Gamify the Audiation: The CrazySquare Project

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Abstract: In a world in which a large amount of ICT game-based systems deal with the musical abilities without really supporting a high level of musical education, CrazySquare, initially implemented as educational instrument supporting the study of rhythm and its representation, currently represents a valid high level of musical education system for teachers who want to involve their students in learning guitar in a professional way, i.e., to be able to play what they hear in their brains (the audiation). CrazySquare has been inspired by the Gordon's theory, which consists of using a more direct approach to sound instead of the musical notation alone (e.g., solfeggio). It is specifically indicated for young teenagers (10 - 13 years old) that approach music and a musical instrument at the same time and for the first time. It has been formalized after ten years of positive results, obtained using the paper-based CrazySquare procedure adopted in Italian middle schools that introduced gamified elements for the audiation. The reported expert-based evaluation, indeed, encourage us to go ahead in the taken direction.

1 INTRODUCTION

Millions of people listen to music every single day. As a consequence, learning to play musical instruments is something that many people have interest in. However, learning to play musical instruments is for many people a rather demanding task, that requires a lot of time and a proper guidance; more often people consider the musical education more than a demanding task. Nowadays, to support people in these challenging tasks, three main solutions exist: musical schools, private lessons, and ICT-tools, since musical activities at main schools are often not sufficient. In Italy, musical teaching activities, at main schools, are organized as follows (D.M. n.201, 1999):

- Primary School: 1 hour of musical education taught by the primary teacher. The quality of the teaching is based on its (not required) expertise.
- Middle School: 2 hours of musical education by a professional music teacher + 2 hours of musical instrument training by a professional musical instrument teacher.

In the *Ministerial Decree 201/99* (D.M. n.201, 1999), there are explicitly described what are the musical education skills (e.g., agogic) that must be acquired by children at the end of middle school (see for details Section 2) but there are no guidelines regarding the pedagogical approaches to achieve them; the only recommendations deal with the acquisition of a high level of these *musical education skills*.

Musical education skills touch on all learning domains, including the psycho-motor domain (the development of motor skills), the cognitive domain (the acquisition of music knowledge), and, in particular and significant ways, the affective domain (the learner's willingness to receive, internalize, and share what is learned), including music appreciation and sensitivity. During the 20th century, many distinctive approaches were developed (see e.g., (Willems, 1946) and (Jaques-Dalcroze, 1921). More recently, Gordon introduced the *audiation* to summarize the different musical education skills. *Audiation takes place when we hear and comprehend music for which the sound is no longer or may never have been present. One may audiate when listening to music, performing from notation, playing "by ear", improvising, composing, or notating music* (Gordon, 2003).

The high level of music education skills, and then the audiation, is guaranteed, at school, by the expertise of middle school teachers; at the same time, teachers pointed out the lack of ICT-solutions supporting the musical education as well as highlighted by (Beck, 2017). In the same literature review, the au-

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thor highlights the diverse ICT-solutions related to the music technology of education, concluding that they are mainly *commercially-driven* and often not adequately evaluated (Beck, 2017). This is in line with the commercial trend of the new millennium, in which the Internet plays an ever-increasing role in expanding access to music-learning resources. On YouTube, for instance, a plethora of instructional videos exist for learning to play virtually any musical instrument; these are used not only by individuals, but they are also being incorporated into educational frameworks (Waldron, 2012). In both cases, these videos do not consider the overall aspects of the musical education but rather psycho-motor domain and in part the musical knowledge. For example, the most popular commercially-driven tool dedicated to learning musical instruments is Yousician (Yousician, 2019); it currently supports the guitar, piano, ukulele, bass, and voice learning. Users are displayed either a gamified, colorful version of sheet music or tablature notation for an exercise and hear a backing track as they play along. A major criticism depends on its nature: being this tool commercially-driven and designed for several instruments, the learning approach of Yousician is only based on the imitative process (i.e., the tablature flows and the rhythm are punctuated as in a *Karaoke* style). These characteristics support a skill acquisition but do not guarantee the acquisition of the audiation (to the best of our knowledge, no studies about Yousician have been reported on that).

