Write a Science Opera (WASO) "Introductory Workshop" - Guidelines

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1.1: Pre-project

Write a Science Opera (WASO) projects are designed as meeting points of several educational disciplines, within both science and the arts.

The "WASO Guidelines" correspond to training activities provided by the Comenius Multilateral Project "Implementing Creative Strategies into Science Teaching (CREAT-IT)". The teacher training seminars are designed to last for one day (4-5 hours). These are Professional Development Workshops\Seminars which qualify teachers to realize 2-3 day WASO projects with their pupils, based on the WASO Guidelines.

Note: Projects may be extended in length if that is possible with respect to time and resources. The WASO Summer Schools train teachers to lead such longer projects.

In the case of longer projects, it is recommended to get additional support from the CREAT-IT team/portal, and/or science teachers, art/music teachers, local scientists and local artists. Previous WASO projects have lasted from several days up to 3-4 months. Please see the Appendix, "Longer Projects", for details.

Training activity for teachers (provided by CREAT-IT)	Resulting basic school project	Comments
1-day Professional Development workshops\seminars *Location of training: Schools/other (e.g. regional Professional Development course organizers)*	2-3 day school projects with pupils (or longer if applicable) *Location: Schools/Science Museum/Local Art or Music Institution*	• 2-3 teachers per school classroom project • Collaboration of science and art\music\dance\drama teachers is recommended • The CREAT-IT project's WASO Implementation Scenarios exemplify

		this training structure.

The WASO Guidelines do not represent a finite collection of exercises and ideas in the field of Science Opera. Each school project is unique with regard to available time, equipment, experience, class size, age of pupils, etc. We therefore propose that you use the WASO Guidelines as a "living document", adding your own ideas where appropriate, and leaving out some of the ideas presented here to fit your time schedule. The WASO team would be very pleased to hear of new ideas, solutions and questions regarding how you created Science Operas with your class (or other group of participants), in order to continuously improve our training seminars and material. These can be uploaded on the CREAT-IT Portal (portal.creatit-project.eu).

Furthermore, while the sections in the WASO Guidelines follow a recommended order, in some projects these sections may overlap, or may even be realized in a slightly different order in order to take advantage of opportunities (e.g. a visit to a science museum) or make way for limitations (e.g. lack of available practice space on a given day).

1.2: Introduction & Concept

Write a Science Opera (WASO) is a creative professional development approach to inquiry-based art and science education in which pupils of different ages (usually spanning ages 10 to 17), supported by teachers, opera artists and scientists create an educational performance.

WASO is first and foremost focused on science discovery in a creative framework. In addition, science communication is also a major factor by allowing a scientific theme to inspire a multi-disciplinary artistic project. In a WASO project, a scientific theme which is the learning focus in that particular setting is chosen to inspire a creative process in a school, culminating in an operatic performance by the pupils. The complete process is guided by teachers from within a variety of disciplines including both science and the arts. Characters, libretto, composition, stage design, costume, as well as Public Relations and budget are designed by the pupils and realized during the project.

WASO is an application of the widespread Write an Opera method, developed at the Metropolitan Opera in New York and then imported and further developed by the Royal Opera House in England (Griffiths, 2012) which has been successfully implemented in many countries since the 1980s.

WASO was developed at Stord/Haugesund University College (Norway), based on dialogues with the European Network for Opera and Dance Education (RESEO), as well as the Royal Opera House's Education department. The WASO approach integrates science education into the original method by involving scientists, science higher education students, science teachers, science museums or local industry, thus leading an inquiry-based creative process demonstrating common impulses shared by the sciences and the arts (Garoian & Mathews, 1996).

WASO relies on and facilitates an empowering, democratic process in that all participants recognize their own inputs in the final, collaborative whole, thus providing a dialogue of respect for other participants' creative ideas, indeed, a wise, humanizing approach to learning from, others' creative ideas. Furthermore, WASO necessarily requires collective idea generation and a solution- finding process which is dialogic in nature.

2: Main Phase: WASO "Introductory Workshop"

The following 1-Day Professional Development workshop provides **late Primary and early Secondary** teachers with knowledge and insight needed to realize 2-3 day long Write a Science Opera (WASO) "Introductory Workshop" with their pupils. If needed, the school projects may be extended (see above).

Specific Implementation Scenarios, in which scientific themes and explorations exemplify the process, are provided in additional documents (see the CREAT-IT Implementation Scenarios). Samples of materials produced during the realization of such projects in schools (see the CREAT-IT Samples).

2.1: Warm-ups

Warm-ups provide physical motion (stretching, running, breathing exercises, etc.), musical exercises (rhythm\pulse exercises), vocal training, creative exploration, as well as positive social exchange and group dynamic.

Sessions should begin with a warm-up, regardless of the session's length.

In the list below, some basic exercises are provided. In addition, teachers of physical education, drama, music and dance in your school will usually be able to add their own repertory of exercises.

2.1.1: Stretching Exercises

Begin with very simple stretching for a variety of areas of the body:

1) Roll shoulders in circular motion 3 times in each direction (forwards and backwards).

2) Roll head in circular motion 3 times in each direction (left and right). NB: Slowly!

3) Facial grimaces to stretch all face muscles (20-30 seconds).

4) Massage face, neck and back of neck with fingers (20-30 seconds).

5) Stand in a circle with each pupil's left shoulder facing out of the circle so that all pupils are facing the same direction in the circle. Ask each pupil to give her\his neighbor a shoulder and back massage for one minute. Thereafter, switch directions and repeat the exercise.

6) Pupils put hands together and reach as high as possible, on tip-toe. Count to 10 as they stand there. Repeat with eyes closed.

2.1.2: Breathing Exercises

Begin with very simple breathing exercises:

1) Pupils inhale (nose) with mouth closed while teacher counts to 4. They exhale (mouth) while teacher counts to 4. *When this exercise has been completed, proceed to 6, then 8. For pupils age 12 or older, proceed to 10.*

2) Inhale (nose) and, following teacher's cue, exhale for as long as possible on the sound "ss". Repeat the same exercise with the sound "sh", and then "f".

3) Create various rhythms which blend nasal inhalation and mouth exhalation. *Note: These should be very short (3-4 seconds at most).*

2.1.3: Name Games

This game allows new groups to become acquainted which each other, while simultaneously allowing each member to present him\herself, see each other, and enhance group communication.

