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Designing an App for Teaching Music to Children with Autism: a Preliminary Study

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Designing an App for Teaching Music to Children with Autism: a Preliminary Study.

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Abstract

Autism is a developmental disorder which has been growing more and more common worldwide during the latest years. According to recent research, autism affects about 1 in 54 children in the US and 1 in 89 children aged 7-9 years in Europe. In this scenario, including autistic students in primary and secondary schools has become an important challenge for both teachers and parents. Music classes have been proved to be a valid means to improve communication and social skills in children with autism, provided that lessons are tailored on the specific needs of each student. In this paper we discuss the principles behind and the challenges posed by the design and development of a mobile application whose goal is to support inclusive music teaching to children with autism. Functional requirements will be described and justified as well as the technical choices we adopted. Finally, a prototype of the application will be presented.

1 Introduction

Autism is the most common condition in a group of developmental disorders known as the autism spectrum disorders (ASDs). It has become very common during the latest years in all countries where prevalence studies have been conducted. Possible reasons of this trend are the increased awareness of autism among health care professionals and parents and the development of early detection criteria, while the role of environmental factors is still a subject of research [4].

Children with autism typically have problems with expressive and receptive language, especially in social contexts, since they are usually unable to recognize others' thoughts, feelings, and perspectives as different from their own [6].Other symptoms include: restricted, repetitive patterns of behavior, interests, or activities, problems following simple directions, difficulty dealing with changes in environment, poor coordination, "self-stimulatory" behaviors, such as spinning, hand flapping, head banging.

Autism and ASD affect children regardless of cultures, financial and educational levels, and geographical areas. [1]. According to recent research, autism affects about 1 in 54 children in the US and 1 in 89 children aged 7-9 years in Europe [2][3].

In this scenario, the issue of including autistic students in primary and secondary schools has become an important challenge for teachers and parents. Actually, autistic children can learn and make developmental gains in many areas of functioning when provided with appropriate educational support and treatment [5]. Such support, anyway, must be tailored on the special needs of each student in the autism spectrum; albeit all students with autism have some sort of difficulty with communication and social skills, ASD symptoms may be present in a wide combination of behaviors and levels of severity, and the range of abilities and degree of developmental delay are unique to each child. Some students with autism are nonverbal, while others may be highly verbal but with language misinterpretation

problems. Many children with autism may present mental retardation, which is not the case of children with Asperger's syndrome, that on the contrary may have above-average intellectual abilities [7].

Music has become a widely used tool in autism therapy. Therapists and teachers can use songs and musical instruments to support cognitive activity in order to build self-awareness and improve relationships with others. Musical activities may improve communication and interaction skills, provided that music classes are inclusive and delivered in a structured, predictable and consistent way [6]. It is important that students with autism are not isolated from their peers without disabilities, which can provide models of appropriate behavior and appropriate social interaction. Learning to play an instrument through an inclusive music program may be the first step towards interaction with others, when music will be played together with the other classmates [8].

This paper describes the issues and challenges posed by the design and development of a mobile application whose purpose is to help secondary school students in the autistic spectrum learn the basic notions of musical theory.

2 Functional Requirements

The goal of the application was to provide students with the basics of music learning, i.e. the concepts of notes and their duration. In order to make it easy for the students to practice not only in the classroom, but also from home or wherever they preferred, it was decided that the application should have run on a mobile platform. Given the peculiarities of children with autism, graphical user interfaces (GUIs) and interaction methods were required to be as simple and straightforward as possible, in order to avoid distractions. Audio and visual reinforcement cues and rewards should have been present, provided that they were unobtrusive. In order to guarantee inclusiveness during the music classes, training modules should have been structured in such a way that they could be effectively used by both students with autism and their other peers. Therefore, a customization layer would have been needed to tailor exercises depending on the specific needs of each student.

