

**Creating bridges between art and
science: insights from the
evaluation process of the
Global Science Opera methodology**

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Abstract: Joining art and science, according to the STEAM approach (Science, Technology Engineering, Arts and Mathematics), has gained more and more attention in the educational field in recent decades. Here we share insights about connections between art and science and possible challenges to address while integrating them in educational contexts coming from GSO4SCHOOL, an Erasmus plus European project built around the Global Science Opera (GSO) methodology, which allows to create an online musical opera about a scientific topic through the contribution of educational communities from all over the planet. In particular, we present the results of the evaluation process of the two Summer Schools for educators about the GSO methodology and related practical approaches to integrate art and science in the classroom, organized within the project, and wider reflections about art and science similarities/differences co-produced by several social actors – researchers, educators, students, policy makers - within a working table conducted in the Italian context, starting from the project experience.

Key words: art, science, STEAM, Global Science Opera, evaluation, education, interdisciplinarity, transdisciplinarity

CNR – IRPPS

Integrare arte e scienza: prime valutazioni dall’esperienza della *Global Science Opera*

Valentina Tudisca and Claudia Pennacchiotti

2023, p. 31 – IRPPS Working papers 133/2023

Sommario: Negli ultimi decenni l’approccio STEAM (Science, Technology Engineering, Arts and Mathematics), che si propone di integrare arte e scienza, si è guadagnato sempre maggiore attenzione in ambito educativo. In questo rapporto condividiamo alcuni risultati sulle connessioni tra arte e scienza, e sulle possibili sfide da affrontare nell’integrarle nei contesti educativi, ottenuti nel corso del progetto europeo GSO4SCHOOL, un Erasmus plus sulla metodologia della Global Science Opera (GSO), che consente di creare un’opera musicale online su temi scientifici attraverso i contributi di comunità educative da tutto il mondo. In particolare presentiamo i risultati del processo di valutazione delle due Summer School organizzate nell’ambito del progetto sulla metodologia della GSO e relativi approcci pratici per collegare arte e scienza in classe, rivolte a docenti, e riflessioni più ampie su differenze/punti in comune tra arte e scienza co-prodotte dall’interazione tra diversi attori sociali - comunità scientifica, educante, studentesca, politica - nell’ambito di un tavolo di lavoro nel contesto Italiano, ispirato dall’esperienza del progetto.

Parole chiave: arte, scienza, STEAM, Global Science Opera, valutazione, educazione, interdisciplinarietà, transdisciplinarietà

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“I believe that when science and art thus join hands the most commanding motive for human action will be reached; the most genuine springs of human conduct aroused and the best service that human nature is capable of guaranteed.” – John Dewey

GSO4SCHOOL - “Leverage students’ participation and engagement in science through art practices” is a 3-year European project (2019-2022), financed by the Erasmus plus Program, involving five European countries (Norway, Italy, Greece, Portugal and Cyprus), and, as partners, players in the field of creativity in education, science education and innovation.

The GSO4SCHOOL theoretical framework, based on pedagogical principles centered on creativity collaboration and inquiry-based learning, aims to overcome inequality in science learning through an innovative transdisciplinary method that fosters the development of school students’ interest, participation, motivation and performance in science and, at the same time, motivates school students and teachers to participate in science & arts initiatives. According to the Global Science Opera (GSO) methodology (Straksiene, Ben-Horin, Espeland, Robberstad, 2022; Urbaniak, Venkatesh, Ben-Horin, 2021), on which the project is based, schools and educational communities from all over the world are invited to co-create a musical opera about a scientific topic - changing every year - which is transmitted online. The GSO vision is to produce annual productions during which a global community explores interwoven science, art and technology within a creative and democratic inquiry process. Adopting a STEAM approach (Science, Technology Engineering, Arts and Mathematics) (BERA Research Commission, 2016; Perales, F. J., & Aróstegui, J. L. 2021; Braund, M., & Reiss, M. J. 2019), creativity, transdisciplinarity and inclusion are at the very center of the GSO4SCHOOL method: integrating different fields of study, students’ research processes and ideas benefit from artistic views and creativity. Indeed, the STEAM pedagogy connects different disciplines with each other in an inquiry and collaborative manner. It brings new pedagogical methodologies in the classroom, using the available technologies and tools. In this way, active, discovery-based, and more engaging learning can be facilitated, with opportunities for collaboration, co-creation and collective knowledge building.

GSO4SCHOOL project reflects the interdisciplinary nature of the STEAM world on a double dimension:

1. it connects concepts and skills from different disciplines in order to look better to a whole;
2. it recommends that teachers with different backgrounds (music, science/math, engineering) work together to bring this STEAM pedagogy to the classroom.

Within the project, as an output and a tangible application of the GSO4SCHOOL theoretical framework:

- two Summer Schools were realized, aimed at enhancing teachers’ ability to integrate creative, collaborative and transdisciplinary practices in their classroom and introducing them to the GSO4SCHOOL methodology and educational materials to be adopted in their classes while working on the Global Science Opera productions;
- two main productions were realized in 2021 (*Thrive, about the topic of ecosystem restoration*) and 2022 (*Creavolution, about creativity and human brain*). The students,

supported by their teachers, developed their own performances while investigating specific issues related to science subjects of their curricula. Based on science themes, they went through all the steps of an opera production. Through this approach the participants learned to collaborate, lead and manage in order to develop a full-scale production. During this process they needed to be innovative, exchange new ideas and to develop cross-sectoral skills such as entrepreneurship skills, teamwork, communication skills, while at the same time they became more motivated and familiar with scientific concepts.

This report collects the outputs emerged from the evaluation process of the two Summer Schools (2021, online, and 2022, in Greece) and from a multi-actor work table with the scientific and educational community realized in Italy, within the Officina Education & Futures event (Pennacchiotti, Tudisca, Valente 2020; Pennacchiotti, Tudisca, Valente 2022), aimed at deepening the possible interconnections between art and science starting from the Italian context.

The outputs of the of the Summer Schools evaluation process were used to further revise the GSO4SCHOOL theoretical framework while those of the work table to enhance the debate on STEAM and interdisciplinary approaches into the educational community at Italian level.

Part 1. THE SUMMER SCHOOL EVALUATION REPORTS

This chapter presents the main results of the evaluation process of the two GSO4SCHOOL Summer Schools, conducted in order to evaluate the School quality and gather inputs for the next GSO educational initiatives.

By means of a questionnaire, we asked the participants who attended the two Schools to evaluate their experience and give inputs to improve the whole GSO4SCHOOL framework.

1.1 Participants' perspectives about 2021 GSO4SCHOOL Summer School

The 2021 GSO4SCHOOL Summer School, originally planned in Greece, took place between 12 and 16 of July, online due to the pandemic situation. The aim of the school was to introduce innovative practices for teaching Sciences in the classroom, involving teachers and other people interested in joining science and art in education and in contributing to implement the GSO 2022 in their country.


CET	Monday 12th	Tuesday 13th	Wednesday 14th	Thursday 15th	Friday 16th
9.00-9.15	Icebreakers	Warmups	Warmups	Warmups	Warmups
9.15-10.00	GSO4SCHOOL framework	FEEL: Workshops and working Groups (discuss the split in groups based on the idea)	CREATE: Workshops and working Groups	CREATE: Workshops and working Groups	SHARE: Workshops and working Groups
10.00-11.00	GSO4SCHOOL Guides and tutorials	IMAGINE: Workshops and working Groups	CREATE: Workshops and working Groups	CREATE: Workshops and working Groups	SHARE: Workshops and working Groups
11.00-12.00	FEEL: workshops and working groups (discuss the ideas)	IMAGINE: Workshops and working Groups	CREATE: Workshops and working Groups	SHARE: Workshops and working Groups	Reflection
12.00-13.30	Out to lunch				
13.30-14.00	FEEL: workshops and working groups (experimenting around the ideas)	IMAGINE: Workshops and working Groups	CREATE: Workshops and working Groups	SHARE: Workshops and working Groups	Preparations for Collaboration after the Summer School
14.00-15.00	FEEL: workshops and working groups (final decision on the main idea)	IMAGINE: Workshops and working Groups	CREATE: Workshops and working Groups	SHARE: Workshops and working Groups	

Image 1: The program of the GSO4SCHOOL Summer School in 2021

19 persons took part in the School.

1.1.1 Premise: information about respondents

This section summarizes information collected about the Summer School participants, related to their country of origin, gender, field of expertise, school level they work with.

All 19 participants answered the questionnaire, from Greece, Portugal, Norway, Romania, Croatia, Cyprus, Italy, Spain, Ukraine, Morocco and China, according to the distribution shown in Fig. 1.1.

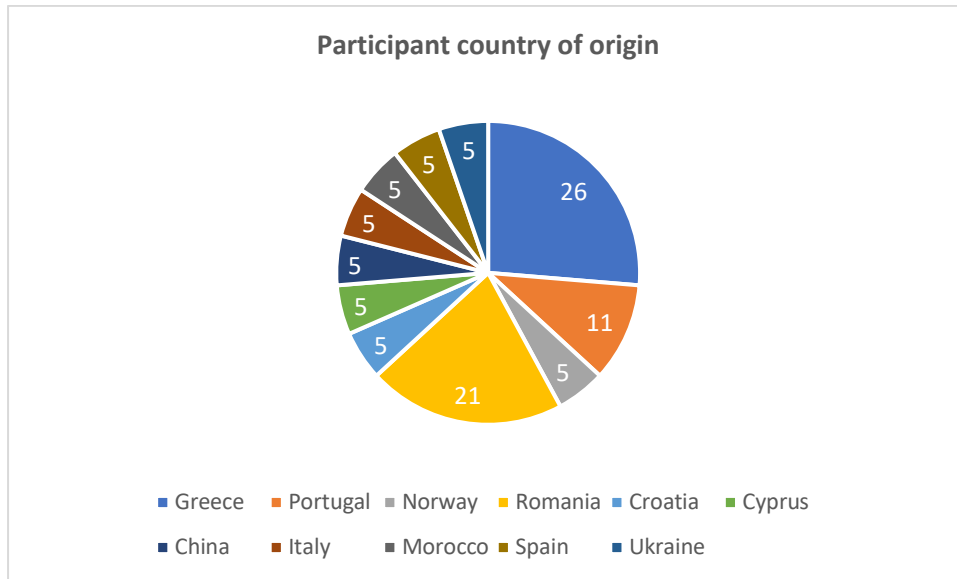


Fig. 1.1 Percentage distribution of respondents by country of origin

Most of respondents were female (Fig. 1.2) and their age is distributed between 24 and 67 years old.

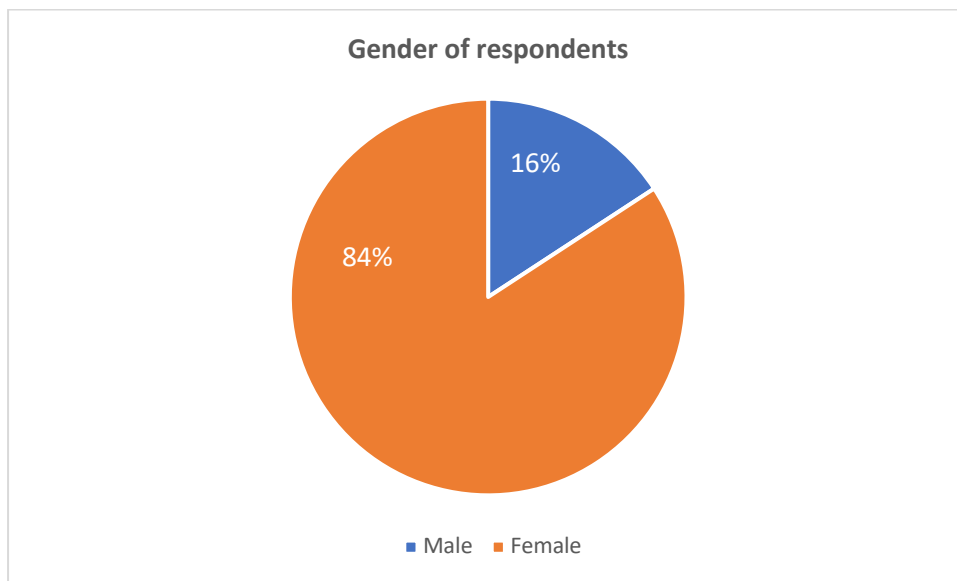


Fig. 1.2 Distribution of respondents by gender

Respondents come from different disciplines, mainly Science, Technology, Engineering and Mathematics (STEM subjects), followed by English and primary school subjects, finally music and STEAM subjects joining STEM and Arts (Fig. 1.3).

