



**Interactive Music Science Collaborative Activities
Team Teaching for STEAM Education**

Deliverable 5.5

Initial Demonstrators of iMuSciCA workbench toolkits

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Executive Summary

This deliverable reports on the implementation of sample items from the lesson plans developed in WP2 using the workbench toolkits of iMuSciCA deliverables [D5.1 \(Initial 3D musical instrument interactive design kit\)](#), [D5.2 \(Initial music activities based on mathematical equations and geometric curves\)](#), [D5.3 \(Initial Pen-enabled canvas for music and audio co-creation and interaction\)](#) and [D5.4 \(Initial Pen-enabled canvas for music and audio co-creation and interaction\)](#). These demonstrators will be used during the usability validation of the prototypes with a small number of students in the pilot testing, as given in WP6.

The workbench can be accessed at:

<http://platform.imuscica.eu/workbench.html>

Example of the workbench following a lesson plan:

http://platform.imuscica.eu/workbench.html?clmc=https://platform.imuscica.eu/imuscica/activity/2_Sc_StndgWavesResFrequencies_L1_RowResonantTones.cmc

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LIST OF ABBREVIATIONS

Abbreviation	Description
2D, 3D	2-dimensional or 3-dimensional space
AJAX	Asynchronous JavaScript And XML
API	Application Programming Interface
LMS	Learning Management Platform
LRS	Learning Record Store
RESTful web services	Representational state transfer (REST) ful web services
STEAM	Science, Technology, Engineering, Art, Mathematics
WP	Work Package
ATHENA	ATHENA RESEARCH AND INNOVATION CENTER IN INFORMATION COMMUNICATION & KNOWLEDGE TECHNOLOGIES
UCLL	UC LIMBURG
EA	ELLINOGERMANIKI AGOGI SCHOLI PANAGEA SAVVA AE
IRCAM	INSTITUT DE RECHERCHE ET DE COORDINATION ACOUSTIQUE MUSIQUE
LEOPOLY	3D FOR ALL SZAMITASTECHNIKAI FEJLESZTO KFT
CABRI	Cabrilog SAS
WIRIS	MATHS FOR MORE SL
UNIFRI	UNIVERSITE DE FRIBOURG

1. Introduction

The Workbench is the place where students can perform STEAM related activities according to the iMuSciCA Pedagogical framework (see [D2.1 “Initial Pedagogical framework and iMuSciCA use cases by learners and teachers”](#)). It provides a set of tools, classified according to the different STEAM domains: music, science/mathematics and engineering/technology.

Tools can be opened (launched) by clicking on the corresponding button. Each tool button is located at the top of the window, in a rectangle of gray color (see Figure 1). Tool domains are color coded, i.e. all tools belonging to the same domain will share the same color. For this deliverable the following colors have been attributed:

- blue for Music,
- orange for Science/Maths ,
- green for Engineering/Technology.

These colors will change in the future when the iMuSciCA graphical design will be completed.

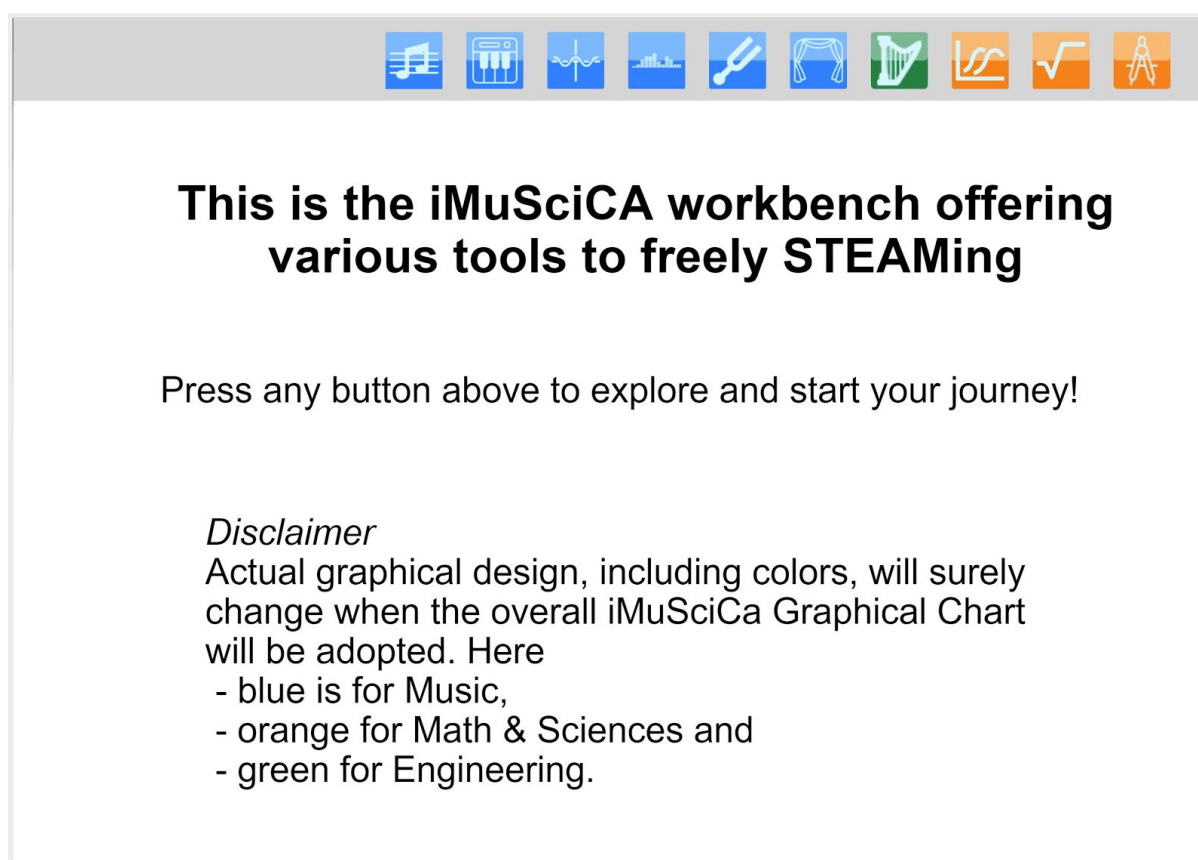


Figure 1. iMuSciCA Workbench landing page

Using the default workbench page as in Figure 1, students can freely use the iMuSciCA tools. They can also follow template iMuSciCA lesson plans (see Figure 2.a, and D2.3 “Initial Educational scenarios and lesson plans for iMuSciCA”). One example can be found here:

http://platform.imuscica.eu/workbench.html?clmc=https://platform.imuscica.eu/imuscica/activity/2_Sc_StndgWavesResFrequencies_L1_RowResonantTones.clmc

In this last configuration, the iMuSciCA tools are directly available inside the lesson where they are needed (see Figure 2.b).