3 Technical Challenges

A survey of the marketplace with regards to musical mobile applications shows a clear predominance of iOS over Android. The latter offers in fact only a limited support for the Musical Instrument Digital Interface (MIDI), the protocol which is used to transmit real time information for the playback of a piece of music. As Android's official site states [9], "The USB host mode APIs permit developers to implement MIDI over USB at the application level, but until recently there have been no built-in platform APIs for MIDI"; this means that a native Android app can control via USB a MIDI device such as an electronic keyboard, but it does not allow to autonomously reproduce or compose music. In order to overcome this obstacle, we decided to adopt modern web technologies. HTML5 and the Web Audio API offer the possibility to develop web applications for processing and synthesizing audio

directly in the browser, as if they were desktop ones [10]. Many advanced JavaScript libraries exist which are built on top of the Web Audio API and allow to develop interactive music by exploiting the browser's engine. Our idea was to exploit these libraries in order to develop a responsive web app, capable of running on any mobile device, be it Android or iOS, provided that is supported an up-to-date version of Chrome (actually, a version greater than or equal to 34.0.1847, released in April 2014 would suffice). In our case, choosing a web application simplified also the software architecture, since it made straightforward to conceive a two-layered software with a "control" layer (accessible to teachers only) to manage the customization of the training programs, and a "client" layer (accessible to students) containing the customized exercises (see Figure 1).

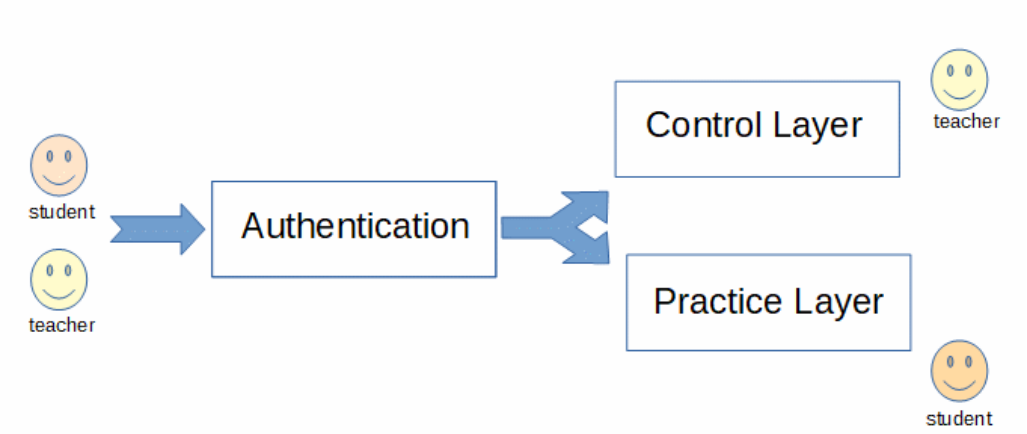

Figure 1: The authentication mechanism and the two logical layers of the application.

Music lessons for children are typically taught via simple keyboard instruments. It was therefore decided that the GUIs of our application simulated an electronic keyboard integrated with interactive features to support the learning of duration and notes. In particular, it was decided to integrate the keyboard with a stave to indicate the symbol of the note to be recognized and an animated progress bar if duration has to be indicated. To accomplish these requirements, the following frameworks based on HTML5, JavaScript and the Web Audio API were adopted:

- NexusUI: a complete framework which allows to build responsive GUIs that simulate musical instruments on the browser. Besides graphical widgets, it provides developers with useful tuning and timing capabilities that make it possible to build realistic musical experiences. It does not allow to reproduce music.

- Tone.js: a framework for creating and reproducing music interactively in the browser. It provides advanced scheduling capabilities, synths and effects, and intuitive musical abstractions built on top of the Web Audio API [12].

- Vexflow: a JavaScript library which exploits Scalable Vector Graphics (SVG) in order to render musical scores and notations (i.e. musical symbols and their position on the stave)[13]

4 The Prototype

According to the functional requirements presented in Section 2, a prototype for the application was developed. Two training modules were identified, and a control section to configure them. The training modules comprised, respectively, exercises for teaching how to recognize musical notes depending on their names and positions on the stave, and exercises through which students would learn the concepts of duration and pause.

4.1 The Control Section

Figure 2 shows a screenshot of one GUI of the Control Section.

