CAN MUSIC PRODUCTION BECOME UNIVERSAL AND HOW CAN PEOPLE WITH DISABILITIES PRODUCE MUSIC?

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SUMMARY

A paper giving a perspective of universal design in music production and more specifically music production for people with disabilities

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1.0 Introduction

In a society, there is always something that is producing a different level of sounds. These sounds may come from birds singing in the morning, alarms, car radios, trains or music. A certain proportion of them are irritating and most likely a large amount is likable sounds. However, common for all sounds is that they produce sound waves. These sound waves are interpreted differently depending on the frequencies a person can hear. On the other hand, there are some people who cannot hear any sound waves at all. Society does, therefore, provide alternatives or assistance for people with hearing disabilities. In many countries, regulation and laws are also passed in order to make the society more inclusive, such as the "US Section 508" (Mueller, 2008), Convention of Rights for people with disabilities, also known as the CRPD[1], and the "Anti-discrimination Act[2]" in Norway. Additionally, strategies like "The European Disability Strategy" (Hosking, 2013) are also used in order to dismantle barriers in society, education and workplaces. Yet, in a rare amount of cases, there are still challenges in different parts of society. For instance, what if a person with hearing loss wants to produce music? How would they approach the music production industry? Do they need to have an idea of what sound is?

In 1848, William Wolcott Turner and David Ely Bartlett were asked about how people with hearing disabilities or deaf people have any sound (Turner, 1848). Their answer was following;

> "They have no more idea of sound than the blind has of colors. As the idea of sound can be imparted to the mind only through the sense of hearing, those who are totally deaf must, therefore, be wholly destitute of any such idea. They may know much about sound; may know how it is propagated; its law of transmission may be familiar to them, and still, they may and must be entirely ignorant of its nature. "

In other words, we can say that they know about how the sound is produced, but they do not know how it sounds like. Therefore, if Tuner and Bartlett were asked about if people with hearing disabilities could be taught music, they responded by saying;

[1] https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html
[2] https://lovdata.no/dokument/NLE/lov/2017-06-16-51

> “Music is obtained from an instrument by a process purely mechanical. The office of the ear is, to aid the hand in execution, by correcting its mistakes and imperfections; but the same office may be performed by the eye. “

Likewise, even if people with hearing disabilities cannot hear the music, they can still feel the music vibrations. For example, when playing drums, each time a person hits the drums he can feel the vibration in his arms. When a person is at a concert, he can feel the vibrations from loudspeakers on his body.

On the contrary, there is a research being conducted in the neuroscience and computer science field on brain and computer interfaces (BCI) to see if a taught can be converted into text and then convert text to brain waves so that the brain gets feedback or reply (Anumanchipalli, Chartier, & Chang, 2019). For the time being, the taught to text process is to some extent functional, but the text to brain waves process is still under research and development.

As a result, this leads to interdisciplinary research to see if sound waves converted into brain waves can be a solution for people. Hence, this paper will look into Universal design and the accessibility implementation in music production and music education. In particular, music production for those who suffer from hearing loss, disability or impairment. Furthermore, how people with disabilities experience music. In addition, how people with disabilities could potentially graduate and get employed in order to stand on their own legs. Lastly, the most common music production desktop applications will be analyzed in order to see if they conform with the principles of Universal Design.

2.0 Background

In this section, there will be given an insight into how people with hearing disabilities face society. Secondly, an explanation will be given on how BCI works and how it can be relevant for people with hearing disabilities. In addition, a nuance of a possible interdisciplinary correlation between BCI and music will be introduced. Lastly, to get an overview of previous studies relevant to music production and music education for people with hearing disabilities, a review of how the issues related to people with disabilities are addressed will be conducted.

2.1 Hearing disability in society

To understand how a person with a hearing disability can produce music, get an education, more specifically feel included in society, it is important to have a general perception and knowledge of the barriers and challenges that a person faces in society and his or her everyday life. Moreover, hearing disability does have different levels to it, and there are different aids, implants or other assistive technology solutions for the majority of those levels.

Shearer, Hildebrand, and Smith (2017) explain that there are five different levels of hearing impairment. The levels are graded from mild to profound, where mild is seen as a hearing threshold of sounds in 26-40 decibels (dB). Profound hearing loss has a hearing threshold of 90 dB. This refers to a total lack of hearing. An individual with profound deafness is unable to detect any sound at all, as claimed by Felman (2018).

