So, H. J. et al. (Eds.) (2020). Proceedings of the 28th International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

LiveDots: Real time Interactive Braille Music Translator to Integrate Blind Students into Music Classes

Claudia GUERRERO-GARCÍA-HERAS[a*], Óscar DÍAZ-RIBAGORDA[a], Lucas DE-TORRE-BARRIO[a], Borja MANERO[a*] & María GUIJARRO-MATA-GARCÍA[a*]
[a]*Complutense University of Madrid, Spain*
*claudiaggh@gmail.com, bmanero@ucm.es, mguijarro@ucm.es

Abstract: Music is a universal cultural expression; however blind students may have difficulties to follow a sighted music class due to the lack of a common written music language between teacher and student. This problem is also present in other academic fields, like science. An approach to solve it is *EDICO*, a real time interactive Scientific Editor. We want to take the solution of real time interactivity to the music field. This paper presents the development process of a real time interactive solution called LiveDots and an experiment to test it in which we develop a real time interactive solution called LiveDots and test it with blindfolded users to check if it could help integration of a blind student in a music classroom. Results show that LiveDots was usable by both sighted and blindfolded users and that real time interactivity may be useful to integrate blind students in music class. These results open up a new horizon of solutions based on real time interactivity to ease blind and sighted students' integration in the same class.

Keywords: Accessibility, blind people, tiflotechnology, inclusive education, education, music, real time interactivity, Braille, Braille music, screen reader, Braille line, computer application.

1. Related work

Braille is the most extended method of tactile reading and writing amongst the blind. It is based on different combinations of embossed dots (Kent, 2012). The extension of Braille to the music field is known as Braille music (de Candé, 2002). Musical Braille not only gives blind students a tool to understand and express music but also shapes how we think and talk about music and, by extension, how we analyse it (Abramo & Pierce, 2013; Johnson, 2015).

However, blind students do not often receive the education needed to understand musical Braille notation and most schoolteachers do not know Braille neither how to facilitate the student's learning. The alternative for blind students in order to improve their musical skills is to attend a school for the blind. In this scenario, blind and non-blind students are taught using different teaching strategies leading to a dichotomy between music Braille and conventional music writing. The lack of familiarity with conventional music writing makes it more difficult for blind students to later join in an environment with sighted musicians, for example in music college or in an orchestra (Goldstein, 2000).

There is a need for blind students to be able to follow a music class with mostly sighted students while learning Braille music notation and understanding the conception of print music (Quaglia, 2015; Buhagiar & Tanti, 2011).

Some of the conventional strategies and tools used by blind or visually impaired students to facilitate participation in class are: enlarged print notation, fellow class members, parents or teachers reading the scores for them and use of Braille music notation whenever it is possible (Frederick & Moss, 2009; Smaligo, 1998). All these tools need either the help of a person who transcribes the score orally or a teacher who knows musical Braille and teaches it to the student which may not always be possible. This makes the student dependent on people around him.

The advance of technology in recent years has given the chance to ease the integration of blind students. There are projects like Braitico (*ONCE*, n.d.), an inclusive Braille literacy method developed by the *ONCE* (National Organization of the Blind in Spain) intended for children to learn Braille. In the field of music, there are computer programs designed to enable visually impaired people to view and edit music in Braille notation (Homenda, 2008) like Braille Music Editor (Veia Progetti, n.d.), studies about how to teach Braille music to children using computer applications (Nicotra and Quatraro, 2008; Borges y Tomé, 2014), approaches to teach music to blind studies using talking music instead of Braille (Capozzi, Prisco, Nasti & Zaccagnino, 2012), score translation programs from print music into Braille music and vice versa like FreeDots (Repain et al, n.d.) and there is even a standard to share Braille music notation in the web called Braille Music Markup Language (Encelle, Jessel, Mothe, Ralalason & Asensio 2009).

These applications allow the teacher to create a print score with an editing score program, like MuseScore (Schweer, n.d.), and to translate it into Braille using a translation program so the student can read it. However, interactivity is missing: if the teacher wants to modify an element of the score to correct it or to make an improvised exercise, first, the changes should be done in the editing score program, then exported and translated into Braille with the translation program and finally the student could see the changes. This is a slow process that does not integrate a blind student into the usual development of a music class.

