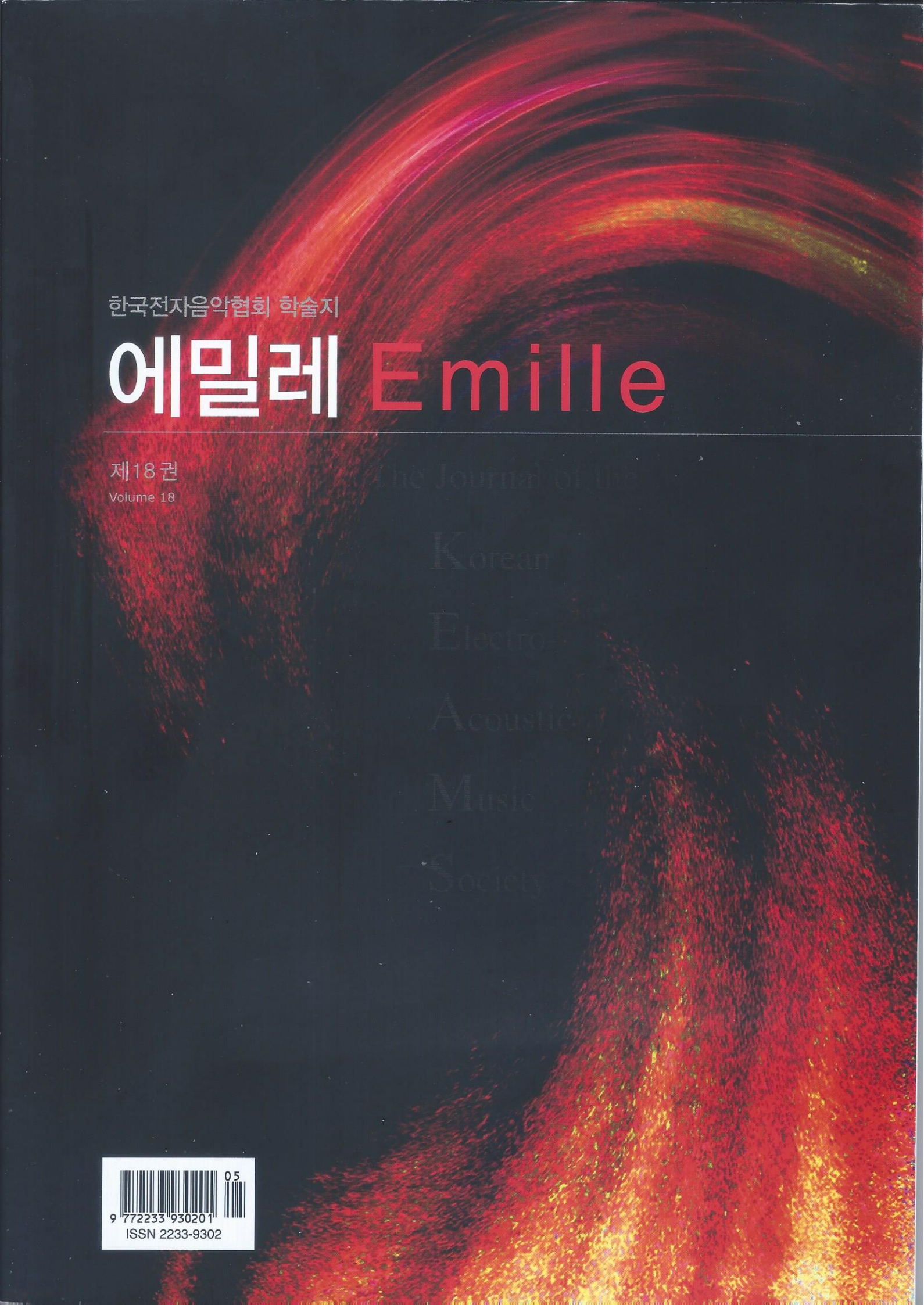

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차례

Collaborative Creation with Soundcool for Socially Distanced Education

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Soundcool is a flexible, modular computer music software system created for music education. Moreover, Soundcool is an educational approach that embraces collaboration and discovery in which the teacher serves as a mentor for project-based learning. To enable collaboration, Soundcool was designed from the beginning to allow individual modules to be controlled over Wi-Fi using smartphone and tablet apps. This collaborative feature has enabled network-based performance over long distances. In particular, the recent demand for social distancing motivated further explorations to use Soundcool for distance education and to enable young musicians to perform together in a creative way. We describe the educational approach of Soundcool, experience with network performances with children, and future plans for a web-based social-network-inspired collaborative music creation system.