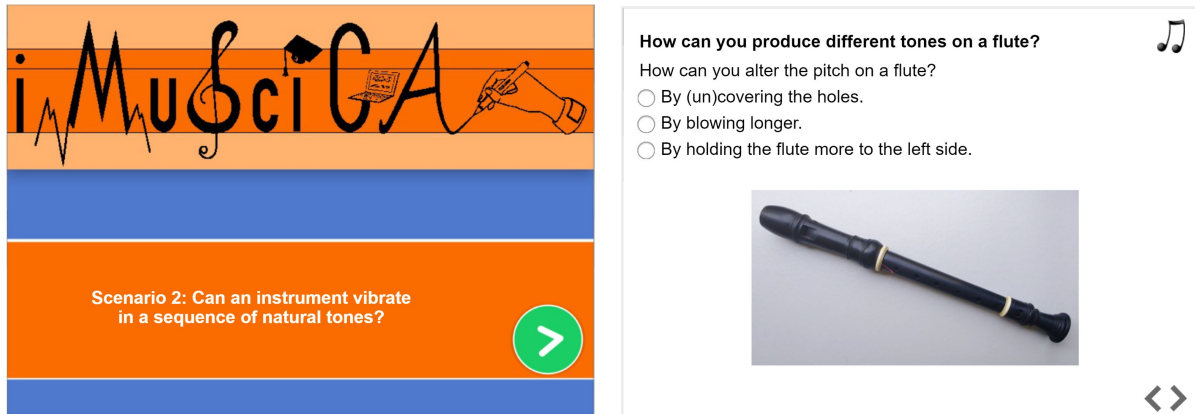


Figure 2.a. Screenshots from an iMuSciCA lesson plan (page 1 and 2)

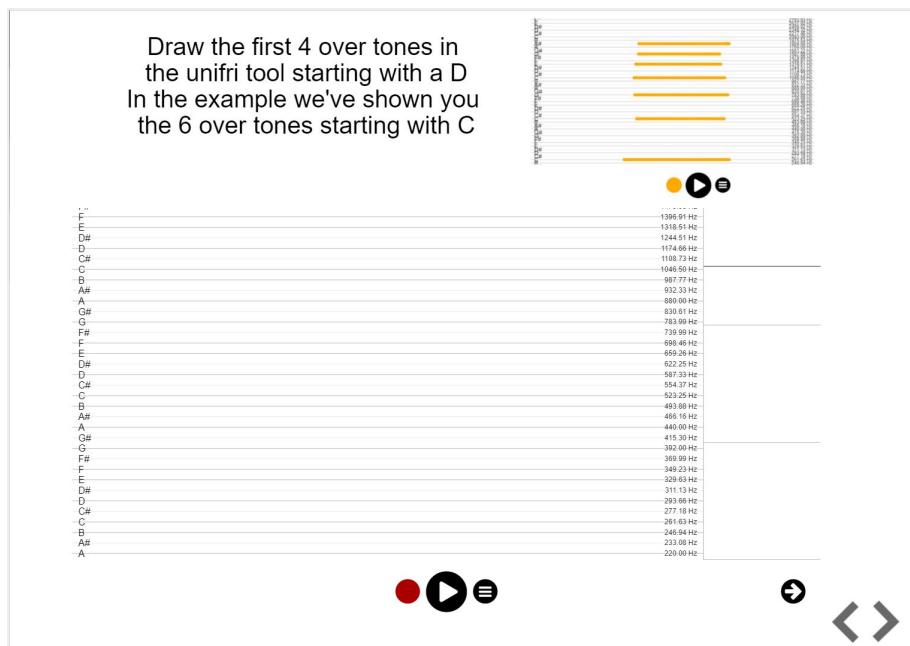


Figure 2.b. Screenshot from an iMuSciCA lesson plan, with a page containing an iMuSciCA tool

2. Workbench

2.1 Installation and technical requirements

The workbench can be accessed at: <http://platform.imuscica.eu/workbench.html>. The workbench is built upon the Cabri engine (graphic card on client computer must support WebGL). After accessing the link, the workbench main screen will be displayed (see Figure 1).

2.2 Description of demonstrator and user manual

When launched, the Workbench displays the following layout:

- A top area containing a set of icons to launch tools. Currently there are 10 tools: 6 for Music (in blue), 1 for Engineering/Technology (in green), 3 for Science/Maths (in orange).
- Just below some general information, including an invitation to click on some of the icons. This text will be updated in the course of advancement of the iMuSciCA project.

Pressing any of the icons leads the learner to each specific tool environment. A description of the tools follows below.

2.2.1 Music tools



Tool 1: Drawing Canvas for Music Creation

This tool allows users to play sounds, where the frequency of the sound can be set by drawing (see Figure 3). The user draws using a (default) orange pen and various parameters that are accessible with additional buttons, including the play button as a white triangle in a black circle. This tool is for example used in lesson plan 2.1 “The row of resonant tones” and lesson plan “Let’s hear Thales’ theorem”.