Step 1: Invite a group-member to say his\her name. The whole group then repeats that name, after which the next member says his name, and so on.

Step 2: Invite a member to say his name accompanied by a short bodily movement. The whole group must then repeat that name together with that movement. Repeat for all members.

Step 3: Invite a member to say her name with her corresponding movement, followed by her saying someone else's name and making that person's movement. That person takes over, repeats their own, and "sends" the game to a further member, and so on.

A more advanced version, for the higher grade levels, includes movements only (without names), increasing the need for memory and concentration.

2.1.4: Counting Game

Simple mathematics during which pupils sit in groups of two, facing each other, and must count to 3 together. Pupils A starts with 1, B continues with 2, A says 3, B says 1 and so on….The pupils are challenges to keep a steady rhythmical pulse. When they are well-rehearsed in this task, introduce a clap instead of the number 2. When the pupils have become comfortable with this stage, introduce a whistle instead of the number 3. Whistling while you laugh may not be so easy…

2.1.5: Movement Exercise (1) - "Friends!"

Step 1: Ask your pupils to move around freely in the room.

Step 2: While they are walking, ask each one to choose a "friend" in the room (but make sure they do not tell anyone who their "friend" is).

Step 3: While they are still walking, ask each one to choose an "enemy" in the room (but make sure they do not tell anyone who their "enemy" is).

Step 4: Ask your pupils to now make sure that their "friend" is between them and their "enemy", so as to "protect" them (make sure they understand that this should happen while they are still moving). It may take pupils 10-15 seconds to understand how the exercise works, but when they do, the result may be quite comical! Allow them to enjoy this for 30-40 seconds before starting another round. Repeat 2-3 times.

2.1.6: Movement Exercise (2) - "Lobsters!"

In this exercise, two of the pupils are assigned to be "lobsters", while all others are "humans". The "lobsters", walking on all fours (facing up), must touch one of the "humans", who then becomes a "lobster". The "lobsters'" goal is to turn everyone in the room into "lobsters". The last "human" in the room is the winner. *Teacher's Tips: Make sure there is ample space for movement, and that there are no loose objects which may fall off tables or shelves during this game (computers, expensive phones, etc.), as this game may be quite active!*

2.1.7: Movement Exercise (3) – "Hand on Red!"

In this exercise, call out a body part, and then a color on which pupils must place that body part. For example: Call out "Hand on Red!" after which pupils must place their hand on anything red

in the room. The last pupil to have placed their hand on something red must call out the next round. Examples: "Foot on Green!", "Ear on White!", and so on. This game can go on for 3-4 minutes. *Teacher's Tips: Make sure there is nothing dangerous in the room, especially when working with very young children (glass bottles, etc.).*

2.2: Music Theater Exercise Based on a Scientific Theme

This is a preparatory exercise which will allow pupils to rehearse the creation of short drama works inspired by various scientific themes related to their curriculum.

Music, drama, text and scenography: We will explore how these elements can work together to tell a story and how they can support different ways of knowing of themes from the science curriculum. In this exercise, pupils are divided into groups of 6-7 pupils each.

Step 1: Each group chooses a character representing a scientific phenomena, theme or explorer, depending on the curriculum area being studied (e.g. Helium, clouds, light, Saturn, Galileo).

Step 2: Pupils choose a specific behavioral pattern (routine) which this character has, and which represents its scientific reality. Teacher's Tips: Most pupils will choose the "typical" motion for that scientific phenomena (e.g. the moon moves in circular motion around something representing the Earth, or Light moves very fast). This is a very good start, but it is also good to challenge them to come up with more inventive ideas which can later be used to create an interesting dramatic character.

Step 3: Each pupil chooses an object that fits into the characters' story (e.g. a balloon for Helium).

Step 4: An extraordinary occurrence takes place which disrupts the pattern.

Step 5: A new situation is now the reality.

Step 6: Pupils give the drama work a name.

Step 7: Allow the various groups to present their work to each other.

Step 8: The complete class is involved in choosing the work of one of the groups to work on together, as a class.

Step 9: Pupils divide themselves into groups (story-tellers, actor\singers, and orchestra musicians).

Step 10: Collaborate with the music teacher in your school to create atmospheric music which can accompany the drama work created by the pupils (preferably improvised, but not created by

electronic sound effects, so as to challenge pupils to find ways of representing the scientific phenomena with their own musical fantasy).

This activity will usually lead to exciting small drama works, which can usually be used in future performances. It is important to pose the correct questions to pupils during the process to ensure they immerse themselves in the science learning and corresponding artistic choices. *Teacher's Tip: Please follow the process and its steps carefully to ensure all pupil groups have a "complete" product to share with the other groups, which they can be proud of. Another important decision to make is which group will present its work first and last.*

2.2.1: Choosing a Scientific Theme

"How many stories are there to tell, actually?" – Omar Zahl Pettersen

There are many ways to choose a theme for the WASO production which will provide the subject matter for an Inquiry-Based Inquiry process. These can be pre-chosen by the science teacher, music\arts teacher, school's principal, or the pupils. Some ideas for choice of discipline:

1) Choosing the current science curriculum in the respective class.

2) Choosing a theme which has proven difficult in previous semesters.

3) Choosing a theme as preparation for future semesters.

If the teacher, or other stakeholder, has pre-chosen a theme, please skip to the next section, "An Inquiry-Based Exercise".

In the case of choosing a theme by the pupils: Ask your pupils to write three scientific themes which they would like the performance to be inspired by. These are written on the class's board, and a democratic choice is made to decide which theme will be used (first allow pupil groups to try convincing others, or grouping together various themes such as "animals and seasons" or "solar system and human life" so that the ideas of as many pupils as possible will be included). The resulting choice is written on the class's board. *Teacher's Tips: The final choice of theme is made with eyes closed or in writing, so that no one group of pupils may dominate the vote's outcome.*

2.3: An Inquiry-based Exercise

The CREAT-IT activities are conceptualized as Inquiry-Based Science Education (IBSE) activities. This is structured around the five IBSE phases suggested by the Cosmos project (2008):

Phase 1: Question Eliciting Activities/Exhibiting Curiosity

Phase 2: Active Investigation

Phase 3: Creation

Phase 4: Discussion

Phase 5: Reflection

In the following table, specific WASO activities are based on an understanding of IBSE, including both teachers' and pupils' inquiry processes, based on the CREAT-IT Pedagogical Framework (see "Recommended Literature" for further details).