The problem of integrating blind students in the classroom is present in almost every field in education. There are many different approaches for a solution, like Aim-Math, an interactive-enhanced mathematics learning system for blind and visually impaired students using text-to-speech to read aloud math expressions (Naruedomkul, 2013). However, this approach is not friendly for a class of blind and non-blind students. Another approach is *EDICO* (Scientific Editor *ONCE*) (Carenas, Cabra, Mata-García, Gea & Hernández, 2018), a project promoted by the *ONCE* and developed in cooperation with the University Complutense of Madrid. It is an accessible mathematics, physics and chemistry editor. It translates scientific language in real time from printed writing into Braille and vice versa. This allows blind students to follow a science lesson interacting in real time with a teacher who doesn't know Braille.

2. Introduction to the project

After the success of *EDICO*, the *ONCE* wanted to develop similar solutions to integrate blind students in other subjects, like music. This is how the idea of LiveDots was born: a music editor that translates music scores from print music to Braille music in real time. LiveDots is an innovative desktop application which allows users to read a score in Braille and in print at the same time and to modify the print score and see the changes in the Braille score in real time. This would give the blind students a solution to the lack of interactivity we explained before.

The main objective of this study was to check if the application LiveDots is useful to include a blind student in a music class. We believed that being able to translate scores into Braille in real time would increase the interaction between teacher and blind students improving blind students' participation. This can be verified by checking if people find the application useful and if they would recommend it. To prove our theory, we formulate the following research question:

RQ1. Can the application LiveDots help with the inclusion of a blind student in a music class?

In addition, to test the utility of the application LiveDots, it is important to verify its usability. Therefore, another goal of this test was to verify usability for both target users: music teachers and blind music students.

On the one hand, it is required that a blind person can use the application LiveDots without any assistance for the application to be useful. It is only necessary to check that the blind person can perform the basic functionalities such as opening and reading a score. When a person is able to read the score, no matter if he or she is sighted or blind, it directly follows that he or she can read the changes when made. Thus, the keyboard shortcuts and the screen reader must be practical and easy to use. To check this, we posed the following research questions:

RQ2. Can a blind person use the application LiveDots without any assistance?

On the other hand, a teacher should be able to use LiveDots even without knowledge on musical Braille. The actions loading a score and doing score changes have to be uncomplicated. Therefore, the last research question was:

RQ3. Can a sighted person with musical background who doesn´t know musical Braille use the application LiveDots?

3. LiveDots application characteristics

Building on the previous requirements (a teacher should be able to use the application without any knowledge about musical Braille and blind students should be able to use the application without any assistance), we decided to implement the following features in LiveDots (Figure 1).

The application uses scores in MusicXML format since it is the most used musical representation format. When it is selected, the score is showed both in print and in Braille. The print score for sighted users is displayed by a stave and musical elements and the Braille score is shown in