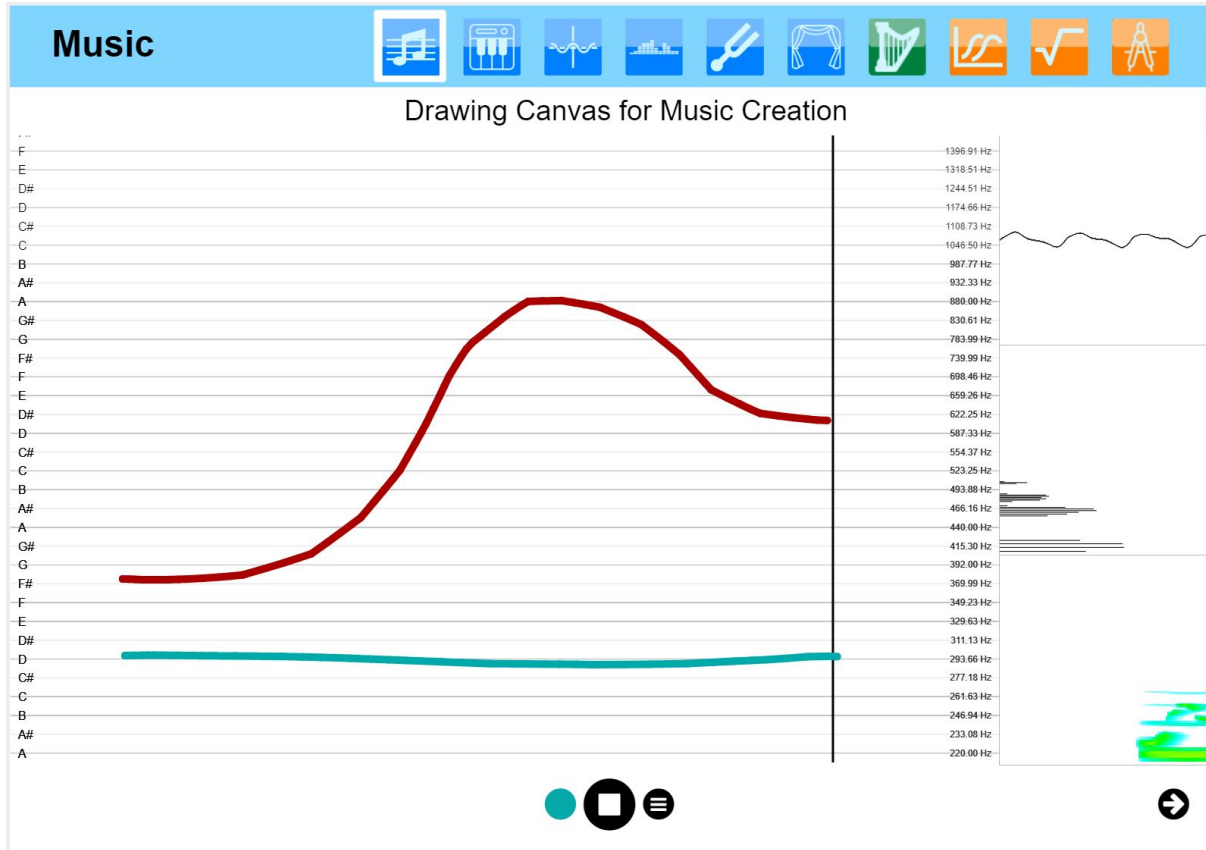


Figure 3. Tool 1: Music Canvas for Music Creation



Tool 2: Performance Sample Sequencer

This tool allows students to work on a performance recording, obtained from the Musical Instrument Performance/Interaction activity environment. Students can use their recordings to generate new music. To this end, stored recorded performances can be imported in audio form into the Sampler's interface. The student can then select samples from this performance recording as regions on the waveform and activate those samples on the sampler's matrix. The user can store the current settings of her/his composition and share it with other students, generating the conditions for co-creation. This tool is used for example in lesson plan 1.2 "What is tone?" to compose a groove by using recorded sounds. This tool allows music creation by selecting sound samples and defining patterns played in sequence (see Figure 4).

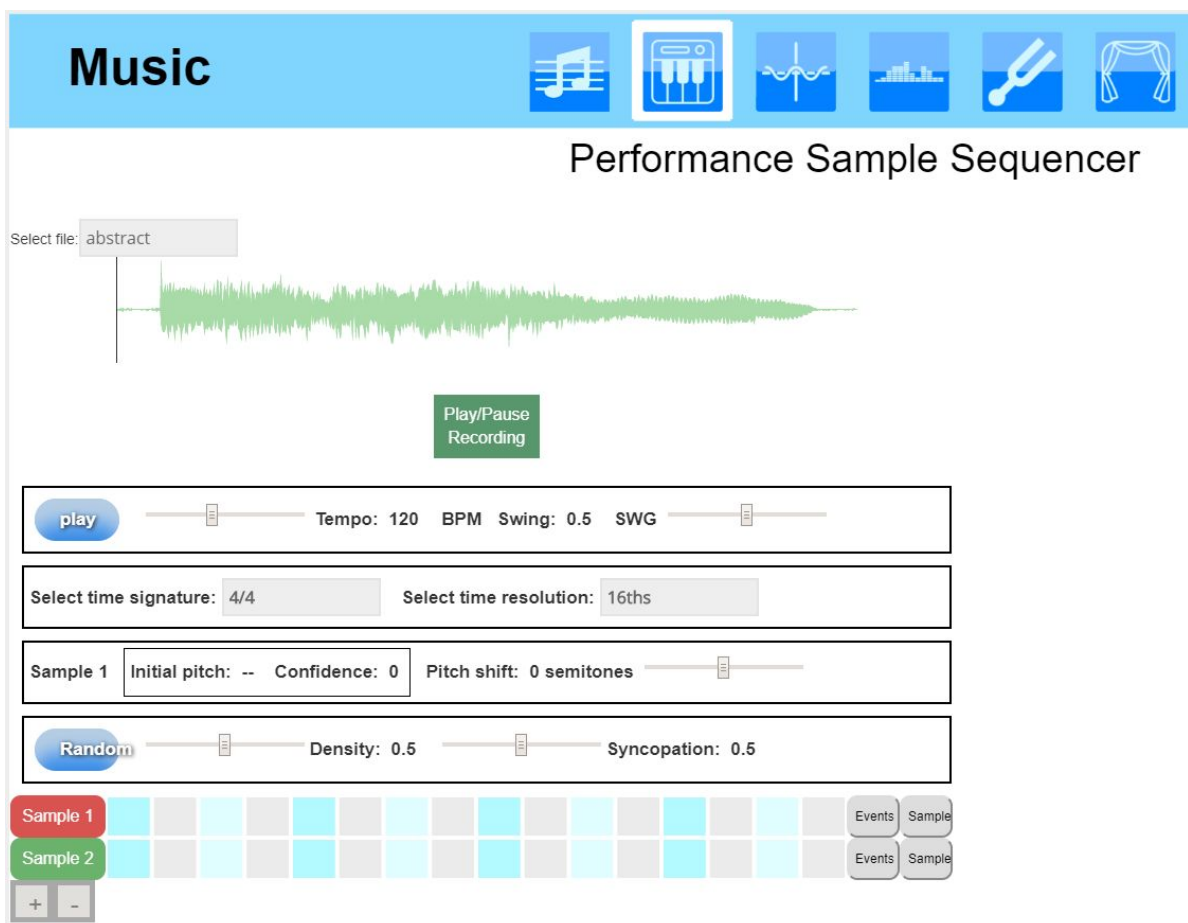


Figure 4. Tool 2: Performance Sample Sequencer.



Tool 3: Tones Synthesizer

The Tones Synthesizer tool allows students to explore timbres as an addition of multiple sinusoidal elements. Students are able to listen to the sound produced by up to eight sinusoidal elements combined (summed), change their parameters (amplitude and frequency) and visualise the produced waveform either of the sum or of each element separately (see Figure 5). This tool can be used for example in lesson plan scenario 3 'Timbre of musical instruments' and 30 'Timbre revisited'.