What it is clear is that when the musical learning tools are not commercially-driven, there are *"...limited effects, although research shows positive impact of this kind of technology"* (Konecki, 2014). This author proposes to include adaptive learning paradigms and real-time tracking of one's playing patterns and he focuses on the use of the artificial intelligence solutions to improve the quality of the learning musical instruments. The most recent literature also focuses on the collaborative aspects in learning music, in general, and a musical instrument, in particular (see e.g., (Schoonderwaldt et al., 2004) and (Burns et al., 2017)), since cultural and social aspects are changing (Finney and Burnard, 2010) (Ferrari et al., 2006) (Pitts and Kwami, 2002). Moreover, in order to keep the interest of students for playing music, new technologies must incorporate certain concepts that appear in computer games (Denis and Jouvelot, 2005) (C. Klimmt, 2003) (Koster, 2013); since these computer programs can improve skill acquisition and can boost students' motivation, these computer systems are becoming more relevant and interesting for use in musical instruments playing education. It is out of the scope of this paper arguing about how the game concept is involved in ICT-learning projects, it is instead crucial to define the concept of gamification as the use of game elements in non-game contexts, since it is largely used in the CrazySquare project. The use of gamification in education is stated as the successful integration of the course contents to increase the students' motivation, performance, and attitudes toward the course. (Nah et al., 2014) reviewed the literature on gamification and found the following design elements for gamification, such as (1) prizes, rewards, points, badges, levels, leaderboards; (2) immediate feedback, progress bars; (3) peer interaction and collaboration; (4) storytelling; (5) avatar, character upgrades, customization, unlockable content.

CrazySquare goes in this direction, applying the gamification elements for the acquisition of audiation, necessary to playing a guitar consciously, guaranteeing a longer learning follow-up. Moreover, similar to Yousician, also CrazySquare analyses the users' playing on their guitar, and provides them with instant feedback and guidance (exploiting the pitch recognition techniques) since from its first prototype (Pennese et al., 2013). Differently from Yousician the current prototype follows the iterative TEL-oriented UCD approach (Di Mascio et al., 2016), supports the audiation and it is designed to guarantee music and musical instruments learning at the same time, also if the user (young teen from 10 to 13 years old) is approaching at the musical education for the first time.

The paper is structured as follows: the pedagogical underpinnings were presented in Section 2, while in Section 3, the theory underpinning the CrazySquare project is outlined and specified; in Section 4 the gamification aspects are reported and some implementation aspects highlighted, while in Section 5, a preliminary evaluation from domain experts, conclusions and future works are described.

2 PEDAGOGICAL ASPECTS

As mentioned in Section 1, in the Italian schools, musical education is organized according to the musical education skills of (D.M. n.201, 1999): melody, harmony, rhythm, timbre, dynamic, and agogic and there is the list of associated musical instrumental skills (e.g., ability of correlate sign-gesture-sound or improvising music ability). These skills are chosen according to the more recent literature in musical educational, see (Willems, 1946), (Jaques-Dalcroze, 1921), (Shamrock, 1986), and (Kodály, 1952). In fact, Edgar Willems, Émile Jaques-Dalcroze, Carl Orff, Zoltán Kodály agree on the fact that the musical education imply the internalization of sounds and the learning of

		D.M 201/99							
		Musical Educational Skills						Instrumental Skills	
Type of Audiation		Melody	Harmony	Rhythm	Timbre	Dynamic	Agogic	Sign-gesture-sound correlation	Esecution and Listening
Type 1	Listening to	X	X	X	X	X	X		X
Type 2	Reading	X	X	X				X	X
Type 3	Writing	X	X	X					X
Type 4	Recalling and performing	X	X	X	X	X	X	X	X
Type 5	Recalling and writing	X	X	X	X	X	X		X
Type 6	Creating and improvising	X	X	X	X	X	X		X
Type 7	Creating and improvising	X	X	X	X	X	X	X	X
Type 8	Creating and improvising	X	X	X	X	X	X		X

Figure 1: Types of Audiation versus (D.M. n.201, 1999) skills.