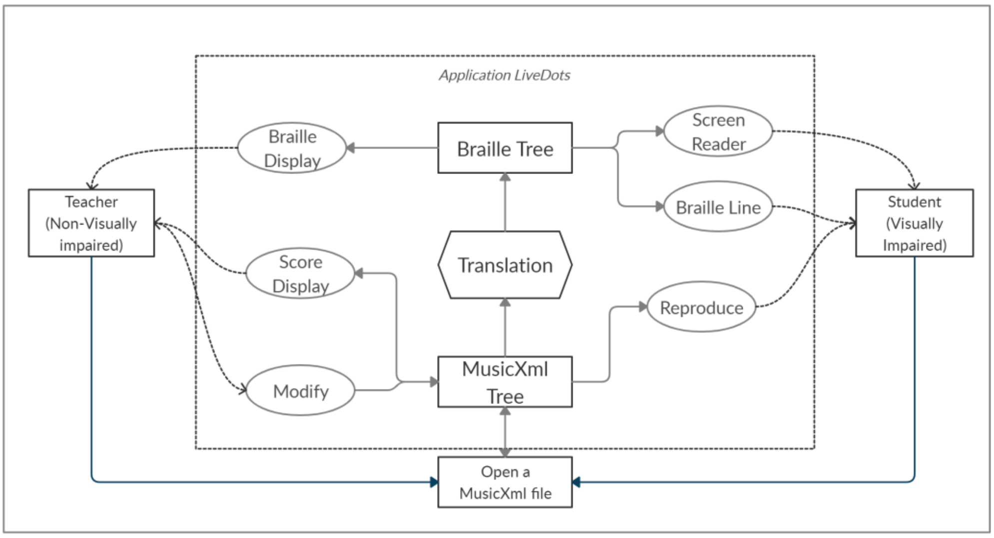

Figure 1. LiveDots Application Concept Design

Musical Braille notation to be read with a refreshable Braille display. On one side, a sighted user can edit the print score. These changes are shown in real time in the musical Braille score, so a blind student could read the new score in the refreshable Braille display at the same time it is modified. On the other side, a blind user can use keyboard shortcuts to use the application LiveDots and read the Braille score by a Braille line or using the screen reader: when placing the focus in the musical Braille score displayed on the screen, the screen reader will say the musical elements as you go through them. These features: screen reading of Braille musical elements and real time modification are an innovation of the application LiveDots. Other applications allow you to edit the score (for example, Musescore), but not in real time, or can be used with a screen reader (for example, Braille Music Editor), but they do not say each musical element in the Braille music score when you select them.

To deal with the translation we took inspiration from a study made on the matter (Goto, D., Minamikawa-Tachino, T. and Gotoh, N., 2007) but in order to allow the real-time translation that makes our application unique we used data binding combined with event handling. The other innovative feature, the Braille score reading, was accomplished by programming a personalized script for the screen reader (JAWS) to use with our application.

Lastly, the application LiveDots can be used by reduced visibility people and color-blinded people. The application allows to regulate the zoom (both in the scores and in the menu) and it is compatible with the Windows Colorblind Mode.

4. Methodology

4.1 Participants and experimental design

The study involved 7 participants. All of them were sighted people without any knowledge on Braille or Braille music. Each of them tested the application twice. They did it first blindfolded and then watching the application. Lastly, they did a questionnaire about LiveDots.
The experiment was designed in order to test if LiveDots could help to include blind students in a music class. First, the participants checked the application and then they gave us feedback with a questionnaire (Figure 2). For the experiment, each participant was provided the application LiveDots. In addition, they used the screen reader JAWS.

4.2 Questionnaire

The questionnaire had two initial yes/no questions. The first one was if getting Braille scores with informatic applications is easier than the traditional way of printing it on a piece of paper, and the second one was if the participant knew an application of translation or reading Braille scores different from LiveDots. Our hypothesis was that the answers would be yes and no, respectively. This would highlight the need of an application like LiveDots to do this translation and reading supporting the first research question (RQ1).

After these two questions, the questionnaire consisted of three different parts to check: usefulness, usability by blind people and usability by sighted people. They consisted of 5 questions each valued in Likert 5 scale, being 1 the worst scoring for the application LiveDots and 5 the best punctuation. To calculate the average value of each question we calculated the mean of the values of the responses.

Finally, there was an open question about what improvements the participant would make to the application LiveDots.

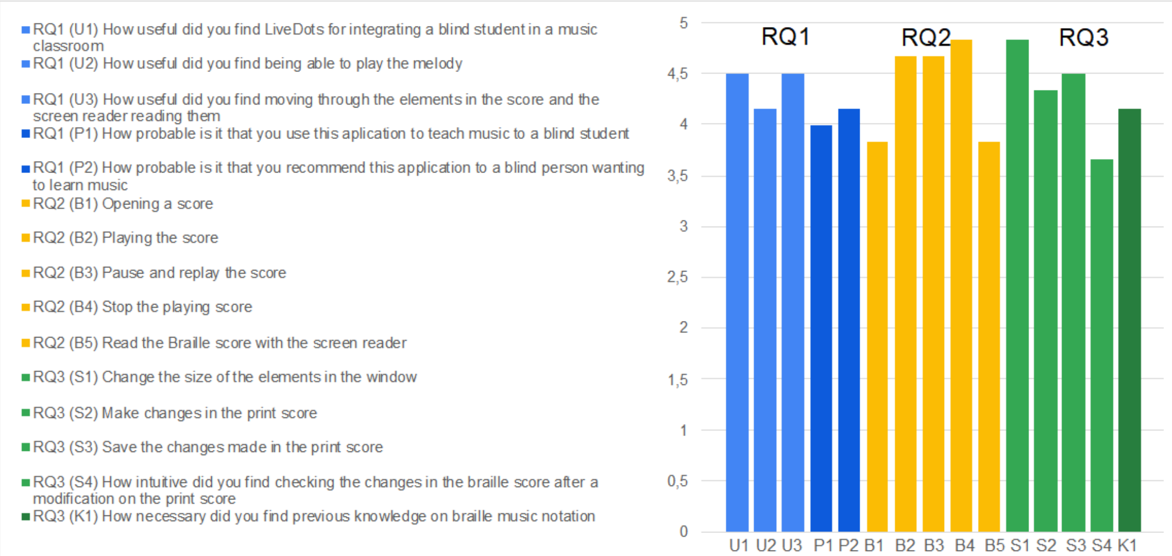

Figure 2. Results of the Likert 5 questions.