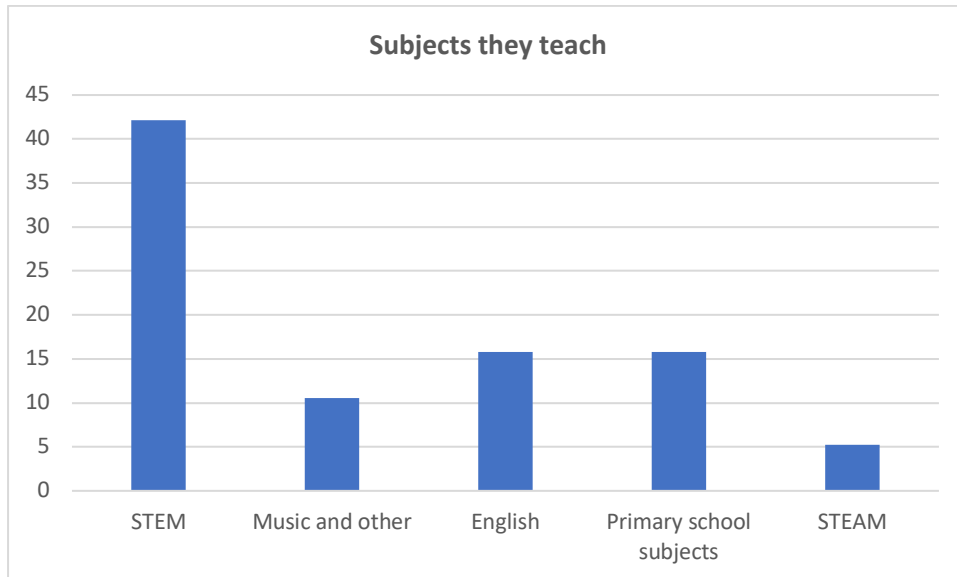


Fig. 1.3 Subject fields of the respondents (percentage values, multiple choice question)

The 42% of respondents work with upper secondary school, 37% with primary school, followed by lower secondary school (Fig. 1.4). The minority of respondents who didn't answer are probably not teachers.

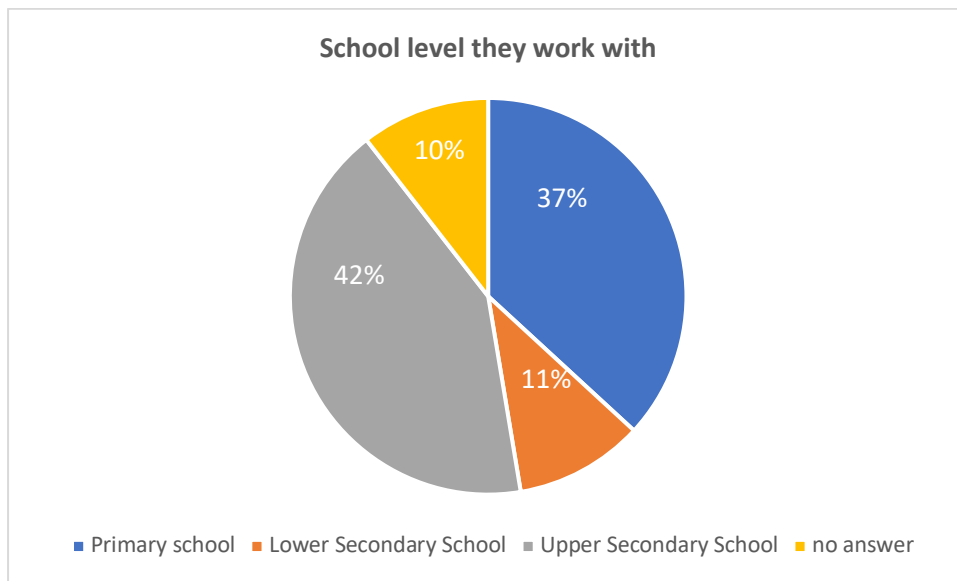


Fig. 1.4 School level targeted by respondents in their work

1.1.2 Respondents' views about the Summer School experience

This section collects respondents' views about their experience with the GSO 2021 Summer School.

The most appreciated topics addressed were the design thinking approach and the scientific insights provided, followed by music and theatre/humor, ecoscenography and drama, dance and other (Fig. 1.5). However, this evaluation can be affected by the fact that – also due to the online modality - not all participants attended all the courses, many focusing only on some of them.

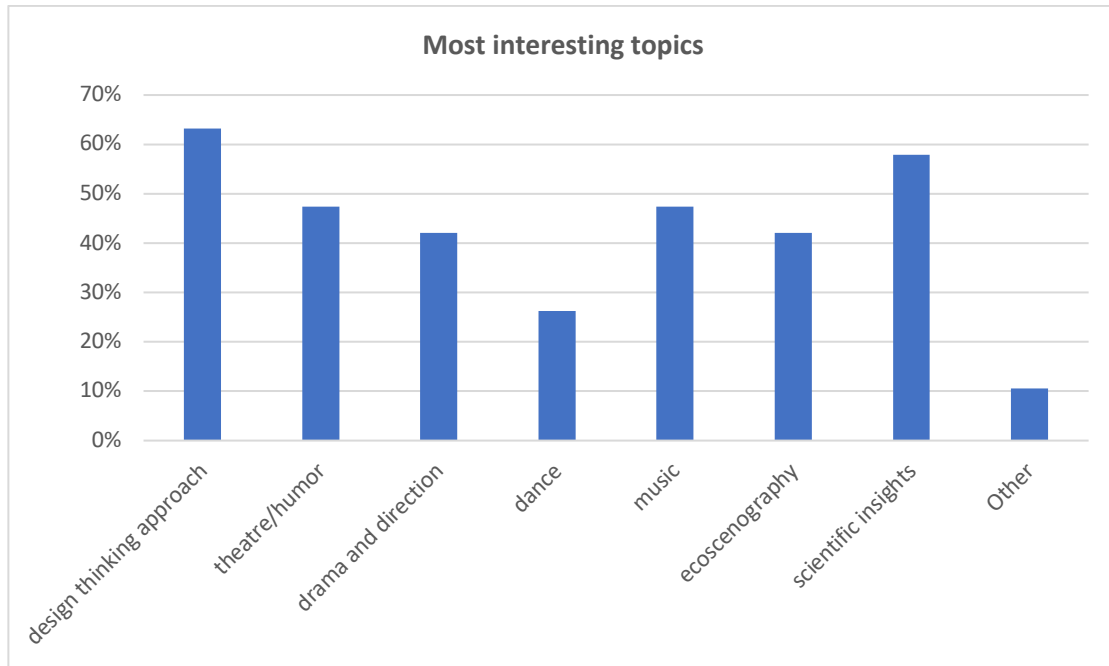


Fig. 1.5 Topics of the 2021 Summer School respondents enjoyed most (percentage values, multiple choice question)

Respondents were asked to suggest possible other topics related to art-science that could be explored; among the proposals, there were ecology, hygiene, cinema; moreover, some suggested to provide more examples related to specific fields of study, exploring deeper into different digital tools, apps and software usable in the creative process (e. g. to create animations and videos), and experiments in some STEM subjects.

The tools provided by the School were evaluated of medium level of complexity by most of respondents (Fig. 1.6).

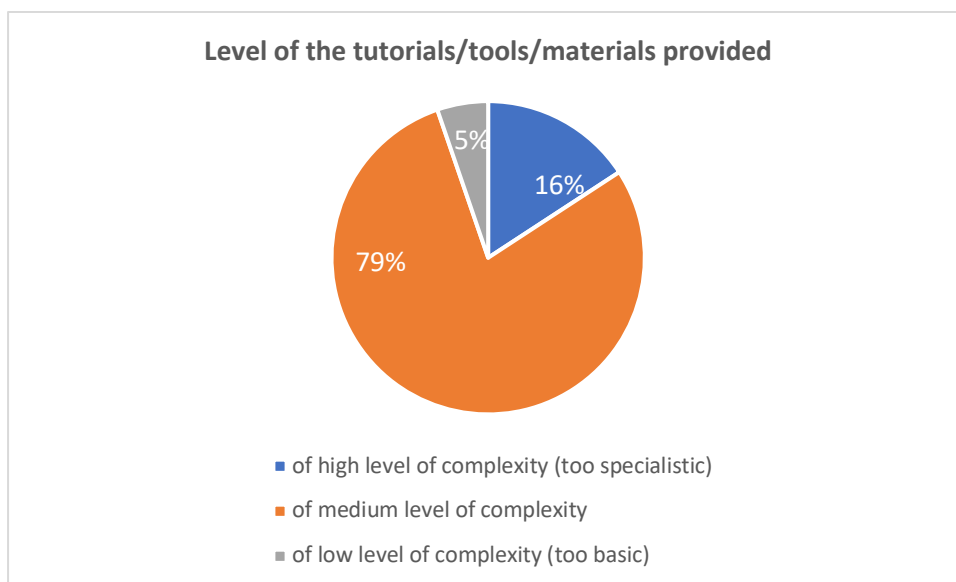


Fig. 1.6 Respondents' view about the level of the tutorials and other teaching materials provided by the Summer School

Participants were also asked to self-evaluate knowledge and competences acquired or stimulated during the school. The 95% declared to have acquired knowledge about the GSO4SCHOOL methodology (Fig. 1.7). As for the competences acquired and stimulated through participation in the School, there were at the first place transversal competences such as creativity (90%), personal and social competences (more than 70%), followed by working in group, critical thinking and multicultural/global citizenship competences (more than 60%); more than 50% of respondents acquired or stimulated scriptwriting/storytelling competences, more than 40% music and scenography competences, scientific knowledge and the capability of learning to learn; more than 30% acquired technological/digital competences, more than 20% the entrepreneurship competence (Fig. 1.8).