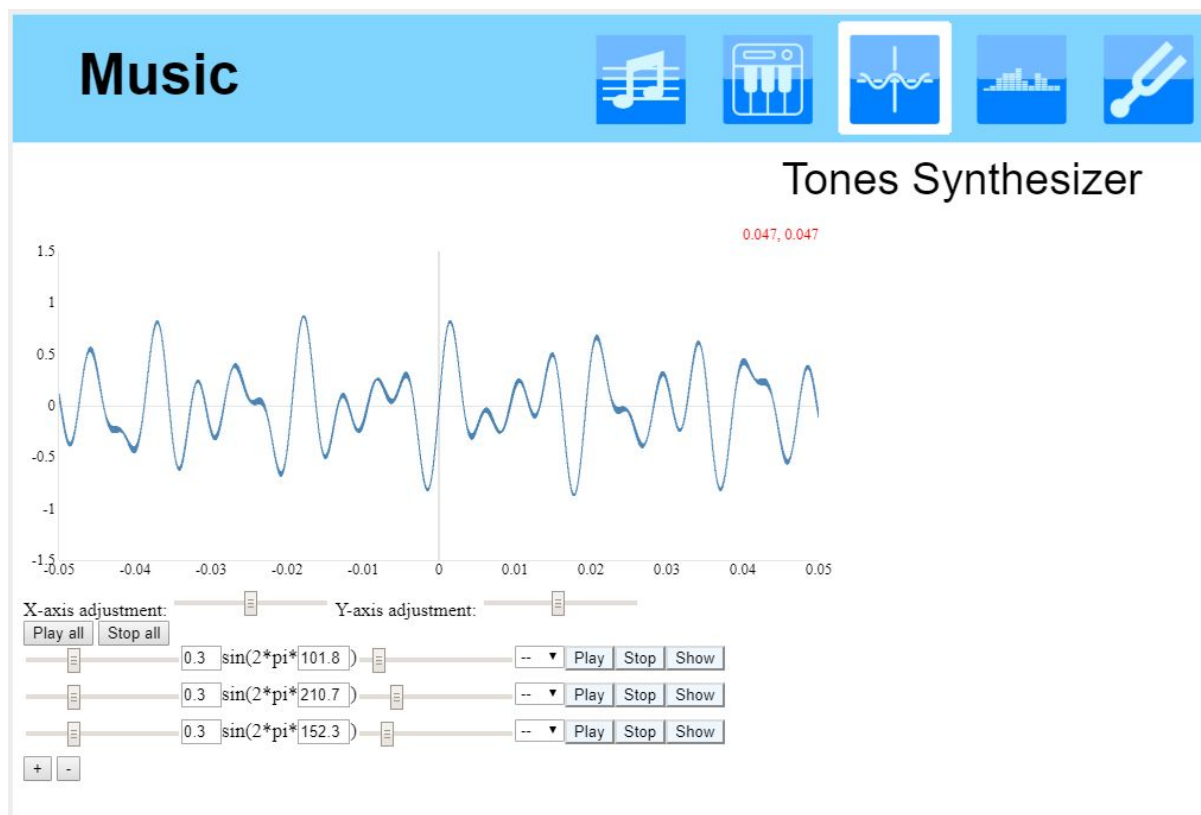


Figure 5. Tool 3: Tones Synthesizer



Tool 4: Sound Visualizer

This set of tools allows users to visualize the sound currently playing, using various representations (see Figure 6.a and 6.b). The first is composed of three parts, the drawing canvas in the middle, the control buttons at the bottom and the visualization views on the right (Figure 6.a). The second, the Snail, is a very high-precision frequency-domain analyzer that delivers an easy to understand representation of sounds based on the scales and notes aligned in spectrally active zones (Figure 6.b - Left). The third type of visualization involves the energy of the sound with respect to time, the tempogram, and a 3D Spectrogram (Figure 6.b - Right). This set of tools can be used for example in lesson plan scenario 3 'Timbre of musical instruments', 30 'Timbre revisited' and 40 'In search of understanding consonance/dissonance'.