IBSE Activity	Potential Arts Activity	Pupils	IBSE Questions for pupils	Possible Use of Social Media	Teacher
Question Eliciting Activities/ Exhibiting Curiosity	Define opera's theme based on scientific Question current knowledge	Pupils think about questions they have regarding the scientific theme	What would you like to know about…? What would you like to find out about…?	Students pose questions on Twitter for feedback. https://twitter.com	Begin cooperation with artists or the music/fine arts/drama/dance teacher at your school in order to generate ideas. Discuss with your students the idea of creating a multi-disciplinary performance designed and inspired by a scientific theme.
Active Investigation	Propose opera characters representing various entities in the learning process Create an "opera company" by dividing students into groups (orchestra/composers, librettists, stage design, opera chief,	Students plan how they will test the scientific inquiry theme	What do you want to find out? Can you invent…? What approach would you use to…? What kind of experiment or observation might work best for your investigation? How will you record your results? What do you expect to see happening? What is your	Students collaborate their planning using Glogster: http://edu.glogster.com/?ref=com	Support students by asking further questions to prompt thinking

	Public Relations, etc.). Explore representing the chosen scientific learning theme as a dramatic storyline. Rehearse existing libretto/music sections.		prediction?		
Creation	Main activity of opera creation and rehearsals, on all levels (costumes, music, staging, libretto, etc.).	Students conduct an investigation	What do you observe? What can you see? What do you expect to see? Why do you think this is happening…? How would you explain…? How is… related to…? What examples can you find to…? How would you organize… to answer…? What is expected/ unexpected? Can you think of a different /interesting way to answer your	Students document their investigation with video and photos to share on websites to open up further debate and feedback, they utilize these comments in their reflection	Continuous guidance and overview of process

			question?		
Discussion	Rehearsals of opera sections, and regular presentations of work developed in the various groups, including discussion of any challenges that arise as part of the working process. Performanceof the Science Opera takes place at the end of this phase.	Using the arts students prepare their results for discussion	How can you explain and interpret the results? What is the relationship between…? Would it be better if…? What information would you use to support your view? What remains unclear?	Share video of discussion on Youtube to open up further discussion within the community. Conduct the discussion with video / audio conferencing. Post images of the work taken on Instagram. Twitter for comment. Present results online using Prezzie or Glogster.	Assess pupil knowledge (see section 4, below).
Reflection	Discuss various specific and focused issues (stage design, libretto, PR activity, group dialogue, ethical decision-		How does the result relate to your original idea / prediction? Do you agree with the outcome / result…why? How would you adapt… to create a	Students write a blog post sharing their reflection with others in the community for feedback and further	Upload results (recordings, assessment) to the CREAT-IT portal (portal.creatit-portal.eu)

making regarding inclusion of all students in the creative process, etc.).	different result? Can you formulate a theory as why this happened? Has your thinking changed? What new question could you ask?	debate. Students prepare an online self-refection presentation using Prezzie, Glogster, Scoopit.

2.4: Drama (1) - Opera Characters, Their Needs and Relationships

In order to create interesting drama characters, we must chart their characteristics which will give rise to the opera's story, answer questions about them, and define what each of them may want as a result of their characteristics. *Note: These are mainly "human" characteristics aimed at creating an interesting story (e.g. in the example below, the planet Mars is "emotional").*

There are various ways of deciding upon the different characters' characteristics. An example is given below. It is important that characters representing scientific phenomena receive both positive and negative characteristics, indeed even conflicting ones (e.g. both kind and jealous), as these will provide possibilities for discussions and reflections about the character.

In the example below, pupils were asked to name a collection of characteristics (e.g. 3 per pupils with two "positive" and one "negative" characteristics). In the example below, characters represent planets in the solar system. Remember that these are both human *Teacher's Tips: Try to avoid choosing the character's gender at this point, to keep things open.*

	Earth	Sun	Mars	Venus	Earth's Moon
Characteristics (both positive and negative)	Caring Irritating Grumpy Happy	Impatient Charming Creative Manipulative	Lazy Emotional Manic Outgoing	Meddling Wierd Funny Musical	Clever Stubborn Open Innovative

	Disgusting	Engaged	Sporty	Controlling	Pessimist
What does this character need as a result of its characteristics?	Someone to care for, someone to complain to	A challenging task, and someone to manipulate	Motivation	Interaction with others	A chance to show its positive capacities

Following this exercise, we may begin defining specific relationships between characters, laying the groundwork for the opera's plot.

2.5: Drama (2) - Conflict Chart

This is a challenging but useful exercise, in which we show, graphically, the relationships and conflicts of interest between the various characters, in order to visualize the drama. These should lead to conflicts of interest to create tension in the opera's synopsis. In the image below, a blackboard drawing of a Conflict Chart created by 6th grade pupils at Haukås School (Norway) during their WASO project in 2012 is presented. The 5 Science Opera characters are represented by the letters A, B, C, D, E. By each letter, several adjectives, both positive and negative, describe the characters. In a rectangle, an idea is given of what that character "needs", as a result of his/her personality. Finally, arrows are drawn between characters, to show how those needs are met by relationships with other characters in the opera.

Teacher's Tips: Allowing for a clear conflict which is easy to understand makes the rest of the process much smoother.

Figure 1: Conflict Chart, example from Haukås School, Norway

2.6: Drama (3) – Synopsis & Six Point Plot

Short summary of the conflict and relations amongst opera characters, and how these develop throughout the opera. Teacher's Tips: 5-7 sentences. The Synopsis should not give away too many details about the conflict and its resolution.

The following is an example of the synopsis of "The Triangle's Wild Ways" (in Norwegian: "Triangelets Ville Veier"), a Science Opera created by Norwegian primary school pupils during their WASO project at the VilVite Science Musuem (www.vilvite.no) which was produced by Bergen National Opera (www.bno.no). This Science Opera was inspired by activities which elicited questions regarding energy, electricity and the Bermuda Triangle. **<u>Synopsis:</u>** *The opera is about two researchers, the daughter of one of those researchers, and two Amish twins. The various characters have different theories about why so many boats have disappeared in the Bermuda Triangle region. The plot takes place on a research boat in the Bermuda Triangle.*

2.6.1: Six Point Plot

Pupils must realize that their opera's plot has a beginning, middle and end. In order to structure the story, the Six Point Plot exercise is a handy tool.

