WASO Implementation Scenario: "The Math Cat", a Math Opera

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Name of institutions:
Stord Haugesund University College (Norway) and the 3rd grade pupils at Sagvåg School, Stord (school year 2014-2015).

The opera was realized as part of the "Improvisation in Teacher Education (IMTE)" project at Stord\Haugesund University College, Norway. It was led by four Elementary School Teacher students (Grunnskolelærerutdanning) as part of their practicum learning phases in elementary schools. These students were Tora Hansen, Lisa Folkedal, Eirin Amanda Leigland, and Ingelin Olsen. The students were coached by the following instructors from Stord\Haugesund University College: Charlotte Tvedte (Scenography and costume design); Kirsti Aksnes (Staging\Regi and Drama); Gunhild A. Rolfsnes (Composer), as well as teachers Anne Brit Holm, Jorunn Bendiksen and Egil Petterteig from Sagvåg School. During "The Math Cat" opera project, empirical evidence was collected for analysis regarding in-training teachers understanding and implementation of the overarching concept of improvisation in teacher education by Masters Degree student Jørn Kristian Sinclair Veum (see http://prosjektsider.hsh.no/imte/).

Title of the educational scenario template:
Creative Strategies, Inquiry-based teaching

Title of the educational scenario:
Write a Science Opera (WASO) – "The Math Cat"

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1: Introduction

The following Write a Science Opera (WASO) Implementation Scenario should be read together with the WASO Guidelines, which provide a detailed plan for the realization of a Creative Arts-Infused Inquiry-Based Science Teaching project within the WASO Case Study. These include warm-ups, a conceptualization of the cross-disciplinary project as Inquiry-Based Science Education, exercises in music, drama, costume-making, schedules for the project, evaluation, reflection and more.

In this specific Implementation Scenario, the curriculum focus is on Math (multiplication table). The CREAT-IT project's main focus is on science, yet the present Scenario offers a focus on math as one of the focuses of STEM (Science\Technology\Engineering\Math).

Specific suggestions for meeting points between the science learning and the opera development are made throughout this scenario, yet this document is conceived as a "living document", and teachers of each unique WASO project are free to design the schedule and creative exercises according to their needs and capacities.

Several *Teacher's Tips* are provided in this document. These tips suggest enhancements and optional activities, and are provided by teachers who have previously conducted WASO projects in their classes.

This Implementation Scenario is designed as a 3-week project with 3rd graders. *Note: In the WASO Guidelines, you will find suggestions for how to realize a longer, more detailed, project if desired.*

The scenario is supported by literature used in the 3rd grade during the study of multiplication (Bakke & Bakke, 2013)[1].

2: Educational Challenges

The following Educational Challenges are observed. Reasons for implementing WASO as a response to these challenges are provided.

[1] Bakke, B. & Bakke, I. N. (2013). «Gonge med 2,5, og 10» in *Grunntal 3a Matematikk for Barnetrinnet (pg. 101-134)*. Drammen: Elektronisk Undervisningsforlag AS.

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2.1 The multiplication table's challenges

Reasoning for choice of approach: The school's head teacher made this choice of theme when presented with free choice of the theme for the opera. His main reason was that the multiplication table often proved to be a challenge for many pupils, and that they carry this feeling with them for several years. His wish was to explore an alternative approach *in addition* to a more traditional way of teaching, and which will include sessions of traditional teaching integrated into the opera's production. These were structures as short sessions led by the class's teacher and which she interwove into the opera preparations at various times.

2.2 Exploring Creative Approaches in Science\Math and Art Education

Reasoning for choice of approach: The Implementation Scenario offers an inherently creative design which stimulates creativity in the IBSE setting. Bridging arts and science approaches means focusing on 'inquiry' in itself as well as 'inquiry' as a basic requirement in creativity and in different creative practices.

3: Scenario Characteristics and Needs of Students

The scenario will be an opportunity for 3rd grade students to explore the multiplication table (especially but not limited to multiplications of 2, 5 and 10).

The approach is more direct than school textbooks, as pupils must directly engage with the material, acquire knowledge, make choices and reflect upon these before the opera may be completed.

The exercise will also allow students to interact (e.g. by working in pairs) and develop social and collaboration skills, thus experiencing how learning math can be a group activity and not only a solitary one: Individual, collaborative and communal activities for change.

Pupils will be introduced to the common creative impulses of math and the arts.