Keywords: Collaborative Creation, Education, Social Distance, COVID.

Soundcool is a free system for collaborative Sound and visual creation that has received several awards and has been invited by the World Science Festival 2019 in New York. See Scarani et al. (2020) and Sastre and Dannenberg (2020) and the references therein for a complete explanation. The Soundcool system offers different modules such as audio and video sources (live audio and video inputs, players, hosts of VST virtual instruments, signal generators), audio and video effects, mixers, video switchers, etc. (See Figure 1). These modules run on personal computers with the possibility for control via Android or iOS smartphones and tablets (see Figure 2), or other devices using the Open Sound Control (OSC) protocol. The system has been used in several education projects in America and in European Erasmus+ education projects, in schools and universities (Sastre/ Dannenberg 2020). The connection of the control devices is typically done using a local area network based on a Wi-Fi hub. However, with students and even teachers confined at home because of the COVID-19 situation and online education, we realized that the networking capabilities of Soundcool could be helpful in distance education.

In 2016 we developed a system allowing telematic performances with Soundcool through the Internet (Scarani et al. 2020). We performed a concert called the GlobalNet Orchestra, with participants at Carnegie Mellon University (CMU) and the Universitat Politècnica de València (UPV) (see globalnetorchestra.blogs.upv.es/). However, this system was too complicated to be used generally and quickly, and we have developed a simpler system for online collaborative creation at a distance. We have tested this approach by recording several performances with students and teachers working from their homes, showing that the system can be used even in the more restricted situation of COVID-19 confinement.

Figure 1. Soundcool 4.0 computer launcher showing Soundcool modules.

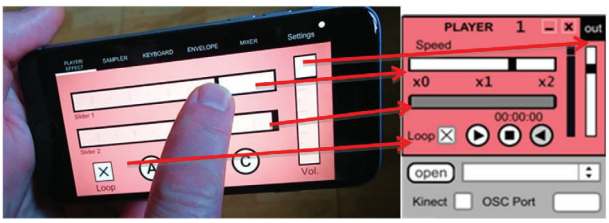

Figure 2. Control of the Soundcool modules with smartphones.

Online collaborative creation and performance

Soundcool was used for a telematic performance between CMU and UPV in 2016. In this performance, our goal was high-quality sound at both performance sites and reliable transmission of parameters in real-time, even at the expense of some added latency.

To deliver high-quality sound, we duplicated the local Soundcool configuration at the remote site. The idea was to deliver the same OSC control messages to a “mirror” Soundcool server so that, aside from small timing variations, the synthesized sounds would be the same, and we would not need to send high-bandwidth audio over the

network. The network would transmit only control information.

Normally, OSC is transmitted over the UDP protocol, which is a "best effort" protocol in which messages may be dropped due to network contention or transmission errors. (Peterson/ Davie 2012) While this is a minor problem in a local network, packet loss can be disruptive over long distances and many "hops" (forwarding retransmissions) as packets transit multiple networks. To ensure reliable transmission, we created simple software to receive OSC locally, forward the messages to the local Soundcool server over UDP, and forward messages to the remote site using a reliable TCP protocol. (TCP uses acknowledgements, retransmission and sequence numbers to guarantee in-order, loss-free delivery of data at the expense of added delay whenever a lost packet must be retransmitted.) Once the messages arrive at the remote site, they are forwarded locally to Soundcool via UDP, making the control system totally transparent to the Soundcool servers, but allowing users to control both servers as one. (See Figure 3.)

