

# 0+1=SOM: Bringing Computing Closer to Children Through Music

Nuno Hespanhol  
Digitópia Casa da Música  
Rua Faria Guimarães, 742 Porto  
nuno.hespanhol@gmail.com

Óscar Rodrigues  
Digitópia Casa da Música  
Av. Vasco da Gama, 755 Sra da Hora  
oscarmsrodrigues@gmail.com

José Alberto Gomes  
Digitópia Casa da Música  
Rua Oliveira Monteiro, 40 Porto  
j@jasg.net

## ABSTRACT

0 + 1 = SOM is a project developed by Digitópia - Casa da Música in cooperation with Braga Media Arts. In this project we developed a series of online tools that use technology and basic mathematical and logical concepts, such as counting and understanding a loop or an if condition, to create music. These tools were later used in a series of four workshops with elementary school children as a creative activity that complements the classroom. This paper describes the process and reasoning behind the creation of the tools (explaining our choices when creating the contents), the role Web Audio played in it (particularly in the ability to schedule precise audio events), the results we have achieved so far, and the feedback we have had from students and teachers. We also discuss further applications and plans for the future.

**Keywords:** music, music education, elementary education, composition, mathematics.

## 1. INTRODUCTION

0+1=SOM,<sup>1 2</sup> a project developed by Digitópia Casa da Música for Braga Media Arts, consists of a series of workshops held in a school context. Its aim is to expose students (6-10 years old) to new technologies applied to art, and it has resulted in the development of original music creation software, and in games created and designed by our team and the students themselves.

Some of the most interesting recent developments in music are related to the fact that ordinary computers and mobile devices acquired capabilities to make, record, store and spread music, while becoming available to a greater number of people. An "active relationship" with music is nowadays within the reach of people who did not go through the process of formal musical education.



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<sup>1</sup> You can find all resources at <https://01som.casadamusica.com>. The code is released under GPLv3 license and can be found on <https://github.com/Digitopia/01som>.

<sup>2</sup> "SOM" is portuguese for "Sound".

This is related to the increasing number of software applications that allow creating and making music in an intuitive manner, ranging from Digital Audio Workstations, such as GarageBand, to specialized mobile applications, like Loopimal. We are thus witnessing a true worldwide revolution in the way we create, perform, spread, listen and learn music.

Digitópia,<sup>3</sup> a part of Casa da Música's education department, aims to explore these surges of development:

- 1) to develop music and creativity in people from a wide range of ages and social environments, especially among children;
- 2) to foster the development of free music software;
- 3) to promote free and open source musical content;
- 4) to encourage social inclusion, and lead to the emergence of multicultural communities of music makers/lovers.

It was in this context that the willingness to create a broader and more sustained program for children (6 - 10 years old), where we could connect new technologies and mathematical thinking to art, began to take shape. The opportunity arose when Braga<sup>4</sup> was selected as the UNESCO Creative City for the field of Media Arts,<sup>5</sup> thus resulting in a partnership and in funding.

0+1=SOM was put into practice in 2017 in three public schools, with very good results. We are now in the second year of application through workshops in nine (different) public schools, reaching close to 1200 children in total.

## 2. DEVELOPING TOOLS

For a multitude of reasons, but specifically because the target audience of this project were students aged 6 - 10, we did not want to assume that a mobile device would be needed in order to use the apps. On the other hand, to suppose an access to a browser in a desktop computer seemed fair, since most classrooms have a computer and an interactive board.

<sup>3</sup> Our website is <https://digitopia.casadamusica.com/>.

<sup>4</sup> Braga is a city and a municipality in the northwest of Portugal. It is the third-largest urban centre in Portugal (after Lisbon and Oporto).

<sup>5</sup> You can learn more about Braga Media Arts at <http://www.bragamediaarts.com/en/braga-and-media-arts/>.

Also, since internet connectivity is often limited in portuguese classrooms, and sometimes even non existent, it would be necessary that all apps would be able to work offline.

In other words, the main technological requirements for the website supporting this project were:

- only a browser should be needed to access it, to ensure it is cross-platform by default;
- it should be possible to download/install the apps, so that they could be used offline.