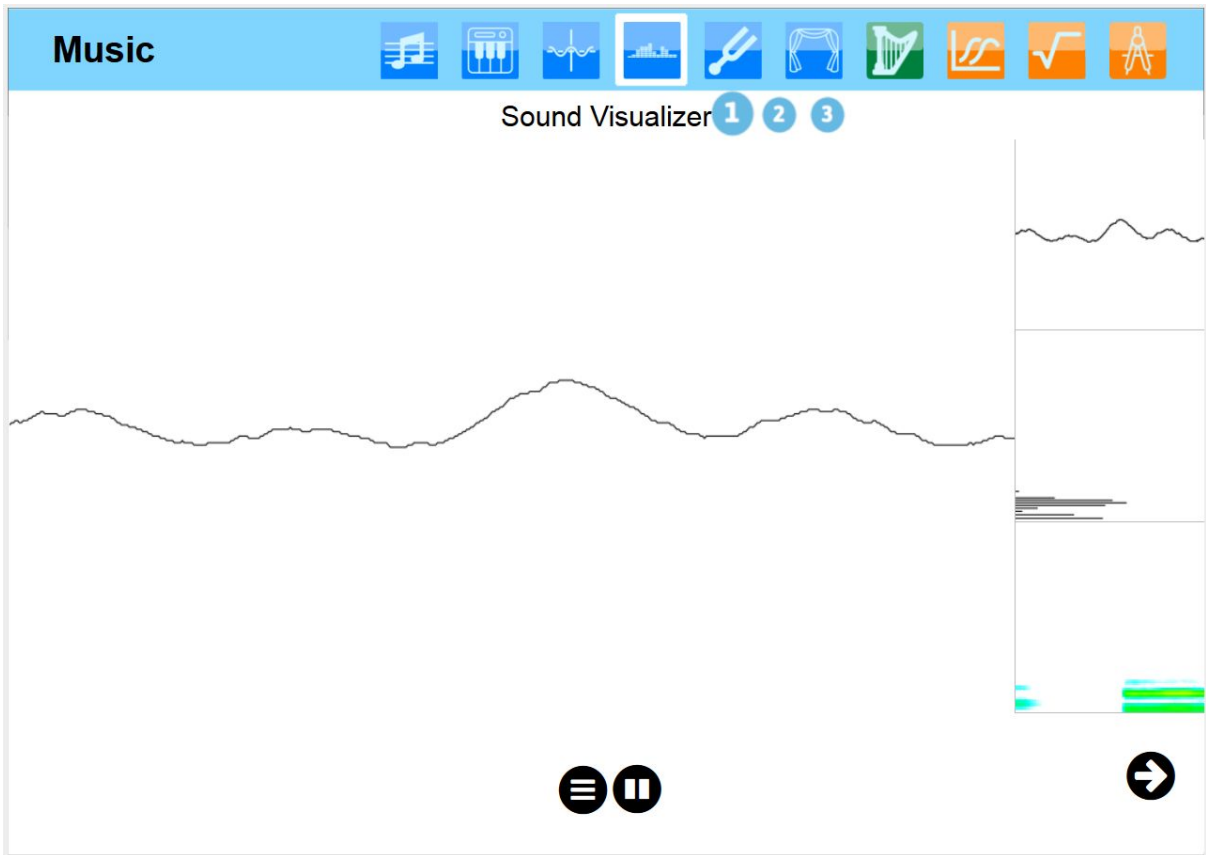


Figure 6.a. Tool 4: Sound Visualizer - set 1

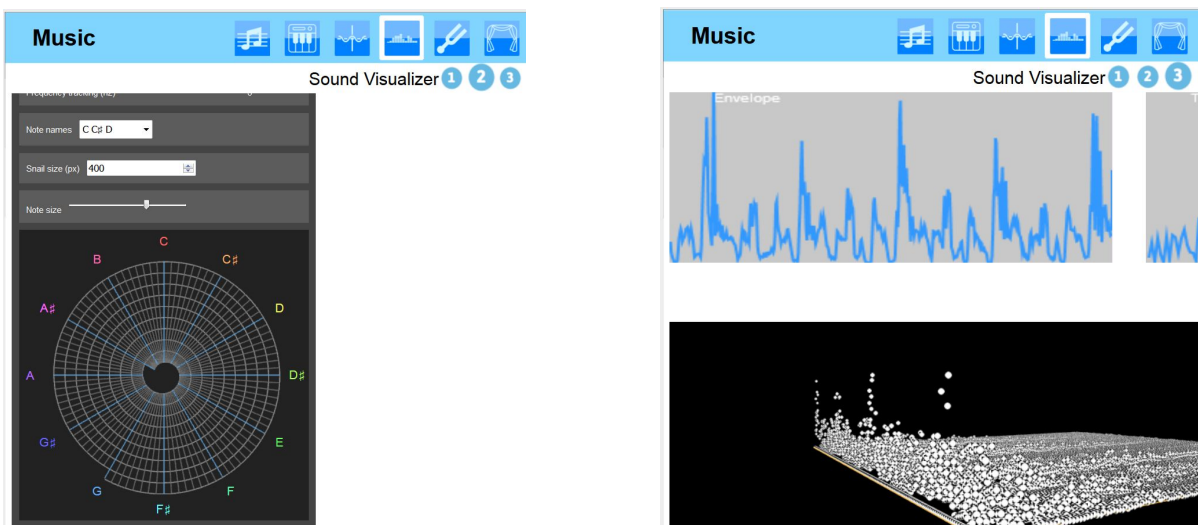


Figure 6.b. Tool 4: Sound Visualizer - set 2 (The Snail) and 3



Tool 5: General Music Tools

This set of tools includes tools pertaining to the basic musical core enabling technologies (see Figure 7) that include a metronome, a reference pitch tool, a tuner, audio input and audio recording.

Music

General Music Tools

play

Tempo: 120 BPM

Swing: 0.5 SWG

Resolution: 16th notes

---Hz

use demo audio

Select file: abstract

use live input

Start recording Stop recording

Figure 7. Tool 5: General Music Tools



Tool 6: Musical Instrument Performance

This tool allows students to use their hands (Leap-based interaction module) and arms/body (Kinect-based interaction module) in order to interact with a virtual instrument (see Figure 8). The environment that hosts these provides the user with the following functionalities:

- Selection of the desired interaction sensor (i.e. Leap Motion or Kinect).
- Selection of the desired gestural interaction type (i.e. free or gesture-based).

- Loading of customized virtual instruments from the which were previously designed and constructed by the user within the 3D Musical Instrument Design environment.
- Recording and storing user’s performance sessions.
- Generate pitch reference tones, as well as detecting and displaying in real-time the pitch of produced sound tones from the performance of virtual instruments.
- Study audio-related visualisations that derive from either real-time performances or from previously recorded sessions.

It should be noted that free interaction and gesture-based interaction are quite different performance approaches. During free interaction, the students are “embedded” within a virtual world where they can see 3D models of their hands and bodies, which, on their side, interact directly with the virtual instruments, such as virtually plucking the strings or hitting the drum membrane. On the other hand, with gesture-based interaction mode, the students use gestures as “motion templates” for triggering musical events related to the virtual instruments. This tool will be used in lesson plans including a musical expression.

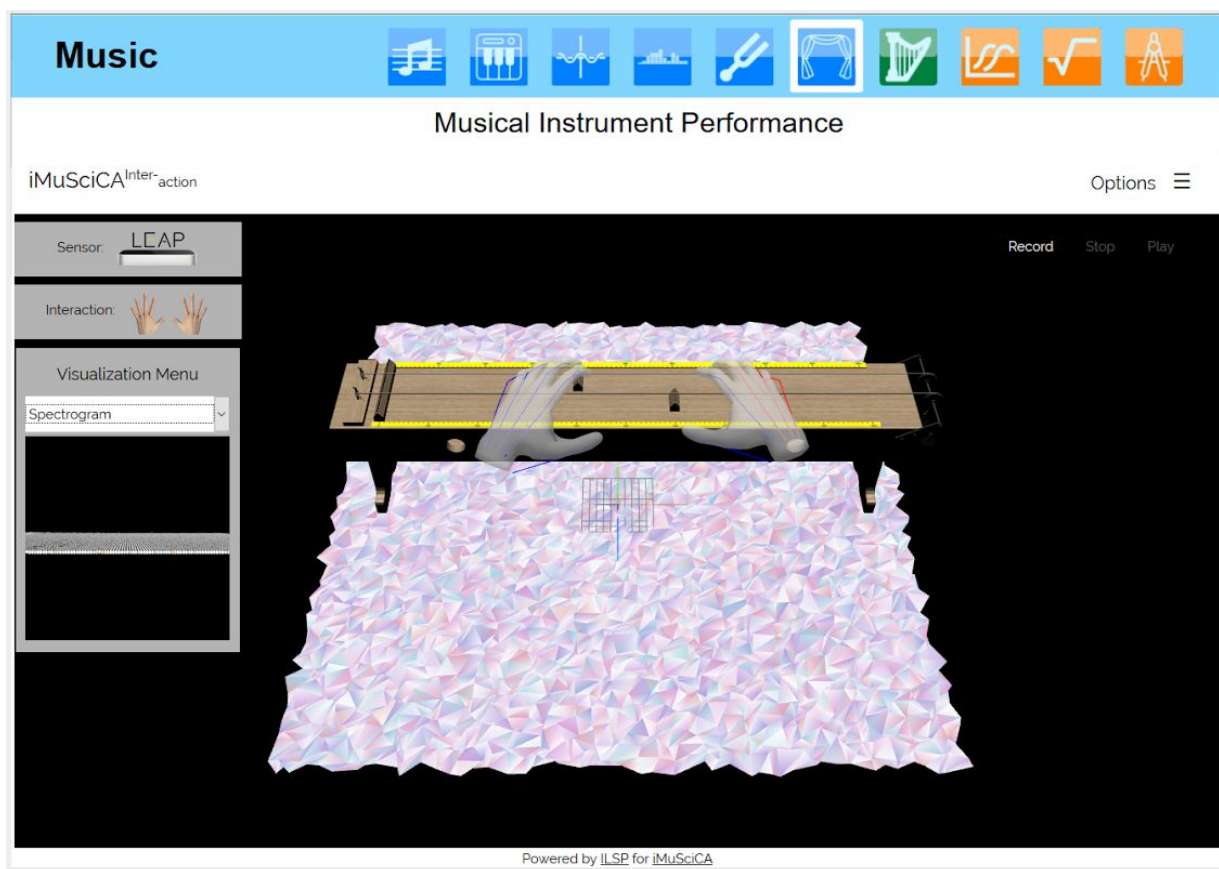


Figure 8. Tool 6: a performance session using the Leap Motion sensor and free interactions with a virtual string instrument

2.2.2 Engineering / Technology tool



Tool 7: 3D Musical Instrument Design

In this environment the user is able to design and adjust the parameters of a 3D model of virtual instruments (see Figure 9). In this version, the user can load pre-designed 3D virtual instruments of a multichord, a circular or square membrane and a xylophone, adjust respectively various parameters (e.g. for the multichord the body length, chord tension, etc.) and check their individual effect on the sound produced when the instrument is excited.

