a fellow to participate to the A&S master at CERN/INFN laboratory.

The third edition has started on October 2021. During the educational phase, a new creativity championship has been added to the engagement activities. It consists in 4 matches where participants are asked to make pictures, videos, a collage and write a story on some generic scientific topic (such as DNA, black holes, dark matter and so on). At the end of every math there are three winners and overall championship is made. At the end of the game, there is a final podium made by the three students who gain the highest scores during all the competition. The local exhibition are ongoing and they will end on May 2022.

3. Methods

During the first two editions (2016/2018 and 2018/2020), more than 7.500 students coming from 200 high schools of 9 geographical Italian regions participated to the project. 58% of the

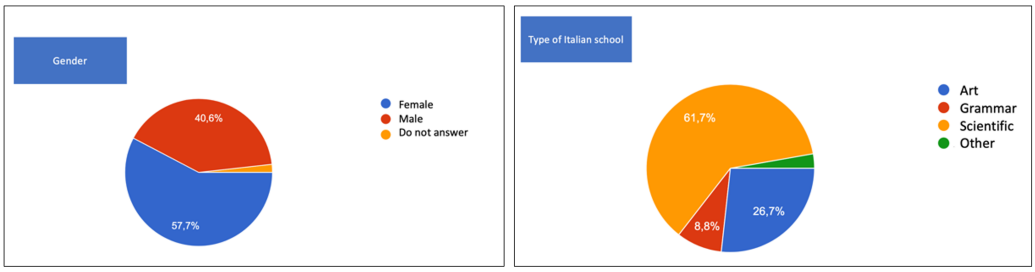

Figure 1: On the left: gender distribution of the entire sample (first and second edition). On the right: Type of high school of the students participating to the first two editions (2016 2020)

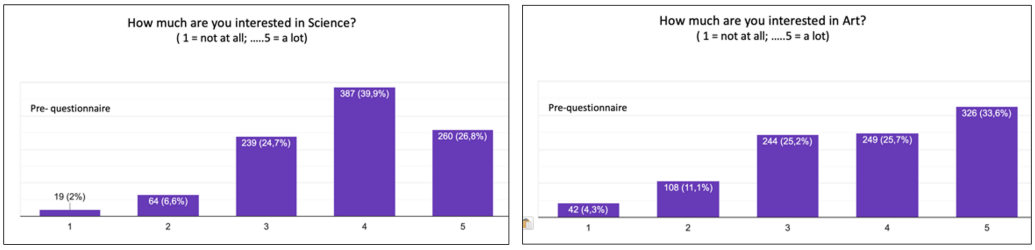

Figure 2: On the left: first and second edition students' interest about science. On the right: first and second edition students' interest in art.

students are female, 62% are from scientific high school and 27% from art schools (see fig 1). About 70% of students were able to produce the artwork and arrive to the end of the project.

The intrinsic multidisciplinary nature of the project allowed us to study students' interest in science and art according to the their activities during the project. To do so, we wrote pre and post questionnaires and we sent them to students at the beginning and at the end of the project. Among the questions we made, we mention: a) how much are you interested in science?; b) how much are you interested in art?. Students could answer using a 5-point scale from 1 (not at all) to 5 (a lot). We also collect some general information about their age, their school provenience (scientific lyceums, grammar or artistic high schools).

We also investigated how students perceived the two main pedagogical and artistic methodologies proposed to them during the creative phase: working in group and create an artwork. We asked them two questions: "how difficult was working in group" and "how difficult was the creation of the artwork". In both cases they could answer by using a 10 point-scale from 1 (very easy) to 10 (very difficult). A detailed analysis of second edition data can be found in [1].

4. Results and discussion

Regarding students' interest in science and art, a qualitatively analysis showed us that students were a little bit more interested in science with respect of the art, being the difference between the twos statistically not significant (see Fig. 2).

Concerning the items working in group and the creation of an artwork, the majority of students evaluated the former as not very difficult. Creativity and the creation of an artwork has been perceived as difficult by the major part of the sample. Let us note that the data coming from second

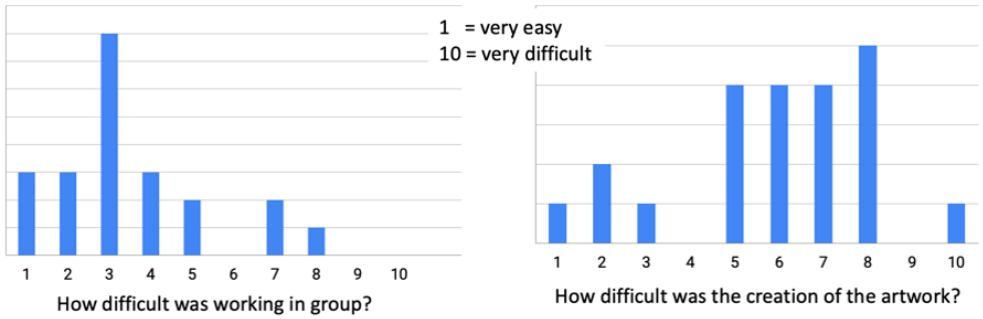

Figure 3: Results from the questionnaire submitted to the 24 winners of the I edition

edition corroborates what has emerged from student's feedback attending the first edition (see Fig. 3).

Finally, the type of high schools and the university field at which they were interested have been used to evaluate if the project engaged all the students to science regardless their attitude. We collected a large variety of cultural interest: 10 students were interested in scientific field, 3 in medicine, 2 in art, and 4 in humanities.

Comparing the type of school of the participants to the questionnaire and that of the winners, we can state that the two samples are compatible with a confidence level of 97.5%. This suggests that all the students have the same probability to have success in the project regardless the type of high school they come from.

5. Conclusions

All the artworks of the first edition have been shown in the local exhibitions. In the case of second edition, three of them and the National exhibition have been done online due to COVID 19 restrictions. Third edition exhibitions are ongoing and they have been anticipated by a creativity championship. More than one thousand students participated to the latter and three students have been awarded for their creations.

The main results obtained from the post questionnaire given to students are that 88% of them like the project, 92% would recommend it to a friend and about 73% enjoyed creating the artwork and show it at a public exhibition.

Students from different high schools (classic, scientific, artistic. . .) are engaged to design and build an artwork based on Science. The competition, the working in group and the possibility to attend the master at CERN/INFN are motivating them to participate to the project.

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