Divide your class into groups of 4-5 pupils. Ask each group to decide upon six defining *action* moments within the plot as it comes forth from the synopsis. Pupils should create six tableaux (a striking pose\scene), which depict these six points in the plot. When these have been rehearsed, each group performs the sequence of Six Points for the rest of the class. The whole class may interrogate this group about why they made the choices they did. <u>One</u> sequence of Six Points is democratically chosen by the class, and is thereafter rehearsed by all groups. This sequence will now become the key to further work on the Science Opera: Many new details will have been created by this exercise. Make sure to document as many of these as possible for the libretto, staging, costumes, etc.

Teacher's Tips: Keep this exercise as simple as possible.

Example of 6 Point Plot in a Science Opera: 1. A scientific question. 2. An exploration activity. 3. A challenge\conflict between characters. 4. A central scene during which main character(s) convey emotion. 5. A new clue. 6. A discovery.

Teacher's Tips: The end of the opera should come shortly after the drama's conflict resolution.

2.7: Presentation

Pupils are invited to tell the whole story of the opera, including its time, place, and as many details as possible.

2.8: Painting Opera Characters in Full Size, Costumes

Choose one of the opera's characters and paint that character in full size[1]. The details are up to the teacher and his/her class. When this exercise is realized this early in the process, it can help define details within the opera's story. In this stage, it is important to pose questions to the pupils which assist them in "moving the story forward", and provide you, the teacher, with important elements within the puzzle which may otherwise would not have become explicit at this phase. While the pupils are working, pose questions aimed at generating reflection about the characters which represent the various scientific phenomena in the opera's story. These questions set in motion a process during which pupils must explore different ways of knowing as they try to imagine various representations of the scientific experiment/phenomena/themes which provide the fundament of the opera's story. *Examples: How would a character representing the Moon dress up? How would a character representing a water molecule use make-up? What would the character "Niels Bohr" like to carry around in his pockets? What kind of facial expressions would a character representing the Higgs Boson have? Where would a character representing a test-tub (which had been used during a class experiment) like to live?*

2.8.1: Costumes

Costume creation allows for the exploration of the character's personality, interaction with society, and more. In the Science Opera, the costume is also an excellent way to communicate your pupils' knowledge and research about a given character. Every item in the character's costume (colors, type of material, the way a hat is worn, etc.) will tell us something about that character.

Teacher's Tips: Material used for costumes need not be bought first-hand. Most pupils will be able to bring old material from home, which will provide excellent raw material for the Science Opera's costumes, while simultaneously communicating to them the importance of recycling.

Teacher's Tips: It is easy to get carried away with ideas, but please remember that the costumes have to be worn and performed in, so they must be practical, as well.

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[1] One can also postpone this exercise until further details have been decided upon, such as the time and place in which the opera's story takes place.

2.9: Music Composition Exercises and Libretto Writing

There is no one "correct" way to write text for a libretto or to compose music for an opera. The libretto and musical composition often develop hand-in-hand during several sessions in which creative inputs are tried out and put together to realize the overall goal of a Science Opera.

2.9.1: Generating Musical Ideas With Pupils

The following are idea-generating exercises which will provide you with some basic building blocks to use during the opera.

Creating Rhythms with Words:

Repeating any word, phrase or even name several times will create an interesting rhythmical pattern which you can use as "building blocks" for melodies. Example: Try repeating the word "Asteroids", or the phrase "Fish in the sea" in a rhythm. When you are comfortable with this, ask a group of pupils to play this rhythm on an instrument (e.g. a drum, a repetitive note on the piano), while the others continue chanting it. Finally, ask your pupils to find a simple melody for this phrase.

Circle Rhythms and Phrases:

Ask your pupils to sit in a circle in random order. Boys get one clap, girls get two claps. The leader "performs" the circle by clapping once for a boy and twice for a girl. Following this, everyone "performs" the circle together. When this has been done, and if time allows, ask your pupils to seat themselves in a new circle of random order, and repeat the exercise so they experience the various rhythms.

Divide your class into smaller groups (5 pupils in each). Each of these groups will have "its own" rhythm. Ask them to practice saying words in that rhythm as they clap it (they can use any words they like). When they are comfortable with this, ask them to add melody to those words while performing the rhythm. Then ask them to do the same with words from the synopsis and libretto.

Record these exercises: This will give you a collection of small pieces which you can use as part of your Science Opera's musical performance.

2.9.2: Composing a Song (Aria)

Note: The following exercise may be realized at various levels. It is recommended for science teachers to collaborate with the school's music teacher, especially in secondary school, yet it is

also possible for the science teacher to realize the exercise alone, following participation in the WASO Training Courses provided by the CREAT-IT project consortium.

Step 1:

Discuss how to create a libretto based on a synopsis. Explain briefly about various composition structures (see Musical Terminology, below).

Step 2:

As an example, finalize a song (aria) text. Make sure the text is short, includes repetitions (of both words and sentences), is divided into verses and refrain, has "powerful" words which will enhance drama and emotional engagement.

Teacher's Tips: The voices of children do not generally have wide ranges. It is therefore best to compose the song with a relatively small melodic range (the distance between the melody's lowest to its highest note).

Make a conscious choice for a Major or Minor key

Choose a key that fits the voice of the pupil(s) singing the song (each melody can be played in several possible keys). Teacher's Tips: For those of you who are not musically trained, a simple way of approaching this is trying out various different starting tones for the melody.

A good first step would be to chant the words of the song with rhythm only (no melodic notes), and accentuating the important places/syllables. These accentuations are good places to introduce a new melody note later, when the text is given a melody.

Large melodic leaps should be followed by small leaps in the opposite direction (e.g. if the melody includes a large leap downwards, it should be balanced by upward motion thereafter).

Two chords will suffice for an exercise of this type. Note: These can be of various types. If you have little music training, do not worry! Two notes, played on a piano, guitar, or xylophone, will, in most cases, constitute a chord which you can use to build a simple melody upon.

Choose a time signature which is relatively easy to use (4/4 or ¾).

Varying techniques is a good practice: Melismatic (using several tones for each syllable) / Syllabic (single tone for each syllable).

