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New Technologies for Music Education*

J. Sastre, J. Cerdà, W. García, C.A. Hernández, N. Lloret, A. Murillo, D. Picó, J. E. Serrano, S. Scarani
Universitat Politècnica de València
Valencia, Spain

R. B. Dannenberg
School of Computer Science
Carnegie Mellon University
Pittsburgh, USA

***Abstract*— This paper describes the objectives and work developed in the project *New Technologies and Interfaces for Music Education and Production* by Universitat Politècnica de València and the Computer Music Group from Carnegie Mellon University: Several education scenarios and application typologies are designed, the use of collaborative creation with Web 2.0 is proposed, and the first implemented applications are described.**

Keywords— Music Education, Technology, interfaces, MAX

I. Introduction

The new schemes for human-computer interaction (HCI), such as the low-cost interface Kinect [1], tablets and smartphones are promising tools to improve the motivation and interest of students, for developing their cognitive skills and to support the learning process. However, music education in many elementary or secondary level classes generally revolve around classical music and are oriented towards the acquisition of knowledge and skills related to traditional musical language and the conventional use of instruments like flute, piano, etc.

The incorporation of new audiovisual technologies and interfaces in music production, where practically any sound material can be used, and in the students' daily life (smartphones, tablets, game console interfaces...) require us to extend the usable universe to teach music if we want to motivate students and improve the learning process. Thus, the objective of our project, started in Jan. 2013, is to implement a modular software system based on low cost interfaces such as tablets, smartphones and Kinect and a collaborative creation system for music education. At a time of high budget cuts in education, the implementation of a low cost education system that might spread in different educational institutions is an important contribution of the university to society. To avoid extra costs the application is intended to use the typical resources that may be available in any classroom and those that students can easily have themselves (tablets, smartphones, etc.)

The implementation platform is Max/MSP/Jitter [39]. Max is a modular graphical development environment for music and multimedia creation developed by Cycling '74 which allows the processing of audio and video in real time. Due to its extensible design and graphical interface, it has been increasingly used in the last years by composers, artists and software developers interested in creating interactive programs. Our application is a creative development environment in its own right, but for running Max patches it requires only the free application Max Runtime. For communication between devices and sensors, we use the OpenSound Control (OSC) protocol [15] from UC Berkeley CNMAT (Center for New Music and Audio Technology). OSC is designed to share information in real time over a network enabling the communication between electronic musical instruments, computers and other media devices, such as mobile devices equipped with Wi-Fi or Bluetooth. This protocol, along with applications such as Touch OSC [16], allows the creation of tactile interfaces in tablets and smartphones, as well as connecting Kinect to control applications developed in Max.

II. NEW TECHNOLOGIES FOR MUSIC EDUCATION

The use of new technologies in music education opens a broad set of possibilities, both reinforcing existing methodologies and allowing more specific activities with respect to research, creation, transformation and classification of sound [2]. One of the earliest projects on musical education with electronic media was Gmebogosse, later called Cybersongosse [3]. Cybersongosse was introduced in 1973 by GMEB (*Groupe de Musique Expérimentale de Bourges*), with the aim of performing experimental pedagogy on an electro-acoustic instrument. The instrument and the pedagogy were developed simultaneously, based on collective practice, with 300 games of identification, learning, creation and communication, with 3 levels of difficulty. Another interesting project was *Alfabetizzazione musicale per bambini con le nuove tecnologie* (children musical literacy with the new technologies), started in 2002 by *Centro Tempo Reale* (Italy) [4]. After an experimental part carried out in IRCAM, Paris, the Project was moved to Italy by L. Berio, co-founder of the RAI *Studio di Fonologia Musicale* in Milan. The target of the project was to introduce this initiative in elementary school. Several technicians and composers developed numerous tools with Max (sound recorders and players, effect processors…) to record sounds from instruments, voices and objects, to use them in a performance by the students. However, the only allowed interfaces were the keyboard and the mouse.

Recent work points to the pedagogical potential of new technologies and new human interfaces [5]-[9]. Additionally, the use of tactile mobile devices is a remarkable market tendency [10]. Tactile devices allow direct manipulation of objects and controls by means of multi-tactile interactions with excellent results in electronic musical instrument generation

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and general educational projects [11]-[14]. Non-tactile devices include Kinect, developed by Microsoft as an interface for the Xbox-360 console. Kinect uses camera images to estimate position and posture of the human body to serve as an input for videogames. Nowadays, Kinect can be programmed using OpenNI, used by OpenCV among others, Synapse and an SDK from Microsoft, which give access to the RGB and depth information [18]-[20]. One of the authors describes music generation integrating Kinect with Max and OSC [17].

