DrAwME: Drawing Canvas for Music Creation - A New Tool for Inquiry Learning

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***Abstract*—DrAwME is an educational environment that is being developed in the context of the iMuSciCA project. iMuSciCA is an H2020 European project which aims at providing an online workbench for the deeper learning of STEM (Science, Technology, Engineering and Mathematics) by bringing Art and especially music in the center of the learning process. DrAwME is a web-based tool that enables the free drawing of music on touch-enabled computers and that is freely available online. DrAwME also provide some advanced sound visualizations possibilities, to let the student explore music and sound properties, that are either generated by the tools itself or captured by the microphone. This tool offers various educational possibilities: the explorations of sound frequencies, the easy creation of small tunes, and the visualization and investigation of sound waves properties. DrAwME permit the creation of creative and stimulating activities to engage the students into the learning process of STEM through the exploration of music. The expected benefit from this innovative educational technology is that students would achieve a deeper understanding of the STEM knowledge they acquired that way. User study among both students and teachers shows the ease of use and the overall friendliness of the DrAwME tool.**

***Index Terms*— Educational technology, music learning, STEM learning, inquiry learning.**

I. Introduction

iMuSciCA is an European project which aims at providing an online workbench for the deeper learning of STEM (Science, Technology, Engineering and Mathematics) by bringing Art and especially music in the center of the learning process. We believe that student would be more eager to learn sciences through creative and stimulating music activities. By encouraging students to engage in exciting interactive music activities, they will become more active of their own learning experience. The expected benefit from those innovative educational technologies is that students would achieve a deeper understanding of the STEM knowledge they acquired that way.

The DrAwME tool is an online educational environment that is freely available online at https://unifri.imuscica.eu/drawme. It offers an easy music creation interface using fingers or stylus on touch enabled computers that is very intuitive and doesn't require any beforehand knowledge, whether theoretical nor practical. DrAwME also provide some advanced sound visualizations possibilities, to let the student explore music and sound properties, that are either generated by the tools itself or captured by the microphone. It will be soon integrated into the iMuSciCA workbench to offer an even wider range of activities by connecting to the other iMuSciCA educational environments.

This paper is organized as follows: next section presents some related works. Section III explains the different possibilities offered by DrAwME. Section IV gives some insights on the benefits of engaging students in the learning process. Finally, we conclude and discuss future work in section VI.

II. Related works

This work is at the crossing between music creation, and the inquiry learning paradigm. The following sections presents the related works to music creation and inquiry learning respectively.

A. Music creation

Different tools to generate sound and music exists, like the will known SuperCollider [13]. SuperCollider is a programming tool in which the user can write a script in the SC programming language that will be interpreted by the tool and generate sound. This tool led to the birth of the algorave movement, where artists program there music in a live show [2].

Other tools are more novice oriented, like CODES (COoperative Music Prototype DESign) [11]. CODES focuses on the easiness of use and on the collaboration between user for music co-creation.

More advance piece of technology include some kind of artificial intelligence or generative music programming to compose music on there own, or in collaboration with the user [1].

Some work has also been done on graphical representation of music, to visualize intuitively the content of a piece of music [3].

B. Inquiry learning

In the last two decades, a shift has happened in education and a new learning paradigm has emerged: online education [7]. One of the critical success factors in online education is the technology, which explain the continuous development of new educational environments [12].

More recently, online learning developments have focused on inquiry learning, where students adopt a scientific approach based on questionning, exploration and testing for a better