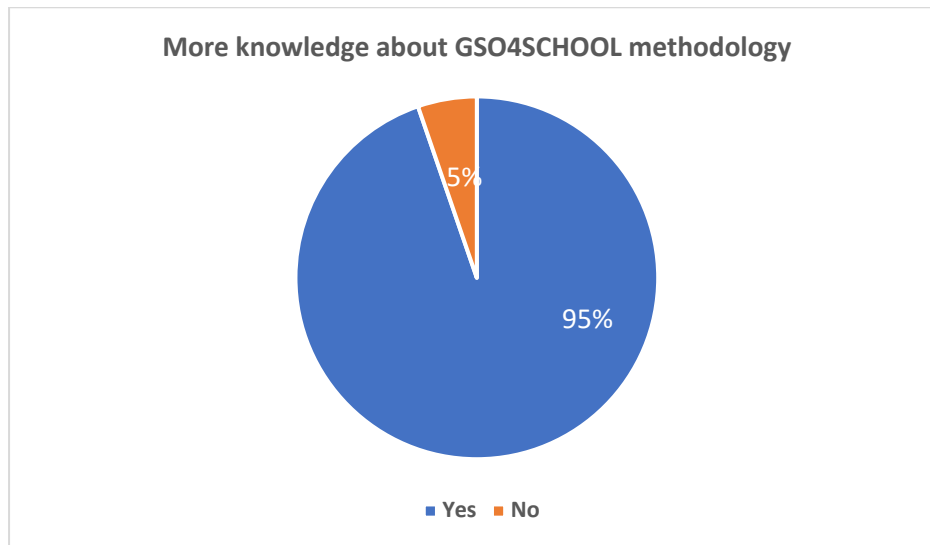


Fig. 1.7 Respondents' views about the knowledge acquired about the GSO4SCHOOL methodology

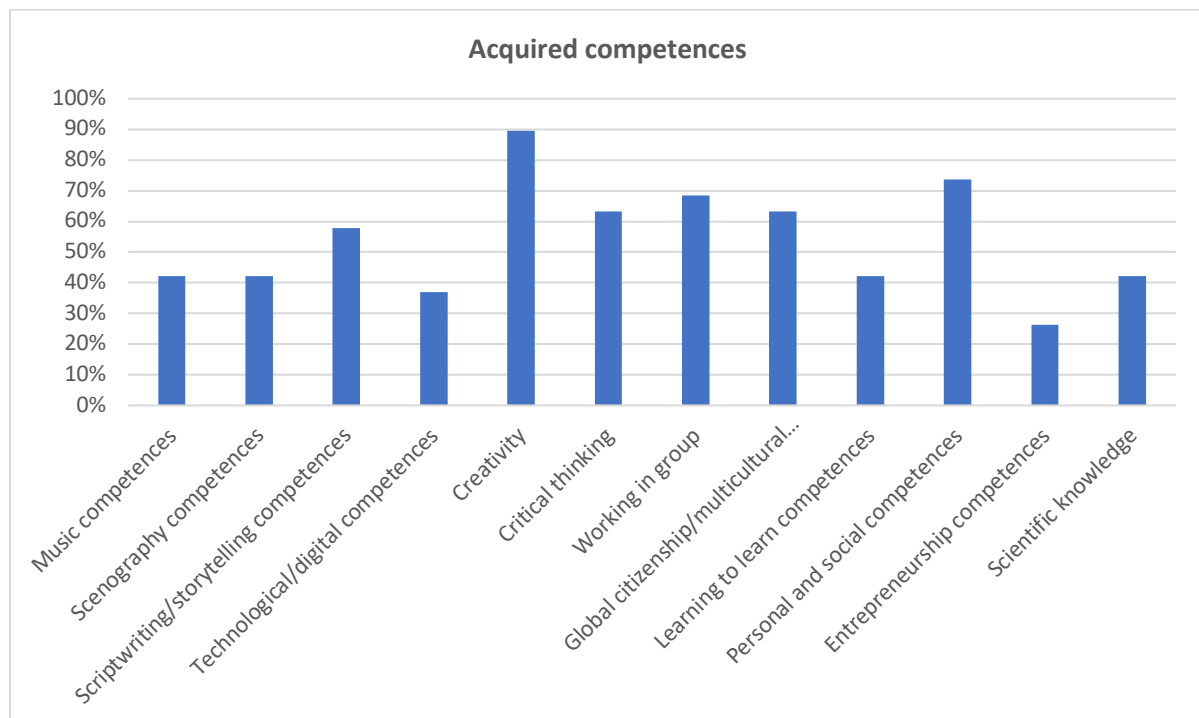


Fig. 1.8 Respondents' view about the competences acquired through the Summer School (multiple choice question)

Creativity is a crucial element of the GSO4SCHOOL methodology, so we also asked to explain how participating in the Summer School affected their creativity. Among the answers, the following aspects were stressed as fostering creativity:

- reaching out of their comfort zone, opening mind
- opportunity to feel free to express ideas
- a friendly and collaborative environment/atmosphere
- interaction with others to be inspired and create synergy
- working in team, also in small groups
- enriching knowledge and acquiring innovative methods
- inspiring, encouraging and supportive facilitators
- receiving feedback, also sharing materials online
- opportunity to structure ideas and impulses in a framework

Quoting one of the respondents: “It was a real challenge since as an adult we loose most of the creativity. It made me break my boundaries and try to do things outside my comfort zone.”

The most appreciated elements of the School were the international environment and the educational tools and materials provided (Fig. 1.9).

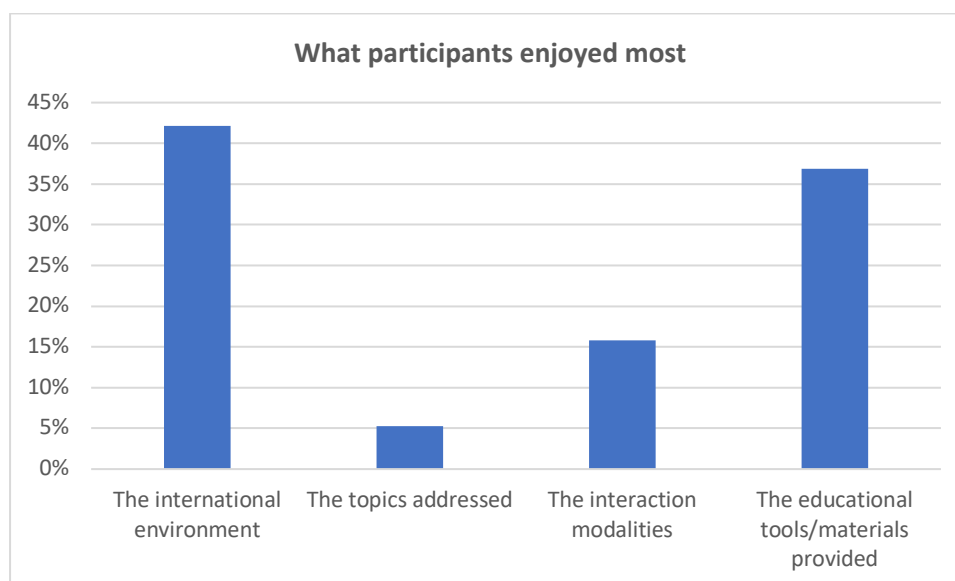


Fig. 1.9 Aspects especially enjoyed by respondents (percentage values, multiple choice question)

The interactivity level was considered as appropriate (Fig. 1.10), most respondents felt to have contributed in the School and did not feel uncomfortable (Fig. 1.11-1.12).

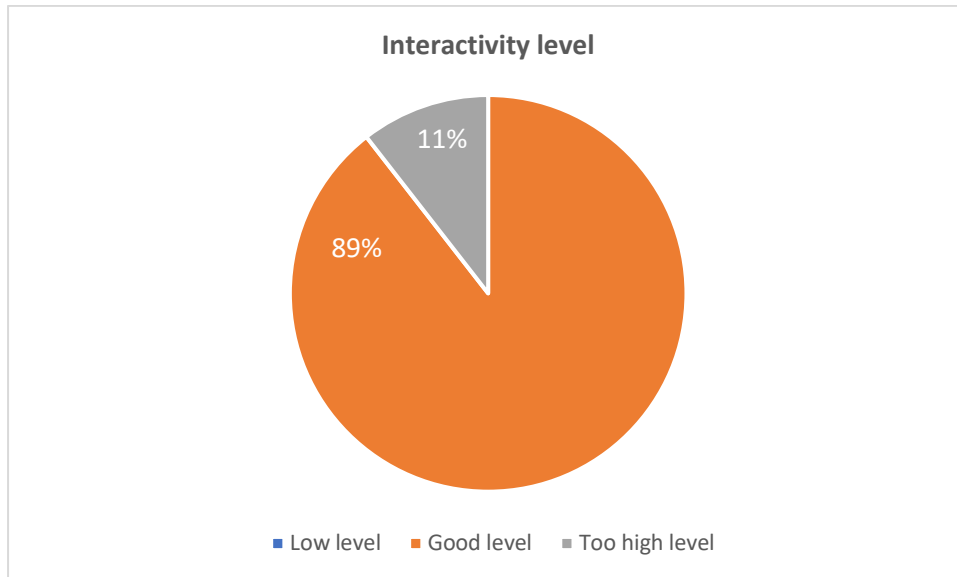


Fig. 1.10 Respondents' view about the Summer School interactivity level

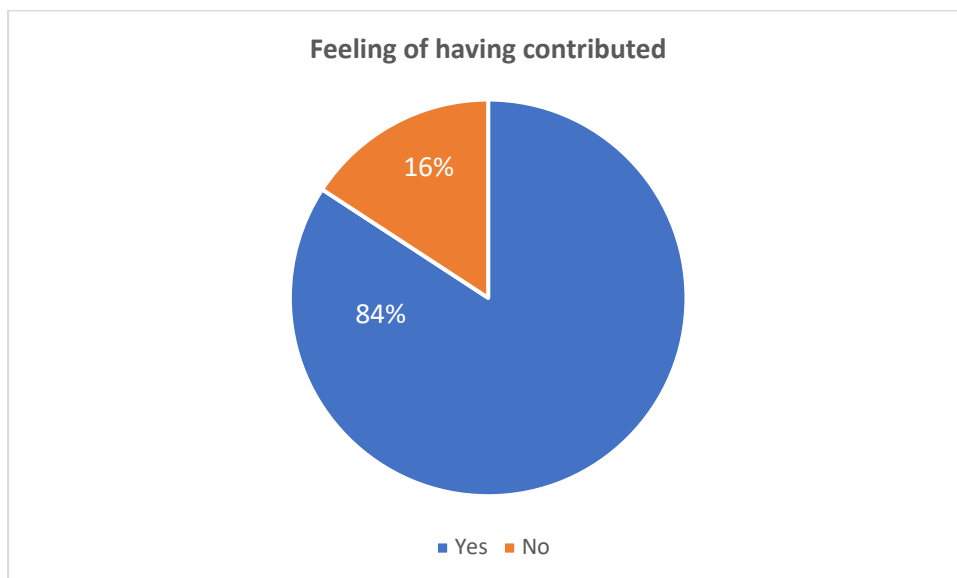


Fig. 1.11 Respondents' perceptions about their contribution in the Summer School

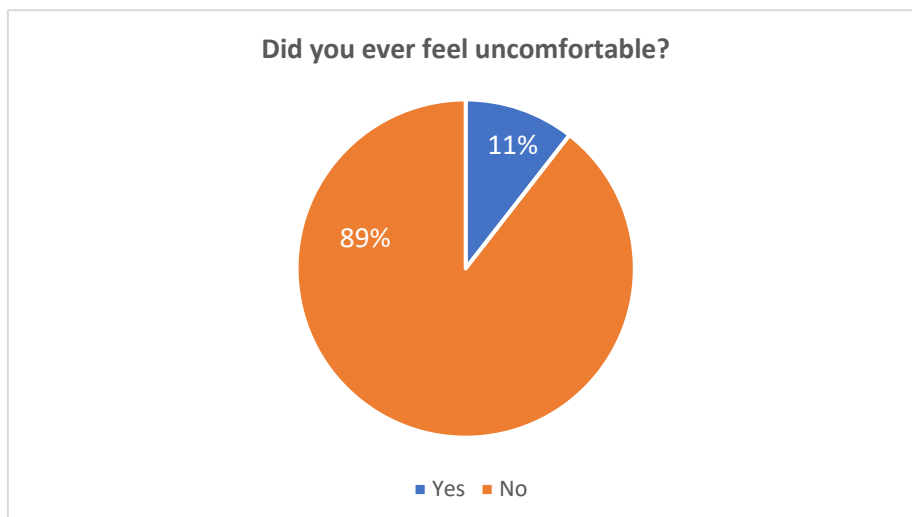


Fig. 1.12 Respondents' perceptions about feeling comfortable during the Summer School

1.1.3 Respondents' perspectives about participation in the next Global Science Opera

We finally collected opinions related to the participation in the GSO 2022, in order to catch possible problems in advance.