A. *Pedagogical references on creativity and sound creation in the Spanish context*

Creative musical education in Spanish schools is paradoxical, to say the least. In a context in which renowned personalities in the spheres of music, painting or literature have made numerous contributions of international relevance leading to real revolutions in their own fields, we do not observe a solid support for creativity in the basic education of our students. In fact, the enhancement of creative experiences in our school system is, at the present time, a certain novelty [28]. The Spanish educational system has suffered from continuous reforms which have barely allowed for small improvements as far as the importance of music and arts is concerned (e.g. *L.O.G.S.E* [31]). Indeed, recent reforms are once again putting at risk the supposed benefits of an artistic education. As music teachers have most often received their training in conservatories or faculties of science and history of music, their practical lessons are typically based on formalist and aesthetic criteria rather than on the creative development of the students themselves. Theoretical load and historicism remain the pillars that define the tendencies of our schools.

The official curriculum is divided into three different units of study: listening, performance/interpretation, musical contexts and creation. This last unit tends to strengthen musical creation inspired by tonal western music, thus leaving aside the contemporary sense of musical creation based on the sound itself as the primary element of exploration, experimentation and creation. Our proposal in this project consists precisely of breaking with this formalist approach in favor of a creative and pragmatic approach [24]-[30] based on the action on the musical elements by creating, improvising and, above all, reinforcing collaborative creation in accordance with the current tendencies emerging from contemporary and informal education practices [26]-[27]. The idea of reinforcing these kinds of more creative practices and the aim of exploring and integrating elements from diverse artistic disciplines helped by new technologies brings a new multidisciplinary concept to our classrooms. The possibility of bringing together music, plastic arts, dance, theatre, audio-visual techniques, poetry, as well as other areas such as mathematics and physics, can bring about a fantastic revolution in the classrooms and will perfectly merge together with the latest contributions in the fields of pedagogy and didactics: The theory of multiple intelligences [25] and other experts moving in this direction [21]-[34].

In these practices we start from a student-centered approach, meaning that we assume that the learning process consists of activities and questions generated by the student rather than by the teacher. In this case, the teacher acts as a guide who facilitates learning and supports the students through their education. Technology is here a means of helping to explore our knowledge and is a very important tool for the search of information and the creation of activities. By incorporating these new technologies we should move towards an approach centered on connectivity, and this means that the learning process has not only an individual dimension, but also a social one. Education implies learning communally and being able to contribute to the construction of knowledge. The teacher is a designer of learning spaces, and technologies play an intermediary role in the construction of knowledge and social interaction. This work lets us reinforce Lévy's idea [29] regarding the concept of collective intelligence and distributed learning.

III. SCENARIO DESIGN. APPLICATIONS

A. *Design of education scenarios in a music classroom*

The fundamental idea in the incorporation of new technologies in music education is to make the most of work done during class time, taking previous experiences as a starting point to create new spaces that will ease the creative use of technology. It should be clear that technology must be integrated in practices done day by day by the teachers in their lessons. This integration must allow for exploration and experimentation with sound, and should not be an element that breaks with practices that are enriching for our students. For the purpose of conducting a field experiment, *Instituto Arabista Ribera* secondary school (Carcaixent, Valencia, Spain) has been selected. This school aims for a creative approach and has experience in the field of new technologies applied to sound creation. The task of the teachers in this school comes defined by Delalande's pedagogy of creation [23] and other authors such as Schaffer [32], Paynter [33] and Denis [22]. In order to facilitate the implementation of these pedagogical premises and the technology in its creation phase, a series of education scenarios have been designed (see Fig. 1).

The first scenario presents two situations which we consider to be interesting for the task of sound creation. First situation: the class is divided into small groups of five or six people. Each group can use a technological device: smartphone, tablet, etc. combined with other objects and traditional instruments, which can be recorded and transformed in real time. By means of a rotating system, each group can carry out different activities within the possibilities of that computer environment. This first scenario fits 1st and 2nd Spanish *ESO* (*Educación Secundaria Obligatoria,* Spanish Compulsory Secondary Education) levels (ages: 12 – 14). The activities in the class should be focused on the acquisition and manipulation of sound at an elementary level, in order to establish a solid basic knowledge. These activities should also include the creation of drawings, static images or videos and the creation of resource libraries which will be used later to make small sound or audio-visual micro-creations. Second situation: focused on oriented musical improvisation and the *soundpainting* technique from Walter Thompson [40]. The objective of this activity is to consolidate the collective listening and boost discussions and debates which will provide a detailed analysis of the sound processes derived from that activity. In this phase, a collection of ideas, rather than a collection of sounds, is produced.