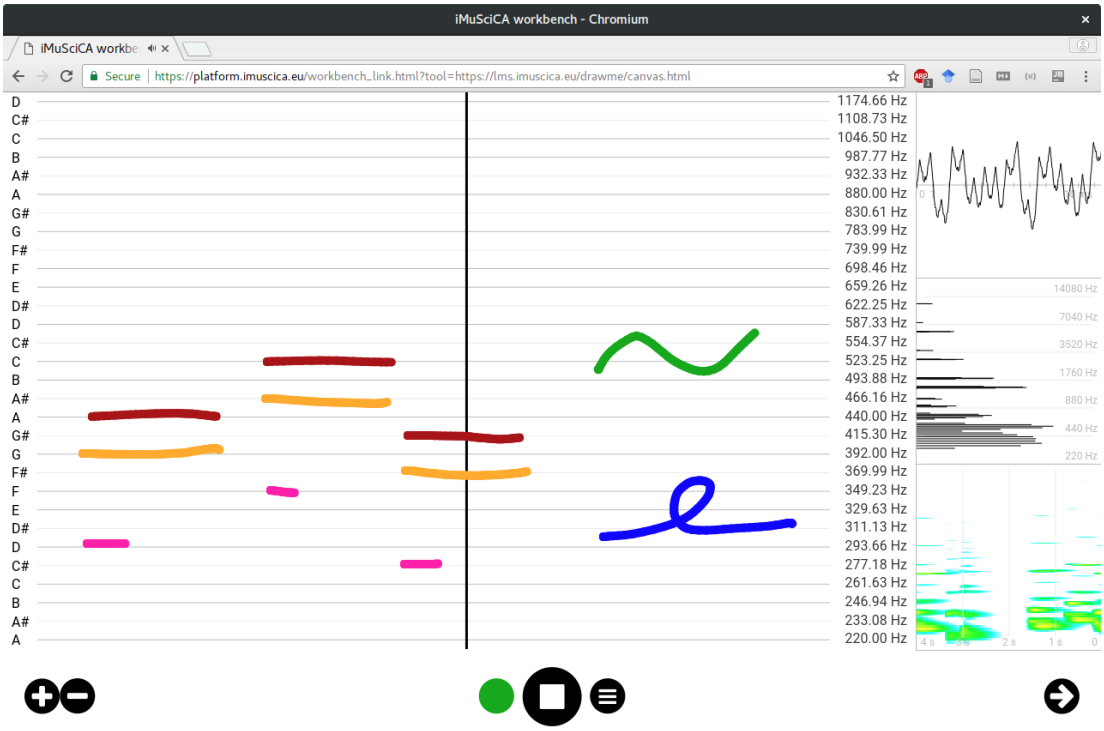


Figure 1: The DrAwME tool, with the drawing canvas in the middle and the visualization miniatures on the right side.

understanding. In inquiry learning, students take initiative in the learning process to build their own knowledge [4],[8].

Some studies shows the requirement for a personal learning space, and highlight the importance of communication and interactions between the students, and with the teacher [5],[6].

Among the recent innovations in STEM education, the Go-Lab federation of online labs enable inquiry based education that promotes the learning of deep conceptual domain knowledge and inquiry skills [9]. Go-Lab offers students to perform scientific experiments with online labs in pedagogically structured learning spaces.

STEM teaching by inquiry learning does not only teach STEM, it also teaches inquiry which is a crucial skill in today society and work market. Inquiry learning teach student how to learn: to regulate their own learning, to continue to learn new knowledge and to update their existing knowledge.

III. A VERSATILE TOOL

The interface of DrAwME is presented in figure 1. It is divided in two parts, the drawing canvas on the middle-left, and the visualization views on the right panel. A few buttons at the bottom provide all necessary options.

A. *Intuitive music creation*

DrAwME is a very intuitive tool, that allow the creation of small music tunes very easily. The x-axis represents time and the y-axis is mapped with the frequency scale, which is displayed on the right in Hertz with a correspondence in notes on the left. The user can draw on the canvas using his finger or a stylus on a touch-sensitive computer and DrAwME produces a live sonification of the handwritten strokes. Strokes can be deleted using the erase button of the stylus (or right clicking with a mouse).

Multiple colors (on the left of the play/stop button), representing different sound types, are available for more creativity. Currently, four waves generators are available: sine, triangle, sawtooth and square and a few instrument timbers: bass, celeste, organ, etc. Once the tune-drawing is complete, the user can use the play button at the bottom to play the whole creation from left to right.

For a wider range of frequencies the user can use the zoom buttons to increase the frequency and time spans. Different options are available in the setting menu (on the right of the play/stop button), like increasing and decreasing the volume and playback speed, and activating the loop playback (repeat mode). A snap to line option is also available when a better frequency accuracy is desired, which will constrain the strokes to be on the note lines.

B. *Easy sound visualization*

Different visualization views are present in DrAwME, which are science oriented to allow the students to investigate the sound properties. DrAwME provides three different visualization views:

- a waveform,
- a Fourier transform,
- a spectrogram.