5. Results

After conducting the experiment, we obtained 7 answers for the blindfolded test questionnaire. We obtained a low answer rate due to the unexpected worldwide pandemic situation which did not allow us to conduct the experiment in the ONCE facilities. Having said that, we managed to get and analyse the results the best way possible. For the Likert 5 questions we calculated the mean of the answers obtained for each question and the results are the shown in the figure 6.

For each group of related questions, we calculated the arithmetic mean of the average answers and represented it in a box plot (Figure 3). For the yes/no questions we obtained that 100% of the testers think that the use of computer applications makes obtaining a score in Braille easier than the traditional methods. And 85.7% of the testers don´t know any computer application for translation and/or reading of braille scores.

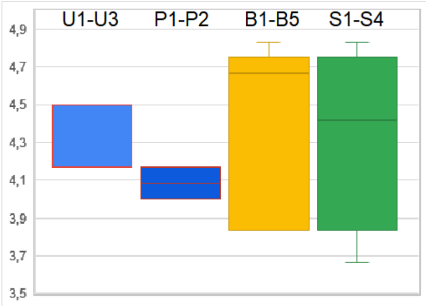

Figure 3. Box plot of the different sections studied.

6. Discussion

Throughout this section, we will try to answer the research questions set out in section 2 by discussing the evidence reported in the results section. First, we note the need of an application like LiveDots in the fact that although all of the participants (100%) think that the use of computer applications makes the task of obtaining Braille scores easier than the traditional method of printing on paper, hardly any of them (14%) know an application to accomplish it. As to test the utility of the application LiveDots (RQ1) it is necessary to test usability first (RQ2, RQ3), we will answer the research questions in that order.

RQ2. Can a blind person use the application LiveDots without any assistance? Yes. The blindfolded test results show that a blindfolded person can successfully perform the main tasks available in the application (4.36/5 in blind usability B1-B5).

RQ3. Can a sighted person with musical background who doesn´t know musical Braille use the application LiveDots? Yes. The sighted test results show that participants without any knowledge on Braille music could use the application without any trouble (4.33/5 in sighted usability S1-S4). Indeed, most of the participants (85%) think that little to no knowledge on Braille music is needed to use the application.

RQ1. Can the application LiveDots help with the inclusion of a blind student in a music class? Yes. After performing the blindfolded and sighted test the participants think that the application and its functionalities can be useful for integrating a blind student in a music class (4.38/5 in usefulness U1-U3) and they would probably use and recommend it (4.08/5 in P1-P2). In addition, RQ2 and RQ3 show that the developed application is also usable, which is a needed requirement for it to be useful.

7. Conclusions and future work

We developed LiveDots as an application to ease the communication between blind music students and sighted music teachers. The present study about provided empirical evidence that real time interactive applications can be used to integrate blind students in sighted music classes. In fact, LiveDots is an example in the music field that can be used to improve accessible education in our society.

The first conclusion is real time interactive applications, such as *EDICO* (application of Mathematics), can be generalized to artistic fields. Also, LiveDots design and the proposed experiment confirmed that the way blind people use computers is entirely different from how sighted users do it. Blind people use a screen reader and the keyboard to navigate with ease and use shortcuts repeatedly. On the other hand, sighted people typically use the mouse to navigate and do not usually know the place of keys.

This study had certain limitations. The instruments used were limited. The blindfolded experiment with sighted people gives an insight into answering our research questions, however the limited time available for the experiment and the global pandemic situation did not allow us to test the application with blind people. Non-sighted people could test the application deeper and check if habitual accessible procedures are followed in the application and if it is comfortable to use.

As a result of the success of the study, we are preparing a new experiment in cooperation with the *ONCE* to take this technology to the classroom. This will be a study involving blind people and music teachers to check the potential of the application LiveDots.

Acknowledgements

This project has been partially founded by the Ministry of Science, Innovation and Universities of Spain (Didascalias, RTI2018-096401-A-I00) and it was supported by the *ONCE*-Tiflotechnology Chair. We would also like to thank to the *ONCE* for their collaboration in this project, particularly to Pablo Carreño Gea, who was part of the *EDICO* project, for his cooperation in the development of LiveDots.