2.9.3: Libretto

The following are some ways in which you could generate material for the opera's libretto with your pupils. Additional ideas were presented, above, in the section about generating musical ideas.

Consider the following before writing the text for any of the opera's sections: What scientific information is available at this point in the opera's development? What does the audience need to know about it? Which emotions are relevant for this section of the opera, and how do they fit into the opera's conflict?

Teacher's Tips: Song texts (arias) are short, and lines may be repeated several times. A good exercise includes choosing a spoken text (e.g. "May we meet tomorrow to discuss John's idea?"), and condense it into the phrase of a song (e.g. "Tomorrow, then?"). The intention of the character singing this phrase will be communicated through facial expressions, the stage lighting, her costume, etc.

The following ideas will help you generate raw material for the Science Opera's libretto. Make sure to take notes of all of their responses, which can be used directly in the libretto.

1. Imagining: When writing the text of a certain section of the libretto, first answer some basic questions: Where is that part of the story taking place? What time of day is it? Who is showing emotions, and who is trying to conceal it? Why? Following this, ask the group to close their eyes, imagine themselves in that situation, and, one by one, give voice to their thoughts.

2. Improvised Think-Tank: Make a list of emotions and scientific concepts which are relevant to the specific part of the opera which you are writing. Ask one pupils to call out some of these at random, while the others improvise sentences related to that emotion and scientific make them think of.

3. Improvising a duet: Choose a section of the opera in which two characters appear together. Ask two pupils to improvise a short exchange between them. *Note: Incorporate any existing costume elements in this exercise to provide inspiration and overcome shyness.*

Following these exercises, you will have a considerable amount of text with which to work towards a refined and complete libretto. When creating a final version, please keep in mind that rhyming is an effective tool, but that not all lines need to rhyme. Also, make sure to vary the meters of the different libretto sections.

2.10: Drama (4) - Stage Direction

In a 3-day project, you may not have time to develop a complete staging for the Science Opera. In this case, it is recommended to choose 1-2 scenes to stage in detail as described below, and to invite pupils to improvise motion which interprets the text and music which others are performing for the rest. Choose 1-2 scenes to stage in detail, as follows:

Storytelling:

Make sure to continuously refer to the scientific research to open further doors between the opera's plot and the scientific inquiry.

Characters:

The characters developed earlier in the process must now become more familiar, and their biographies more explicit.

The"Crossing the room" exercise includes division into groups and trying out some of the characters' characteristics: What do these mean for how we move and behave? If time allows, let the different groups experience various characters: Exploring characters which represent scientific themes is both fun and important work. Get to know them. What are their habits? How do they walk? What kind of voices do they have?

Make sure to ask pupils how the results of the previous exercise may become more interesting to watch on stage.

Teacher's Tips: When presenting the characters to the whole class, allow the pupils to present in groups. This is recommended for the security all pupils will feel as group members.

Teacher's Tips: As soon as the opera's theme has been chosen, you may consider deciding when and where the action takes place (e.g. on the Moon in the year 2000), as children enjoy being concrete about such things. But remember that the earlier you define the opera's time and place, the less room there is for creative choices later in the process. You, as their teacher, must choose when to make these decisions.

Improvising with the scene:

Save the actual libretto text for later. Begin with movement and improvisation, giving directions as you go along. First, allow pupils to "play" and experiment with the scene, acting it out in their own words and movements, and bringing out the scene's *emotion*. Discuss what the main goal in the scene is with the pupils.

Do not worry about memorizing the text at this point. In this way, genuine acting will take place without much planning and distraction.

Adding sub-texts: Add movement and facial expressions to the text (e.g. walking, dancing, smiling), exploring how this impacts the scene's sub-texts and generates further ideas.

Working with the libretto:

Begin working on staging with the libretto earlier in the project, but make sure to allow pupils to "play" and experiment with it, letting it grow. Good questions to ask here are: How can you say this sentence when you are angry? Sad? Joyful? *Teacher's Tips: In the early stages of working with a libretto, do so without the music. Also, remember that practicing should always focus on new elements each time it is done.*

Tableaux: Ask pupils to create "before and after" tableaux of the scene's emotion. This helps digest the scene's meaning in the opera's plot.
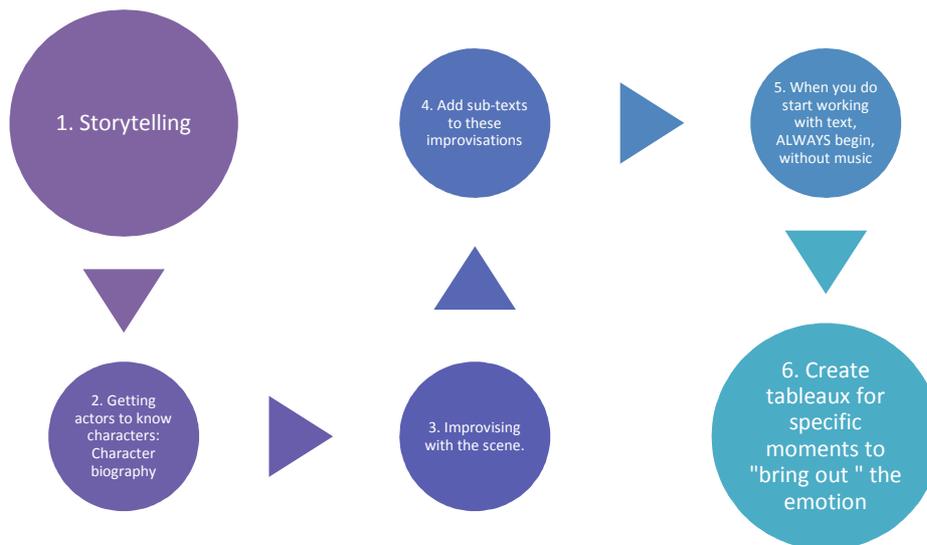

Figure 2: Drama and Stage Direction Exercises

3: Sharing – The Performance

3.1: Equipment

The amount of available equipment (sound amplification, light, musical instrument, projectors, etc.) varies from school to school, and there is no "one size fits all" which can be described as a definitive approach. Some things to keep in mind when considering the kind and amount of equipment to use for your WASO project:

It is not always necessary to amplify a performance: If you are realizing a 3-day WASO project, it may be easier to perform the opera in a small room without sound amplification equipment. *Teacher's Tips: Drummers may use "brushes" instead of sticks, or play one percussion instrument which is easier to control with regard to sound levels if they are beginners on that instrument.*

If you do use sound amplification equipment, make sure you notify the people in your school who know most about that equipment as early as possible. *Teacher's Tips: Always know in advance how many electrical sockets are available, and where to find extra electricity cables.*

If you do use sound amplification equipment, make sure you schedule a long enough sound-check before the science opera's general rehearsal. *Teacher's Tips: A sound-check is not a rehearsal. Make sure to focus on the sound during this session.*

If you do use sound amplification equipment, make sure to explain about how to avoid feedback by e.g. avoiding pointing microphones in the direction of your speakers.