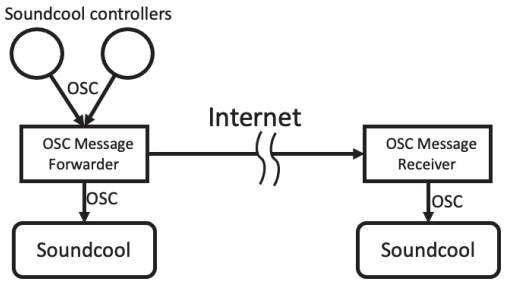

Figure 3. For network performance, controls for local Soundcool application are duplicated and transmitted reliably to a remote site, where duplicate OSC messages are constructed and forwarded to another "mirror" Soundcool configuration.

As the pandemic isolated teachers and students, we looked for a simple way to use Soundcool. Videoconference systems like Zoom allow a single Soundcool server to send sound to all participants with minimal setup since participants are already connected by videoconference. Participants need only send OSC messages from smartphones and tablets to the Server to enable real-time collaboration. Aside from packet loss, the main difficulty is that Soundcool network ports are not immediately accessible over the Internet due to standard security precautions in ordinary home routers. However, it is not difficult to reconfigure typical home routers to allow receipt of UDP messages with specific port numbers. Only the teacher running Soundcool needs to do this because routers only block *incoming* traffic, not *outgoing* messages from students. Once ports are opened, students from anywhere on the Internet can control Soundcool, given the Soundcool program's Internet IP address and the proper port numbers.

A drawback of the UDP protocol, again, is that it does not guarantee that messages are delivered. Tests should be conducted to see if the rate of lost messages is low enough for educational applications. Our first test was done on June 14, 2020 in a Webinar with the Association of Music Teachers of the Murcia Region (ADMURM, Spain) where a Soundcool program running in Valencia was controlled by a teacher and her smartphone in the city of Murcia, at a distance of about 200 km. (youtu.be/B4I3G2YCG-s?t=1736) (See Figure 4.)

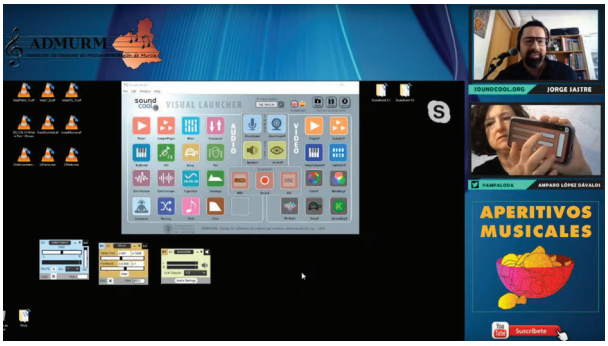

Figure 4. Control of Soundcool in a PC in Valencia from a smartphone in Murcia, Webinar ADMURM (Spain), June 14th, 2020.

Our first telematic performance with the new system featured a collaborative creation with participants from their homes in Madrid and Valencia in Spain, and Pittsburgh in the USA, on June 17, 2020. It was a Remix of the famous Kraftwerk's "The Robots," which was proposed by Jesús Jara, director of the Escuela Municipal de Música y Danza María Dolores Pradera (Madrid, Spain). Participants included his young Sonotronic (curriculum) students, another teacher from the school, Juan Manuel Escalera, and Roger Dannenberg, Stefano Scarani, Saúl Moncho, Manuel Sáez and Jorge Sastre from the Soundcool team. Jesús and the computer with Soundcool were at the school, and he shared his screen with all the participants over a Zoom videoconference. The performance was based on triggering samples by the participants, creating a soundtrack for the video, which is taken from the animation "Superman: The Mechanical Monsters" (1941). Participants also controlled the cut-off frequency of a low-pass filter, some effects, and mixer levels. See Figure 5 and youtu.be/O8IRLvGZnb8 (English subtitles available).

The delay and UDP packet loss rate was noticeable but acceptable. From Pittsburgh (worst case), we can measure less than 1% of packets are lost and average round-trip time is about 120 ms. Perhaps due to Zoom and multiple OSC connections, we estimate the loss to be closer to 20% and adding the delay of Zoom makes the response time around 0.5 s. The packet loss can be mitigated by making slow control changes and finishing each gesture with a few small changes, since every small

change sends another packet, and at least one out of every few packets is highly likely to get through.

