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Unit Introduction

Overview

Grade Level/Band: Middle School Technology, Engineering or Computer Science Classrooms

Summary

This unit is a STEAM-focused introduction to the use of interactive microcontroller systems. Students will learn to use and code Microbits and construct and play a paper piano using a Microbit.

STEAM Integration

This lesson integrates computer science, technology, engineering, and music. Students will go through the process of building a paper piano using a Microbit controller (engineering). They will use their understanding of the binary matrix to develop a pattern to create code for seven piano keys (technology and computer science). Through creating this code for the piano keys, they are learning the notes on the piano, understanding scales, and major/minor keys. The teacher can extend this lesson to challenge the students to compose a song using the Paper Piano or play a composition on their pianos.

Instructional Method

This lesson is rooted in Problem-Based Learning, however due to some of the technical components of this lesson, students are provided with instruction sheets. If students and teachers have experience with MicroBits and coding, they may allow for more design and exploration.

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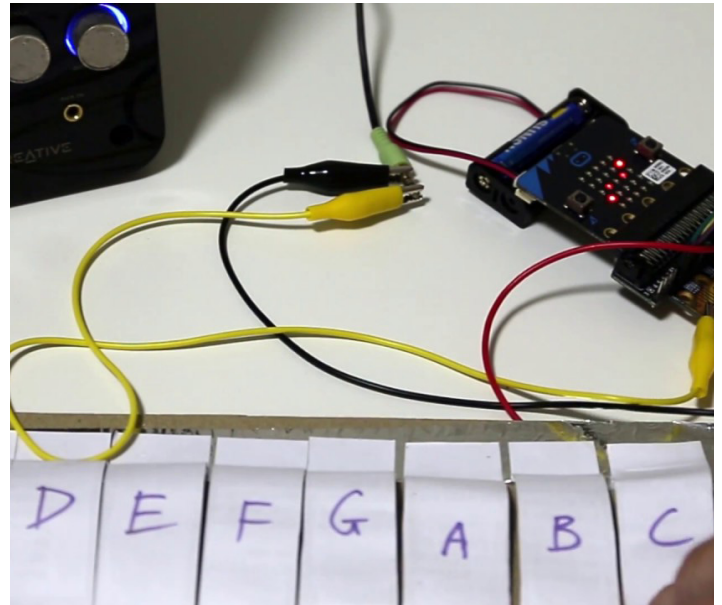
Investigation/Activity #1

Overview

Lesson Overview

Get ready for your students to learn coding and music through the creation of paper piano using a MicroBit. After engaging in highly technical work through the construction of a paper piano and writing code for seven keys—they will have the opportunity to perform on their newly designed instrument.

Time Required: 5 - 6 class periods (This includes additional tutorials on microbits, if your students have more experience in Microbits, it may take less time)

Learning Goals

STEM Learning Goals
- To use conditional statements to control the actions of code
- To control the output of a device using input from a user
- To write code that reflects the relationship between an input and multiple outputs
- To determine the amount of outputs possible from a given number of inputs based on binary numbers

Arts Learning Goals
- To explore the interrelated principles between music and computer science
- To create and share melodies and rhythmic phrases using digital tools

Standards

Priority Standards - STEM

- MS-CS-FCP-2.3: demonstrate an understanding of the fundamental concepts for how computers process programming commands (hex, binary, sequence of commands, conditionals, loops)
- MS-CS-FCP-3: utilize computational thinking to solve problems
- MS-CS-FCP-4: design, develop, debug, and implement computer programs
- 4.2: utilize the design process to brainstorm, implement, test, and revise an idea
- 4.6: develop an event driven program
- 4.7: create a program that accepts user and/or sensor input and stores the result in a variable
- 4.9: develop a program that makes a decision based on data or user input
- 4.10: debug a program with an error
- MS-CS-FCP-5: explore the relationship between computer hardware and software
- 5.4: create a product that analyzes how simple computer hardware can be used to develop innovative new products that interact with the physical world

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Priority Standards - Arts

- MSGM.CN.1 Connect music to the other fine arts and disciplines outside the arts.
- Recognize the interrelated principles between music and other subject areas.
- MSMA.CR.2 Improvise melodies, variations, and accompaniments.
- Create melodic and rhythmic phrases from a variety of available sound sources (e.g. traditional/nontraditional instruments).
- MSMA.CN.1 Understand relationships between music, the other arts, and disciplines outside the arts.
- Describe ways in which other disciplines taught in the school are interrelated with those of music.
- MSMT.CR.1 Generate musical ideas for various purposes and contexts.
- Generate melodic, rhythmic, and harmonic ideas for compositions or improvisations using digital tools

Supporting Standards - STEM

- MS-CS-FCP-6 Create digital artifacts to address a current issue requiring resolution.
- 6.4 Develop a program for creative expression or to satisfy personal curiosity which may have visual, audible, and/or tactile results.