References

Abramo, J. M., & Pierce, A. E. (2013). An ethnographic case study of music learning at a school for the blind. *Bulletin of the Council for Research in Music Education*, *195*, 9–24. https://doi.org/10.5406/bulcouresmusedu.195.0009

Buhagiar, M. A., & Tanti, M. B. (2011). *Working toward the inclusion of blind students in malta: the case of mathematics classrooms (malta'daki görme engelli öğrencilerin katilimini sağlamaya yönelik çalişma: matematik dersleri örneği)* (Vol. 7, Issue 1). http://eku.comu.edu.tr/index/7/1/mabuhagiar_mbtanti.pdf

Candé, R. de. (2002). *Nuevo diccionario de la musica / New dictionary of music*. Grasindo. http://books.google.com/books?id=4Dh0t9P5tqIC&pgis=1

Capozzi, A., De Prisco, R., Nasti, M., & Zaccagnino, R. (2012). Musica parlata : AAA methodology to teach music to blind people. *ASSETS'12 - Proceedings of the 14th International ACM SIGACCESS Conference on Computers and Accessibility*, 245–246. https://doi.org/10.1145/2384916.2384975

Carenas, J. M., Cabra, A. B., Mata-García, M. G., Gea, P. C., & Hernández, D. H. (2018). *Prácticas EDICO ¿ Qué es EDICO ?* 100–108.

Dos, J. A., & Borges, S. (2014). Teaching Music to Blind Children: New Strategies for Teaching through Interactive Use of Musibraille Software MicroFenix View project Mapavox View project. *Procedia - Procedia Computer Science*, *27*, 19–27. https://doi.org/10.1016/j.procs.2014.02.004

Encelle, B., Jessel, N., Mothe, J., Ralalason, B., & Asensio, J. (2009). BMML: Braille Music Markup Language. In *The Open Information Systems Journal* (Vol. 3).

Frederick, by W. (2009). *Quality of Experience in Mainstreaming and Full Inclusion of Blind and Visually Impaired High School Instrumental Music Students*.

Goldstein, D. (2000). Music pedagogy for the blind. *International Journal of Music Education*, *os-35*(1), 35–39. https://doi.org/10.1177/025576140003500112

Goto, D., Minamikawa-Tachino, T., & Gotoh, N. (2007). A transcription system from MusicXML format to Braille music notation. Eurasip Journal on Advances in Signal Processing, 2007(1), 1–9.

Homenda, W. (2008). Breaking accessibility barriers: Computational intelligence in music processing for blind people. *Studies in Computational Intelligence*, *107*, 207–232. https://doi.org/10.1007/978-3-540-77662-8_9

JAWS – Freedom Scientific. (n.d.). Retrieved May 30, 2020, from https://www.freedomscientific.com/products/software/jaws/

Johnson, S. (2015). *Understanding Is Seeing*. https://doi.org/10.1093/OXFORDHB/9780199331444.013.7

Kent, D. (2012). *What is Braille?*. Enslow Publishing, LLC.

Koelsch, S. (2013). From Social Contact to Social Cohesion—The 7 Cs. *Music and Medicine*, *5*(4), 204–209.

Naruedomkul, K. (2013). *Aim-Math: An audio-based interactive media for learning mathematics*.

Nicotra, G., & Quatraro, A. (2008). CONTRAPUNCTUS Project: A new computer solution for braille music fruition. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *5105 LNCS*, 303–309. https://doi.org/10.1007/978-3-540-70540-6_45

ONCE. (n.d.). *BRAITICO - Web de Educación de la ONCE*. Retrieved May 30, 2020, from https://educacion.*ONCE*.es/braitico

Quaglia, B. W., (2015). Planning for Student Variability: Universal Design for Learning in the Music Theory Classroom and Curriculum. *Music Theory Online*, *21*(1).

Repain, A., Marzin, A., Sacc, C., Royer, J., Lang, M., Kainz, Ms. S., Froment, N., & Loubatier, X. (n.d.). *GitHub - mlang/freedots: MusicXML to Braille Music transcription*. Retrieved June 1, 2020, from https://github.com/mlang/freedots

Smaligo, M. A. (1998). Resources for Helping Blind Music Students. *Music Educators Journal*, *85*(2), 23–45. https://doi.org/10.2307/3399168

Veia Progetti. (n.d.). *Bme2*. Retrieved May 5, 2020, from https://www.veia.it/en/bme2_product

Werner Schweer. (n.d.). *Software gratuito de composición y notación musical | MuseScore*. Retrieved May 30, 2020, from https://musescore.org/es