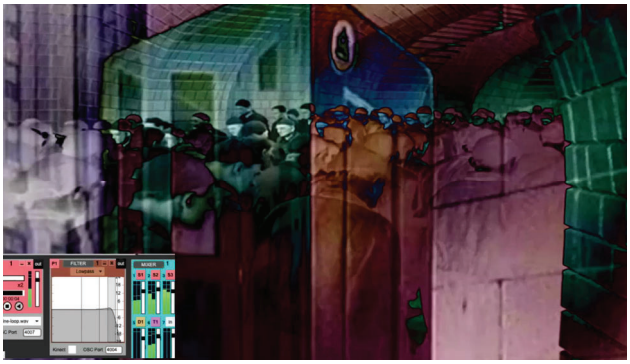

Figure 5. Kraftwerk Remix performance with participants controlling a Soundcool filter, a mixer, players and effects (some of them are shown bottom left) from Madrid and Valencia (Spain) and Pittsburgh (USA), June 17th, 2020.

At the end of July, we offered an online course on collaborative music and audio-visual creation with Soundcool for socially distanced education, and there we challenged the students to make a TV show as the final course work. It consisted of a piece of news and a concert called Crónicas Terrícolas (Earth Chronicles). This time we used Microsoft TEAMS for the course videoconference. (See Figure 6.) One of the participants from Valencia (Spain) controlled a video switcher (top right of Figure 6) to change the video source according to the TV show structure.

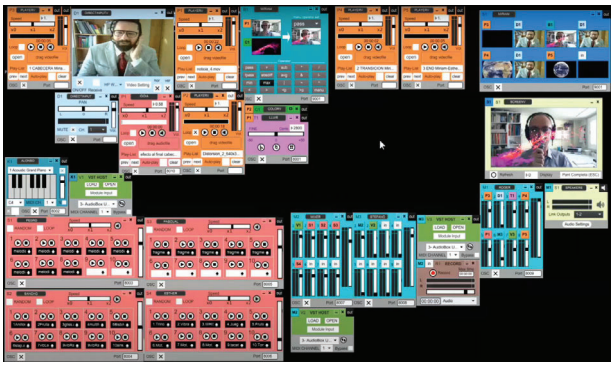

Figure 6. Soundcool patch for the Earth Chronicles show with participants in several cities in Spain and Pittsburgh (USA), July 28th, 2020. The patch includes four (4) sample players (lower left), mixers, video players, a video switcher and multiple audio and video effects processors. Patching (not visible) is by clicking an output button and input button in sequence. These buttons and connection indications are generally in the upper left and right corners of modules.

The TV show video could be seen in full screen, however we preferred that the participants see the TV show in a small window so that they could also see how they controlled the Soundcool modules from their homes. The central computer with Soundcool was at Sastre's office in Valencia. He was the TV show announcer using the live video from a webcam. In the following we explain the work that can be seen at youtu.be/rXQ73PWxzSk (English subtitles available). The piece of news part was triggered by a sound at audio player (P1, Red color) controlled from the Basque Country (Spain) as a sudden alarm sound. It was about a computer virus infecting computers in Catalonia (Spain), the location of the participant who proposed this part. He recorded video previously, which we played at the central Soundcool computer. To represent a virus, the participant controlled a transposing effect applied to the video voice and a participant from Valencia (Spain) controlled video blending with another video (controls are visible at top center, and result is visible at the right of Figure 6). After that, a musical performance took place. Melodies and extended techniques for clarinet and flute had been previously composed and recorded by the participants. The quantity of granular synthesis VST delay effect applied to the music was controlled by Stefano Scarani in Valencia along the piece, and Roger Dannenberg controlled the final mixer levels for the whole TV show with his smartphone connected from Pittsburgh (USA). The piece was improvised in sections cued by Sastre's holding up 1 to 5 fingers in sequence:

1) 2:14. The music starts with some improvisations in a virtual instrument (a free vocal type VST) controlled by a participant in Castilla la Mancha (Spain).
2) 2:31. Pentatonic clarinet melodies are played using a Sampleplayer module controlled from Andalusia by their composer. They are mixed with the clarinet extended techniques played by another Sampleplayer from the Madrid Community by the clarinetist that recorded them.
3) 3:17. Atonal melodies from the Valencian Community are played in a third Sampleplayer by their composer and mixed with flute extended techniques from the Murcia Region played in a fourth Sampleplayer by the flutist that recorded them. Also, after in this part at 3:44 there is a sign with both hands for all the participants to stop performing except for the granular synthesis delay, to give variety to the music.
4) 3:54. Again, pentatonic clarinet melodies, but with speed change effects and some more participants performing.
5) 4:42. We end with a return to the VST instrument improvisation and a final granular synthesis delay effect.