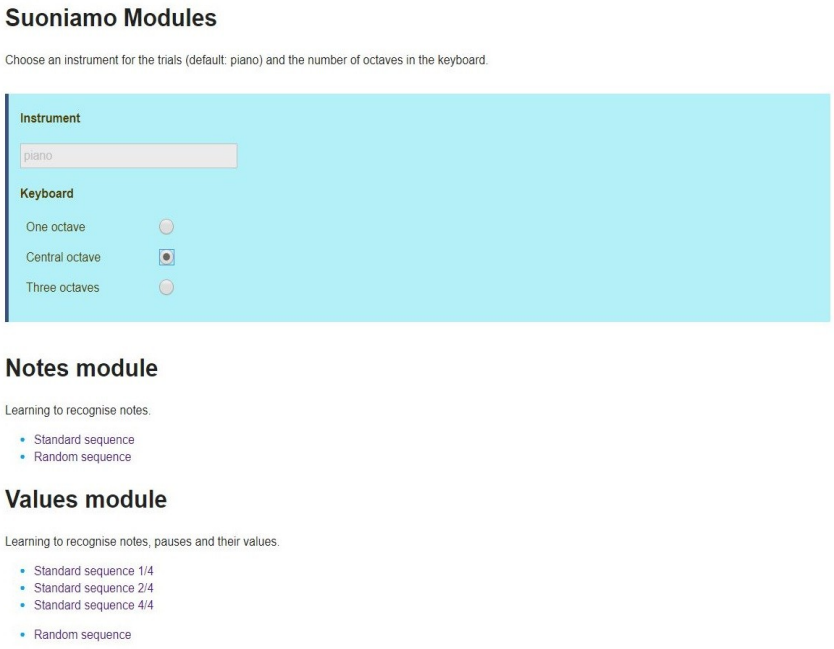

Figure 2: A control GUI to set parameters for practicing sequences

Depending on a student's learning level or individual skills, it is possible to program exercises on the standard sequence of notes, or on a random sequence. It is also possible to choose between three different versions of the virtual keyboard used for the exercises: the keyboard can be formed by a single

octave, three octaves or the central octave surrounded by some keys of the upper and lower ones. Colors associated to the notes can be customized, as well as the notes denomination (Italian or English); it can also be decided whether all of the keys in the keyboard should be colored or only the ones to practice on. Hints showing the names of the notes can be provided in the upper portion of the keyboard. In Figure 3 an “advanced” three-octave virtual keyboard is shown, where the central octave is highlighted with one different color per note and no textual hint is provided.

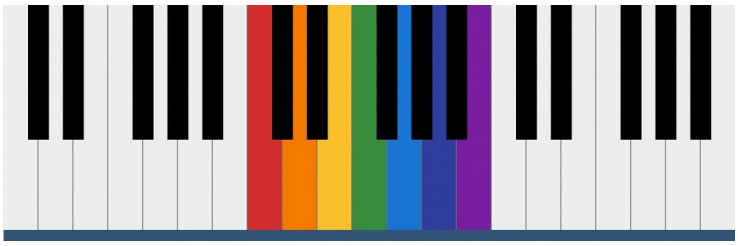

Figure 3: A three-octave virtual keyboard with colored keys in the central one.

4.2 The Notes Section

Figure 4 shows a screenshot of the Notes section. For each musical note on the keyboard a unique color is associated; the same color is used to highlight the name of the note on the upper side of the interface, while the corresponding symbol is shown on a stave. The screenshot refers to the most simplified configuration, in which only the key to be played is colored and emits a sound. Hints are provided with the name of each note on the corresponding key.

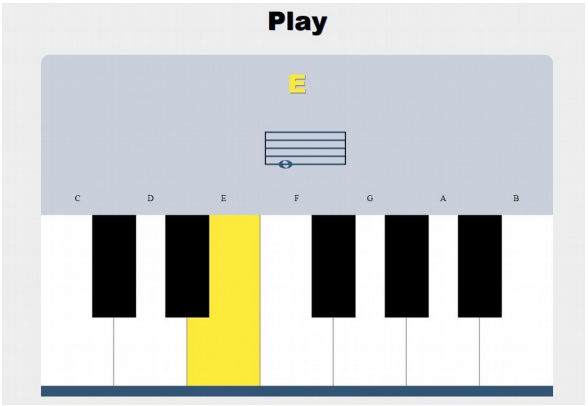

Figure 4: A simplified keyboard to learn musical notes, with visual hints.

4.3 The Values Section

This section is used to teach the concepts of duration of notes (i.e. their values) and pauses. Since the student must keep pressing on the right key for the proper amount of time, a vertical progress bar is provided, which is divided in four sections. The progress bar is synchronized with the “key-pressed” action on the keyboard. For simplicity’s sake each tick on the progress bar corresponds to one second, hence playing a two-fourths value note means to keep the corresponding key pressed for two seconds. A smiley is placed next to the stave in order to signal if the student has succeeded in the exercise; if the correct key is pressed for the proper amount of seconds, the smiley turns from grey to green and an approval sound is played as a reinforcement. Figure 5 shows two screenshots of the GUI taken before and after the correct execution of an exercise. The most simple keyboard was chosen, with only one octave, textual hints above the keys and the color cue on the key to be played.