a musical instruments is not really achieved if sounds are not internalized. This concept has been clarified and formalized by Edwin Gordon. Edwin Gordon's Music Learning Theory (Gordon, 2007) provides music teachers with a comprehensive framework for teaching musicianship through *audiation*, Gordon's term for hearing music in the mind with understanding and comprehension when the sound is not physically present. The sequence of instructions is *discrimination learning* and *inference learning*: the former is the ability to determine whether two elements are the same or not the same using aural/oral, verbal association, partial synthesis, symbolic association, and composite synthesis; the latter students take an active role in their own education and learn to identify, create, and improvise unfamiliar patterns. The skills and content sequences within the *Audiation Theory* (Gordon, 2019), composed of eight *Types* (e.g.,"reading", "writing") suggested us to establish a learner model necessary to design an adaptive learning system dedicated to the guitar learning. The learner model is based on the mapping between the Gordon's Types and the (D.M. n.201, 1999) skills, as shown in Table of Figure 1. Section 3 is the result of this research activity.

3 THE CrazySquare PROJECT

CrazySquare was born for Italian young teenagers (10 - 13 years old) attending primary and middle schools, who approaching music and a musical instrument (i.e., the guitar) for the first time; the contexts in which learners could interact with are: the classroom, as a support during the teaching activities, and the home, as a support of homework activities. The CrazySquare is designed as an Advanced Learning System (ALS) following a TEL-oriented UCD approach (Di Mascio et al., 2016). This methodology expands the traditional iterative user-centered design approach in order to emphasize the necessity of designing in parallel both a psycho-pedagogical stimulation plan and the system modules realizing it in a context of mutual dependency, along with the choice of a psycho-pedagogical assessment strategy.

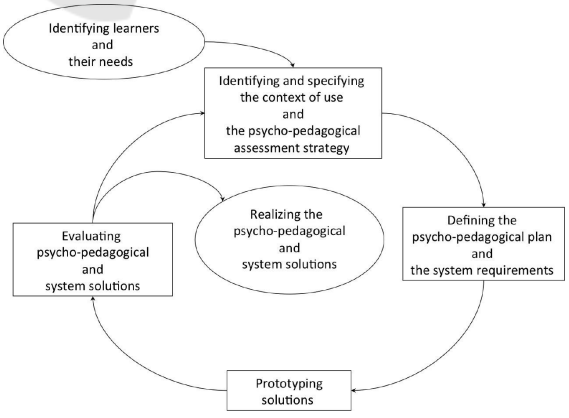


Figure 2: The TEL-oriented UCD schema.

The current stage of the project is the prototyping solution deployment at the second iteration. The first iteration produced the first prototype detailed in (Pen-

nese et al., 2013) and mainly focused on the merging aspects between the study of rhythm and its representation with the technique on the musical instrument. The second prototype mainly focus on the audiation aspects according to the designed stimulation plan, explained in Section 3.1. Gamification aspects are present in both prototypes as explained in Section 4.

3.1 The Stimulation Plan

As to the teaching/learning, based on the Gordon's approach (Gordon, 2003), CrazySquare is grounded on gamification ideas of *learning through gaming*, *training via iterations*, and of *rewarding structures* for pushing students' learning forward. Each learning experience can be divided in three phases, referring to a customary *warm-up*, *peak* and *relax* workload (Di Mascio et al., 2013):

- *Teaching Phase - warm-up*, which currently takes place in the classroom with the musical instrument teacher; during this lesson the teacher will introduce the concepts that will be trained during the execution of the exercises foreseen by the assessment phase.
- *Assessment Phase - peak*, which currently takes place via CrazySquare and consists of a series of "play and enjoy" learning experiences performed with an *instrument* (voice/hand or guitar), with the help of two of the following types of *metronome*:
  - *Acoustic metronome*;
  - *Visual metronome*;
  - *Harmonic metronome*;
  - *Musical accompaniment*;
  - *Metronome off*.
- *Relaxing Phase - relax*, which currently takes place via CrazySquare and consists of playing with relaxing games, which aims to lower the cognitive load and to engage the player.

These learning experiences (two or three per week) have to be run in private having own individual interaction with the system, for a max of 30 minutes. As to the stimulation plan, it is grounded on one basic principle: progresses are to be assessed during the assessment phase, by associating hearing and playing within playing sessions. Coherently with the learning theory, also these sessions referring to warm-up - peak - relax workload: during the warm-up and peak phases, young teens play with learning games (before more easy then more complex) gaining points, while, during the relax phase, young teens play with relaxing games; points and games are designed as tangible rewards.