Finally, the announcer says goodbye. The entire show consisting of music compositions, recordings, etc. was prepared in a few days. The UDP packet losses and delays, as before, were acceptable for this application, showing that collaborative creation and performance with Soundcool is possible even in a confinement situation. We note that precise timing and rhythmic synchro-

nization are not possible within this approach, but that merely shifts the pedagogical and musical focus to sound textures and music organization at larger time scales. Details at smaller times scales can be addressed through the use of samples with rapid and even rhythmic events.

The role of the teacher in collaborative education

The new teaching paradigm is based on interaction and collaboration between teachers and students. Students locate information when they need it. They have a device in their pocket with which to answer a question at any time. Why then does the teacher have to offer them material that they can find themselves? Collaborative education focuses on the work of the mentor teacher, as a guide to select necessary content, taking into account the students' interests and individual needs. Project learning is essential for this new digital collaborative training. This approach, far from being new, has been known since the middle of the 20th century. The basic levels of Bloom's taxonomy of learning (Bloom 1956) already anticipate this. Knowledge (theory) and the understanding and the application of these theoretical contents (problem solving and practical sessions) are levels that digital technology already provides without the need for a wise teacher to provide them. However, the complex levels of learning, knowledge analysis and synthesis, and innovation are not offered by technology alone. The teacher must be the center of the dynamization of knowledge and must use the means that his students use daily.

For young people, the Internet, social networks and apps constitute very relevant spaces for socialization, encounter, exchange and knowledge. This is why Soundcool has been considered since its inception as a collaborative learning and creation tool where the teacher has a vital importance in the learning and creation process. As Professor Duart says in his editorial "Internet, Social media and Education," "Teachers have the challenge of being permeable to the changes that occur in the communicative environment and social uses of the Internet. The true transformation is found in the educational dynamics, in the educational process that takes place in the classroom and, today more and more, out of it." If you really want to motivate and reach students, you will have to understand their environment and adapt the teaching to it. And this is the fundamental basis for the development of the Soundcool project, especially as an integrator of STEAM (Science, Technology, Engineering, *Arts*, and Mathematics – a broadening of STEM) for student learning. Due to this interest, a large part of the project's efforts has focused on generating tutorial materials for teachers (see Figure 7) so that they can use the tool in the classroom or online as in our last remote connection project. Therefore, several sound, music, audio-visual and multidisciplinary projects are available for teachers in soundcool.org/en/projects/ (see Figure 8), and teacher video tutorials for acoustics and language (Spanish) are available in bit.ly/3lsJibu (see Figure 8). These tutorials have focused on explaining to teachers how to create collaborative training activities with their students using the Soundcool tool, both with all the students in the classroom and with the current social distancing due to the effect of COVID-19.

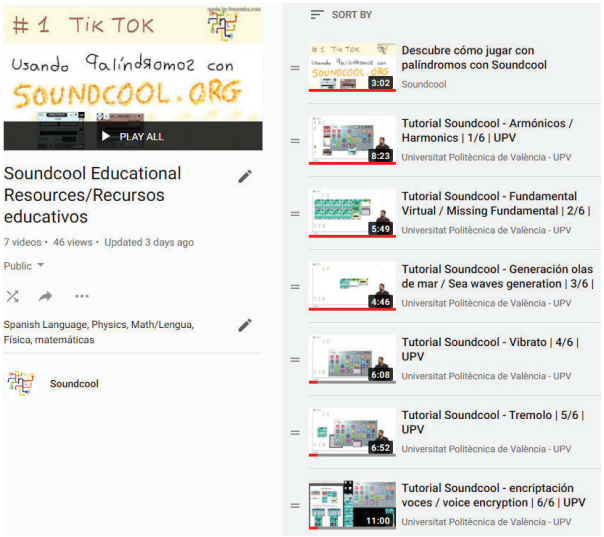

Figure 7. List of Soundcool teacher tutorials.