With previous projects,<sup>6</sup> we recurred to the openFrameworks<sup>7</sup> library to develop multi-platform native applications. However, this approach posed a number of problems to us in the past,<sup>8</sup> and so we were keen to experiment with web technologies. Furthermore, with the advent of the Web Audio API, it is now possible to handle precise scheduling of audio [5], which would be needed for the apps we intended on developing, as the rhythmic aspect is, as we will see, crucial. So, for this project, we made use of the Tone.js<sup>9</sup> audio framework. For the graphics, we used Adobe’s Snap.svg<sup>10</sup> library. Also, in some specific cases the p5.js<sup>11</sup> library was used.

For the offline capabilities, we use the Service Workers API<sup>12</sup> that caches all necessary resources so that it doesn’t have to rely on the network. We also make each separate app a different Progressive Web App<sup>13</sup> that can be installed, placed on the homescreen and be launched in full screen, thus providing a native-like app experience.

## 2.1 Rhythm and Counting

The aforementioned Web Audio API’s ability for precise audio scheduling provided the technical cornerstone for developing apps exploring one of music’s most fundamental dimensions: rhythm. Besides being essential in music pedagogy (see, for an example, Dalcroze’s Eurhythmics [6]), the rhythmic dimension of music is also deeply grounded on an elementary mathematical basis and it involves counting and time-awareness skills, all of which are a part of the elementary education *curriculum*, our target audience. So the first app created - called *rhythm* - was a circle with eight small dots which allowed the users to create a simple *loop* using colors, with a body percussion sound associated to each one - foot stomp for blue, clap for green and finger snap for red.

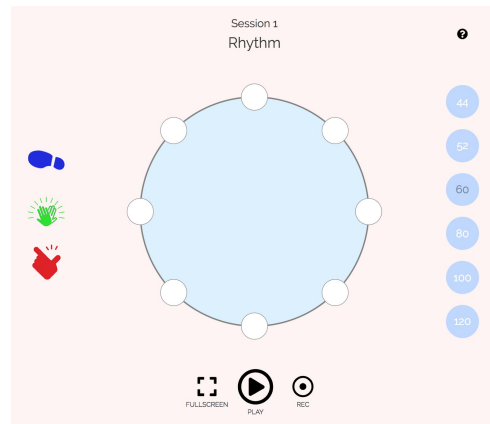


Figure 1. Interface for Session 1 (Rhythm)

This circle allows users (students) to compose their own musical phrase using these sounds, interacting and improvising with the help of the website. They also have the ability to change tempo, using a fixed list of BPM values (44, 52, 60, 80, 100, and 120 - we found it important to restrict these values at this early stage, so as not to draw attention to minute tempo differences, but rather focusing on the rhythm), and record their own phrase in a .wav file, for sharing or incorporating in other projects.

The values for each sound are also converted to a binary string, such as 1 0 1 0 1 1 0 0, where 1 means play and 0 means silence. This concept was further developed on the notation website, used as an extra (and called “Session 5”) where students associate 1 to an eighth note, and 0 to a rest, serving as a way to introduce musical notation on the elementary school.

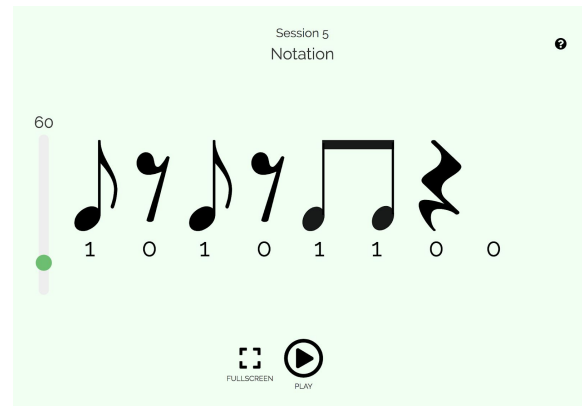


Figure 2. Interface for Session 5 (Extra - Notation)

Again, they have the ability to set their own tempo, this time using a slider, which allows them to be more precise and choose any value between 40 and 160, as this tool is used when students are already familiar with BPM values. Although these tools may seem somewhat basic, we have found them to have a very good balance between difficulty and interest for kids aged 6 - 10. From a programming point of view, there’s always room for adding features - such as changing the number of points in the circle, or the array’s length - but we have chosen not to do that since it adds a layer of complexity that could distract them from the main goal - to produce a musical phrase that sounds good using three colors and sounds or an on/off switch (that is, the zeros and ones on the

<sup>6</sup> See <https://digitopia.casadamusica.com/portophone-app> and <https://digitopia.casadamusica.com/Gamult>.

