Co-funded by the
Erasmus+ Programme
of the European Union

STEAM2GO PROJECT

Mobile makerspaces for promoting maker education in schools democratizing STEAM education and innovation development for all the learners

Erasmus+ KA2 2020-1-PL01-KA201-081698

Learning Scenario

Theremin “the sound creation”
proposed by IIS Leonardo da Vinci

Difficulty level: low
Reference age: from 16 to 18 years
Cost: currently quite low

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GRANT NUMBER: 2020-1-PL01-KA201-0816

Project title	Theremin “the sound creation”
Partners authors	IIS Leonardo da Vinci *Antonio Caserta & Renato Gatti*
Project abstract	Theremin is an electronic musical instrument, which does not involve physical contact of the performer with the instrument. It is based on oscillators which, working on frequencies outside the audible spectrum (here ultrasonic), produce sounds by altering their characteristics following the presence of the musician's hands in the sensors field. It is based on the physical principle of the “beat” which is then translated into the range of audible frequencies. Students begin with the study of the system and the devices to be used - through Internet research - and the definition of the block diagram. An in-depth analysis will be carried out on the logic diagram and on the various components and then move on to programming an Arduino board, connected to two proximity sensors that will control the frequency and intensity of the audible output sound.
Students’ age	From 16 to 18 (3rd to 5th grade of High School)
Educational goals	- search on the web of the functions and devices that can be used for the construction of a Theremin - identification of possible uses (e.g. music production, music therapy) - block diagram and description of the functions of each block - analysis of the parameters and functions to be controlled - two ultrasonic range sensors will be used in a program function to translate the distance to frequency and volume. - software development for the management of the ultrasonic and audio range oscillators by Arduino Boards - making a model of Theremin in paper, cardboard or wood (optional). - testing of a working prototype - creation of a technical sheet of the Theremin system and short summary of the results

Phases of the project	*Exploring* - Targeted research on the internet on how a theremin works, both in the original version and in the version illustrated in our project - Discuss how to realize the circuit using the materials provided by the Mobile Maker Space - Research on the internet about various programming software - Identify the possible uses of the proposed system (e.g. films, advertisements, cartoons, etc.)
	Identifying functional specification - Use the materials of the STEAM2GO Mobile Maker Space to make the prototype - Identify the main functional blocks of the system
	Creating and testing the prototype - Create the block diagram of the system - Make the interconnections between external devices (ultrasonic proximity sensor and loudspeaker) and Arduino - Build the program using Arduino making the Theremin works - Testing the working prototype
	Documenting and reflecting - Video and photos of the final product - In plenary: technical discussion regarding the critical issues and possible improvements of the project carried out.
Prerequisites	- Basic mathematical knowledge (solve simple equations, knowing how to understand and apply a formula) - Basic knowledge of combinatorial and sequential logic - Knowledge about the use of basic electronic components (resistors, LEDs, pushbuttons) - Basic use of the PC.

Outputs	- Photos of the circuit of Theremin - Paper/cardboard model of the Theremin made by the students. - Video showing the correct functioning of Theremin as the electronic instrument - Arduino source code
Total number of hours	8/16 hours (based on the students average level and the time spent in the preparatory phases)
Number of sessions	**4 to 8 sessions** (maximum duration: 2 hours) 1. Analysis of the system and its operating procedures 2. Design of the electrical musical instrument. 3. Interconnections between external devices and Arduino 4. Programming the Arduino and test it
The most relevant involved disciplines	- Mathematics - Technology - Electronics - Information Technology - Realization of artifacts related to a technical-scientific project
Hardware needed	Each group needs - 1 x Arduino uno or mega - 2 x Ultrasonic Sensor HC-SR04 - 1 x Solderless Breadboard Half Size - 1 or 2 Speaker: 0.25W 8Ohms - Jumper wires kit - Wiring cables kit (M/M and M/F)
Software needed	Each group needs - Arduino IDE - Access to Autodesk Thinkercad - Word/Excel - A drawing program
Crafting material needed	Each group needs 1 x some sheets of A4 size white paper or paperboard 1 x Cutter 1 x Scissor 1 x Glue 1 x Double-sided tape 1 x Pencil 1 x Pencil sharpener 1 x Some fine permanent markers of various colors 1 x stationery equipment like pencils, pens, paper sheets

Inclusive perspective	No changes are needed to carry on the project with special needs students because the system provides an immediate audio-visual feedback.
Supporting materials for the teachers	*The guideline for teachers:* https://drive.google.com/file/d/1-Xx9Jt6WYzsub6iEcsbjuuYVudPVYUVE/view?usp=share_link
	The folder with all the programs: https://drive.google.com/drive/folders/1Dps_LUY2dDcOXTO0j4B_HW8BNMAnj2cV?usp=share_link
	The folder with all the figures: https://drive.google.com/drive/folders/1jMIFRoyl3hY0Bh-5Bfjl2gUGiw99eICz?usp=share_link
	The folder with all the videos: https://drive.google.com/drive/folders/16yFmWo_WqZ2scNj4Z77yu1VBYalxfbCq?usp=share_link
	Worksheet for students https://steam2go.eu/?page_id=435
Alternative solutions and additional implementations	Alternative programming solutions (from simple to more advanced) are described in the teachers' guidelines.