One of the critical points was the choice of the topic of the GSO 2022 during the Summer School. Participants were invited to choose a topic among the following:

- Artificial Intelligence
- The Creative Brain
- Black Holes

According to a voting procedure after a participatory exchange of ideas, the final choice was “the Creative Brain”.

The 95% of respondents declared to be satisfied with this choice (Fig. 1.13).

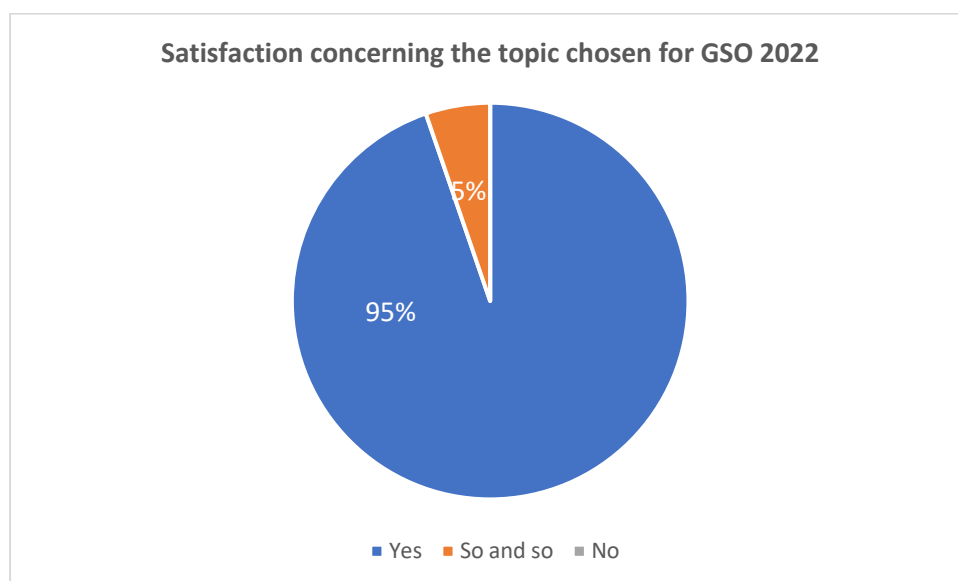
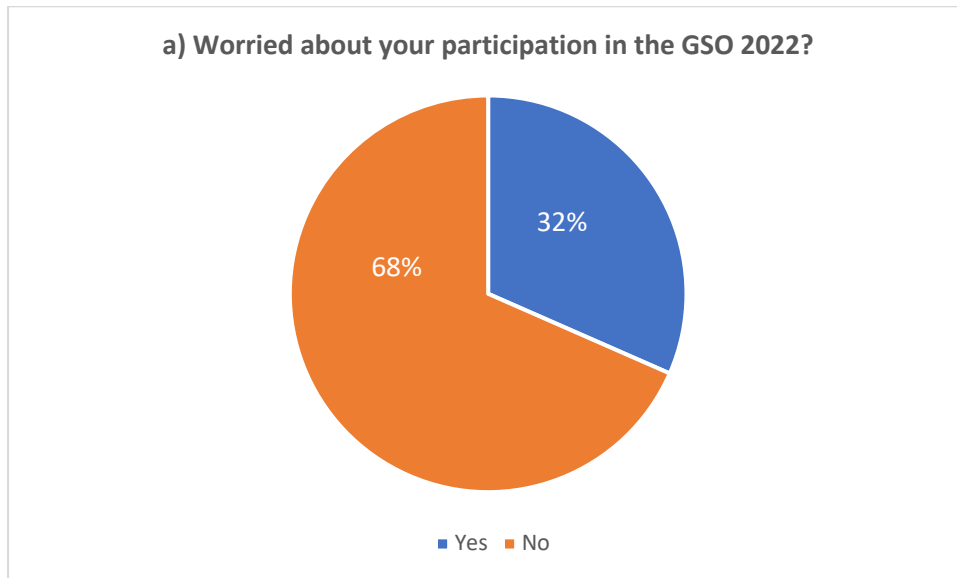


Fig. 1.13 Respondents' satisfaction level about the topic chosen for the GSO 2022

However, the 32% of respondents declared to be worried about their participation in the next GSO (Fig. 1.14a-b). The main reasons of these answers are not having enough time and the workload required to participate with their students.



For those who answered Yes:

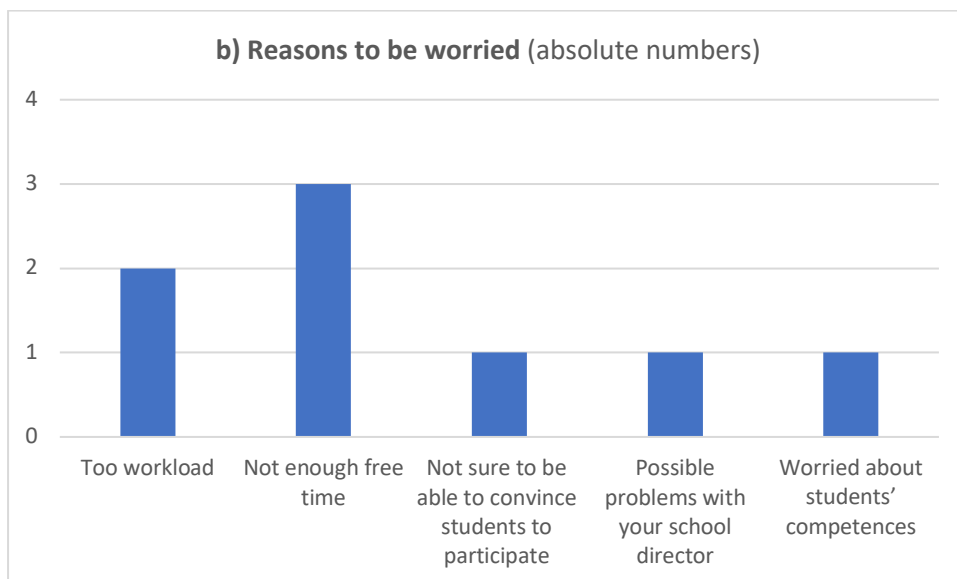


Fig. 1.14 a) Respondents' worries about their participation in the GSO 2022
 b) Possible reasons to be worried according to respondents (absolute numbers)

1.1.4 Conclusions about the GSO4SCHOOL Summer School 2021

Based on these results, the Summer School received a very positive evaluation by most of the respondents, which was also confirmed by the final open comments at the end of the questionnaire, appreciating e. g. the creativity stimulation, the "learning by doing" approach, the possibility of

exchanging ideas with other educators and learning innovative methodologies, expressing the desire to stimulate students’ creativity through the methodology acquired.

Moreover, we also collected a few inputs to improve the next Summer School edition, scheduled in the first half of July 2022. One of the challenges was considered the duration, probably also due to the online format imposed by the pandemics; other suggestions concern e. g. to encourage the music production of the GSO covering several musical genres according to students’ country of origin.

1.2 Participants’ perspectives about the 2022 GSO4SCHOOL Summer School

The 2022 GSO4SCHOOL Summer School took place in Marathon, Greece, between 3 and 8 of July. The aim of the school was to spread the Global Science Opera methodology in the project partner countries, as innovative practice for teaching Sciences in the classroom, involving teachers and other people interested in joining science and art in education and in contributing to implement the GSO in 2022 and in the future.

PROGRAMME						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	
3 July 2022	4 July 2022	5 July 2022	6 July 2022	7 July 2022	8 July 2022	
	09:30 - 10:00 Welcome - Icebreakers	09:30 - 10:00 Warmups	09:30 - 10:00 Warmups	09:30 - 10:00 Warmups	09:30 - 10:00 Warmups	
Participants' arrival	10:00 - 10:30 The GSO4SCHOOL Framework		10:00 - 13:00 CREATE: Workshops and working Groups - Participants lead by the tutors will start developing their activities	10:00 - 12:00 CREATE: Workshops and working Groups - Participants lead by the tutors will finalise developing their activities	10:00 - 11:15 Preparations for Collaboration after the Summer School	
	10:30 - 11:15 GSO4SCHOOL Guides and Tutorials	10:00 - 12:00 IMAGINE: 4 Workshops [Music - Ecoscenography - Dance - Script/ Characters]	(* Lunch Break will be 13:00 - 14:00)			
18.00-20.00 Keynote Talks Open schooling for deeper learning in science Dr. Sofoklis Sotiriou Ellinogermaniki Agogi	11:15 - 12:00 Design Thinking Workshop [Feel - Imagine - Create - Share]				11:15 - 12:00 REFLECTION	
			12:00 - 14:00 LUNCH BREAK			
Creativity at its best: Making science by making art Dr. Pierluigi Paolucci Istituto Nazionale di Fisica Nucleare and CERN			14:00 - 15:30 FREE TIME		14:00 - 15:00 End of the Summer School - Certificates	
GSO4SCHOOL - Leverage students participation and engagement in science through art practices Associate Professor Janne Robberstad Western Norway University of Applied Sciences	14:00 - 17:00 FEEL: Presentations from Greek participants (15') Present the GSO Theme: CREAVOLUTION - Workshops and working Groups (discuss ideas and the groups)	14:00 - 17:00 IMAGINE: Workshops and working Groups - Participants lead by the tutors will schedule their activities		14:00 - 18:00 SHARE: Workshops and working Groups - Participants lead by the tutors will develop and finalise their presentations/ performances		
The inner workings of an international multi-actor collaboration towards food system transition: FoodSHIFT 2030 In action Luke Schafer University of Copenhagen			15:30 - 24:00 Visit to Acropolis - Dinner			
	18:00 - 24:00 Visit to Sounio - Dinner	17:00 - 22:00 FREE TIME		18:00 - 20:00 Performance		
				20:00 - 22:00 Social Event - Farewell Dinner		

Image 2: The program of the GSO4SCHOOL Summer School in 2022

29 persons took part in the school, selected and invited by the project partner institutions, their expenses being covered by the project funds. 22 of them answered the questionnaire. This was the first Summer School organized by the project in presence, differently from the previous one in 2021, online due to the pandemics.

1.2.1 Premise: information about respondents

This section summarises information collected about the Summer School participants, related to their country of origin, gender, field of expertise, education level they work with.

Differently from the 2021 edition, where participants were from a wider variety of countries (also extra-European), in this case we had only participants from the project partner European countries: Greece, Portugal, Norway, Cyprus, Italy, according to the distribution shown in Fig. 2.1. This is due to the fact that this time the School was not online but in presence and only participants from the partner countries could receive a budget for the travel expenses.