Physical characteristics of the room (e.g. where the audience is placed, the height of the stage) will greatly impact the sound quality. Take time to explore the various possibilities.

If you do use light equipment, it is a good idea to allow 2-3 pupils to take charge of this area early on in the process.

3.2: "Process versus Product" Dilemma

In WASO method, as in many other arts education school projects, the learning process lies at the heart of the activity and its design. At the same time, your pupils' ownership of that process, and their attitudes towards it will, to a large extent, depend on their feeling of pride and mastery during its performance in front of other people. A pupil may have written a wonderful piece of music inspired by an exploration during her physics class, but if she did not have ample time to rehearse it, she will not be proud to perform it. Less is more, therefore. It is a much better idea

to perform a well-rehearsed 15 minute Science Opera that a 30-minute long Science Opera which the pupils feel insecure about.

3.3: Your Audience

Usually, your audience will include other school pupils, teachers, and, possibly, parents.

In-school audiences: The way in which other pupils and teachers are informed about the event is crucial. Make sure they get a short, accurate message about what will take place. Posters or verbal announcements usually work well in these situations.

External audiences: Posters, flyers and word-of-mouth are the best ways of advertising the event in your local community.

3.4: Announcements

Try to engage an official person to introduce the opera to your audience before the performance. This can be the school's head-teacher, leader of the parents' committee, or a local scientist.

3.5: Additional Acts to Include in the Event

Inviting other school ensembles (such as the school's Marching Band or Choir) to perform before (warm-up act) or after the Science Opera can be a good idea, which spreads the word to other classes as well. *Teacher's Tips: Make sure to invite them well in advance.*

3.6: Performance

Performances, especially during a premiere, are always exciting: There is usually a sense of too little time to go through every detail, and there will always be things that did not work out as you had planned. It is important to accept this as part of the process. If possible, try to arrange for more than one performance of your Science Opera.

4: Reflection and Evaluation of Your WASO School Project

The CREAT-IT project portal (portal.creatit-project.eu) is aimed at collecting and sharing both recordings (images, written material, videos, audio files, etc.) and evaluation of the various projects, regardless of a project's length.

Evaluation of the project should be considered in advance, and integrated as part of the project.

In Appendix 1, below, you will find a template which can be used to collect feedback and stimulate pupils discussion following the WASO project. Appendix 2 is aimed at evaluation of the teacher's feedback.

5: Post-Project (Follow-up, Online Support & Documentation)

You and your pupils have undergone a very creative, idea-generating process. It is recommended to document this during its preparation and its performance for future use and reference.

Each science opera project is unique and represents a source of extremely valuable documentation. Videos, transcriptions of libretto at early middle and final phases, recordings of improvisations and the subsequent discussions of analysing these in choosing sound samples for the opera's composition, sketches of costumes, etc. should all be kept as ideas for future projects and empirical data for future research. A good idea would be to share your practice and results with other teachers who are interested in exploring the WASO method. The CREAT-IT project Portal (portal.creatit-project.eu) is the perfect place to share your results, and get ideas for future projects from teachers in other schools, in other countries.

Elements from the WASO project (e.g. a song, a costume) may be used and referred to in "regular" teaching following the project, conjuring positive memories and a reminder of the creative process which was undertaken.

Teacher's Tips: It may be useful to work with the same group of pupils once more, as they now are familiar with the project's premises and potentials, although for various reasons, the school may wish to realize the next project in another class or even grade level.

6: Musical Terminology

The following are the main types of music structures we use for setting the libretto (text which tells the story) to music. *Note: Not all of these forms must be used in every WASO production.*

1) Aria: Solo song by one character. The plot's "action" is stopped to allow this character to express a certain emotion and inner feelings.

2) Duet: Two singers, preferably each singing their own verse followed by a section in which they sing together.

3) Ensembles: Three or more singers

4) Choir: The choir can be used to "comment" during the other songs, or as simple choir pieces.

5) Overture: Instrumental (no voices) opening piece which sets the mood of the opera.

6) Interlude: Music performed between acts or scenes.

7) Recitative: "Spoken Song" which tells a story, and which propels the plot further by revealing action (what has taken place, what will take place, a secret, etc.).

7: Recommended Literature

CREAT-IT literature may be found on the following website: www.creatit-project.eu, including: The CREAT-IT project's Guidelines for creativity in Science Education; WASO Implementation scenarios; WASO Samples.

Link to Royal Opera House (Write an Opera): http://www.roh.org.uk/learning/teachers/write-an-opera

8: References

Cosmos (2008) Guided Research Model. Development of an Educational Scenario Template. [online] available from
http://www.cosmosportal.eu/cosmos/files/help/COSMOS_Learning_Activities_Templates.pdf
[retrieved 5th June 2014]

Garoian, C. R. & Mathews, J. D. (1996).A common impulse in art and science. Leonardo 29(3), 193-196

Griffiths, H. (2012). Write an Opera Teachers' Notes. London: Royal Opera House and Den Norske Opera & Ballett

Appendix 1: Evaluation of WASO Activities with Students

This is a short guideline that should help you to get valuable feedback from your students about their perception of the WASO project they've participated in. We encourage you to ask additional questions if needed.

Before you begin, please consider some general suggestions for gathering feedback from your students:

Make sure you tell your students that you are not grading their responses, but rather trying to get a feel of their perception

Respond to any feedback, good or bad, with gratitude, and reflect upon it – ask for and/or suggest actions that might result from it

Do not get discouraged by the inevitable few negative comments. Try to see everything as constructive criticism

Take notes– write down your impressions and conclusions made during the evaluation

Print out the following questionnaire and hand it out to the students at the end of the class (at the end of the project). Give your students about 5 minutes to fill it in – ask them to do it in silence, without commenting out loud. They should not sign the questionnaires. The main purpose of this is to provoke individual reflection among students. The written responses could also serve you as additional source of information while summarising students' feedback.