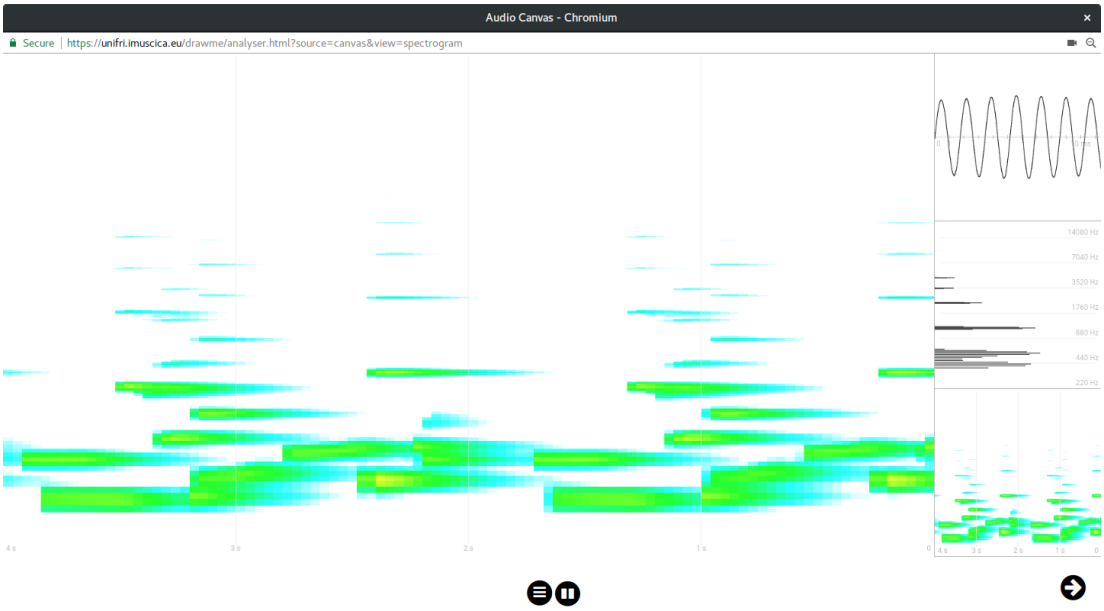


Figure 2: The DrAwME tool in visualization mode, with the selected view (here the spectrogram) in the middle and the visualization miniatures on the right side.

The waveform view displays the sound wave oscillation, which can be used by the student to measure the period of the signal (especially when using sine oscillator as a timber). The Fourier transform shows the different frequencies that compose the signal. The spectrogram displays the evolution of the Fourier transform with time, which gives a image of the sound produced by DrAwME over time.

The three visualization tools can be magnified by clicking on any of the miniatures. In visualization mode, (when a visualization is magnified, see figure 2), it is also possible to switch between the input between the drawing canvas and the microphone to visualize the sound produced by voice or any real instruments.

The visualization view can be paused, to further explore its properties at a specific time, and the frozen graph can be exported. This allows students to use other tools, either provided by iMuSciCA like Cabri as well as others, to investigate the wave form and Fourier coefficient properties for instance [10].

The DrAwME learning environment implements the LTI protocol (Learning Tools Interoperability) which allow it to be easily be integrated into LMS (Learning Management System) like Moodle or Canvas.

IV. Engaging students

The main interest of DrAwME is to offer an intuitive and unconstrained tool that students can use for a lot of purposes, from music creation to scientific sound analysis.

A. Art discovery

DrAwME can be used to bring students to art, by making them discover music creation without any knowledge requirement. The tool interface is very simple, and the sound creation very intuitive which allows anyone to create small tunes as they like. Not any basic knowledge on music is required, no music score reading abilities nor instrument playing skills are needed. With DrAwME, anyone can become an artist.

B. Engaging into STEM

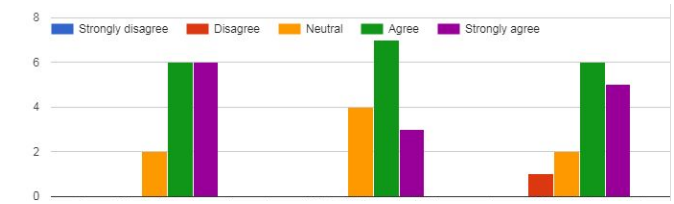
DrAwME is also a whole educational environment in itself, first by allowing the scientific analysis of sounds, but further than that by engaging students into this scientific approach. This tool support new pedagogical methodologies by fostering discovery based learning. Students can explore different phenomena and laws of physics through creative music activities. This engagement of the students in those learning activities gives them a deeper understanding of the acquired knowledge in the end.

This learning environment foster the active learning of the student, that explore and investigate STEM topics through music. In this context, the teacher leaves his standard role of knowledge repository to go towards being a learning catalyst, and knowledge navigator.