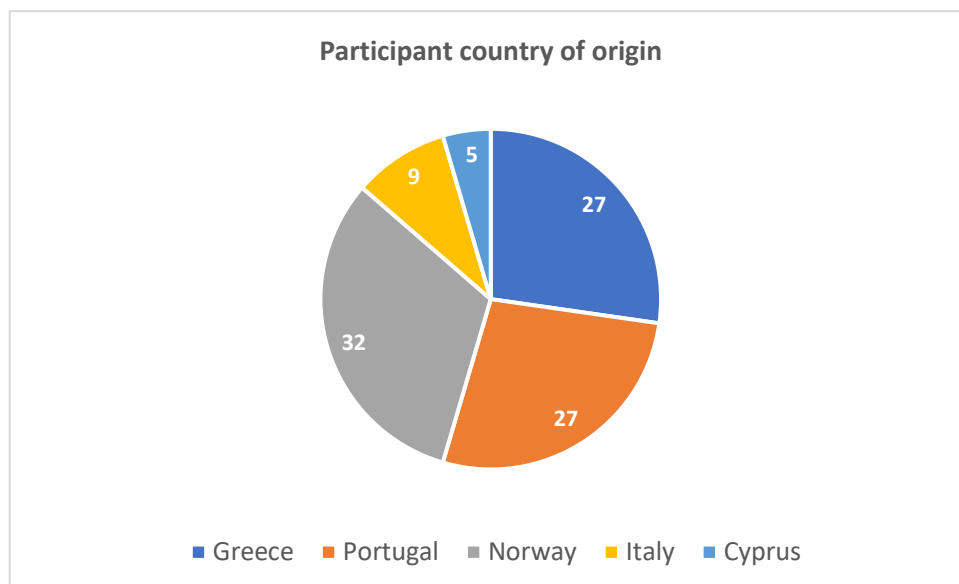


Fig. 2.1 Distribution of respondents by country of origin

As in the 2021 Summer School, most of respondents are female (Fig. 2.2).

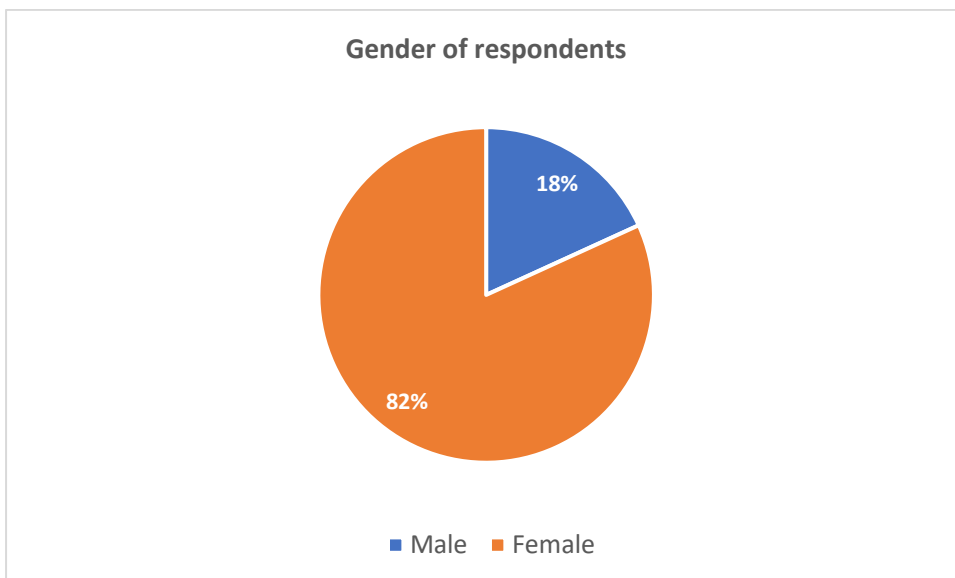


Fig. 2.2 Distribution of respondents by gender

Their age is distributed in a balanced way between the ranges 20-35 (23%), 36-45 (27%), 46-55 (32%) and more than 56 years old (18%).

Respondents have expertise in different disciplines, mainly artistic subjects – including Music, Drama, Arts - and Science, Technology, Engineering and Mathematics (STEM subjects). A minority of participants teach Pedagogy, English, primary school subjects, STEAM subjects joining STEM and Arts (Fig. 2.3).

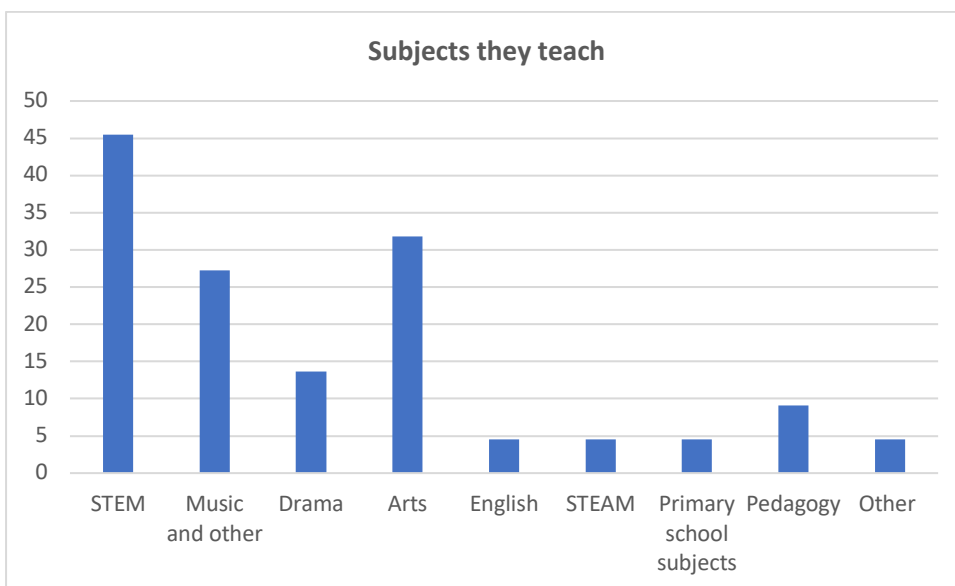


Fig. 2.3 Subject fields of the respondents (percentage values, multiple choice question)

About a third of respondents (32%) work at university, followed by upper secondary school (23%), primary school (18%) and lower secondary school (9%) (Fig. 2.4). Among those who replied “Other”, someone teaches at pre-school level.

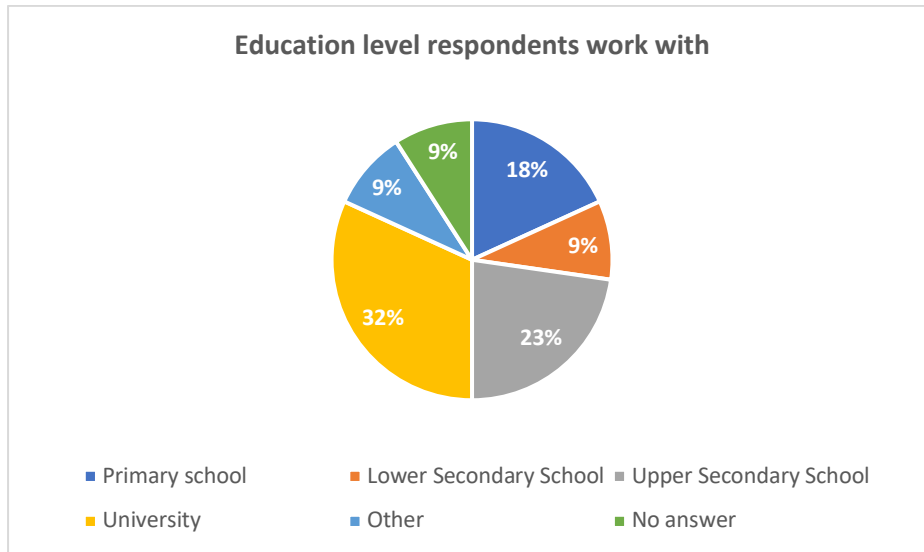


Fig. 2.4 Education level targeted by respondents in their work

1.2.2 Respondents' views about the Summer School experience

This section collects respondents' views about their experience with the GSO4SCHOOL 2022 Summer School.

The most appreciated topics addressed were the design thinking approach and the scientific insights provided, followed by the GSO4SCHOOL framework, dance, ecoscenography, music, guides and tutorials, script/characters (Fig. 2.5).

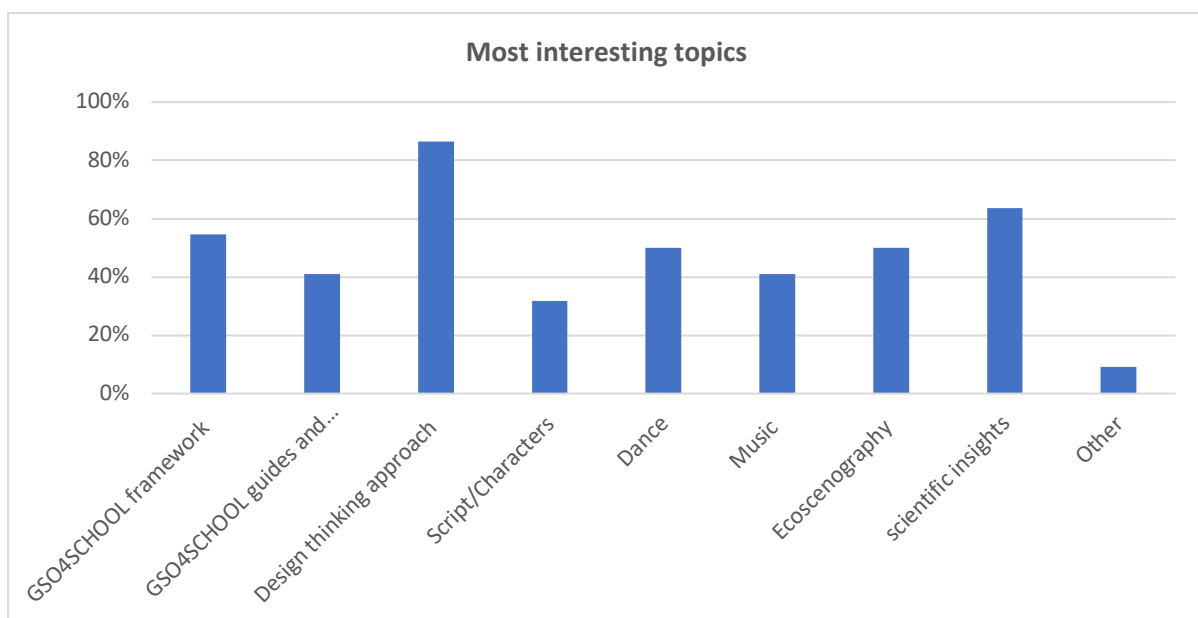


Fig. 2.5. Topics of the 2022 Summer School respondents enjoyed most (percentage values, multiple choice question)

Among the most appreciated things, someone mentioned the interdisciplinarity approach and the ideas given to make classes more interesting and creative. Someone highlighted that there was an aspect not considered enough: the science behind the “creative brain”, which is the focus of the GSO 2022 *Creavolution*.

Respondents were also invited to suggest other possible topics related to art-science that could be explored; among the proposals, there were drawing and painting; community art and performance; more audio-visual tools; more scientific insights; more methodological aspects to consider, like using design thinking as a tool for STEAM education and ways to combine many different subjects.

The tools/materials provided by the School were evaluated as adequate by almost the 70% of respondents (Fig. 2.6). No one considered the materials as insufficient.