A1.1: QUESTIONNAIRE FOR THE STUDENTS

Note: This questionnaire appears in the CREAT-IT project's Deliverable D6.2 for general cases. In the following version, it has been adapted specifically for WASO projects It is meant for students (pupils) who have participated in a WASO project.

What is your strongest impression of the WASO project you participated in?

How difficult was it for you to participate in the WASO project? Would you say it was:

too difficult

challenging

neutral

too easy

Did you feel motivated to participate in the activities of the WASO project?

Not motivated at all

Motivated to some extent

Very motivated

What could be done differently to make the project more motivating for you?

What did you enjoy doing most?

Was there something you did not enjoy doing? What? Why?

What was, for you personally, the most useful part/activity of the WASO project with regard to understanding/learning the lesson?

If you compare it with the usual class in this subject, are there, in your opinion, advantages of WASO? If yes, what are they?

Are there any disadvantages in comparison with the usual class? If yes, what are they?

Anything you would like to ask/ add about the WASO project?

A1.2: Discussion

Start a group discussion following the questionnaire students answered, question by question. While gathering the answers we encourage you to:

1. Ask for a rationale/explanation for each answer by posing the "why?" questions and asking them to compare impressions with the traditional class.

2. Ask for suggestions for improving and try to agree upon the actions that result from it.

3. Summarise at the end.

You do not need to focus much on the quantitative data (e.g."*5 pupils liked it, 6 didn't, 7 were indifferent*") but rather try to gain more in-depth information and to draw conclusions (e.g. "*majority/minority **felt**… **because…***").

A1.3: Summary

Summarise the findings using mainly the feedback gathered during the group discussion, but also using written students' answers, if available.

A1.4: Report

Report on students' feedback by answering the following questions:

1.Which activities/aspects of WASO project were, from the students' perspective

the most enjoyable?	
the least enjoyable?	
the most difficult?	
the most inspiring?	
the most engaging?	

2. Based on the feedback you gathered from the students, is there anything you would change in the project, or do differently next time? What? Please explain.

Appendix 2: Demonstration Activities EVALUATION QUESTIONANNAIRE FOR TEACHERS

Dear Sir/Madam,

We want to know about your experiences with implementing WASO with your pupils. The questionnaire is short; it takes less than 10 minutes to complete.

It is very important to stress that we need your **honest opinion**. All critics, good or bad, will be understood only as your support to the CREAT-IT project's activities and project outcomes. Please note that the questionnaire should be completed individually.

The survey is anonymous. Data gathered will serve only for the purposes of this project.

Thank you for your time!

Have you encountered any (significant) problems while delivering the lesson using WASO/Science Theatre/Junior Science Café case study? If yes, what were the problems?

(MULTIPLE ANSWER POSSIBLE)

I've encountered no (significant) problems

Lack of financial/technical support

Lack of time for my own preparation before the project

Lacking skills/knowledge I needed to implement WASO

Opposition among students

Opposition among colleagues

Opposition among superiors

Opposition among students' parents

Something else. What?_____

How did you deal with these difficulties?

From students' perspective, which activities/aspects of WASO project were **the most enjoyable**?

_____

From students' perspective, which activities/aspects of WASO project were **the most difficult**?

_____

From students' perspective, which activities/aspects of WASO project were **the most engaging**?

_____

What is your assessment of the **level of students' engagement** during participating in WASO/Science Theatre/Junior Science Café project, in comparison to their engagement during the traditional class?

They are less engaged than after traditional lesson

They are more engaged than after traditional lesson

I am not sure

Based on the feedback you gathered from the students, is there anything you would change in the project, or do differently next time? What? Why?

After your experience with implementing WASO/Science Theatre/Junior Science Café, do you feel confident to independently design and conduct project that foster creative science teaching in the future?

I do not feel confident enough

I feel confident enough

Do you plan to realise the WASO/Science Theatre/Junior Science Café or a similar, independently design project again in the future?

Definitely not

Probably not

Probably yes

Definitely yes

What would encourage you to realise the WASO/Science Theatre/Junior Science Café or similar project again in the future?

Appendix 3: Longer Projects

A3.1: Introduction of Long Project

The **Write a Science Opera (WASO) Summer Schools** are aimed for teachers (and others) who wish to produce a full 15-day project with their class (projects can also be longer, lasting up to one year). In this appendix, information is given as a supplement to the Guidelines (above) in order to extend and deepen the project.

The typical long project lasts 15 working days, including the final performance, yet projects may take up to a year, depending on the needs and wishes of the respective school personnel. During the 15-day version, a very intensive process is undergone typically with one class of up to 25 pupils. During this time, little else is done besides the opera project. Taken to the other extreme, a project spanning over the space of a whole school year may be realized by a two or three hour period each week with a final performance at the end of the school year. Any combination of these may be successfully realized. In our experience, the first and foremost important success factor is to cater to the needs of the specific school teacher and class with regards to time schedule, way of working, interaction with the pupils and space for realization of the project, empowering both teacher and pupils to use their strengths and optimal working and learning environments in the process. This is done through individual, collaborative and

communal activities for change by including as many stakeholders within the school and community as possible in the planning process early-on.

A3.2: The Schedule

There is no one-size-fits-all schedule for WASO. The 7th grade project schedule below was created by Norway's Bergen National Opera for a WASO project at the VilVite Science Center (www.vilvite.no). The 15 working days were spread over the course of two months, to accommodate the schedules of those involved, not least of these the school. During this project, three artists and a project leader collaborated with the science centre and the pupils' teachers. Should this not be the case in your school, you will need to engage teachers of both science and the arts in your schools, or assume more of the responsibilities yourself, and provide for the extra time by, for example, enlarging the number of working days during your project, to make time for the various involved processes.