4: Rationale of the Educational Approach

The scenario is designed as a transversal meeting point between the Write a Science Opera (WASO) methodology and an Inquiry-Based science & math education model. It follows a structured approach while opening doors to experiencing new possibilities on several levels. As part of the exploration towards the school opera's creation, students are asked to explore mathematics and specifically multiplication, supported by indicative questions, all of which will infuse and inspire the opera's creation: The opera's design, libretto, characters, costumes, and music all represent potential ways of interpreting the students' inquiries. Based on those inquiries, the students are asked to come up with their own conclusions and compare them to their initial predictions. They thus engage in Possibility Thinking (PT) regarding how the creative

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artistic process can act as a base for deeper inquiry as well as an aesthetic medium of communication of the various hypotheses and evidence-based conclusions. The complete activity, within both math and art, is based on students' creation and observing skills.

Students have the opportunity to explore the "Math Cat" (in Norwegian: *Reknekatten*) within hands-on exploratory math activities at the same time that they are experiencing a similar hands-on process with musical instruments, costume creation, lighting, performance, etc. creating a deep understanding of the importance of materials. The "Shadow & Light" workshop by Assistant Professor Charlotte Tvedte (Stord Haugesund University College, Norway) exemplifies this. During the workshop, pupils engage in hands-on work with creating various "city-line" figures (e.g. buildings) from used cartons (adding a dimension of importance of recycling to this workshop). The work is done as inspiration for the "Math Cat" opera's scenography, while questions are asked regarding the multiplication of lines and rows of "windows" in each "building".

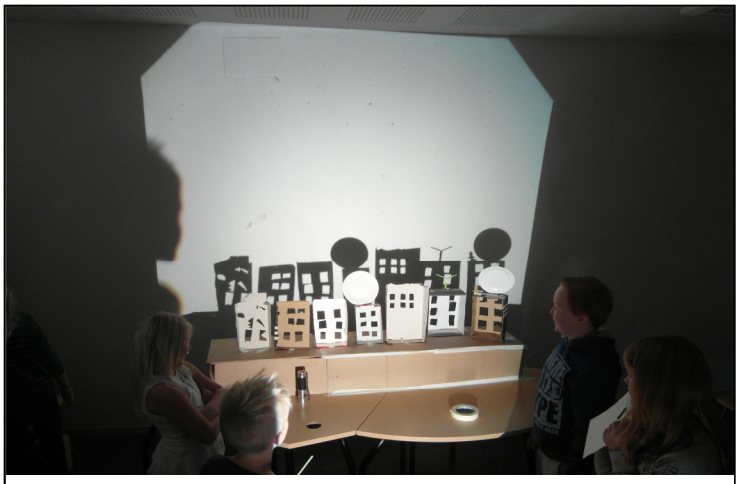

Image 1: 3rd grade pupils at Sagvåg School, Norway, during Assistant Professor Charlotte Tvedte's "Shadow & Light" workshop in preparation for their WASO project

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5: Learning activities

The CREAT-IT activities are conceptualized as Inquiry-Based Science Education (IBSE) activities. These are structured around the five IBSE phases suggested by the COSMOS project (2008)[2]:

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 the CREAT-IT Pedagogical Principles and an understanding of Inquiry Based Science Education, as described in the CREAT-IT Pedagogical Framework (see "Recommended Literature" for further details).

[2] 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]

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Science unit topic

Multiplication Table

Class information

Year Group: 3rd grade primary school

Age range: 8-9

Sex: both

Pupil Ability: The scenario allows space for pupils of various abilities to participate, e.g. pupils with language difficulties may contribute on an equal level to others by performing in the orchestra.

Materials and Resources

What do you need? Various music instruments (drums, piano, small xylophones, iPad with Garage Band), large paper, marker pens, various materials for making costumes, lights in various colors. Optional: Stage

Where will the learning take place? On site or off site? In several spaces? (e.g. science laboratory, drama space etc.), or one? Learning can take place in school (regular class or music room). It is a good approach to have several rooms available during the phase where pupils are split into groups (see WASO Guidelines)

Health and Safety implications? In the case of sewing of costumes or cutting cardboard, it is important to ensure maximum safety by having a qualified teacher available at all times and corresponding instructions. For cutting cardboard it is recommended to have at least one teacher present per 3 pupils.

Technology? "Garage Band" software used to explore sounds for the opera, and a computer with internet (searching for information). We used a "Smartboard" to discuss examples. Also, it is a good idea to record sessions on video and evaluate them afterwards with pupils.

Teacher support? Team teaching with both math and arts (music\dance\design\drama) expertise is recommended.