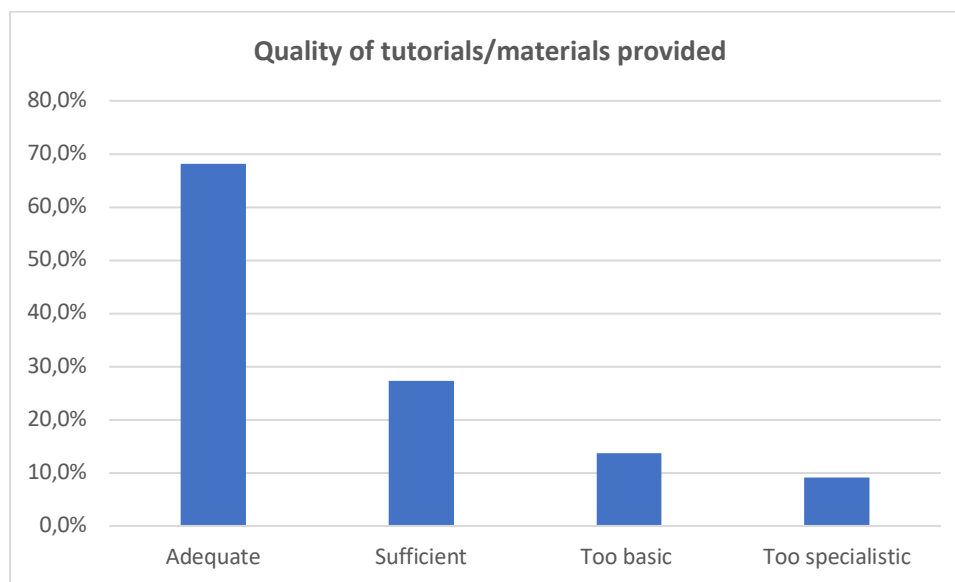


Fig. 2.6 Respondents' view about the level of the tutorials and other teaching materials provided by the Summer School (percentage values)

Respondents were also asked to self-evaluate knowledge and competences acquired or stimulated during the school. The 95% declared to have acquired knowledge about the GSO4SCHOOL methodology (Fig. 2.7), exactly the same as in the 2021 edition.

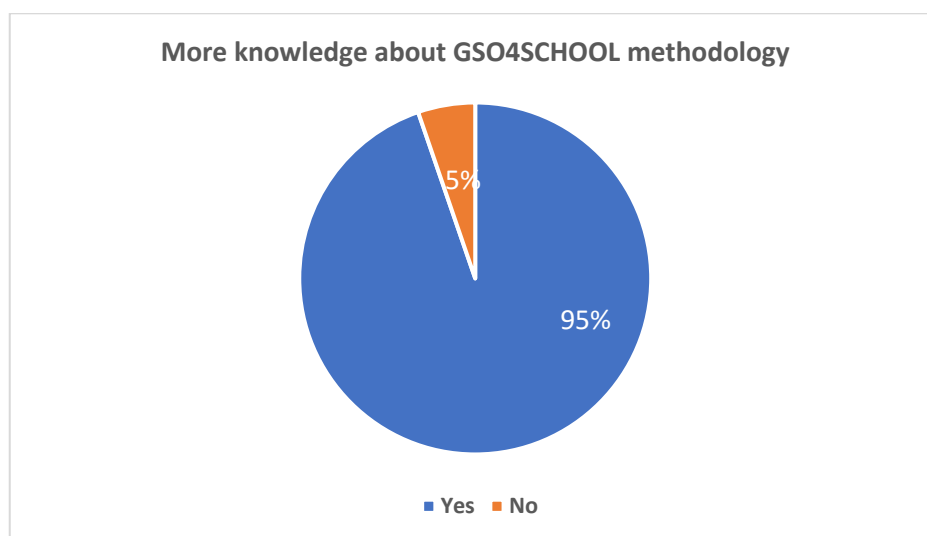


Fig. 2.7 Respondents' views about the knowledge acquired about the GSO4SCHOOL methodology

64% of respondents declared to have more certainties about how to create a GSO, and for the half of them the interest in the GSO increased.

As for the competences acquired and stimulated through participation in the School, at the first place there were transversal competences such as working in group (77%), personal and social competences (68%), and creativity (59%), followed by multicultural/global citizenship competences, artistic skills like scriptwriting/storytelling and scenography and scientific knowledge; less than 25% stimulated the capability of learning to learn, music competences, technological/digital competences, critical thinking, multilingual and entrepreneurship competences (Fig. 2.8).

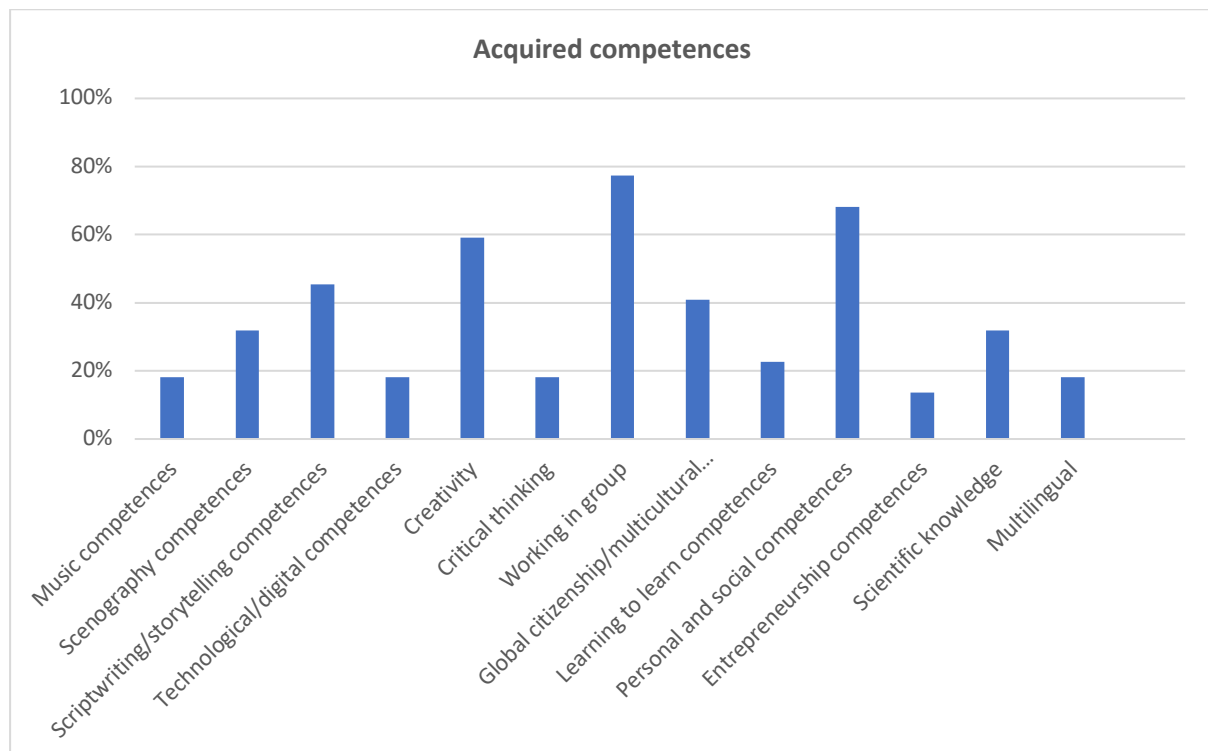


Fig. 2.8 Respondents' view about the competences acquired through the Summer School (percentage values, multiple choice question)

Respondents were further asked to explain how their participation in the Summer School affected their creativity, which is a crucial element of the GSO4SCHOOL methodology. Among the answers, the following aspects emerged as connected to the creative processes fostered by the School:

- becoming more and better open to uncomfortable situations where personal development is necessary and dependent on creativity;
- learning to go out from own comfort zone and realizing that it is rewarding;
- becoming more secure about working in a creative process and more aware of what are the valuable factors;
- experiencing at the same time the pleasure of co-creating together and the difficulties of the process;
- feeling the power of creativity in developing a strong connection between the participants;
- working in transdisciplinary way;
- being enriched by different cultures and expertise, overcoming barriers.

The most appreciated element of the school was the international environment, followed by the interaction modalities, the “performance moment” and the topics addressed (Fig. 2.9).

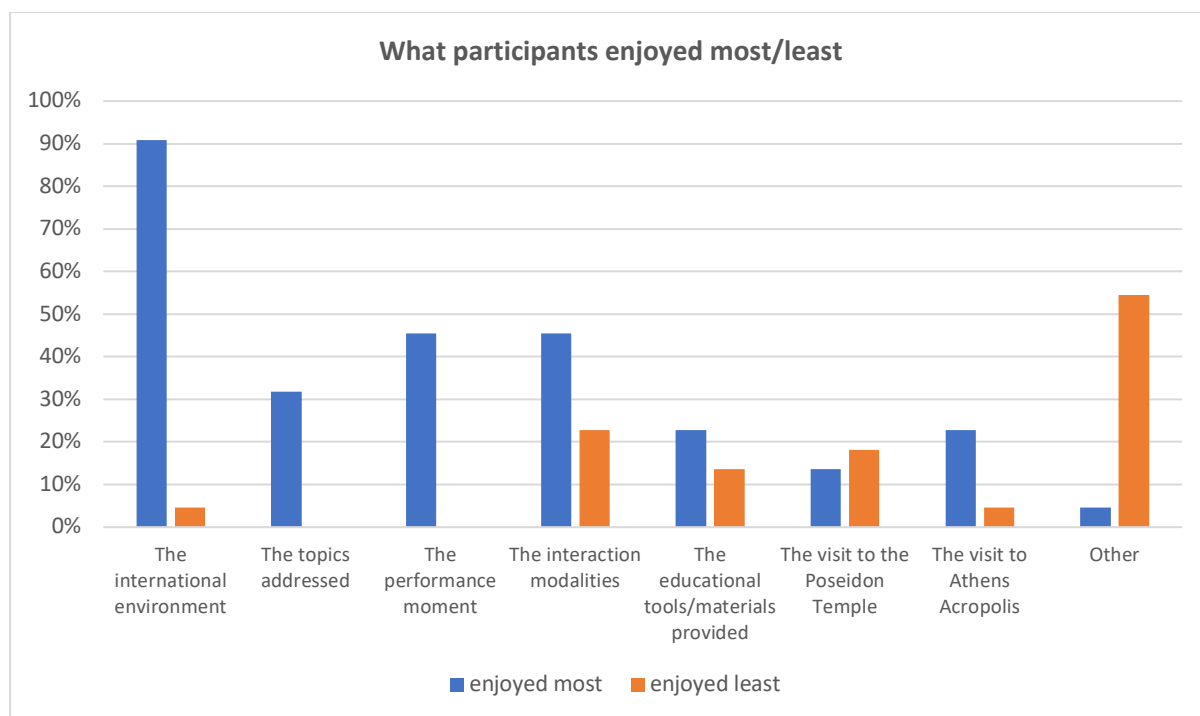


Fig. 2.9 Aspects enjoyed most/least by respondents (percentage values, multiple choice question)

Among the aspects that were less appreciated, for example there were: the time pressure, having a too dense schedule and, in some cases, not having been able to know more about participants from other countries. Moreover, addressing the topic of “creative brain” from a scientific point of view was perceived as a missing part.

The touristic activities organized – the visit to the Athens Acropolis and to the Poseidon Temple – did not result as the most appreciated activities. Based on some respondents’ comments, one of the reasons was the long bus travelling with long waiting times, while they would prefer doing something else within a shorter distance.

The interactivity level was considered as appropriate by 77% of respondents (Fig. 2.10), while about a quarter found it even excessive.