Supporting Standards - Arts

- MSGM.CR.1 Improvise melodies, variations, and accompaniments.
- Improvise simple rhythmic and melodic variations.
- MSGM6.CR.2 Compose and arrange music within specified guidelines.
- Compose short pieces within specified guidelines.
- Use a variety of traditional and nontraditional sound sources and digital tools when composing and arranging.
- MSMT.CR.2 Select and develop musical ideas for defined purposes and contexts.
- Select melodic, rhythmic, and harmonic ideas to develop into a larger work using digital tools and resources.
- MSMT.CR.4 Share creative musical work that conveys intent, demonstrates craftsmanship, and exhibits originality.
- Share musical work (e.g. sound design, mixed-media project, composition, improvisation) that demonstrates a proficient level of musical and technological craftsmanship, and the use of digital tools and resources in developing and organizing musical ideas

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Anticipated Measureable Outcomes

Students will be able to:
- Use conditional statements to control the actions of code.
- Control the output of a device using input from a user.
- Write code that reflected the relationship between an input and multiple outputs
- Determine the amount of outputs possible from a given number of inputs based on binary numbers
- Understand the basic notes on a piano and how numbers in the binary matrix correspond to those notes.
- Compose and play a simple song using the paper piano.

Nature of Integration

This activity will be implemented in a technology, engineering, or computer science (STEM) classroom as a core activity. It can be connected to a music classroom and students can use and apply their pianos to compose and perform music. Music teachers may want to collaborate will a technology or engineering teacher to complete this activity

Background

Art Background Information for Teacher

A STEM teacher needs to know the basic C-Scale on a piano. https://piano-music-theory.com/2016/05/31/c-major-scale/

A basic understanding of the notes on a piano would be helpful to give the students a deeper understanding of the design and code for the seven keys on the basic paper piano. If the teacher wanted to dive deeper into the lesson—they can learn about major/minor keys and how to compose basic songs on the piano.

Here are links to some resources on the basic piano notes:

Piano Keyboard notes: http://www.piano-keyboard-guide.com/piano-notes.html

Basic Song composition activities: https://www.myfunpianostudio.com/piano-improv/piano-composition-for-beginners/

STEM Background Information for Teacher

An arts teacher would need an understanding of MicroBit programming and basic circuitry.

The MicroBit website has great resources for getting started with MicroBit technology in your classroom: https://microbit.org/get-started/first-steps/introduction/

Tutorials for MicroBit Practice: https://makecode.microbit.org/tutorials

Coding using MicroBit: https://ryanstutorials.net/microbit-tutorial/

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Preparation

Materials and Supplies

Each participating student will need:

- Computer
- [MicroBit](#) (includes cables and battery pack)
- [Wires and alligator clips](#)
- 2 pieces of cardstock
- 1 sheet of aluminum foil

- Pencil
- Ruler
- Glue stick
- scissors
- headphones (not wireless)

If you are teaching this in multiple classes, you can reuse the microbit, wires and alligator clips, rulers, glue, scissors with each class. You will need to have new cardstock and aluminum foil for each student. *For virtual classes, we recommend sending these materials home as a kit.*

Advanced Preparations Needed

Teacher should review this PowerPoint prior to implementing lesson: https://docs.google.com/presentation/d/1O21yUIsUAphKRhjr4pBUU6k09qyWWmv4R3xXCuTiD9A/edit#slide=id.g80a8f03cee_0_0

If students haven't already been introduced to MicroBit, start off with a couple classes dedicated to getting them familiar with the parts and coding environment.

Here are some fun tutorials for students to try to get started with mircobit: Tutorials for Microbit Practice: https://makecode.microbit.org/tutorials

It is important for the teacher to become familiar with MicroBits for this lesson. We would recommend that the teacher construct a sample Paper Piano prior to implementing the lesson with their students. It will be important to have a model for the students to view. It will allow the teacher to provide troubleshooting advice.