Prior pupil knowledge

No prior knowledge regarding the specific area of multiplication table. On the contrary: The school in question, Sagvåg School, specifically waited until the beginning of the opera project to commence with the theme of multiplication.

An understanding of the basic 3rd grade learning plan in math (addition and subtraction) is needed.

Optional: music lessons including composition exercises; basic drama exercises; dance; arts & crafts classes; experience with school stage performances is an advantage

Individual session project objectives *(What do you want pupils to know and understand by the end of the lesson?). Note: A detailed plan for these sessions are provided below.*

During this scenario, pupils will

- Learn basic knowledge about the multiplication table (mainly multiplications of 2, 5 and 10, but also others); Experience musical, visual design, drama techniques as tools for the opera. *Note: Teachers may decide the math opera's theme (e.g. fractions) before the project or allow pupils to choose the theme themselves. Each approach has its advantages: In the case in which the teacher chooses the theme prior to the project, it will be possible to realize the project during a shorter time-span. On the other hand, pupils will experience greater ownership and agency if they are allowed to choose the opera's theme themselves. In both cases (teacher choice or pupils' choice) it is important and motivating that the pupils investigate their own questions connected to the chosen*

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theme. In the case of the current scenario, the theme was chosen by the head teacher.

- Students will gain knowledge and experience with group-work in which various groups will create specific synopsis, libretto, composition, scenography, costumes for the Opera, accompanied by a continued exploration of the multiplication table. The libretto should include key concepts connected to the mathematical theme. A specific mathematical question (e.g. 5x2=10) can be of great inspiration to scenography, costumes and music. *Example: One of the characters in "The Math Cat" is the number 5, allowing pupils to consider what kind of "personality" and "characteristics" this number would have as opposed to the numbers zero, one, six, etc.*
- The student should be able to calculate basic multiplications. Students will learn to realize common impulses between discipline knowledge in both science\math and arts by performing a multi-disciplinary artistic performance (school opera) which demonstrates and deepens scientific and emotional understanding of the curriculum-based subject at hand. Throughout the scenario, pupils will learn to make their own decisions during inquiry processes, make their own connections between questions, planning and evaluating evidence, and reflect on outcomes.

Assessment

The WASO Guidelines' Appendix 1 provides an evaluation plan for students who took part in the WASO project. This questionnaire includes questions about their level of enjoyment, level of difficulty, comparisons to more traditional teaching methods, etc.

How will you record this? Questionnaires will be filled out by pupils and collectively delivered to the CREAT-IT team.

Differentiation

How can the activities be adapted to the needs of individual pupils?

Some pupils have had more training in arts disciplines (e.g. music, drama, costume-making). These pupils may be encouraged to do more advanced work. Examples: A pupil who has had piano lessons may be encouraged to compose an extra aria for the Opera; a pupil with good stage presence may be asked to assist the other performers in learning how to express the section(s) of the libretto which they will be performing.

The creative process is in itself inclusive of all pupils. The more pupil voices there are with different thoughts and viewpoints (independent of level of understanding), the greater the pool of ideas will be for the opera's story.

Key Concepts and Terminology

Math terminology:

1) Multiplication
2) Various numbers between zero and ten
3) Relationship between addition and multiplication as calculation techniques
4) Counting
5) Understanding of amounts

Arts terminology:

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 and may introduce its main musical themes.

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

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		secret, etc.). 8) Tableau: A dramatic activity in which a group of pupils are asked to physically construct an opera scene through body placement, facial expressions, and props 9) Various musical instruments

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During this scenario, students will

- Create a multi-disciplinary artistic performance (school opera) which demonstrates and deepens pedagogical, aesthetic and emotional understanding of mathematics, and specifically the multiplication table, supporting discipline knowledge in both the math and arts educational disciplines.
- Learn basic concepts and calculation techniques within multiplication table.