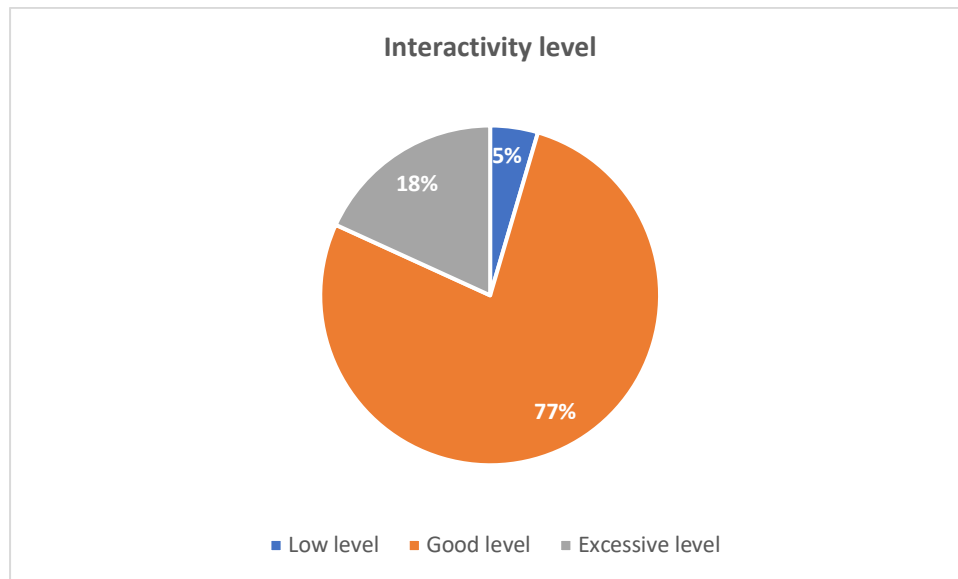


Fig. 2.10 Respondents' view about the Summer School interactivity level

Among the comments related to interactivity, the quality of participants with whom to interact and collaborating with people from different countries was appreciated, so that some considered not enough the time spent together to explore their valuable competences, “talents and knowledge”, probably not enough emphasized from the beginning. Also the possibility of exchanging ideas about their experience with GSO so far was appreciated.

Someone complained about too little flexibility and having a too tight time schedule to work in depth on something and be more reflective together, and also for the groups to get each other to know better. Moreover, the program should devote more time for each technique, or allow to choose some to specialize on. Moreover, it was noticed that the coordination – communication, organization, having common objectives - among the instructors in some cases did not work well, which led to “interrupt the creative process several times due to organizational information or changing topic”, lacking clarity about what they expected from participants in terms of goals to reach. Someone, more specifically, found less quality in the last two days. Finally, for someone, own English level was not good enough to be able to properly interact.

100% of respondents felt to have contributed in the School, even more than in the 2021 edition (84%), which can be expected considering the modality in presence. Those who feel not having contributed attribute this to the fact that time for dialogue and for reflecting on the topics proposed was too short.

In 2022 32% of respondents declared to have felt uncomfortable during the school in some moments (Fig. 2.11), a percentage much higher than in the 2021 edition (11%). Also in this case the in presence modality has made the difference, forcing participants to face their limits and to go out of their comfort zone.

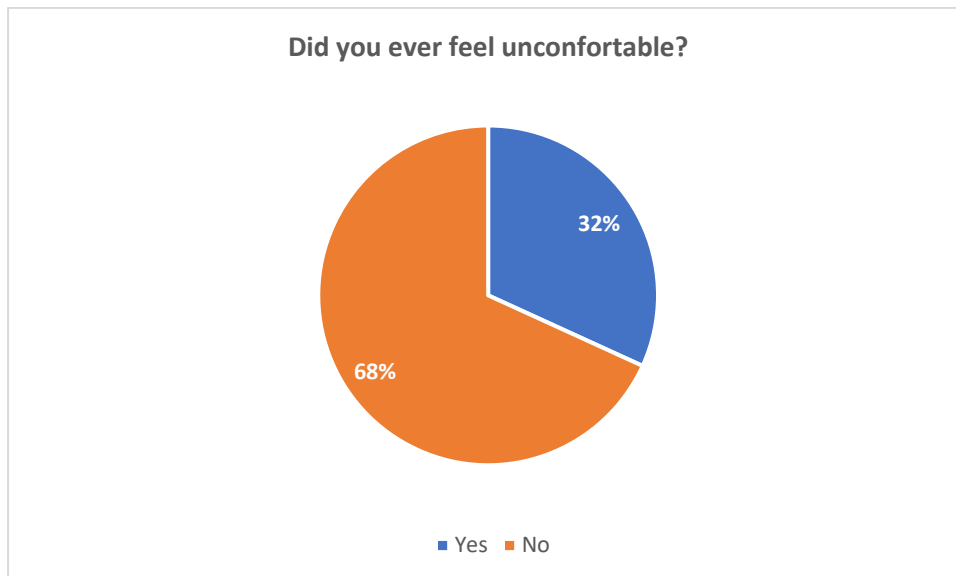


Fig. 2.11 Respondents' perceptions about feeling comfortable during the Summer School

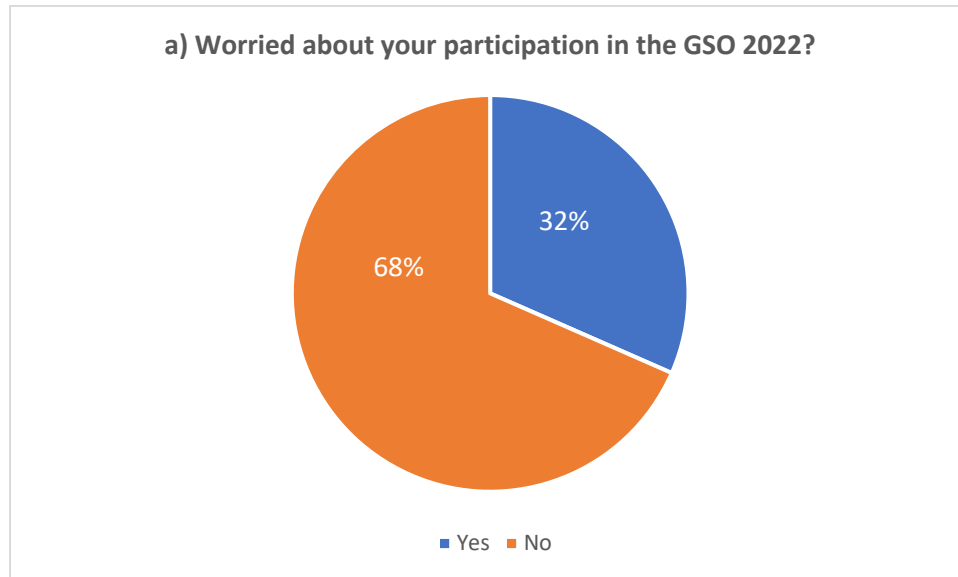
Feeling uncomfortable was mainly due to a not enough flexible time schedule, the interaction modalities and the English level. In less cases it is was due to the scientific topic, too long sessions and relationship with the staff; someone considered the time to develop the scene as too limited (e. g. the “Dopamine Song”). Feeling uncomfortable was further strengthened by the “threat” of having to present the scene on stage in the final performance, which led to anxiety and also sometimes to “lower the quality towards ‘easier-to-learn-quickly’ elements”. The short time didn’t help feeling comfortable performing on stage and even led some participants to skip mandatory plenary activities to prepare the performance. This was exacerbated by the fact that sometimes the process was unclear, not being clear how much time they had for working on their “scene”. According to a participant’s suggestion, a possibility to avoid the anxiety would be to frame the performance in a different way, not as a “polished performance”, but as an “unfinished process presentation”, followed by a discussion about groups’ thoughts behind the presented work, what next steps could be, giving value to the materials’ potential.

Finally, someone felt forced to expose him/herself more, but recognized that it was good for his/her personal development.

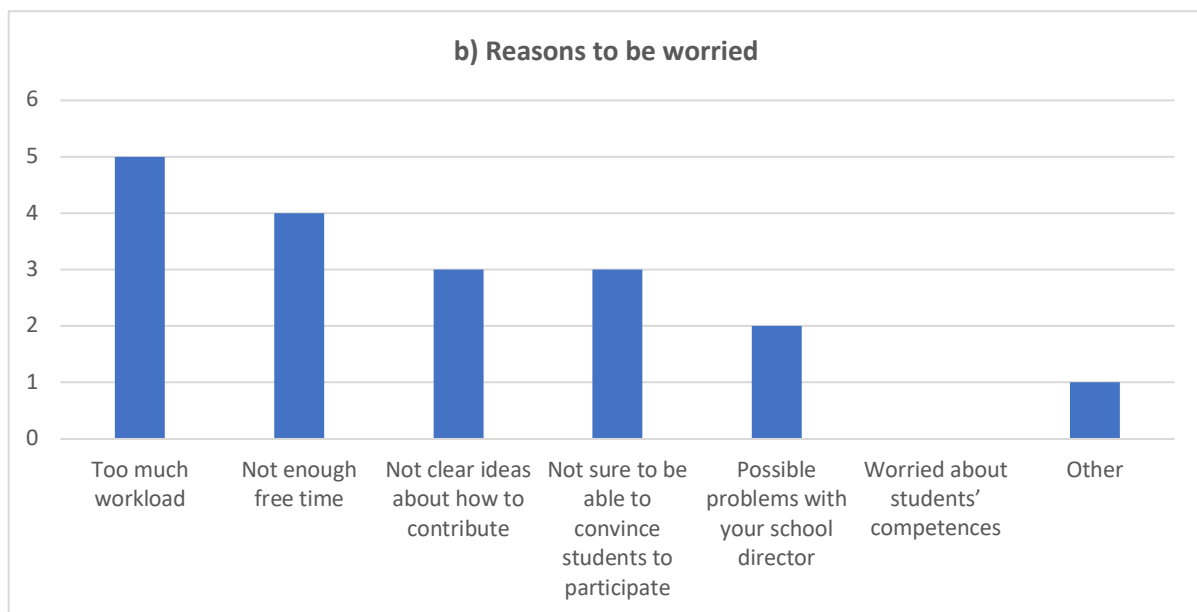
1.2.3 Respondents' perspectives about participation in the next Global Science Opera

We finally collected opinions related to the participation in the next GSO, in order to catch possible problems in advance.

About a third of respondents (32%) declared to be worried about their participation in the next GSO (Fig. 2.12a-b), the same percentage as in 2021 Summer School respondents. The main reasons are the workload required to participate with their students and not having enough free time, followed by being not sure to be able to convince students to participate, not having clear ideas about how to contribute, possible problems with the school director, worries about students’ competences. Lack of money was also mentioned as a reason.



For those who answered Yes:



*Fig. 2.12 a) Respondents' worries about their participation in the GSO 2022
b) Possible reasons to be worried according to respondents (absolute numbers)*

A further aspect we wanted to explore, because emerged as critical from the 2021 GSO experience, was the collaboration between teachers from different countries, in order to understand how to foster this opportunity that is embedded in the GSO methodology and spirit, but that is not enough realized yet. As a matter of fact, so far the GSO has been in most cases realized as a collection of scenes produced in different countries, but separately. So, respondents were asked to provide opinions about which are the barriers and facilitators to the international collaboration between teachers from different countries to create a scene together.

Among the barriers, the followed were identified: resources needed, like money to travel and time needed; the different languages, if not having a good English level; different ways of thinking; different time schedule between schools of different countries; not knowing how to make a scene

together; not knowing how to make students active in the collaboration process; problems from local school leadership; differences in the age of the groups; possible stress caused by the collaboration.

Among the suggested facilitators, the following were mentioned: having resources, e. g. scholarships; personal interest and willingness to collaborate and co-create; being creative; being open-minded; having common interests; exchanging creative processes; working with students of the same age; spending time together in person and less online, also together with the students; internet apps for collaboration and digital meetings; exchanging video files; research collaboration programs; having a foreign language in common; distributing the works between partners. Someone also mentioned that having time to plan the collaboration during the Summer School would have been a facilitator.

However, a total of 64% of respondents declared to have met other teachers/educators from other countries with whom they are planning to collaborate to create a GSO scene together.

1.2.4 Conclusions about the GSO4SCHOOL Summer School 2022

Based on these results, the Summer School received an overall positive evaluation by the respondents. A positive element mentioned in the final comments was the opportunity of “being in creative processes and talking and reflecting on the processes”, a sort of “meta-view” that may be key to actual change in teacher practice.