Figure 8. Basic Soundcool projects as radio workshop, soundtracks, producing and recording loops at soundcool.org/en/projects/.

It has been essential for our project to create not only a tool, which will remain as a mere technological development, but to design a whole model and a teaching methodology that allows teachers to apply this methodology in the classroom. Teachers are encouraged implement technology not as an end but as a means for education and training and to introduce innovation in the class-

room through the development of collaborative projects, either in person or in virtual form.

Given the current situation in which we are immersed, students can be reached at any time, but the teacher has to be willing. It makes no sense to close communication with the student outside the classroom, and a collaborative environment must be created that allows this continuous and constant interrelation with all the students, whether in the classroom or in a virtual environment. This is what our tool offers to the teacher: places where the teacher is the center of learning without having to be in the classroom in person and without losing control of the training of their students.

Toward Soundcool as a Social Network

Music is an inherently social process. Soundcool has shifted the focus of electronic music from the individual working alone at a computer to a collaborative design and performance process. As we explore how best to deliver Soundcool conveniently to young users and even non-technical teachers, we have begun a complete re-implementation, moving Soundcool from a Max-based desktop application (cycling74.com/products/max) to a Web Audio application (www.w3.org/TR/webaudio/) running in the browser. We now have the basic modules of Soundcool running in Web Audio (github.com/ rbdannenberg/soundcool), and our goal is to offer a website where anyone can simply open their Web browser in order to use Soundcool.

One advantage of a web-based Soundcool is that users will automatically be interconnected through a shared server. This will enable collaboration through:

- sharing and copying examples, tutorials, and completed works. Students can learn from others or publish their projects to be seen by friends and relatives,
- joint projects can be undertaken by sharing module patches and audio or video samples. Users can compare different versions,
- group performances where each participant downloads and operates a “mirror” of the shared patch. As performers adjust parameters, cue sounds, and make selections, the changes are transmitted through the Soundcool server to all mirrors, and all changes are effected globally.

In this paradigm, it would not be difficult for groups of 2 to 20 play together, even with modest network bandwidth since all audio is generated locally[1]. We expect to make a first release before the end of 2020.

Summary and Conclusions

Soundcool is an easy-to-use but high-quality and very capable system for computer music creation. While intended for young students, Soundcool has found many uses in professional settings due to its combination of flexibility, high-quality sound, and ease of use (see bit.ly/soundcool-pro). Much more than mere technology, Soundcool was designed from the beginning to support collaborative creation, particularly through the simplicity of controlling modules using smartphones, tablets, and Wi-Fi.

The control of Soundcool over Wi-Fi led us to use Soundcool as the basis for collaborative network performances, sending Soundcool audio and screen-sharing to performers using a Zoom videoconference, and using Internet connections from smartphones and tablets to Soundcool for collaborative control by the group.

The collaborations and performances so far have been very encouraging, including a performance with school children from Madrid and with teachers from several cities from Spain. We look forward to more performances.

In the future, we aim to make collaboration and interaction even simpler by creating a web-based version of Soundcool that will be inherently networked and interconnected. This continuation of the Soundcool project will make it even easier to share media, sound design, patches, and real-time collaborative control at a distance.

Soundcool has shown great promise as an innovative approach to music education, a way to expose young students to the possibilities of creative and experimental electronic sound, and a powerful means to enable collaborative creation. Given our current need for social isolation, Soundcool has become a vehicle for bringing young performers together again, by making network performances simple enough for teachers and students without extensive knowledge of networking and computer systems. We look forward to many more possibilities for music and education as we create a Web Audio version of Soundcool.

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[1] In some situations, it may be practical to stream live audio and/or video from performers in addition to control information, perhaps building on WebRTC (webrtc.org). However, given frequently encountered bandwidth limitations, especially in education, we leave that to future work.