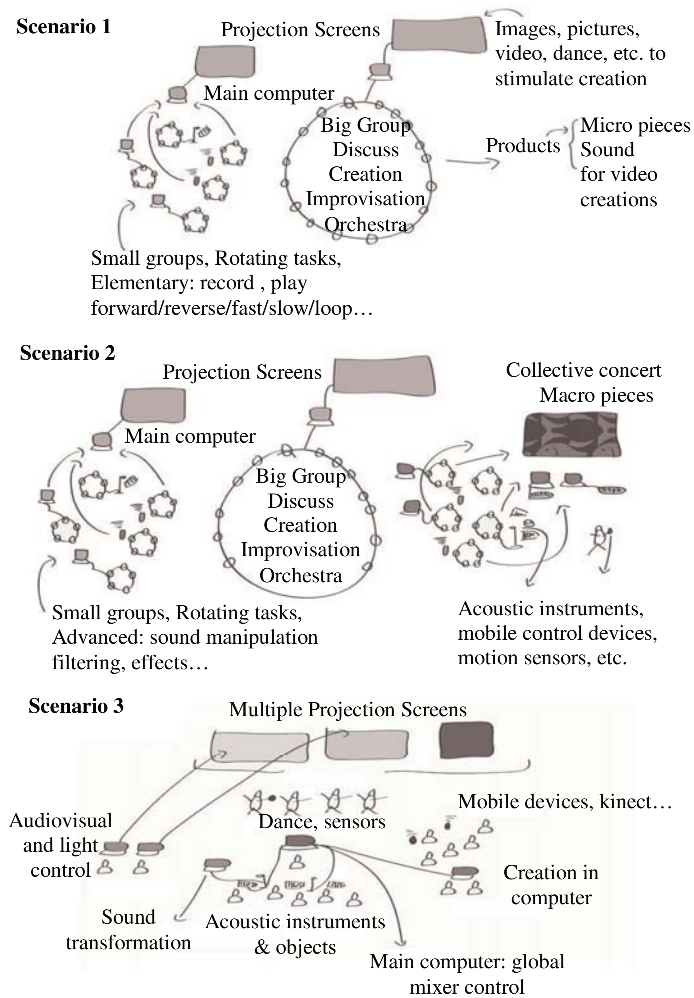

Fig. 1: Designed Music Education Scenarios

The <u>second scenario</u> is oriented towards 2nd and 3rd *ESO* levels students (age: 14 – 16). These students should have acquired the basic skills of the first scenario. The task here will be focused on developing a greater creative autonomy in a *do it yourself* line, reinforcing the idea of creative work. Initially, the activities should consist of sound manipulation and transformation by means of effects and filters, as well as the incorporation of audio-visual material, which will allow a greater integration between sound and visual material, and even between other kinds of languages such as dance, poetry, etc. Unlike the first scenario, here we try to arrange specialised groups, fitting the students' interests. Through specialised work and taking advantage of the resultant synergy, bigger projects in which different artistic disciplines merge can be created.

The <u>third scenario</u> has live performance as its main goal, and allows the development of the work done in class and its adaptation to the real stage. The development of various technological modules should guarantee an optimal connectivity between the different devices and should offer the possibility of adaptation to different stages. This third scenario closes the circle through contact with the audience and makes possible the creation of a product which is the result of a process similar to that of the one followed by any creator. Hence, the creative act is understood as an attitude towards life and education, as a true agglomeration of experiences.

B. *The modular system*

As mentioned above, the project provides a series of independent and modular applications (modules), able to work independently or connected to each other. Given the education scenarios, the applications are able to be wirelessly controlled. One can use one or more modules on each of the computers in class, according to the specific available processing power. This strategy allows the creation of custom work tools, able to communicate both within a single computer and between different computers connected to each other, thus allowing the creation of an orchestra where individual participants in addition to playing together can share information, controls, and then different sections of elaboration and creation of musical material. This interconnectivity also allows the creation of a general controller, identified as the orchestra conductor, which can be controlled by the teacher.

