STEAM learning using a web-based workbench of music science interactive activities

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The educational movement of STEAM

- Cross-disciplinarily connected skills in the educational process to promote creativity, critical thinking, innovation, risk taking

- Alongside with knowledge and skills in Science, Technology, Engineering and Mathematics (STEM) fields

- Bring Arts (A) at the heart of the academic curriculum

STEM + A = STEAM
Inspired by trends, challenges and technologies

Source: New Media Consortium (NMC) Horizon Report 2015
iMuSciCA Vision

Interactive Music Science Collaborative Activities

John & Beatrice
iMuSciCA students

Alexandra is teaching geometry and waves

John and Beatrice incorporate new knowledge in their instrument design

They explain their 3D instrument to their classmates

Co-creative design, visualisation, and testing of 3D instruments that sound

3D printing of the instrument for the concert

Garry & Alexandra
iMuSciCA teachers

Teachers design iMuSciCA class lessons for STEAM learning

Garry gives individual feedback to Beatrice

Teachers exchange knowledge from different subjects

Alexandra discusses the learning outcomes with John

Teachers committee measures the impact of IMuSciCA on deeper learning and refines lesson for next year

At the end of the semester, a concert is taking place where students celebrate their deeper learning

Logo Design & sketches by Andrin Hubacher

Team Teaching for STEAM Education

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Logo Design & sketches by Andrin Hubacher
iMuSciCA
interactive Music Science Collaborative Activities

- Design and implement a suite of software tools and services on top of new enabling technologies integrated on a platform that will deliver interactive music activities for teaching/learning STEM

- New pedagogical methodologies and innovative educational technology tools to support active, discovery-based, personalized, and more engaging learning

- Provide students and teachers with opportunities for collaboration, co-creation and collective knowledge building
iMuSciCA objectives

- Develop and explore original and innovative enabling technologies to facilitate open co-creation tools incorporated in music activities to support STEAM learning

- Develop a workbench of music activities to give learners the opportunity to discover phenomena/laws of physics, geometry, mathematics and technology

- Encourage students to engage in innovative interactive music activities with advanced multimodal interfaces to discover new ways to look at science and technology to support creative and artistic interventions

- Enable teachers to design engaging project/problem based STEAM learning activities
iMuSciCA enabling technologies

Virtual 3D environments to design personalized musical instruments using geometric forms and tools
iMuSciCA enabling technologies

Computer generated sound produced by varying the design parameters of musical instruments with interpretations of the related physics and mathematics.
iMuSciCA enabling technologies

Gesture and pen-enabled multimodal interaction of the learners with the virtual 3D musical instrument for co-creation and music performance
iMuSciCA enabling technologies

Interactive STEM authoring and learning environments with advanced tools for the creation and presentation of lesson plans

45,329 cm³

\[ \frac{1}{3} + \frac{1}{4} = \frac{7}{12} \]
iMuSciCA enabling technologies

Pen enabled environments with handwriting recognition technology for mathematical expressions and geometric shapes

\[ \frac{3x^2 + 5}{\sqrt{x}} \]
iMuSciCA enabling technologies

Deployment of 3D printing technology for realizing the physical musical instrument as a tangible physical object
iMuSciCA STEAM pedagogy reflects real world

- Interdisciplinary
- Inquiry across STEAM fields
- Different inquiry paths
- Collaborative and co-creative learning across fields
- 21st Century Skills across STEAM fields

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<tr>
<th>Music</th>
<th>Science / Maths</th>
<th>Engineering / Technology</th>
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Inquiry Based

Music / Science-Mathematics/ Technology-Engineering

1. **Engage**
   Wonder, ask questions, explore, observe – Identify problems, questions and chances – Relate to background knowledge

2. **Imagine**
   Identify relevant variables to investigate – Identify Relevant Solutions to use - Use imagination and make hypothesis – Choose potential solution

3. **Create – Investigate/Design**
   Plan the Investigation – Design the Prototype – Carry out Investigation – Build the Prototype

4. **Analyse**
   Analyse Data from Investigations and Draw Conclusions – Evaluate the Prototype – Explain by Relating to Background Knowledge – Optimise the prototype – Describe and explain the results in the different STEAM-fields and the connections between them

5. **Communicate and Reflect**
   Communicate results and conclusions – Communicate the product – Perform – Reflect on Feedback and incorporate in further processes
Educational scenarios and lesson plans
### A Generic Educational Scenario across STEAM Fields and IBSE Phases

<table>
<thead>
<tr>
<th>Phase</th>
<th>Music</th>
<th>Science/Mathematics</th>
<th>Engineering/Technology</th>
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<tbody>
<tr>
<td>Engage</td>
<td>Lesson Plan 1</td>
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<tr>
<td>Imagine</td>
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<td>Lesson Plan 1</td>
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<tr>
<td>Create/Investigate/Design</td>
<td>Lesson Plan 4</td>
<td>Lesson Plan 2</td>
<td>Lesson Plan 2</td>
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<tr>
<td>Analyze</td>
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<td>Lesson Plan 3</td>
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<tr>
<td>Communicate &amp; Reflect</td>
<td>Lesson Plan 4</td>
<td>Lesson Plan 3</td>
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iMuSciCA main outcomes

- **Workbench of Music Activities** containing methodological and advocacy tools of advanced enabling technologies to assist learners in developing co-creative processes for STEAM learning.

- **Cross-disciplinary lesson plans** for secondary education to teach physics, geometry, mathematics and technology combined with creative music activities.

- **Professional development material** for teachers and educators for adopting innovative STEAM teaching methodology.
Evaluation of deeper learning with iMuSciCA

- Formative evaluation
  - Pilots in Greece, Belgium and France (~30 students and ~6 teachers)

- Summative evaluation
  - Pilots in Greece, Belgium and France (~300 students and ~50 teachers)

- Qualitative and Quantitative methods and instruments
  - Surveys, questionnaires (teachers and learners)
  - Pre & post tests (learners)
  - Tracking learner’s activity (mouse clicks, response times, frequency of hints, etc.)
  - Tracking learner’s behaviour
Advanced monitoring tools for tracking learner’s behaviour

- Eye tracking
- Facial expressions analysis
- Galvanic Skin Response (GSR) sensors
- Electroencephalography (EEG)
iMuSciCA workbench

https://workbench.imuscica.eu
iMuSciCA vision becoming alive
Thank you!

EUROPEAN COMMISSION
Communications Networks, Content and Technology
Learning, Multilingualism and Accessibility