Learning is obtained achieving 4 main skills (from now denoted as A, B, C and D) reported in the second row of the Figure 5. These skills, each of them positioned under its own Audition Type, are described as follows:

- **A**: Perceive and maintain the pulsation for predefined *beats per minute* (bpm) value;
- **B**: Recognize and execute by reading a sequence of *rhythmic symbols*;
- **C**: Play with the instrument *musical notes*, articulating them through reading of rhythmic symbols;
- **D**: Execute change chords at different speeds.

A, B, C and D are achieved by acquiring increasing **competences** (the complete list is reported in the fifth row of Figure 5), obtained considering two levels of difficulties (base and advanced) of the corresponding **skill object** (in the third row). For example the skill *C* is obtained acquiring the competences A^{ba}, A^{ad}, B^{ba}, B^{ad}, C^{ba} and C^{ad}.

3.2 Realizing the Stimulation Plan

From an interaction point of view a competence has to be viewed as a Matrix organized in **blocks**: the competence A^{ad} is achieved playing with a minimum of 2 blocks to the maximum of 4 blocks (see Figure 3), following the state diagram in Figure 4, in which movements are unlocked by gaining one, two or three points (or stars). Each competence has its own associated block matrix (see the seventh row of Figure 5). In CrazySquare we designed 4 types of blocks as clear observing, for example, the competence A^{ad}, that is composed of the all 4 block types.

Each block is composed of learning exercises from now denoted as **Ex** (min 4 Ex, max 6 Ex) plus only 1 relaxing games accessible after gaining a sufficient number of stars. The interaction with a block always starts with a learning exercises and ends with a relaxing games according to the mentioned cognitive workload. the 4 blocks differ from each other according to different visit flows of exercises.

Generally, each competence **K** (representing the Matrix), with $K \in \{A^{ba}, A^{ad}, B^{ba}, B^{ad}, C^{ba}, C^{ad}, D^{ba}, D^{ad}\}$, can be identified by a set of mXn different Ex, where m is the number of Matrix rows and n is the number of columns. Then an Ex_{ij}, is characterized by an User Input Type $y \in \{Hands/Voice, Guitar\}$ and by a System Sound Type $z \in \{$*acoustic metronome, visual metronome, harmonic metronome, musical accompaniment, metronome off*$\}$. In general, we can define a learning exercise Ex of the competence K as:

$$Ex^{\mathrm{K}}{}_{\mathrm{ij}}|(y,z)$$

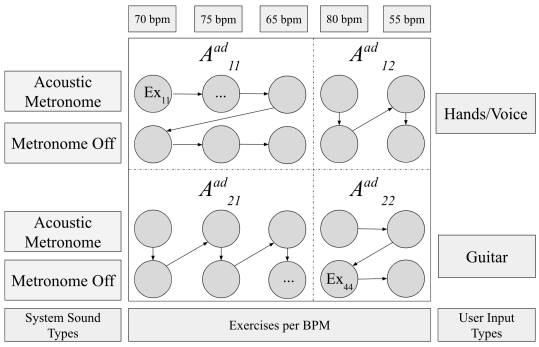


Figure 3: The structure of A^{ad} competence shown as block matrix.

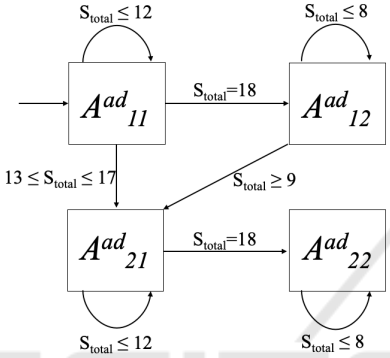


Figure 4: The state diagram of the competence A^{ad}.

For example, the competence A^{ad} is composed by 20 exercises, performed as a linear sequence according to the flow of the corresponding block type.

At the end of each Ex, the young teen gain **stars** as reward, that we indicate with $s \in \{1,2,3\}$, according to its performance. At the end of every block, after a *relaxing game*, according to the total number of stars won in every exercises, indicated with S_{total}, the system gives the user the possibility to continue along the learning flow appropriately, according to a predefined state diagram, see for example Figure 4 representing the state diagram of the competence A^{ad}.