IBSE Activity	Potential arts activity	Student	Teacher	CREAT-IT Pedagogical Principles (apply to all Phases)
Phase 1: Question Eliciting Activities	Explore the various instruments. 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 math theme. Define opera's *specific* theme based on the proposed question **"In which different ways can we calculate the number of lego blocks"?**	Generate, write down and draw words\ideas about multiplication and other mathematical techniques, and shares with others in order to learn from their previous knowledge	Activates previous knowledge in mathematics (addition, subtraction), and, by inviting students to experiment with the various musical instruments, motivates them to raise questions they are wondering about based on these: The teacher introduces multiplication by using 10 colorful lego blocks divided into 5 groups of 2 and asks the following question: **"In which different ways can we calculate the number of lego blocks?"** Following the initial responses based on addition, the teacher leads pupils to the idea that they can *multiply* in order to reach the same answer. *Teacher's Tip:* *Including "traditional" teaching sessions within the opera creation can provide positive inspiration for both.*	*Professional wisdom is respected and encouraged*: It is vital that CREAT-IT has, at its heart, the wealth of teaching and discipline knowledge and expertise that practitioners bring to the project. The following are the CREAT-IT Pedagogical Principles which are realized: 1. Individual, collaborative and communal activities for change 2. Risk, immersion and play 3. Dialogue 4. Interrelationship of different ways of thinking and knowing 5. Discipline knowledge 6. Possibilities 7. Ethics and trusteeship 8. Empowerment and agency

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Phase 2: Active Investigation	Propose opera characters representing various entities in the learning process (e.g. a Math Cat, various numbers), etc. Divide students into groups (orchestra/composers, librettists, stage design, opera chief, Public Relations, etc.). Explore representing the chosen mathematical learning theme as a dramatic storyline.	Explores the proposed question by collecting information.	Provides further examples of multiplication from "real life" situations (e.g. "how many apples, cars", etc.) and leads a discussion based on the following questions: What do you want to find out about multiplication? What can you use it for?
Phase 3: Creation	Main activity of opera creation and rehearsals, on all levels (costumes, music, staging, libretto, etc.). Various specialized workshops, such as the "Shadow & Light" workshop (see description above).	Students explore multiplication as an integral part of the creation of their opera.	Leads a discussion based on the following questions: What is a science opera? A math opera? How can you represent mathematic concepts such as addition, subtraction, multiplication, fractions through arts? What do you observe in the way your knowledge is learned? Teacher defines central key concepts to be included in the process. Asks following questions: What do you expect to learn about the multiplication table? How would you explain the way you are learning? What is expected/ unexpected in this way of learning?

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Phase 4: Discussion	Discussion of any challenges that arise as part of the working process, including questions such as: Which concepts should be included in the libretto? Performance of the "Math Cat" Opera. *Note: The discussion and creation phase will necessarily overlap.*	Prepare results for discussion. Perform the "Math Cat" Opera.	Helps students evaluate results. Leads a discussion about multiplication, and what their learning in this field has contributed to the opera. Asks the following questions: Which are these the point about Multiplication that we want to communicate? What information would you use to support your view? How can the "Math Cat" opera be used to help 2nd graders understand the multiplication table next year? What remains unclear?
Phase 5: Reflection	Reflect upon various specific and focused issues (stage design, libretto, PR activity, group dialogue, ethical decision-making regarding inclusion of all students in the creative process, etc.).	Upload results (recordings, assessment) to the CREAT-IT portal (portal.creatit-project.eu) with the help of the teacher.	Creates an overview of what has been learned in the classroom during the project. The teacher guides the student to further open-ended study The teacher invites students to reflect on the resemblances and differences of creating art and math.

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Image 2: 3rd grade pupil with the ten lego blocks used by the teacher Anne Brit Holm to exemplify calculations

6: Performing the Opera – Additional Information

6.1: Students

The maximum recommended group size for each WASO project is 25-30 divided into 6-7 groups of various functions, as described in the WASO guidelines. *Teacher's tip: additional students in other musical, visual arts, dance classes may take part in the final performance event by providing a warm-up act to the opera, for example. This engages the WASO class in a dialogue with a wider circle of pupils in the school.*

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Image 3: 3rd grade pupils during "The Math Cat" opera at Sagvåg School, Norway

Students perform mathematical prediction and realize a creative, arts-infused case study scenario: Recording observations; Performing predictions compared to results; Developing experimental models; Participating in creative case study scenario (WASO).

Students as Group Participants: Use or evaluate a technique for learning the multiplication table.

6.2: Project instructors

External opera artists and scientists in collaboration with art, music and science\math teachers from the school. Note: the number of external artists and scientists\math educators in each unique project will depend on various parameters such as budget, availability, length of project, available volunteering professionals, number of school teachers assigned to the WASO project, number of students involved, etc.

Teacher: Presents ideas and evidence; Asks questions; Identifies misconceptions.
School leadership: considering the nature of the WASO project, with regard to the need to orchestrate teachers and professionals from various fields, it is crucial that the school's leadership is involved in project planning, realization and evaluation. This is true due to the need for the WASO project to accommodate each unique school's schedule, specializations, students of special needs, geographical location, rooms, etc.

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