Likewise, Felman also mentions that hearing loss has three different types. The first type being conductive hearing loss, which means that the sound vibrations are not passing through from the outer ear to the inner ear. Sensorineural hearing loss is caused by a dysfunction of the inner ear, the cochlea, auditory nerve, or brain damage, which is the second type explained by Felman. Lastly, there is a type called Mixed hearing loss, which is a mixture of the conductive and the sensorineural type. Fortunately, there is help available for people with all types of hearing loss, depending on both the cause and severity of the deafness. On the contrary, sensorineural hearing loss is incurable at this moment in time. The treatments that are available today for people with hearing loss are hearing aids that amplify the sound, and cochlear implants, which is useful if the eardrum and the middle ear are functioning correctly.

Nevertheless, to give an example of a person with a hearing disability, Shaheem Sanchez, who recognizes himself as a deaf dancer, was interviewed by AJ+ in 2018, which is an online news channel owned by Al Jazeera Media Network (Ulrich-Verderber, 2019). In the interview, Sanchez showed how he listens to music and dances to it. First, he put his hands on the speaker and then felt the vibrations and memorized them. Then he looked at the lyrics and memorized them. Then, in the end, he dances to it, while simultaneously having the lyrics and the melody saved in his memory. Similarly, when Sanchez watches a music video, he needs to have video captions or subtitles in order to understand and memorize the lyrics. Additionally, Sanchez also uses American Sign Language (ASL) to communicate with others. As a result or consequence, when he travels with public transport, it does get very tiring for him to communicate, since he needs to pay attention to the environment and the timetable screen in order to see if he will get off on the next stop.

Similarly to Sanchez, Danny Lane a CEO, who is a profoundly deaf musician and pianist, leads a charity organization called “Music and the deaf” in the UK (Lane, 2006). The charity is working with accessibility in education and music for people with hearing disabilities, young people and adults. Through workshops in schools and the community, teacher training, talks and performances, Music and the Deaf has engaged thousands of deaf and hearing children and adults.

Thus, we can see that people with hearing disabilities do face many different challenges in their life. For instance, there are challenges such as lectures in education, announcements when traveling, and music production in particular. In order to make people with disabilities feel more included, society needs to reduce its demands and rather strengthen the individual’s ability (Fuglerud, 2014).

2.2 BCI and the relation to hearing disability

An area that requires multidisciplinary skills to develop and achieve a goal, BCI, where there is a general consensus of a new frontier in science and technology (Ebrahimi, Vesin, & Garcia, 2003). Research has exploded in the area of BCI and many different institutions are working on BCI. Therefore, a formal definition for the term BCI has been set forward (Wolpaw, Birbaumer, McFarland, Pfurtscheller, & Vaughan, 2002);

> "A brain-computer interface is a communication system that does not depend on the brain's normal output pathways of peripheral nerves and muscles."

There are two categories of BCI's, one that is invasive and another which is non-invasive. The invasive category does harm the user, more specifically the interfaces are implemented inside the brain. Therefore, invasive BCI's are often used on rats for lab experiments instead. The non-invasive category does not cause any harm and can be used as a cap. There are both pros and cons to the two categories. For instance, the invasive category gives more detailed signals, because of the electrode being directly placed on the brain. On the other hand, the non-invasive can either measure the electrical potentials produced by the brain which is called electroencephalography (EEG) or the magnetic fields with a technique called Magnetoencephalography (MEG) (Panoulas, Hadjileontiadis, & Panas, 2010).

To get a better understanding of how BCI is in practice, Figure 1 gives an idea of how BCI works and what technologies are used.

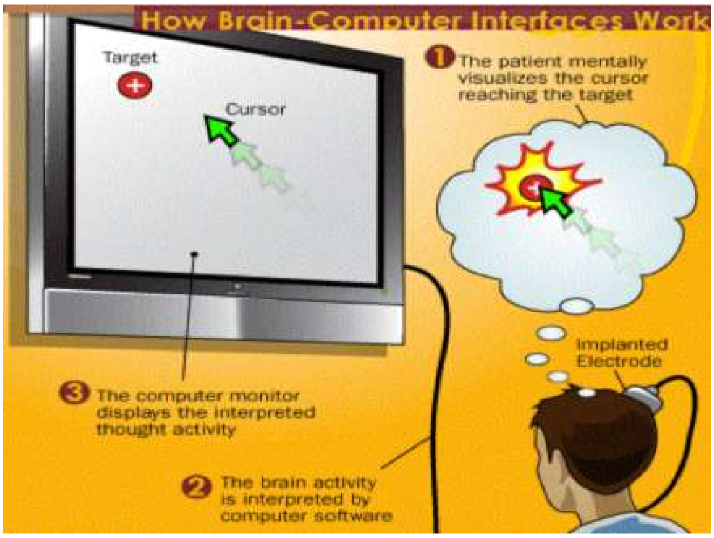

Figure 1: An illustration of how BCI works, retrieved from ("The Brief History of Brain Computer Interfaces ", 2014)

Generally, BCI operates in 4 phases, as mentioned in (Reini), that is also illustrated in Figure 2:

1. **Signal Acquisition**: Brain signals are recorded on the scalp of the users using electrodes, which are mounted on an EEG cap. This happens non-invasive, no harm is done to the user.