4 GAMIFY THE AUDIATION

In this section we aim at highlighting the gamification elements used and introduced in the two prototypes of the CrazySquare system. In order to to that, we report here some system specification.

4.1 The System Specification

The first version of the game aimed to be playable on different devices, i.e. PC running different OSs and Android devices. The prototype was mainly implemented using *Processing* software, a Java programming environment which already provides audio libraries for signal processing, such as Ess, Sonia, Beads, Minim, with a fair number of features (i.e. AudioSources, ForwardFFT, etc.), as well as libraries for signal synthesis and composition such as SoundCipher, and Tactus5 (Pennese et al., 2013). In particular the library *Minim* has been chosen for signal processing purposes. Moreover, for sound synthesis, the use of *SoundCipher* was exploited. For the very first digital prototype these choices seemed to be the best solution since they guaranteed real time response and easiness of understanding for future improvements.

The current prototype of CrazySquare has been developed only for mobile devices (i.e. tablets and smartphones) with Android OS. It was mainly implemented using Android Studio 3.2, the official integrated development environment for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It's also used the Kotlin programming language, a modern language based on JVM (Java Virtual Machine), introduced in Android Studio from version 3.0. Currently, instead of using libraries provided by Processing software, we had chosen TarsosDSP library, a Java music library which proved to be the most complete and suitable for the objectives of our project.

4.2 Gamification in the 1st Prototype

The gamification aspects have already been introduced in the first prototype, since it focused on the specification of psycho-pedagogical strategy, i.e., the homonym paper and pencil game: a square with 16 boxes, each one graphically representing the impulse (i.e., a snap made by the teacher). A young teen aimed to overcome some different levels of difficulties in terms of the understanding and the execution of rhythmic symbols and melodic sequences. The gamification element of **immediate feedback** has been realized via pitch detection of a note; it is approached with the introduction and the use of an instrument: playing a particular and instructed note (or more than one for a harmonic instrument) within the constraints of rhythmic symbols in the boxes represented. The number of different notes induced the difficulty of **levels**, i.e., a second gamification element. Notes can be associated with colors, so the young teen can compose a little melody in a row, declaring and assigning himself a task, for which the game will just control the right execution. After the complexion of a certain number of levels the first prototype of CrazySquare

Type of Audiation	Type 1		Type 2		Type 4			
Skills	A		B		C		D	
Skill Objects	BPM		Rhythmic Symbols (RS)		Musical Notes (MN)		Chord Change Speed (CCS)	
Base (ba)/ Advanced (ad)	BPM^{ba}	BPM^{ad}	RS^{ba}	RS^{ad}	MN^{ba}	MN^{ad}	CCS^{ba}	CCS^{ad}
	70-75-65	80-55			Mi, Fa, Si, Do, Sol, La	Sol, Re	Chord change / 1/2 Common Time	Chord change / 1/4 Common Time
Competences	A^{ba}	A^{ad}	B^{ba}	B^{ad}	C^{ba}	C^{ad}	D^{ba}	D^{ad}
Min-Max blocks to play	2 → 2	2 → 4	8 → 16	10 → 20	6 → 12	24 → 48	2 → 4	4 → 8
Block Matrix	$\begin{bmatrix} A_{11}^{ba} \\ A_{21}^{ba} \end{bmatrix}$	$\begin{bmatrix} A_{11}^{ad} & A_{12}^{ad} \\ A_{21}^{ad} & A_{22}^{ad} \end{bmatrix}$	$\begin{bmatrix} B_{11}^{ba} & B_{12}^{ba} \\ \vdots & \vdots \\ B_{81}^{ba} & B_{82}^{ba} \end{bmatrix}$	$\begin{bmatrix} B_{11}^{ad} & B_{12}^{ad} \\ \vdots & \vdots \\ B_{10\,1}^{ad} & B_{10\,2}^{ad} \end{bmatrix}$	$\begin{bmatrix} C_{11}^{ba} & C_{12}^{ba} \\ \vdots & \vdots \\ C_{61}^{ba} & C_{62}^{ba} \end{bmatrix}$	$\begin{bmatrix} C_{11}^{ad} & C_{12}^{ad} \\ \vdots & \vdots \\ C_{24\,1}^{ad} & C_{24\,2}^{ad} \end{bmatrix}$	$\begin{bmatrix} D_{11}^{ba} & D_{12}^{ba} \\ D_{21}^{ba} & D_{22}^{ba} \end{bmatrix}$	$\begin{bmatrix} D_{11}^{ad} & D_{12}^{ad} \\ \vdots & \vdots \\ D_{41}^{ad} & D_{42}^{ad} \end{bmatrix}$
Min-Max stars per exercise	1 → 3	1 → 3	1 → 3	1 → 3	1 → 3	1 → 3	1 → 3	1 → 3
Total Min-Max stars	26 → 36	26 → 60	104 → 240	130 → 300	78 → 180	312 → 720	26 → 60	52 → 120