This tool is used for example in lesson plan 2.4 “Changing the pitch of the fundamental” and lesson plan A2 “Design a monochord playing note A”.

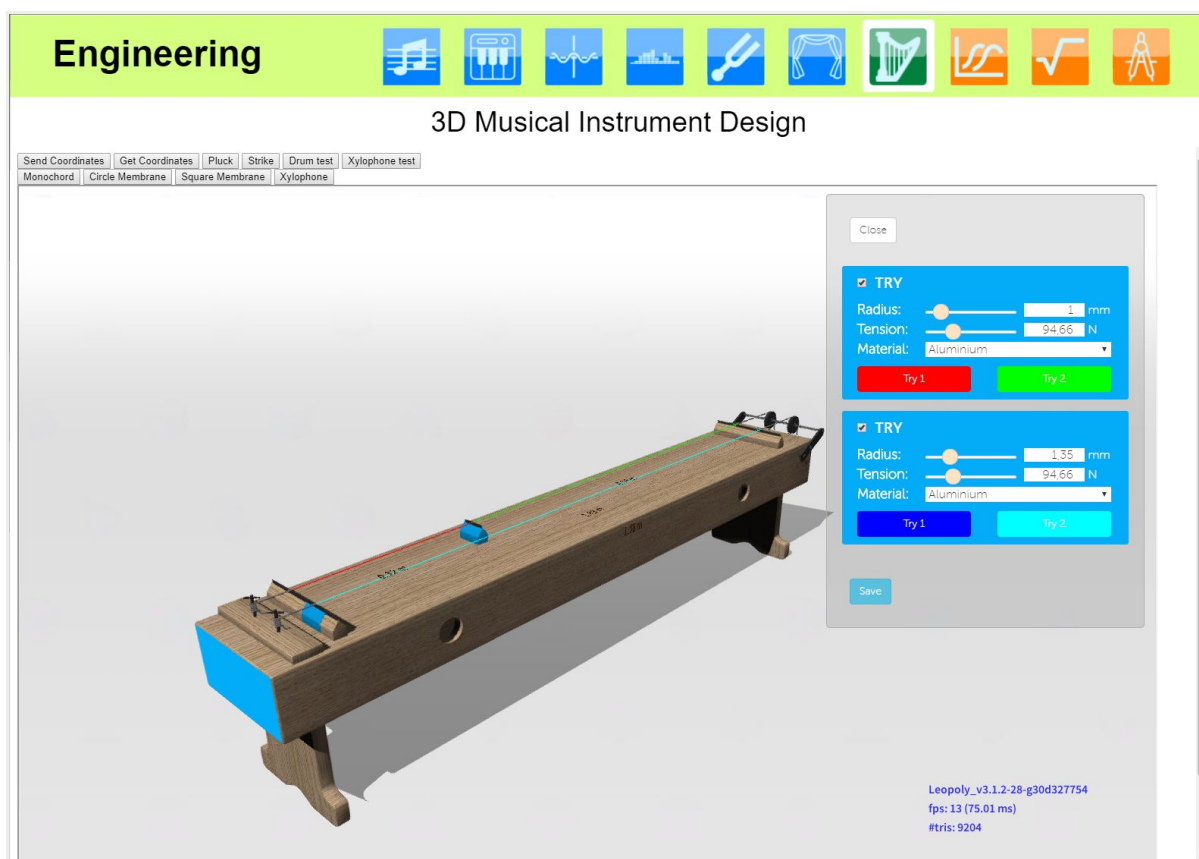


Figure 9. Tool 7: 3D Musical Instrument Design

2.2.3 Science / Maths tools



Tool 8: Sonification of mathematical equations and geometric curves

This tool allows users to draw functions and play a particular sound for them (see Figure 10 and D5.2 “Initial music activities based on mathematical equations and geometric curves”). The

sound/frequency play is related with the y-value of that particular function. This tool will be implemented in lesson plans for higher secondary schools.

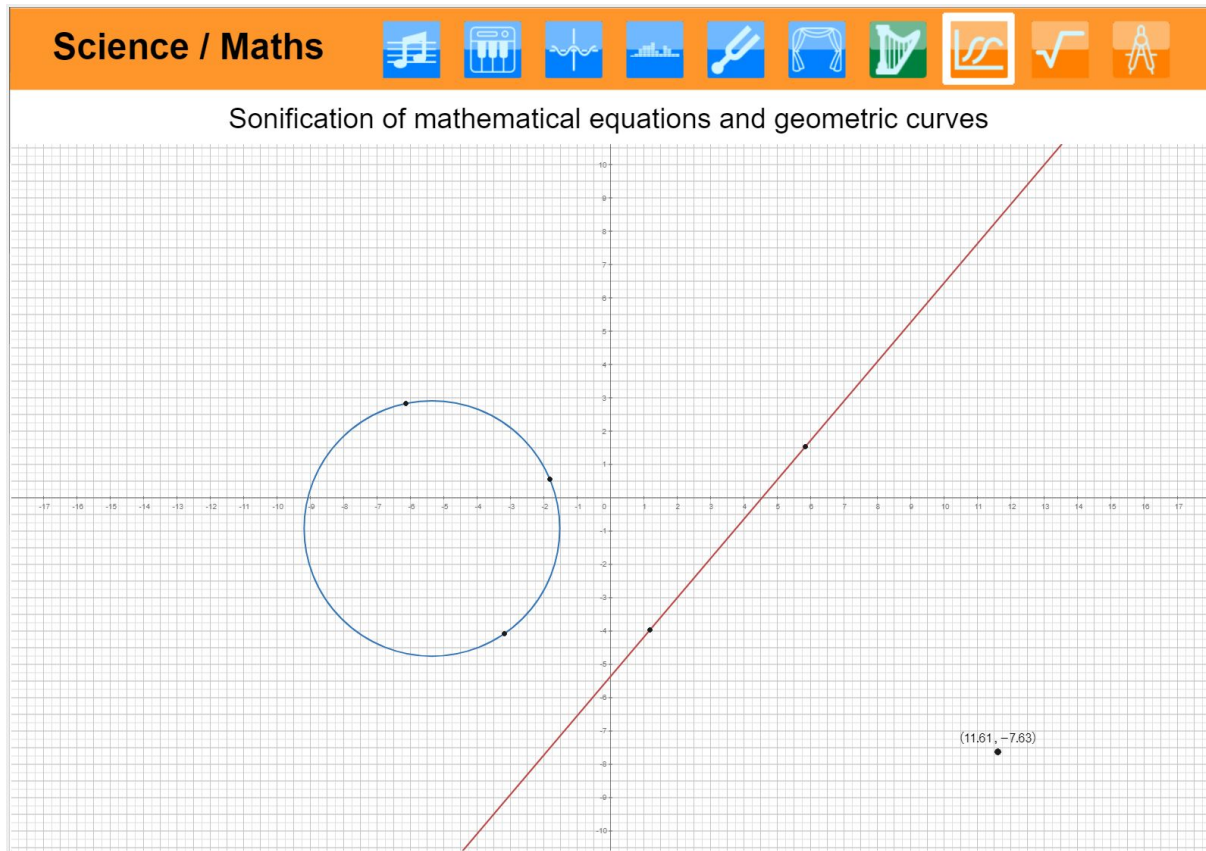


Figure 10. Tool 8: Sonification of mathematical equations and geometric curves.



