Title:	**Let's hear Thales' theorem**		
Keywords:	Monochord, frequency, tension, length, musical patterns, geometrical proportions, Division of the Canon (Sectio Canonis).		
Short Description:	Students use iMuSciCA to divide a string length (or membranophone area) in equal parts keeping tension (and radius in case of string) in constant value and then listen to its different corresponding lengths (or areas). Students perform a composition based on segment divisions and reconstruct their models to achieve same results by altering tension.		
Lesson Plans included:	-Understanding the similarities between geometrical segments and musical instruments. (2 Lesson Plans) -Dividing the sounding string into parts by following the Thales theorem. (3 Lesson Plans) -Achieving the same audio results through altering tension / Experiment with membranophones (3 Lesson plans) -Preparing a musical composition and final performance using motifs (sets of notes), (2 Lesson plans)	Date:	30/9/2017
Educational Objectives:	Learn the relationship Sectio Canonis, frequency, tension and length of a monochord. Explore the similiarities between the Pythagorean proportions and tension of an instrument's sounding body.	Estimated Duration:	20 hrs
Author(s):	P. Stergiopoulos	Age Group:	15-17 (14-16)
Contributor(s):		Language:	English
Status:	Final	Difficulty Level:	Medium
Dissemination level:	Public	Special Needs Addressed:	No

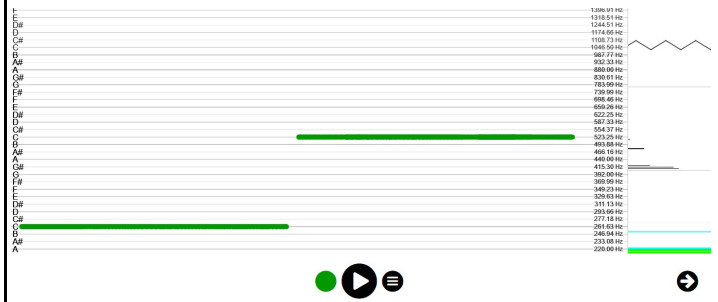
Title: “Let’s hear Thales’s theorem”

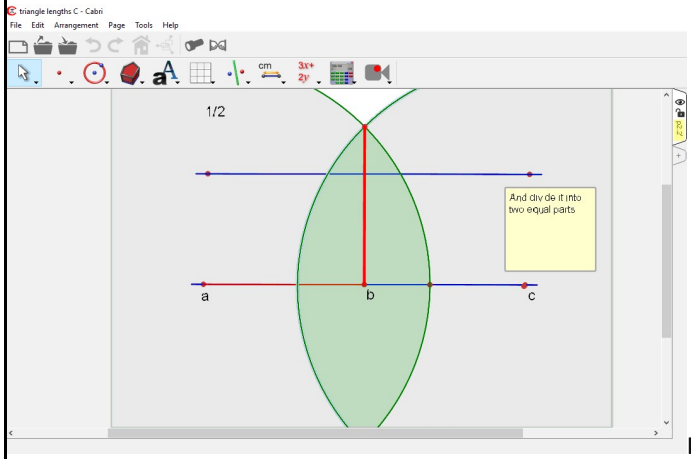
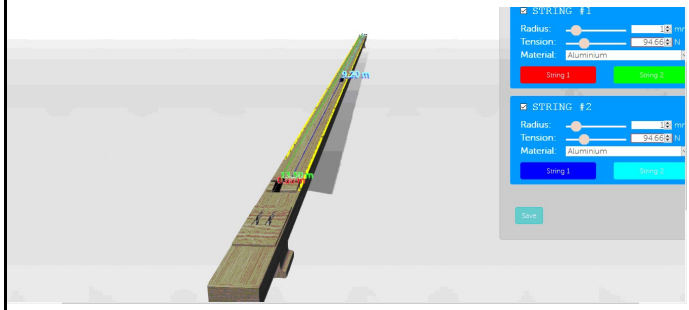
Description: Students use iMuSciCA to divide a string length (or membranophone area) in equal parts keeping tension (and radius in case of string) in constant value and then listen to its different corresponding lengths (or areas). They select a number of string-lengths (or surfaces) to form their own “scale” in a polychord (bichord, trichord, tetrachord, etc.), (or in more than one in case of membranophone). With the help of their music teacher, they use this scale to compose motifs (sets of notes) making brief rhythmical patterns. By altering the tension, students then experiment with new instruments, achieving the same frequencies used in their above scale. They compare their scientific results in table-format and perform the same composition with their new models.