Figure 5: Gamify the audiation.

offered **riddles**: a rhythmic pattern is played, and the player have to put the right box in the right position inside the crazy square. The evaluation of the first prototype of CrazySquare highlighted issues about pitch detection algorithms, solved in (Rinaldi et al., 2015) and skill-based classification (the learner model) on which the psycho-pedagogical stimulation has to be based.

4.3 Gamification in the 2nd Prototype

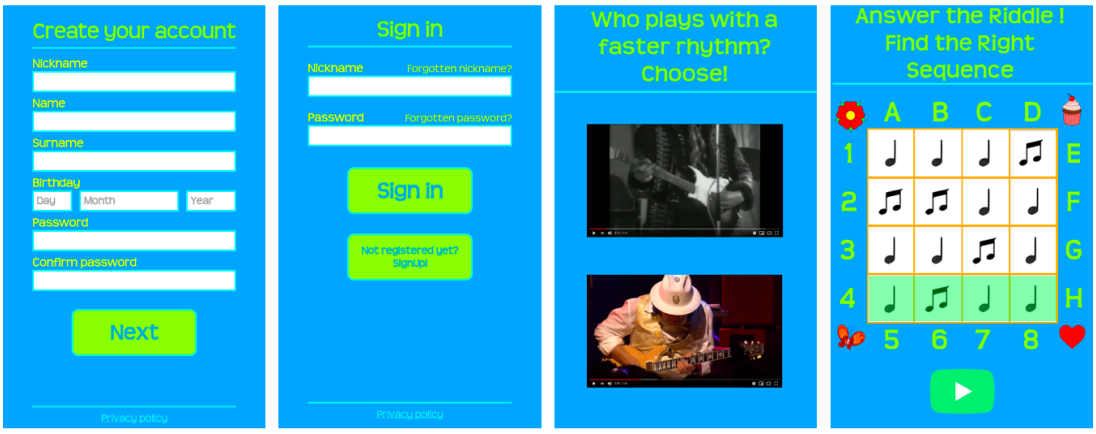
Similarly to the first, the current prototype has seen a significant improvement and the introduction of gamification elements, according to (Nah et al., 2014). Currently, as described in detail previously, the game-system provides different learning games. The gamification element of **immediate feedback** is provided inside every exercise, because the game-system notify immediately, with colors and with assignation of **points**, if the player has done the activity correctly or no. In every exercise, according to points obtained by the player, the system provides to assign an appropriate **reward**, i.e. from 1 to 3 stars. Furthermore, inside each matrix, there are some **unlockable contents**, represented by blocks, which are unlockable only if the player obtains a certain number of stars at the end of each Base Level.

For example, for the competence A^{ad} there are the following exercises:

- $Ex_{1\text{-}j}|$ (Hands/Voice, Acoustic metronome): By listening to the metronome, perceiving and keeping isochronous pulse, indicated by $j \in \{70bpm, 75bpm, 65bpm, 80bpm, 55bpm\}$, clapping the hands or with the voice;
- $Ex_{2\text{-}j}|$ (Hands/Voice, metronome off): Without listening to the metronome, perceiving and keeping isochronous pulse, indicating by $j \in \{70bpm, 75bpm, 65bpm, 80bpm, 55bpm\}$, clapping the hands or with the voice;
- $Ex_{3\text{-}j}|$ (guitar, acoustic metronome): By listening to the metronome, perceiving and keeping isochronous pulse, indicated by $j \in \{70bpm, 75bpm, 65bpm, 80bpm, 55bpm\}$, with the guitar, pitching a string.
- $Ex_{4\text{-}j}|$ (guitar, metronome off): Without listening to the metronome, perceiving and keeping isochronous pulse, indicated by $j \in \{70bpm, 75bpm, 65bpm, 80bpm, 55bpm\}$, with the guitar, pitching a string.