However, some critical points emerged, in particular: the lack of clarity about the priorities and what was expected by participants, also probably due to insufficient coordination/communication among the organizing staff; and the short time, not allowing participant discussions about complex issues, making them feel under pressure, not having enough free time. Someone complained about the fact that in some cases the instructors were too authoritative.

Moreover, some suggestions about how to improve future summer schools were provided: having scientific experts to provide inputs on the main theme; spending more time on the pedagogical framework, “especially about how to establish and maintain ‘living dialogic spaces’ as a basis for creative processes”; downplaying the performance element.

Further suggestions were also given with reference to the ongoing production of the Global Science Opera *Creavolution*, stressing that “a better connection should be made between the main topic (creativity, evolution and revolution) and the story/scenes development” (e. g. a proper story could be about an artist with creativity crisis that must visit own mind/brain to solve the problem).

Finally, from a more practical point of view, someone would have appreciated the organization of further activities outside the GSO4SCHOOL frame, like experiencing an art space and going to a scene production together.

According to organizers’ opinion, it was recognized that it would be useful taking some time to let participants share their expertise at the beginning of the week, which might have established some connections and collaborations based on this knowledge, and in general giving more visibility to participants’ resources.

As for the crucial aspect of international collaboration, we may say that it was a missed opportunity. Indeed, in that context there was the chance to establish groups that would continue to collaborate after they got home - maybe based on field of expertise, making sure there was one STEM-teacher, one musician/music-teacher and one drama/dance/other in the group, all representatives from different countries – but this was left to the participants’ spontaneous relationships, instead of fostered in a structured way.

Part 2. REPORT OF THE WORK TABLE “ART & SCIENCE IN DIALOGUE”

Reflections starting from the Global science Opera in the Italian context

This chapter presents the main results emerged from the work table realized in Rome on December 13 2022 within the GSO4SCHOOL project, in collaboration with the [Officina Education & Futures](#) annual participatory conferences aimed at envisaging and conceiving desired and desirable futures of education.

The “Officine” are organized by the research group “Social studies of science, education, communication” of the Institute for Research on Population and Social Policies of the National Research Council of Italy (CNR-IRPPS), focused on participation as a key factor to promote sustainable and shared innovation: scientific and educational communities, students, societal actors and policy makers share ideas, debate and co–create knowledge (Tudisca V., Pennacchiotti C., Valente A., 2022a; Pennacchiotti C., Tudisca V., Valente A., 2022). This approach is aimed to align research processes and products to the needs, values and expectations of society, in line with the European conceptual framework of “Responsible Research and Innovation”, with the “Sustainable Development Goals” (Agenda 2030) and the principles promoted by the “Conference on the Future of Europe” promoted by the European Parliament, the Council and the European Commission.

The “Art & Science in dialogue” work table is the ideal continuation of the one realized within the Officina 2020 named “Futures of scientific citizenship and Global Science Opera” (Tudisca, V. et al. 2022). It was aimed at reflecting on the possible interconnections between art & science. Ten invited panelists among researchers, teachers, policy makers and students and three researchers from the National Research Council of Italy contributed to the debate focused on two aspects:

- Differences and touchpoints between art and science
- How to integrate art & science in education

Participants:

Valentina Tudisca, Claudia Pennacchiotti, Adriana Valente – CNR-IRPPS (coordinators); Domenico Braccioldieta – IISS Leonardo da Vinci in Cassano delle Murge; Silvia Caravita – CNR-IRPPS; Lapo Rocco del Balzo – President of the Building Committee of the Provincial Student Council of Rome; Daniela Donisi – ITISG Armellini of Rome; Silvia Mascalchi – Gallerie degli Uffizi; Elena Gaudio – Ministry of Education; Nicola Margnelli – Myosotis Cooperative; Flavia Salustri – President of the Student Council of Rome; Alessia Vaglivello – Regional coordinator for the Lazio Student Council, Gen. Dir.USR for Lazio

SCIENTIFIC COMMITTEE: Adriana Valente, Valentina Tudisca, Claudia Pennacchiotti (CNR-IRPPS), Elena Gaudio (DGOSV-MI), Alessia Vaglivello (USR Lazio)

The working table is arranged within the Erasmus plus GSO4SCHOOL European project

The aim of the working table is to shape and discuss visions on interconnections between art and science and on the opportunities and obstacles associated with different innovative methods and approaches in education, starting from sharing experiences.

By tackling the different issues in the discussion, a network of elements and points of contact has emerged and brought together art and science, even where common sense would seem to indicate a radical difference in perspectives.

2.1 Differences and points of contact between art and science

2.1.1 Scientific and artistic methods and processes: is it really true that scientific and artistic methods are radically different? The former being rigorous, rational and codified, anchored to models, built on a collective experience (involving a peer review process, requiring a strong dose of collaboration); the latter more individualistic, irrational and subjective, outside the box, without the need of proof? During the discussion, this concept of dichotomy has gradually waned. The creative dimension and the centrality of intuition, the urge to think in an "unconventional" way, outside the box, are part of both the artistic and the scientific process: Goethe had already underlined how, even in the research process, the creative dimension allows insights that would not be possible through rational thinking alone. It has also been pointed out that creativity in both processes can be expressed and consolidated only by studying and by means of a profound knowledge of the historical and cultural context in which the artist and the scientist live. Furthermore, even scientific processes are not "neutral" and "objective" but, as human processes, they are often guided by biases linked to social rules and "collective thoughts", as Fleck (2012) noticed. Finally, both artistic and scientific processes often share a feeling of unease, of apprehension; both the artist and the scientist push themselves to the limit of what is known in order to overcome it; they go beyond the acquired frames in order to produce new knowledge; they must accept uncertainty and darkness. Both look at reality with new eyes that go beyond pre-existing patterns.

2.1.2 Science and art as an individual or shared act? Does this exploration of new territories result in a purely individual dimension or does it also bring along the need to communicate, that is to establish and share relations? Would this issue mark a difference between art and science? The artistic experience is usually shared but it is not necessarily intended with this aim. In the past, the work of art was often commissioned with a pedagogical or communicative intent, the artist worked for a principal; often, the creative act itself was shared, (e.g.: in the collaboration between artists in Renaissance "bottega"). However, today the artist's intimate expressive call seems to have acquired greater importance in the genesis of the work of art. In science, however, collaboration and peer review processes are well-established practices in the production and validation of research results; the discovery, in order to be regarded as such, must be endorsed by the scientific community. Once approved by the scientific community, it should also be shared within the social community, although several studies have shown that these steps have not always been followed.

2.1.3 Science and art as an exclusive good? In a neoliberal context where market logics prevail, artistic and scientific production, in order to be economically sustainable, are often forced to fit into an institutional and economic system that influences them and threatens of institutionalizing them all while jeopardizing creative freedom and liberty of thought. Instead of free sharing and confrontation, marketability prevails and the exclusivity of possession represents an added value. In the artistic sphere, for instance, reference has been made to the recent phenomena of encrypted art; the Uffizi Museum has also promoted NFTs (non-fungible tokens, which represent the deed of ownership and the certificate of authenticity of a single asset) of digital reproductions of works of art, which can be used privately. As far as science is concerned, as highlighted by the Eurobarometers of recent years, society itself is fully aware of the centrality of basic research and an example in the

opposite direction can be identified in the Gray literature, which - despite being originated by needs of secrecy - comes out of the normal channels of the book trade, and is made available to the scientific community in a free and non-profit form, ideally binding to the open access philosophy.

2.1.4 Science and art as builders of bridges and dialogue for peace: both art and science can foster intercultural dialogue and peace. For this reason, throughout history, they have been the first target of totalitarianisms (let's think at the processes of marginalization to which artists, disliked by power, have been subjected in history and at the limits imposed on the scientific activity, on the dialogue between scientists and on science teaching in recent dictatorships).

2.2 Proposals to integrate art and science in the educational field

2.2.1 Promoting "embodied knowledge" (embodied cognition): in teaching, communicating and understanding complex topics such as scientific ones, it is necessary to overcome the Newtonian model, as well as the tendency to study elements isolated from the context. This approach has dominated science in the modern age and is still dominant in science education, strongly based on frontal, static classes and shaped by the idea that learning takes place, above everywhere else, in the mind. While being confronted with an increasingly complex and uncertain reality, in which urgent issues, personal and collective values are under discussion (Funtowicz, Ravetz 1994), it is instead mandatory to refocus on a learning process that is able to restore the complexity of the phenomena, subject of study, as well as their relationships (Heath-Carpentier 2022). Together with bodily experience and embodied cognition, recognizing the close interaction that exists between mind, body (as already underlined by Dewey, Pestalozzi and Montessori) and environment in the cognitive process (as also highlighted by posthumanist theories) become crucial. In this way, knowledge and learning emerge from the sensory-motor dynamics between the embodied agent and the natural environment in which it is embedded (Varela, Thompson, Rosch, 1991). Scientific knowledge is thus connected to a practical exemplification, an experience and a context and therefore becomes meaningful. In this effort to enhance embodied knowledge, art education comes in handy, which, in addition to promoting skills necessary to create a work of art, brings the sensory and emotional component back to the heart of the educational process.

2.2.2 Retrieving the interdisciplinary dimension of learning processes: it is necessary to overcome the traditional "disciplinary" educational approach, split up by subjects, which re-proposes a clear caesura between scientific and humanistic culture. Artistic education helps perceiving things in a more complex way; artistic processes are cognitive, but through physical actions, they improve cognitive abilities and stimulate creativity, two fundamental aspects in the scientific field as well. In this sense, it is therefore urgent to recover the concept of unity of knowledge (Morin 1993) that permeated the Renaissance period, while promoting truly interdisciplinary or transdisciplinary educational paths, also by means of the co-presence and participation of different teachers in all phases of the learning process and the involvement of figures and professionals outside the school world (art, research, restoration ...). Approaches such as STEAM Science, Technology, Engineering, Arts, Mathematics (Sandu P. Tudisca V., Valente A., 2020) can help mend the link with the complexity of reality.

2.2.3 Relaunching the cooperative method: a concrete opportunity for art and science to meet in educational contexts has been identified in the promotion of the cooperative method, a method of democratic management of the classroom centred on enabling processes of co-construction of

knowledge, between on the one hand students and on the other students and teacher. An opportunity in which one could operate immediately is represented by the PCTO courses (Paths for Soft Skills and Orientation), that can be carried out in museums, theatre companies, research centres and scientific laboratories in which, by enhancing the "O" of orientation, it is possible to actively involve and empower students in the co-creation of their own personal path.

CONCLUSIONS

Based on the outputs of the Summer Schools' evaluation process and of the work table with the scientific and educating community, integrating art and science in education helps promoting transdisciplinarity, enactive approaches to learning and enhances creativity in education (Sandu P., Tudisca V., Valente A., 2021).

The transdisciplinary perspective is at the basis of the Global Science Opera overcoming the strict separation between scientific and humanistic knowledge, enhancing the interconnections and contaminations among disciplines, helps the students to perceive the deepen unity of knowledge and the existing links between the parts and the whole, to grasp the "texture" of complexity as Morin said (Morin, 1993), and to face uncertainty. Integrating art & science could enhance the "scientific citizenship" intended as the "informed exercise of citizenship rights", in a context – "the so-called knowledge society" – in which knowledge is the primary engine – of social, economic and cultural dynamics (Greco 2008; Elam, Bertilsson, 2003; Mejlgaard, Stares, 2010; Goven, 2006).

Moreover, through the Global Science Opera performances, students and teachers make experience of the interplay between brain, body and world and develop creativity one of the essential aspects of the Global Science Opera methodology.

To put theory into practice, teachers and educators need support, the possibility of exchange ideas with other educators and learning innovative methodologies and tools (for example going deeper into different digital tools, apps and software usable in the creative process).

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