Suggested Day-by-Day Schedule for a 15-day WASO Project

Day	Activity	Where	Who	Comments
1	Project presentation	School	Teachers, pupils, project leader	Other artists and the school's principal may join this session. This day should include games as well as a short introduction to basic music, drama and group interaction activities.
2	Electricity Workshop	Science Centre	Teachers, pupils, science educator/teacher	It is a good idea to contact the Outreach/Education department of your local science centre at least a month before an eventual visit. This activity can be substituted by visiting a university's biology lab or a local technology firm's premises, to inspire the opera.
3	Science research	Science Centre	Teachers, pupils, science educator/teacher	Exploration of the topic
4	Science research	School	Teachers, pupils	Exploration of the topic
5	Science research	School	Teachers, pupils	Exploration of the topic
6	Meetings	School	Meetings with all teachers, followed by progress report, meeting with pupils	
7	Music composition	School	Composer/music teacher	Ideas may often be generated by improvising sound-scapes inspired by various moods
8	Scenography	School	Visual arts teacher/Stage designer	

9	Libretto writing	School	Drama pedagogue, language teacher	Libretto writers may libretto writers may experiment with non-linear, experimental writing methods and approaches which will help avoid an overly illustrative story-line?
10	Auditions for roles, division of pupils into groups	School	All instructors/teachers pupils	The recommended groups are listed above. For each group, a group leader should be designated.
11	Continue writing, building stage, creating costumes and rehearsing music	School	Relevant teachers, and pupils	At this stage it is recommended to define some milestones by which to judge progress.
12	Continue writing, building stage, creating costumes and rehearsing music	School	Relevant teachers, and pupils	
13	Continue writing, building stage, creating costumes and rehearsing music	School	Relevant teachers, and pupils	
14	General rehearsal	School	All	With sound system and lighting if applicable

15	Performance	School and/or Science Center	All	It is a good practice to invite an official (e.g. member of municipality, headteacher) to give a short speech prior to the opera's performance

A3.3: Extra Considerations (Instructors) for Longer Projects

The school must consider whether or not to include coaching practitioners of the opera project, in addition to the school's teachers. Some opera houses (e.g. Bergen National Opera) have, in the past, provided trained specialists with the following areas of discipline knowledge in the field[23] who, in turn, will collaborate with science teachers in schools to provide different ways of knowing:

Project leader/coordinator: This may be an employee of the school or an external figure (e.g. someone from a local opera house or the school principal).

Drama/libretto specialist: The work involved is to instruct the creation of a storyline, characters, and libretto inspired by the originally chosen scientific topic (examples provided in the "WASO samples" document)

Stage/scenography specialist: The work involved is to explore the importance of materials by instructing the creation of a stage, costumes and lighting inspired by the originally chosen scientific topic (examples provided in the "WASO samples" document)

A composer: The work involved is to instruct the creation of a musical score and instrumentation inspired by the originally chosen scientific topic (examples provided in the "WASO samples" document), as well as instructing the rehearsing and performing of the opera.

Another approach to the staffing and, correspondingly, incorporating the knowledge and agency of new learners, is to engage student-teachers who will take part in the project as part of their practicum (field work) phase of education to become a teacher. Any combination of these is possible as long as it is well planned and co-ordinated with the school and based on the professional wisdom of practitioners within both the scientific and artistic disciplines.

A3.4: Creating the Opera Company

Immersion and play a central role in WASO. The class in question will create an "Opera Company", including all relevant functions for which various pupils must take charge. The way in

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[2] In addition, a lighting specialist should be included if the budget allows for it.

[3] Week-long WASO training courses are the optimal place to train for WASO projects. Information regarding these may be found on www.creatit-project.eu

which the choice of which pupils take which roles must be as democratic as possible. The following list of functions is not the only possible way of structuring the Opera House, as various institutions have developed their own versions of how the roles are structured. Some of these (e.g. Opera Chief) are single-pupil or two-pupils roles, while some (e.g. orchestra) are group roles. In the case of the latter it is recommended to designate the task of "group-leader" to one of the pupils in that group, empowering that pupil and enabling him to make decisions and experience their consequences.

Roles	Single or group	Areas of responsibility	Comments
Opera Chief	Single/ Double	Overall management, communication with group leaders	
Stage Manager	Single	Overall responsibility for stage including costumes, lighting, props, backstage, etc	
Scientific Research	Group	Collection and dissemination of knowledge, inquiry regarding the scientific topic, to the rest of the Opera Company	Some projects may choose to omit this group and rather see the whole Opera Company as a scientific research group
Orchestra	Group	Composition of most of the opera' score, playing in rehearsals and performances	Some sections of the opera may be composed by all pupils
Actors/singers	Group	Performers on stage	1. Main role performers usually undergo an audition if there are several pupils wishing to perform the role (although the decision of whether or not to realize auditions is up to

			the specific project leaders. If realized, auditions may be led by the Composer of the project (Adult), the school's music teacher, and the Opera Chief (pupil), for example. 2. Pupils who are not especially talented at singing must *not* be excluded from performing a vocal/acting role.
Public Relations (PR)	Group	Creating posters/opera programmes, publicity/entry tickets. Contacting local newspaper. Creating opera's budget.	The following budget areas are optional, but may be included: Sponsors (e.g. a local bakery), ticket sales (although the entrance may be free of charge), charity (discussion of what to do with the income), budget for opera materials such as costumes, props, etc.
Scenography	Group	Design and creation of sets, costumes, props, etc.	
Lighting	Single or small group	Lighting	This may be integrated into the Scenography group if needed.

A3.5: Linkcast, Internet-based Collaboration

For those interested, WASO provides the opportunity of combining several schools, indeed schools from various countries, in the creation of science-inspired performances by the employment of ICT tools (e.g. Simultaneous performance via communication tools such as Skype, "Linkcast"[4]) or simpler approaches such as collaborative idea generation by e-mail. This type of learning occurs on individual, collaborative and communal levels, and enables different ways of knowing in a creative process in which pupils and teachers may engage in Playfulness (e.g. Simultaneous improvisation), Participation (e.g. Inclusion of pupils in the music making of those in other countries, Pluralities (through recognition of, and literally working with, other cultures), and Possibility thinking, during which pupils and their instructors engage in imagining

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[4] Linkcast includes "Audiovisual Linear Interaction (ALI)" & "Audiovisual Bideractional Interaction (ABI) practices (for a brief reference please consult: http://dma.ea.gr/en/node/87). In CREAT-IT, Petros Stergiopoulos (EA, Greece) is the Streaming designer/coordinator of these activities.

new ways of interpreting the specific curriculum themes at hand: the creative result of the combination of the CREAT-IT principles and the existing practices. This approach allows participants to experience their ideas on individual, collaborative and communal levels.