Each exercise is composed by two steps and it starts with 4 *alignment beats*: this first step is meant to help the player to synchronize with the bpm provided for that exercise. After this step, 20 beats have to be executed by the player at the bpm provided for that exercise. Stars, indicated by s, will be assigned in the following way, according to the performance of the player:

- $s = 1$ if the player executes properly at most 10 beats;



(a) (b) (c) (d)

Figure 6: Some screens of the current prototype of CrazySquare.

- $s = 2$ if the player executes properly a number of beats between 11 and 15;
- $s = 3$ if the player executes properly at least 16 beats.

Relaxing games planned for this competence consist of watching two different videos of people playing music, belonging to different genres and/or epochs, and choosing which one of the two has the fastest or slowest rhythm. Figure 6(c) represents the relaxing game appears after the learning exercises of the competence A^{ad}: it consists in showing two videos without the sounds support and in asking to the young teen to tap the video having the high bpm.

4.4 The CrazySquare GUI

At now, if a student wants to play with CrazySquare, he/she must have a personal account, reason for which the system provides the possibility of sign-in or sign-up into CrazySquare in an easy way. The system, as you can see in the Figure 6(a) and in the Figure 6(b), provides a way to sign-in or to sign-up and a smooth way to retrieve the forgotten nickname or password, according to the guidelines generally suggested by mobile design patterns. If the user does not have a personal account, the system provides a way to create one, characterized by a two-step procedure: the first dedicated to the user, the second dedicated to parents. Indeed, CrazySquare is an application which is used by teens aged between 10 and 13 years, consequently we must take into account that they are minors: from the article 8 of General Data Protection Regulation (GDPR 2018 - art. 8: "Conditions applicable to child's consent in relation to information society services") it is evident that there are some limitations determined by existing legislation in term of privacy and processing of personal data in applications which provide services of the information society (such as mobile applications). Consequently, it is necessary to have an explicit consent from the person exercising the parental authority of the underage user who uses the application.

All displays of the application are characterized by a consistent graphic, distinguished by an alignment and a central symmetry of graphics elements, and buttons, as well as being tap-friendly, assume an almost invariant position among the various displays (Di Mascio et al., 2004). The Nielsen Norman Group also discovered that young teens also have unique usability problems-not surprisingly as they encountered difficulty reading large chunks of text, especially when the text was written above their reading level (Budiu and Nielsen, 2014): for this reason CrazySquare has adopted a language that is clear, simple and close to teen slang. Furthermore, we chose a standard color palette characterized by very bright and lively colors, in accordance with the typical preferences of young teens, and three more palettes, which are won as rewards, in order to give to the users the chance to personalize their game interface.

5 CONCLUSION AND FUTURE WORKS

In this paper, we presented and discussed the second prototyping solution of CrazySquare, which is a valid high level of musical education support for teachers who want to involve their students in learning guitar in a professional way. This game-system has been inspired by the Gordon's Theory (Gordon, 2003), which hypothesizes that musical learning is

based on the audiation. The application of the concept of gamification in our project is a key point, as its elements (described by (Nah et al., 2014)) have a proved positive impact on learners, increasing their motivation, performance and attitudes toward the course. As we have already explained in Section 3, the CrazySquare project follows a TEL-oriented UCD schema and, moreover, in every step of this design approach we have collaborated with domain experts, who expressed positive impression and that validated, thanks to their experience, the psycho-pedagogical solution obtained after the 2° step of the 2 ° cycle of iteration. Consequently, in the next future, we have planned to evaluate the current prototype with end users. Moreover, further testing on the validity of the proposed psycho-pedagogical methodology is going to be carried on. The results, that will emerge from this evaluation phase, will allow us to proceed with a more refined cycle of iteration of the TEL-oriented UCD.

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