It is important that the modules are completely functionally independent microsystems, based on a common communication protocol. In this way one can ensure the creation of a complex system from a few elements, a system that can evolve over time thanks to the efforts of many developers, similar to the contributions to programming languages such Max [39] or Pure Data [41]. Taking into account the different education scenarios designed in the previous section, we have designed the next typology of the Modular Systems to be developed:

1) Modules in/out and mixing
2) Modules record/play
3) Sound processing modules (effects, controllers)
4) Instrument modules (samplers, synthesizers)
5) Visualizing systems (piano-roll, spectrum…)
6) Metro and time synchronization (metronome, timecode)

Communication modules (common communication protocol, specific modules for the control from external systems such as Kinect, smartphones, etc.).

C. *Learning with collaborative Web 2.0*

As an alternative to the dominant model of e-learning projects, we consider projects that are grounded in "common-based P2P production". The power of this mode of production is based on the fact that they do not depend either on public resources or on the law of supply and demand, but on the resources and interests shared by a crowd of individuals.

Common-based P2P cultural projects have appeared in the last years thanks to communication technologies and Web 2.0

development. In the beginning, these projects were linked to the computing field—like the open source movement—and to the creation of decentralized “peer-to-peer” networks, which allowed users to share archives freely. In the last years, Web 2.0 improvements in social networks, open contents software and P2P networks applied to the field of communication (such as telephony, instant messaging, video streaming, etc.) have modified the traditional model of production. In Web 2.0 many innovative projects have found the chance for self-management by getting the material and the human resources (crowdsourcing) and funding (crowdfunding) from different users and institutions to achieve their aim. Over the last few years different P2P production online platforms have emerged in music [44], fostering the exchange of information and resources to develop musical collaborative projects. Hence, we can conclude that the P2P production model arises as one of the best alternatives to face the contemporary cultural panorama, particularly the musical one. Our objective is to offer to music students the knowledge and tools that Web 2.0 can give them to develop their own projects. In order to achieve that, our e-learning methodology will be developed in the following way:

1) We will start by letting students know about those music projects that have been developed successfully in Web 2.0, so they will be able to analyze both their crowdsourcing and crowdfounding strategies and the online platforms and tools that have been used.

2) Students will experience the use of some of the collaborative tools they have identified in those projects.

3) They will familiarize themselves with online platforms as wikis and wordpress that allow them to make a collaborative space to create, develop and spread their own projects.

4) They will be asked to analyze the development stages of an innovative collaborative project in Web 2.0 and to identify which tools are the most appropriated for each stage.

5) Students will be asked to create an innovative music project through an online platform by using crowdsourcing and crowdfounding strategies. To achieve this they will have to distinguish in their website as many pages as the stages of their project, and to use as many collaborative tools as necessary.

6) Finally, they will be taught to “viralize” their projects by using different web positioning strategies.

The assessment of this project will be based on the analysis of the relevance and applicability of the proposed projects.

D. First works and developed applications

In the first months of the project several modules have been developed based on the designed scenarios. The first one relates to the “Assemble outreach” event which took place in Feb. 2013 in Pittsburgh (USA), for which a Max application and a website were developed. This event was inside a project named “Learning Parties”, which are intended to be fun, educational after-school events for neighborhood children and community members. In them, each expert or group of experts hosts a mini workshop, activity, or demonstration and kids walk around and participate at their own pace. The assemble outreach event was concretely geared toward children under the age of 13, and was an excellent opportunity to test the first module developed in the project, related to the *acquisition and manipulation of sound at an elementary level, in order to establish a solid basic knowledge* from education scenario 1.

The main objective of this application was to show the students how pitched sounds are composed of overtones at concrete frequencies (harmonics) (see Fig. 2). The module allows playing recorded sounds and recording sounds, preferably long sustained pitched sounds, so that they can be filtered afterwards hearing the result. Both the original and the filtered signals are shown in the time and frequency domains. By using a very narrow resonant filter and changing its central frequency to the frequency of the different harmonics of the recorded sound, those harmonics are amplified and can be heard, thus showing the actual presence of these frequencies within the original sound. A sound with long notes of flute, clarinet, bassoon, organ, square wave, and other instruments was provided, and the students were also encouraged to record their own voices singing a long pitch. Thus, this module corresponds to the typologies 2) Modules record/play, 3) Processing modules of sound and 5) Visualizing systems, described above. Apart from the module a website was developed to attract the interest of children on electronic music, which also fits on the intention of establishing a solid basic knowledge. The web is entitled “Some Curious Things about the Origins of Recordings” [42], presenting a short history on the early recording systems with ancient pictures and videos and a language suitable for the intended children ages.