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Activity

Engage

Students

- Introduce the students the idea of designing their own instruments using coding and hardware.
- Introduce the Guthman Competition
  - The Guthman Competition is like the Shark Tank or "X-Prize for Music and is the one of the top competiitons for music technologists. The featured instruments are a mix of digital and traditional performances that transform how we perform and experience music. Artists are challenged to invent the next greatest instrument while applying their knowledge of science, math, technology, engineering, and music to the process. They are also challenged to think about how the instrument can solve a problem or reach new audiences.
  - Students should click on the Gallery of the Guthman Competition: There are 29 instruments. Students should click on 3-5 videos of the instruments. They should read the side panel and view a description of the instrument, read about the most unique engineering element, and most unique music element of the instrument. They should take notes about each instrument and share the notes with a partner.

Teachers

- If you made a sample paper piano, model it for the class and ask students if they have ever designed their own instrument. What type of instrument did you design? How did you design your instrument? Have you ever thought about designing your own instrument? What type of instrument would you design? Teachers
- Introduce Guthman Competition (See above for description)
- Ask students to go to the Guthman Gallery : https://guthman.gatech.edu/gallery   and view 3-5 videos of the instruments
- They should record in their notebooks a description of the instrument, engineering and music components of the instrument, and the purpose of the instrument. They should share this information with a partner or the class.
- Tell students that they will now how have the opportunity to design and create their own piano.

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Explore #1

Students

- How can you design your own instrument?
- How can you use coding and hardware such as a MicroBit to design an instrument?
- Introduce MicroBit activity - https://microbit.org/get-started/first-steps/introduction/
- Students do an initial independent exploration of the MicroBits
- Microbit Exploration: https://drive.google.com/drive/u/1/folders/1RV-w62GYiX9X3KILM8v0j7dx-MgKtnTRg

Teachers

- Review instructions for introductory MicroBit Activity
- Allow students to explore MicroBits

Explain #1

Students

- Students review basic microbit activities
- Students complete facilitated tutorials: https

Teachers
- Teacher facilitates tutorials on Microbits to ensure understanding

Explore #2

Students

• Each group of students is given a set of initial parts (a piece of cardstock, foil, scissors, a glue stick, and a ruler) to start piano construction

• Students will follow a loose set of instructions in order to construct the piano

• Along the way, students will fill out tables to convert the 7 keys into a binary matrix and code

• Students use a microbit to connect the piano and speaker/headphones together

• Click on this Google Link for instructions to construct the paper piano: https://docs.google.com/document/d/1XgbGlC-i6Amn_P6YVftgwCcCiSg7sHiCZ2O1cI_SB4Y/edit?usp=sharing

• Use this worksheet to fill out the binary tables: https://drive.google.com/drive/u/1/folders/1RV-w62GYiX9X3KILM8v0j7dxMgKtnTRg

Teachers

• Distribute materials and remind students of the proper procedure for connecting wires to the MicroBit

• Make sure students are coming to the correct conclusions when filling out their binary tables

Explain #2

Students

• Using their understanding of the binary matrix, students will develop the pattern on the piano wires to allow the use of 7 keys

• Students explain how the pattern they've found allows the 3 inputs of the microbit to read 7 different notes

• Students will use knowledge of how to code one key to work in tandem with their understanding of the binary table to create code that makes all 7 keys work

Teachers

• Walk students through the first part of the code - getting one key to work

• Facilitate discussion on patterns in code and how they can adapt what they already know to fit other use cases

• Here is the link for the code: https://makecode.microbit.org/v0/03107-69090-41198-50535

Elaborate

Students
- Students will identify errors in their wiring or piano construction through testing
- Students can additionally expand the project to include the use of the two buttons on the microbit - potential functions such as changing the key and switching between major and minor

Teachers
- Facilitate discussion on why we use binary for the piano vs individually connecting each key to an input
- Discuss different methods of input that students can use with the microbit to modify how the piano works
- Discuss potential ways to make the piano's circuit or code more efficient

Evaluate

Formative:
- Binary to note table
- Note to code table
- Project reflection

Summative:
- Finished piano + code
- Essay Questions:
    - How this paper piano make learning music/playing a piano more accessible to students?
    - What other instruments could odesign using this process? How would you expand your paper piano to create the "next" great instrument?