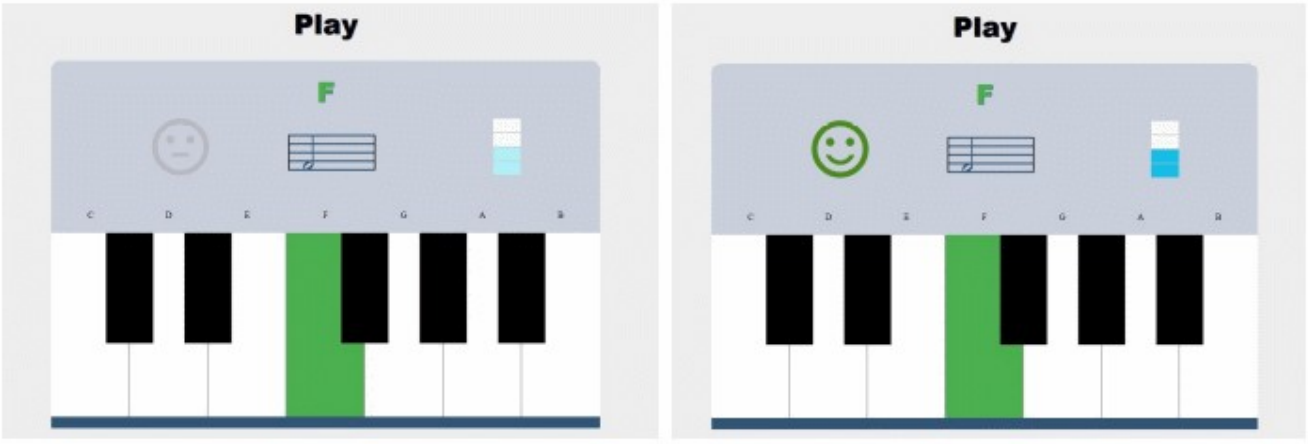

Figure 5: The virtual keyboard before and after the correct execution of a half note (F).

Similar exercises can be configured to help students familiarize with the concept of pause: in this case, the stave will display the symbols of a pause surrounded by two notes of the same value and three progress bars will account for the correct execution of each symbol. Figure 6 shows such a GUI (in this case the Italian notation was chosen for the notes).

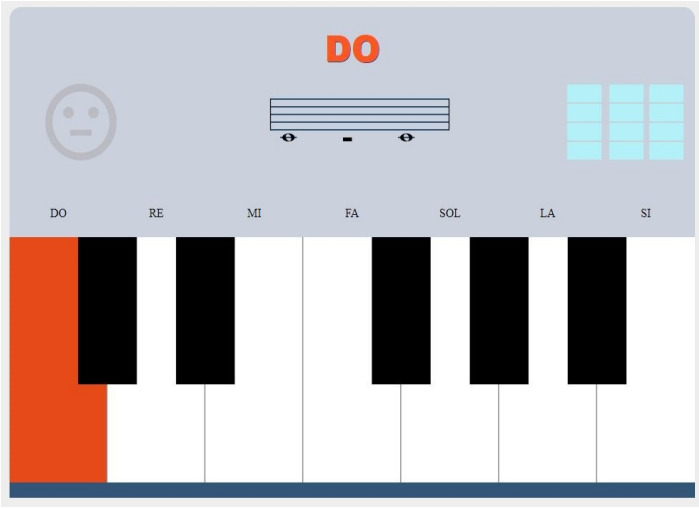

Figure 6: A virtual keyboard used to teach the concept of pause.

5 Future Work

The functionalities developed for the first prototype of our application are limited to the basic concepts of musical theory. The application's aim is to provide an aid tool which can be used by all of the students in an inclusive music class. Learning to read notes, pauses and play them with the correct duration on an individual mobile device while in the same classroom with others, is the first step towards performing simple melodies together. In this perspective, more functionalities should be provided, such as guided reading of a score and recording of a self-performed melody.

6 Conclusions

We have presented the first prototype of a web application conceived to be used as a mobile app, the aim of which is to help students with autism learn music in an inclusive class. We have described the principles behind the design of the application and the consequent technical choices we adopted. An overview of the first prototype has been provided. Finally, we have pointed out further features to be added in order to provide more advanced support to inclusiveness.

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