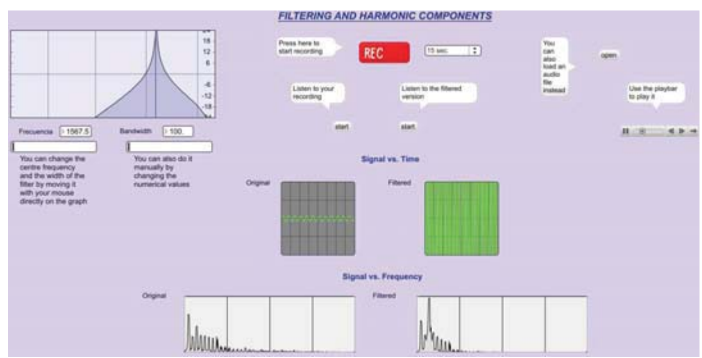

Fig. 2: Assemble Outreach Max module for showing sound harmonics

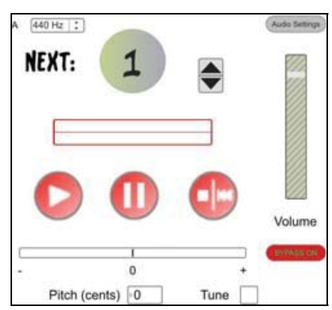

Fig. 3: Module for mixing processed recorded sounds with live instruments

The next developed module is related to the live performance practice of the third educational scenario and also with the modules of typology 2) Modules record/play. This module is intended for live performances along with traditional instruments. A number of sound files are automatically preloaded when the Module Max patcher is initialized and a simple and intuitive user interface appears (see Fig. 3). Students are intended to record and process a number of sound files to be played in certain times of the live performance. The module shows the number of the file that is ready to be played. Following the indications written, for instance, in a traditional score, or just decided previously in class, the student can play the appropriate track for each part of the concert in real time. Once one track ends, whose progress is shown by the central bar, the file number in the gray circle increases by one and the next track is then ready to be played. Additionally, the module provides control arrows to choose any of the tracks for rehearsal situations, the possibility of overlapping among the successive played audio files, and pitch tuning. This module was tested in three live concerts given in the Carnegie Mellon University School of Music held on May 1st, 2nd and 6th, 2013, (among them the concert "Computer Music from Carnegie Mellon") with the piece "Déjà vu" for flute (A. Gordon), viola (L. Krentzman), cello (C. Green), piano (E. Eryılmaz), and recorded/processed audio. The piece was written by author J. Sastre preparing a total of 16 audio files that were played in rehearsals and concerts using the module. The tuning capability was necessary in several occasions where the pianos for the rehearsals were not exactly in tune, and work to reduce latencies to a minimum was addressed. Fig. 4 presents an example of audio file number indication in the score.

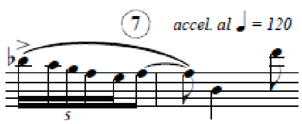

Fig. 4: Example of score number for audio file in Déjà vu piece

The next types of modules deal with the basic concepts of audio processing and can be interconnected (see Fig. 5): *record* from any computer source or from another module; *play* with the basic controls reverse, speed and loop; several basic effects as *feedback delay*, *panoramic*, *transposer* and *pitch shift*; an audio *routing* module; a *mixer* with 8 inputs; a *VST* host module to be used with VST instruments and effects; an *OSC* module to receive midi notes and controls from a smartphone/tablet via Touch OSC; and an *audio* module to configure audio in/out and MIDI devices. All of them can be controlled by IOS or Android tablets/smartphones, and Kinect, with very simple and homogeneous interfaces. The teacher or students should setup the desired combination of modules and their connections in the computer or computers available in the classroom for the concrete activity from scenarios 1, 2 or 3 from Fig. 1. Then each student can control one of the modules with his/her own smartphone/tablet or Kinect being placed in whichever place around the class the activity needs.

All the modules are executed with Max Runtime. As mentioned above, this is the free version of Max which allows the execution, but not editing, of existing Max patches, thus perfectly meeting the needs of this project. The use and interconnection of the modules was designed similar to that of Max. In general terms, modules have inputs and outputs, and outputs are connected to inputs similarly to the way it is done in Max. The main difference is that in Max the connections are done with cables, and when using Max Runtime that capability is not available due to the restrictions of the Runtime version. Instead of this procedure, the modules are connected "wirelessly" by using Max native objects "send" and "receive" (and its signal versions "send~" and "receive~"). There are input and output buttons in all the modules, and the connections are made by pressing an output button first and then an input button. An output can be connected to several inputs and each input has a disconnect button as well. As for the OSC communication between the computer and other mobile devices, all the devices must be connected to the same network and the sending address of the mobile devices must be set up to the IP address of the computer where the modules are being run. Additionally, the receiving port for each module can be configured to match it with the sending port of each mobile device so that each one can control a different module.