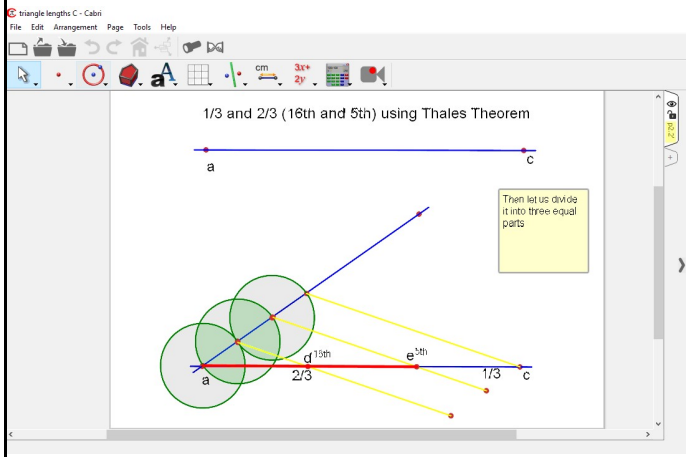
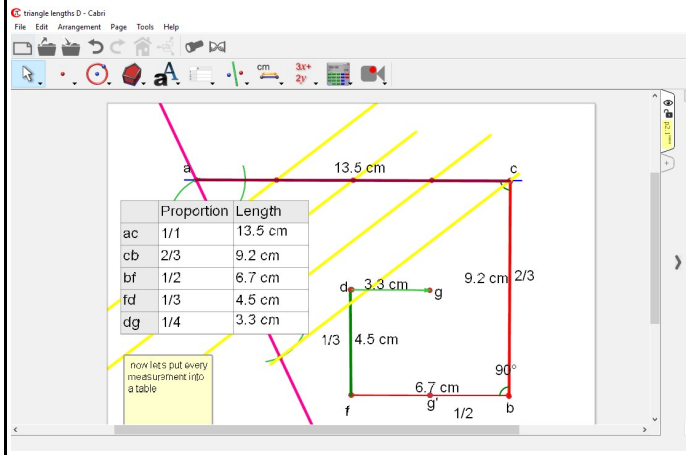
This ten-hours scenario requires that students have their own computer using iMuSciCA platform.

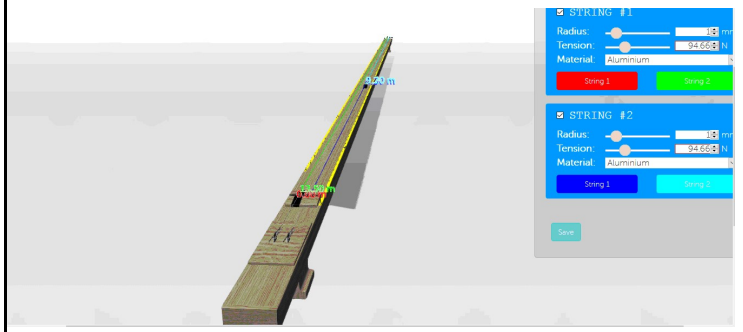
E: Engineering/Technology, S: Science/Mathematics, M: Music

Phases	Field	Time	Description	Activity	Remarks

Imagine	M	1	The musical octave	A music teacher introduces students to the idea of the musical octave using a real instrument (either a guitar, a xylophone, or a flute) Students play on the canvas producing senses of octaves. Teacher encourages students to experiment with octaves in different pitches. Lesson ends with students making a meaningful sequence of octaves. With the help of their teacher they compose an “octave melody” which is written in music notation. (Each octave is produced by one student)	 Image 1 UNIFRI canvas for playing octaves Students observe the relation between different pitches starting from different notes

Engage	S,M,E	1	Introduction to the segment bisection	Teacher introduces segment bisection. Students study bisection with their own string lengths. They measure the original segment and its half and then produce a bichord using the engineering environment.	 Image 2 Cabri express environment producing bisection  Image 3 Leopoly environment constructing the bichord

Engage	S	1	Thales' theorem	Teacher recalls the Thales Theorem and asks students to study the division of their own string lengths in 3, 4 and 5 parts. They express each segment in terms of proportions. They measure the lengths of each segment according to these proportions. Results appear on table.	 Image 4 CABRI express environment to produce the division  Image 5 Measurements on a table

Create	S, E	1	Thales' theorem in bichords A	Teacher introduces the idea of transforming students' segments into strings (uniform scaling is introduced at the teacher's discretion) Students apply measurements of segments as string lengths into a bichord.	 Image 6 LEOPOLY environment is used to produce the different string lengths. Multiple computers may be used to produce all strings Students use LEOPOLY environment to produce different string lengths. At this stage two computers may be used. Their corresponding String-lengths may be adjusted to agree with each other.

Reflect	S	1	Thales' theorem in bichords B	Students record the sound produced by the monochords and use the EK ATHINA analyzer to observe similarities between different pitches. Teacher helps students to observe relations between string frequencies, proportions and their respective lengths.	Use tables to verify and observe the similarities between different sounds and their acoustical proportion (e.g. if 1/1 is fundamental, then 1/2 should should be half the frequency. The same applies for its length.
Communicate	M	1	Thales' theorem in Music using bichords	Music teacher helps students compose the results in a meaningful manner	Using the sequencer teachers select a sequence of notes using combinations of bichords to produce sets. Then they record the results and listen to them.

Imagine	M	1	Can string tensions “play” the same results instead of lenghts? Teacher introduces the idea of producing string instruments that have the same pitches with the existing models but without altering lengths	Teacher introduces lengths in a real guitar having the students listen to their proportions (mainly octave). Students experiment with LEOPOLY environment making alternative string lengths resembling their octave in their own models.	Pitches are altered not by string-length but by tension

Create	S,E	1	Teacher encourages students to experiment with tension but keeping a “uniform” length. of strings	Students experiment with altering tension and write the results in a table until they match with the existing. Teacher helps students to understand that they need to quadruple (4x) tensions in order to produce octave results	Teacher and students use LEOPOLY environment to experiment with different tensions and WIRIS to make calculations. WIRIS environment can be used to produce a graph as well.

Reflect	S, M	1	Building the instruments and preparing for a concert Teacher encourages students to produce a final concert using selections of instruments (with tension and “natural” lengths	Students prepare the instruments built with string tension. Music teacher helps students select different strings in a meaningful musical sequence (sets of notes played by different computers). Students prepare presentations of their work and the final composition.	IRCAM snail help students observe the differences between the same pitch played with strings in tension and strings played in their “natural lengths” Students experiment and rehearse with the actuators 
Communicate	M.S	1	Final Presentation and Concert	Students present their work in groups and then perform their composition	-