<sup>7</sup> Available at <http://openframeworks.cc>

<sup>8</sup> As a small team, the development cycle for both Android and iOS proves to be a challenge

<sup>9</sup> Available at <https://tonejs.github.io/>

<sup>10</sup> Available at <http://snapsvg.io>

<sup>11</sup> Available at <https://p5js.org>

<sup>12</sup> [https://developer.mozilla.org/en-US/docs/Web/API/Service\\_Worker\\_API](https://developer.mozilla.org/en-US/docs/Web/API/Service_Worker_API)

<sup>13</sup> <https://developers.google.com/web/progressive-web-apps/>

notation website). For them to be successful at this task, they need to handle some key skills in technology and computing that could be further developed in programming, such as counting, being aware of the loop, the basis of an if/then logic (i. e. if blue play feet, else if green clap), and controlling elements interactively. We try to stimulate these skills by providing them with these tools, games and activities.

## 2.2 Melodies and Songs

Further developments of the percussive websites are those where users can also use pitches, expanding on their previous experience by using the same principles with musical notes. For this we have chosen the pentatonic scale, due to its harmonic potential and the fact that it has few dissonances, and the ability to produce intuitive and easy to sing melodies (the use of the pentatonic scale for composing and improvising in early ages has been advocated by many musical pedagogues, perhaps the most notable being Kodály [7]).

Here we are inviting users to create (and share) their own tunes and to begin having a sense of pitch awareness - playing with musical tones of different pitches to create melodies.

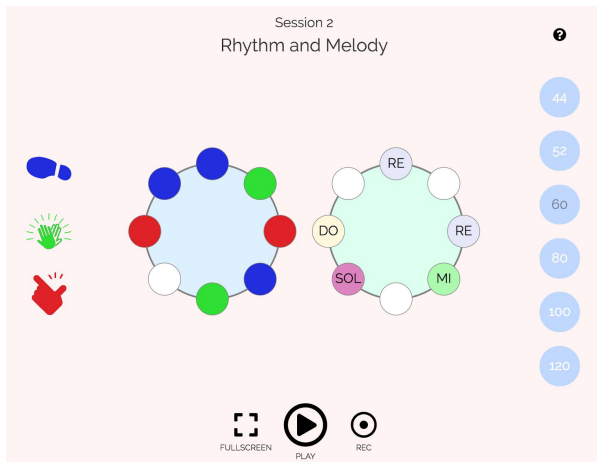


Figure 3. Interface for Session 2 (Rhythm and Melody)

A third website, called *sequencer* allows them to use and explore musical form. They can create, for each of the circles (that is, the percussive and the melodic ones), three different musical phrases, combining and alternating between them, creating more complex songs with a sense of structure that they can later record and share.

The fourth website, called *song*, allows users to create a song based on sequencing musical instruments (short musical phrases that were pre-recorded). The goal is for students to explore different instruments and the role they play in a song, combining them in multiple ways and creating a sense of form and progression with a logic of on/off. They can also participate in the song, recording a one-bar bit of sound, such as their name or a simple melody or rhythm. This is due to Web Audio's ability to use the browser to record, save and process sound, using the device's built in microphone.