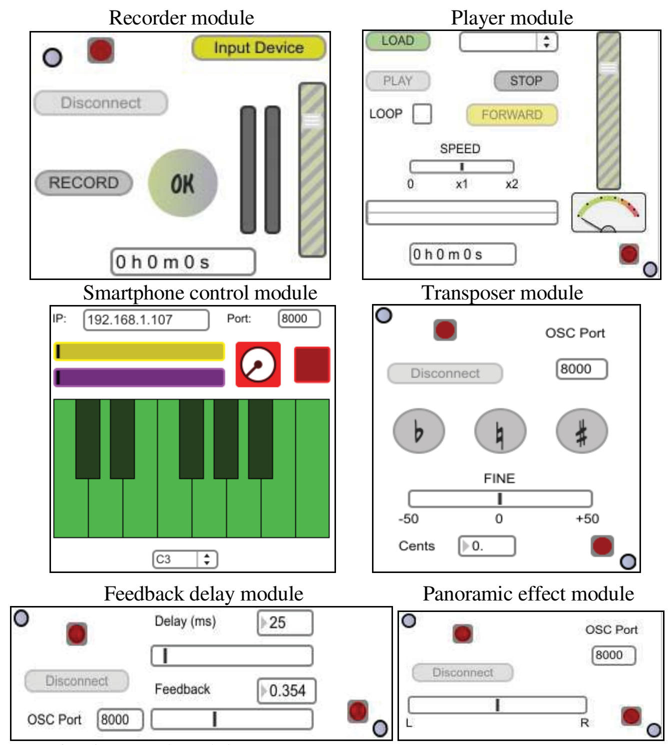

Fig. 5: Several modules

The different modules will be tested by author A. Murillo, pedagogue and music teacher, at the *Arabista Ribera* secondary school mentioned above, in the next course starting in September. The Web 2.0 collaborative creation system will be developed and tested in the same class. For this project we will use the 5 Usability quality components that Nielsen define in his usability test methodology [43]: *Learnability*, i.e. how easy it is for users to accomplish basic tasks the first time they encounter the musical e-learning tool design; *Efficiency*, i.e. once users have learned the design, how quickly they can perform tasks and do they feel that the tool gives them more information than other ICT instruments used in class; *Memorability*, i.e. when users return to the design after a period of not using it, how easily can they re-establish proficiency and can students improve their level of use without a teacher in class; *Errors*, i.e. how many errors do users make, how severe are these errors, and how easily are they corrected; and

Satisfaction, i.e. how pleasant is the design to use in comparison to other tools for learning music. There are many other important quality attributes. A key one is *Utility*, which refers to the design's functionality, i.e. if it does what users need in the music e-learning. The modules and collaborative creation system will be improved according to the tests, and then the production of many other new modules (effects, filters...) will be addressed, including the preparation of suitable documentation for teachers and students.

IV. CONCLUSIONS

The present paper describes an on-going project that aims at creating an educational system for teaching music in secondary school and its first outcomes. For this project, a study of educational needs of secondary school students, as well as of official programs defined by the Spanish public education system, has been done. Three different scenarios have been defined for the use of the developed system in the classroom that correspond to different levels and educational goals, such as sound and video creation, handling and filtering, group playing or performing. Two parts have been proposed for the system: a set of modules for manipulating sound in real time and a collaborative creation system based on Web 2.0. The first project outcomes have been described, corresponding with a subset of the modules, two of which were tested in practical situations with success (the *Assemble Outreach* event and the three concerts mentioned above). The modules allow for interconnection, and wireless devices such as mobile phones or tablets can be connected simultaneously to the base systems running in the available computers at class. Thus computers in class become consoles for the manipulation of sound and co-creation by many synchronous participants.

The next steps in the project will be: The development of the collaborative environment based on Web 2.0, which will allow participants to share their projects and to contribute to repositories of sound samples or modules that can be used for the creation of other projects; the test of the modules in the classroom, planned for the next secondary school course; and the creation of an attractive and common appearance for both the modules and the collaborative environment.

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