Session # 1	- Analysis of the system and its operating procedures - Approaching and first analysis of the Arduino IDE - Reply to the related section of the worksheet
Cooperating model	The students work in groups of 3-4
Classroom setting	Classroom are equipped with - the STEAM2GO Mobile Makerspace - 1 table for each group (a worksheet is available in each table) - 1 chair for each student - Working stations with laptops or PC connected to the internet - 1 projector or interactive whiteboard
Time	Maximum 2 hours

Activities	1) The teacher describes the conceptual idea of the Theremin as an electronic musical instrument and lists the contents available for the STEAM2GO Mobile Makerspace (20 minutes) 2) The teacher creates the groups of students (10 minutes) 3) Research on the web by students of the general operation of the Theremin, its various forms and its possible uses (20 minutes) 4) The teacher briefly demonstrates the STEAM2GO mobile maker space and helps the groups to explore the available crafting material and tools (10 minutes) 5) The students discuss in groups and decide upon their model and the crafting material that they will use. (10 minutes) 6) Stimulating questions from the teacher for the plenary session: if the hand approaches or moves away from one of the sensors, what happens? If the hand approaches or moves away from the other sensor, what happens? If we wanted to represent the variation of the emitted frequency of the sound and its intensity in analogy with the visible spectrum how could we do it? (30 minutes) 7) The answers are brought in the plenary by one representative from each team (10 minutes) 8) Presentation of the posters or other material made by the groups. (10 minutes)
Outputs	Each group: - Creation of a poster with the Theremin tool that each group proposes (project on paper of the physical structure, poster and video of the model made of paper or cardboard) - Photo or video of the posters or other material made by the groups.
Extra-session	The teacher facilitates discretely the learning process and supports where needed.

Teacher's input	The teacher asks stimulating question to the students. If the hand approaches or moves away from one of the sensors, what happens? If the hand approaches or moves away from the other sensor, what happens? If we wanted to represent the variation of the emitted frequency of the sound and its intensity in analogy with the visible spectrum how could we do it?
Notes	The teacher helps students go through the different phases of the project, facilitating the learning process, encouraging students and ensuring that all the students have a role towards creating the final artefact

Session # 2	Design of an electrical musical instrument. *This session focuses on electrical circuit making*
Cooperating model	The students work in groups
Classroom setting	Classroom is equipped with - the STEAM2GO mobile makerspace - 1 table for each group (a worksheet is available in each table https://drive.google.com/file/d/1Ys_khi2k_AOaJyH5RigFll6xLGVJbj31/view?usp=share_link - working stations with laptops or PCs - 1 projector or interactive whiteboard (optionally for demonstrations)
Time	Maximum duration of session: 2 hour
Activities	1) The teacher introduces Arduino in the class and demonstrates electrical circuit making process through Tinkercad (if the students are not familiar) (40 minutes) 2) The students are encouraged, in teams, to select the electrical components from the mobile makerspace needed create the circuit (40 minutes) 3) The teacher checks the progress that has been made by going from group to group (20 minutes) 4) Experience sharing in the class and discussion about the next stages that will take place in session 3 (20 minutes)
Outputs	The students - Produce the electrical circuit - Create simulations in Tinkercad to test their circuit. - Test the circuit
Extra-session	Nothing to mention

Teacher's input	The teacher can raise questions to ensure that the students have understood how the circuit operates and what the different electrical components do.
Notes	The teacher acts as facilitator and co-maker.

Session # 3	Interconnections between external devices and Arduino *The focus is on finding the connections between external devices and Arduino*
Cooperating model	The students work in groups of 3 or 4.
Classroom setting	Classroom is equipped with - the STEAM2GO mobile makerspace - 1 table for each group (a worksheet is available in each table https://drive.google.com/file/d/1Ys_khi2k_AOaJyH5RigFll6xLGVJbj31/view?usp=share_link - working stations with laptops or PCs -1 projector or interactive whiteboard
Time	Maximum 2 hours
Activities	1) The teacher introduces proximity sensors in the class through simple examples and brief demos (60 minutes) 2) The students in teams will use Tinkercad and make experiments with the sensors and the Arduino code (60 mins.)
Outputs	The students will produce - Electrical artefacts with proximity sensors and Arduino
Extra-session	They can consider possible mechanisms for sharing the results/the project with a broader audience
Teacher's input	Question can be raised regarding 1) the overall experience and 2) ideas for extending and further personalizing the project
Notes	

Session # 4	Towards creating an interactive and functional model *The focus is placed on programming the model and creating a functional artefact.*
Cooperating model	The students work in groups of 3 or 4

Classroom setting	Classroom is equipped with - the STEAM2GO mobile makerspace - 1 table for each group (a worksheet is available in each table https://drive.google.com/file/d/1Ys_khi2k_AOaJyH5RigFll6xLGVJbj31/view?usp=share_link - working stations with laptops or PCs -1 projector or interactive whiteboard
Time	Maximum 2 hours
Activities	1) Realization of hardware interconnections between Arduino and external bread boards (60 minutes) 2) Creation of the code to program the Arduino board via IDE, which will control the frequency and intensity of the audible sound coming out of the instrument. (70 minutes)
Outputs	The students will produce - A completed - Theremin with ultrasonic proximity sensors, loudspeaker, multicolor LED and Arduino board
Extra-session	We can consider all the possible activities to share the the project and its results with a broader audience.
Teacher's input	Question can be raised regarding 1) the overall experience and 2) ideas for extending and further personalizing the project
Notes	