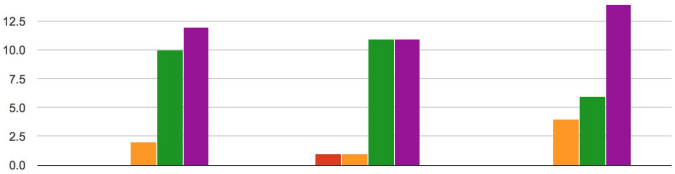
Since this tool is freely available online, the students can also access it from home to continue investigating the topics seen in school, but also for personal use. DrAwME can be use to create music samples, or small tunes for phone ringtones for instance.

V. In-school tests

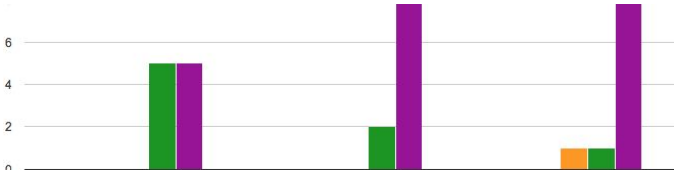
DrAwME as been tested in three schools (in Belgium, France and Greece) during the first pilots test of the iMuSciCA project. The goal of tis usability tests was to validate the activity environment and improve the interface where changes are needed.



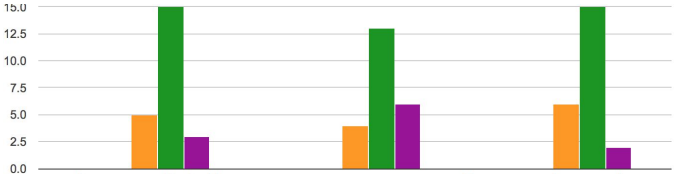
(a) Teachers (14 adults)



(b) Students from Belgium (24 children)



(c) Students from France (10 children)



(d) Students from Greece (23 children)

Figure 3: Overall usability test results: teachers (a), students from Belgium (b), France (c) and Greece (d) commenting statements 1, 2 and 3 about ease of use of the DrAwME tool to complete the study (blue corresponds to 'strongly disagree', red to 'disagree', yellow to 'neutral', green to 'agree' and purple to 'strongly agree').

The test scenario was intended to lead the students to draw specific shapes (e.g. a rectangle), to listen to them, to try different timbres by changing the stroke color, to find out how to delete their drawings and activate the "snap to lines" option. All participants (teachers and students) were then ask to comment on their agreement with the three following statements:

Statement 1: I am satisfied with the ease of completing the tasks in this study.

Statement 2: I am satisfied with the amount of time it took to complete the tasks in this study.

Statement 3: I am satisfied with the support information when completing the tasks.

Figure 3 presents the overall results of the usability tests of the teachers, students from Belgium, France and Greece. Most of the participants agree or strongly agree on the ease of using DrAwME to complete the study and are satisfied with the time it took them to find how to execute the different tasks. The participants are also generally satisfied with the support information that is provided by the user interface (UI).

The participants were also asked to fill more specific questions about the different tasks of the study and the elements of the UI (user interface) that was used to that purpose. It appears that most of the UI elements have a clear meaning (colors corresponding to timbers, identification of the visualizations, playback controls, etc.) of their purpose except two: the erase function and the "snap to line" option. As a results, the erase functionality will be redesigned and the "snap to line" option will be more explained.

Some participants among the teachers suggested an undo button, to easily remove erroneous strokes. A pause functionality was also suggested to be able to investigate more the sound properties at a specific time. All those results and suggestions will be taken into account before the next pilot testing phase. The second phase of pilot testing will consist of a real teaching scenario using the DrAwME learning environment in order to evaluate the impact of using DrAwME on the student learning.

Overall concerning the user-friendliness of the DrAwME environment, the students were generally very satisfied. Student get engaged very quickly in with the DrAwME tool, with a high level of joy and contempt. DrAwME really catch the student interest and attention, which is a mandatory step in inquiry learning.

VI. Conclusion

DrAwME is a very versatile and innovative learning environment that is developed in the context of the iMuSciCA project. It allows the intuitive creation and exploration of sound and music, without requiring any previous knowledge from the user. The tools offers multiple visualizations to analyze sound and music from a more theoretical point of view and led students into the physics of the sound waves.

DrAwME is designed to offer a exploration and inquiry based approach to STEM (Science, Technology, Engineering and Mathematics) through creative and stimulating music activities. The inquiry approach of learning leads the students to be more engaged, and results in a deeper understanding of the acquired knowledge.

iMuSciCA is an ongoing project and the DrAwME tool will be integrated into the iMuSciCA workbench, creating many more possibilities of interactions and investigation. Students will be able to customize and design their own virtual instrument in 3D, and then use DrAwME to test its sound. They will also be able to export the sound frequencies to mathematical tools to analyze the sound properties easily.

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