Tool 9: Math Equation Editor

This tool allows users to write math equations using menus and keyboard, or by handwritten recognition (see Figure 11). This tool will be useful in any of the iMuSciCA lesson plans.

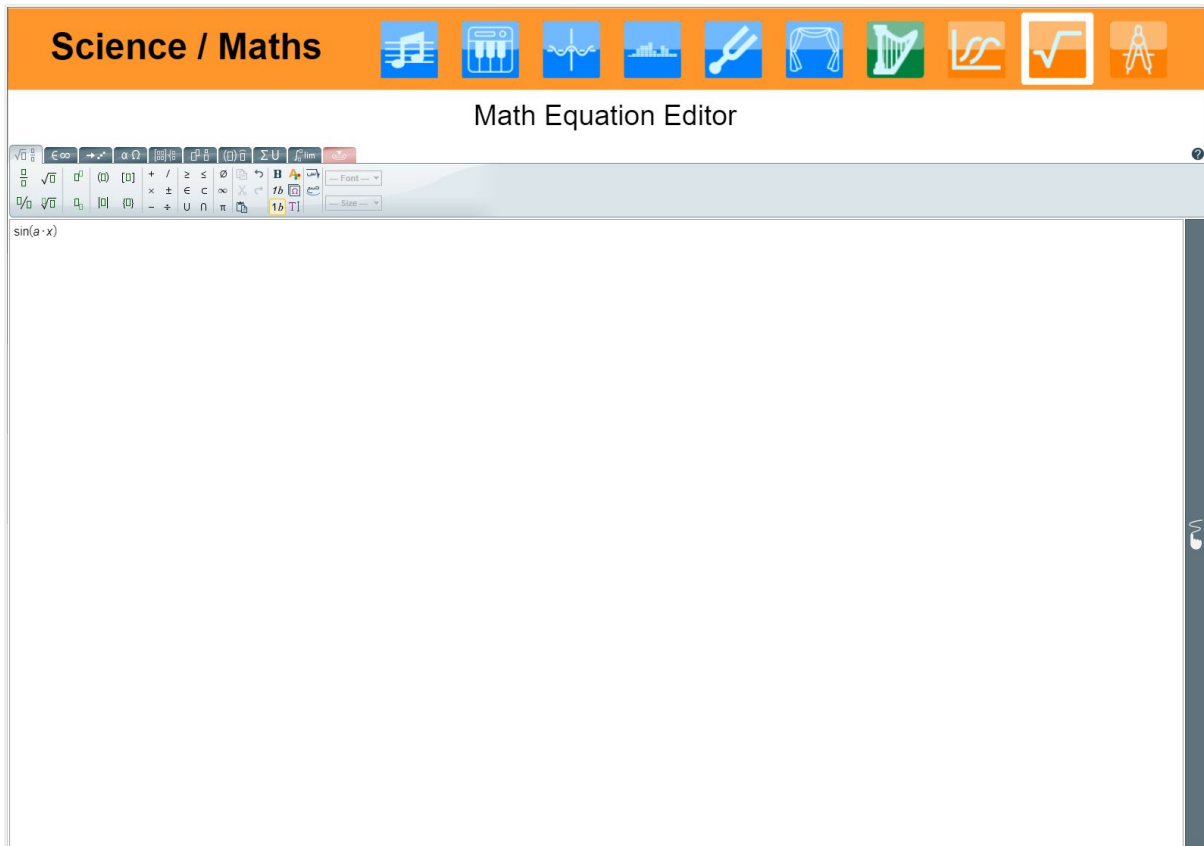


Figure 11. Tool 9: Math Equation Editor.



Tool 10: Geometry and Algebra Tools

This environment is based on Cabri Express, a Math all-purpose exploratory environment (see Figure 12). Various math tools (geometry construction and algebra tools, including an advanced calculator) are available from a pile located on the left. Constructions can be performed in 2D or 3D. An extensive user guide of this specific environment is provided separately. This tool will be used to measure and to make simulations, for example simulations about the superposition of waves (e.g. lesson plan 2.3 “How do standing waves occur?”).