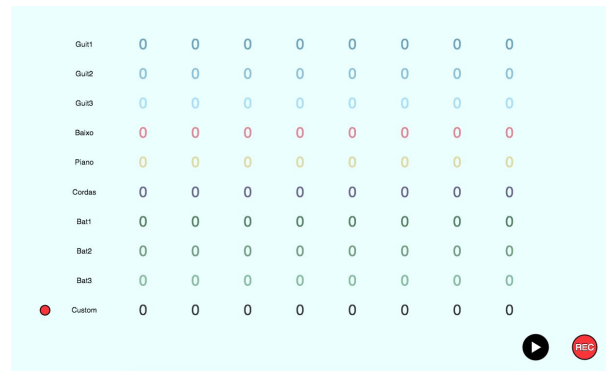


Figure 4. Interface for Session 4 (Song)

## 3. WORKSHOPS

These tools have been used in the classroom, by our team, with a total of around 1200 students aged 6 – 10, from the Braga Municipality in Portugal, from 12 schools, ranging from the city center to the outskirts. Each class (from the 1st, 2nd, 3rd and 4th grades) had a total of four different sessions, each one with a specific program. So, in the last year, the practical side of the 0 + 1 = SOM project had 192 sessions in total.



Figure 5. A session happening in a classroom

Parallel to the websites, we developed a series of games, that were used during the warm-up part of each workshop, aimed at stimulating the skills we would later need. Examples include:

1. The Robot Game, where we have a student playing a robot, another playing controller, and everyone else serving as an obstacle, with the goal of making the robot leave the room through the door, using a set of only four instructions: walk, stop, turn left and turn right;
2. The Numbers Game, where the class has to count to eight collectively, but only one (unknown - could be anyone) student could say one number at a time. If two or more people say the same number, everyone loses the game and we have to start over. The goal is to focus and to listen to everyone;

3. The Raft Game, where we simulate that we are on a raft drifting in the ocean, and have to follow the captain's orders, ranging from simple to complex;
4. The If-Then-Else Game, where one person shouts an if, then... else statement for the class to complete, such as "if you are wearing jeans, clap your hands, else dance macarena".

The main focus of the first sessions was to introduce the counting system, and for students to clearly understand what a loop is, using real word examples such as seasons, days of the week, or months, and how a computer works - it follows your orders scrupulously, as experienced in the Robot Game. We finish by giving the students a task to create four different rhythmic patterns and memorize the last one. They have to write it down on a sheet of paper (copying what's on the website) and then hand it to us on the second session.

The goal of the second session is to listen and introduce pitch awareness (so the Numbers Game was used). We play them back the rhythms they composed and previously wrote on the paper, and they have to identify their own. We are always surprised because nearly everyone is able to do so. We later sing the notes from the pentatonic scale, introduce the melody-making website and assign the task of creating four melodies and memorizing the last one.

On the third session the focus is following instructions and creating form. During the warm-up we use the Raft Game. We sing them back their melodies for them to identify (again, nearly everyone is able to do it) and end the session with musical exercises and assigning the task of creating lyrics for their own melodies.

On the last session we focus on creating a short performance of a piece written collectively, using the lyrics, melodies and rhythms that we worked on before, and introduce musical instruments such as percussion instruments, synthesizers, keyboards and iPads. We end the project by singing and performing the piece we created.

In each of the workshops we use tablets (a set of three iPads) connected to the speakers and, in most cases, a projector. It is equally important to us to set everything in the classroom so that they can continue to use our website (and others) afterwards, which proves to be somewhat challenging - most schools aren't very well equipped with computers, technical equipment and good quality internet connections.

## 4. CONCLUSION

0+1=SOM is a project that combines web development with the practical application of the tools in the classroom, by a team of two musicians with some background in programming. It is an example of a cross-disciplinary project that aims to expand both the scope of the classroom materials and the range of the websites, from the virtual world to real world contexts.

## 5. ACKNOWLEDGEMENTS

0 + 1 = SOM wouldn't be possible without the support of Casa da Música's educational department (and it's director, Jorge Prendas), which gave us, throughout the years, the pedagogical and workshop leading skills necessary to do the project in so many different contexts and realities. The support from Braga's City Hall (Câmara Municipal de Braga<sup>14</sup>), particularly from Maria Tavares, was also key, and gave us the conditions to apply these tools on the terrain, as was the involvement from Braga Media Arts.

Our team also includes a very valuable member, not part of this paper, Tiago Oliveira, who is, aside Óscar Rodrigues, part of the educational team that works in schools, which is critical for the state of constant evaluation, update and future developments of the project.

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