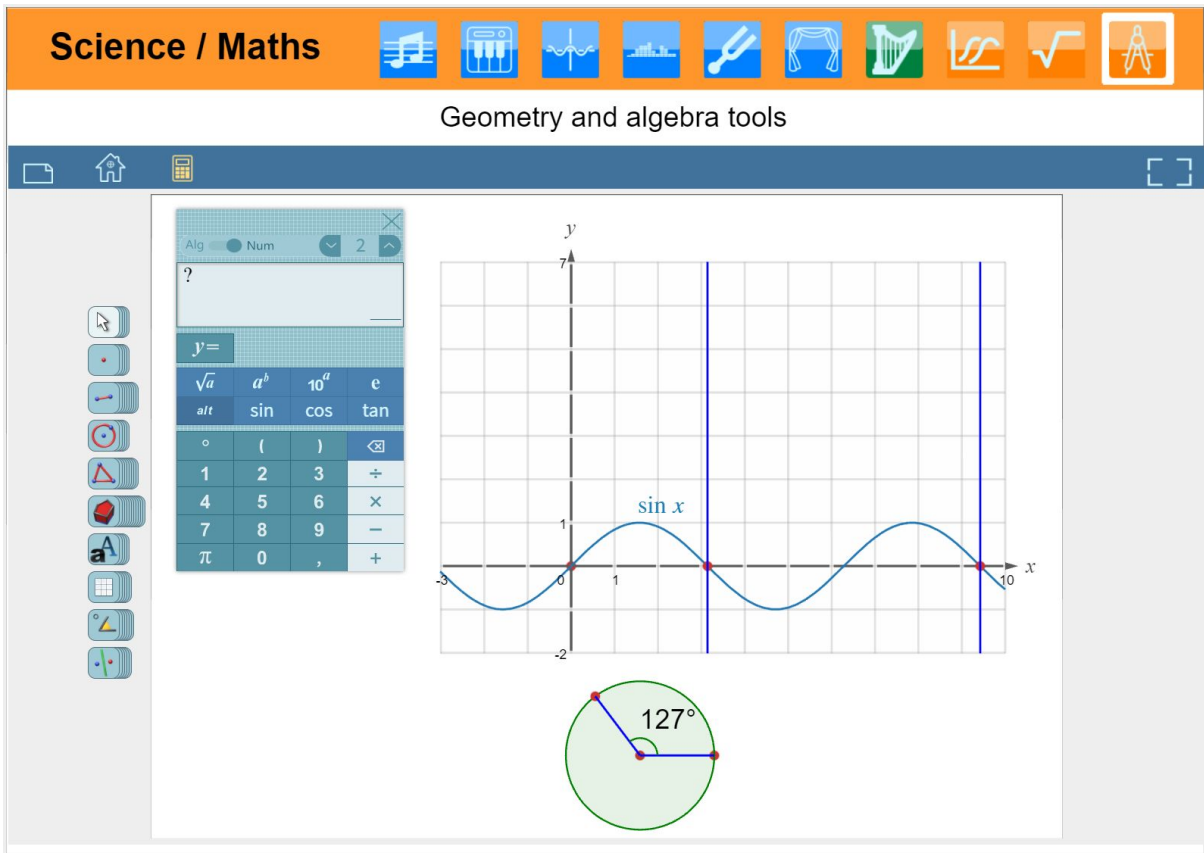


Figure 12. Tool 10: Geometry and Algebra Tools.

3. Learning Management System (LMS)

The goal of the LMS is to give access to the lesson plans and to handle student access and grading (see Figure 13).

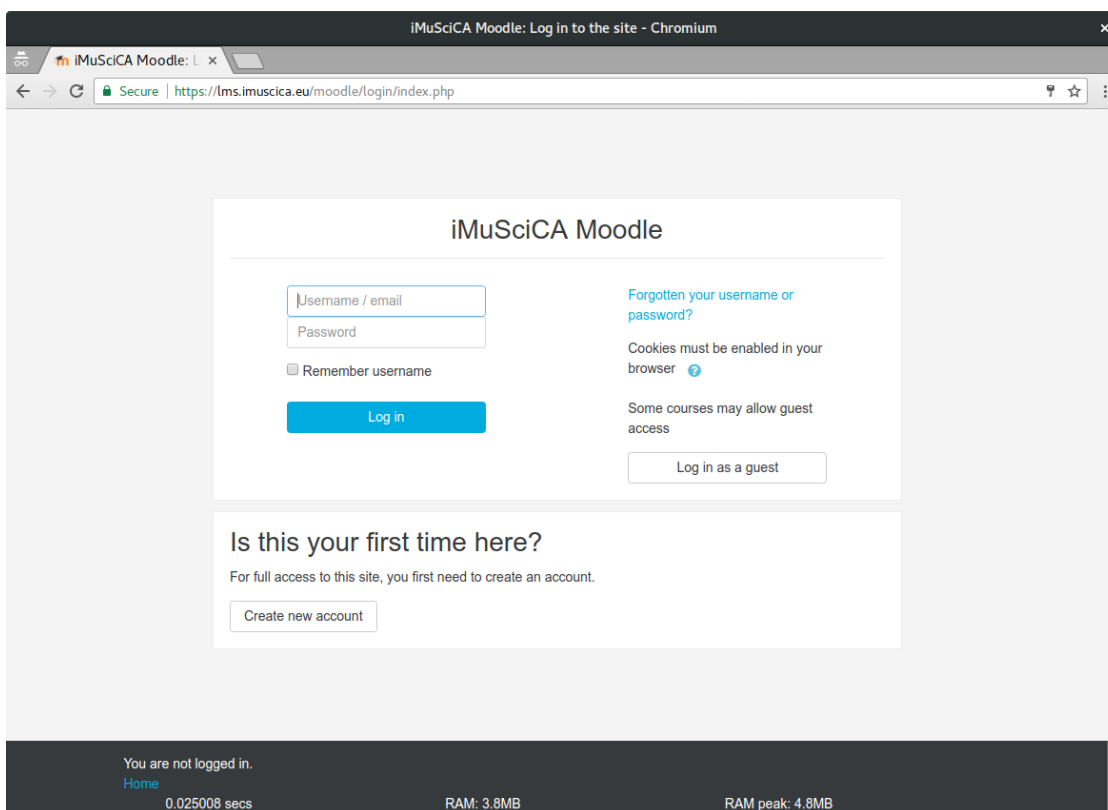


Figure 13. The Moodle platform on the iMuSciCA LMS server.

3.1 Installation and technical requirements

For the pilot tests, we provide a server with a LMS so that the different schools don't have to install and configure one, and so that we can easily implement the workbench integration and the different lesson plans. We chose to use the well known LMS Moodle and we installed it on the iMuSciCA LMS server, which is available at the following URL: <https://lms.imuscica.eu>.

3.2 Description of demonstrator and user manual

The documentation of Moodle is available online at: <https://docs.moodle.org>.

4. iMuSciCA Management Platform

The goal of the backend platform server is to host the workbench and the lesson plans, to store student records and to record information about the workbench usage (both technical and pedagogical).

4.1 Installation and technical requirements

The backend platform server hosts two different things: first the workbench HTML page, and second a RESTful API web services that provide different functionalities for the workbench. The platform server is available at the following URL: <https://platform.imuscica.eu>, which hosts the workbench (<https://platform.imuscica.eu/workbench.html>) and the Webservice RESTful API entry point (<https://platform.imuscica.eu/imuscica/>, not accessible with a browser).

4.2 Description of demonstrator and user manual

The different functionalities of the backend platform server can be accessed by sending AJAX request to the corresponding RESTful API web services.

4.2.1 Serving Activity Files

Learning content can be listed by sending a GET request to the following URL:

<https://platform.imuscica.eu/imuscica/activities>

Specific learning content can be accessed by sending a **GET request (or accessing it with a browser)** to the following URL with the correct project, scenario, lesson plan and activity ID:

https://platform.imuscica.eu/imuscica/project_id/scenario_id/lesson_plan_id/activity_id.clmc

4.2.2 Learning Record Store (LRS)

The LRS stores and serves students learning collected records in order to allow them to save their progress between classes. The LRS can be accessed by sending **POST/GET/DELETE requests (but not with a browser)** at the following URL: <https://platform.imuscica.eu/imuscica/storage> providing the student and file ID.

New file can be stored by sending a POST request, file can be updated with a PUT request, and deleted with a DELETE request. Files can then be accessed with a GET request.

4.2.3 Student Tracking Progress

Student progresses on the workbench can be tracked by sending a **POST request (but not with a browser)** to the following URL: <https://platform.imuscica.eu/imuscica/tracking> with the student and activity ID.

4.2.4 Technical Logging

Technical behavior of the workbench can be logged by sending a **POST request (but not with a browser)** to the following URL: <https://platform.imuscica.eu/imuscica/logging> with the student and activity ID.