2. **Signal Preprocessing**: The measured signals are quite weak, even eye-blinks greatly influence them. Therefore, complex algorithms are applied to enhance the signal quality to reveal brain patterns.
3. **Decoding/Encoding**: Preprocessed signals are analyzed with modern machine learning methods to identify brain patterns of the designated imaginations
4. **Control and Feedback**: Every action should cause an adequate reaction. If you grasp a glass, you do feel the glass beyond your fingers, get a measure of its weight and feel the temperature of it. This "feedback" helps us performing our tasks of daily life without even fully recognizing them - like adjusting the grasp force we put on the glass when we "feel" that it is heavier than expected. For a person with no sensation in the hand, this sensation cannot be felt anymore. Therefore, substitutes have to be implemented - which are called feedback.

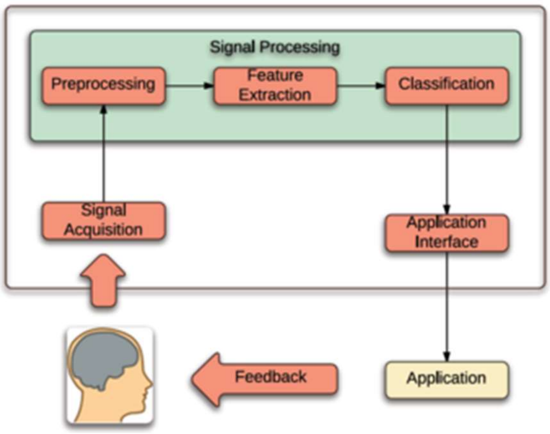

Figure 2: The four phases of BCI, retrieved from (Reini)

As a result, we see that the last phase of the BCI needs substitutes for the “feedback” phase. In fact, this feedback is what is relatable to an idea for the solution of profound hearing disability and sensorineural hearing loss. The currently available technology which is similar to this idea is the cochlear implant. Back in 1976, researchers stated that “the cochlear implant is the first long step in the search for a mechanical prosthesis that would restore hearing to the profoundly deaf” (House, 1976). The cochlear implant is a system that consists of one or more implanted electrodes for direct electrical activation of the auditory nerve (Wilson et al., 1991). Comparingly, we can see that the BCI and the cochlear implant uses electrodes on different parts of the brain. The next step for BCI research in relation to hearing disability would, therefore, be to translate the feedback to the brain. Moreover, this idea could make a statement and a possibility that a human is able to hear the sound without having an auditory nerve.

2.2.1 Possible nuance of correlation between BCI and Music

When BCI is used to measure or analyze the brain signals, it can see what type of signal the brain is producing. It can either be an Alfa signal wave, Beta or Gamma wave (Panoulas et al., 2010). The different waves can show the emotion of a person. If the person is producing Alfa, he is alert. Once the person closes his eyes or starts to actively think about solving a concrete problem (Folgieri & Zampolini, 2014), the brain starts to produce beta waves. Lastly, the brain produces gamma waves when a person is in deep sleep. However, all the different waves do also have a relation to the nerve system. Essentially, the nerves could be affected by the environment where the person is.

Therefore, a possible correlation between BCI and music could come from music therapy. Since one of the goals of BCI is to communicate with another person, music therapy could be used in a welfare technology environment. If a person with ADHD, or a disability that causes muscular pain, has a change of brain wave signal, the BCI could then analyze the signal a play a song which could calm the nerves and make the person relax to ease the pain.

For instance, Folgieri and Zampolini (2014) discussed how music entertainment applications seemed to be more effective in translation to commands then cerebral signals into actions or commands. In addition, the authors also presented a prototype developed for producing music consciously with brainwaves. The main aim of use with BCI was to improve the gaming experience, but they also put a research effort into applying BCI in music entertainment as well. The authors' research method was a qualitative user observation study. The observation included two different experiments where both contained two different user groups. The first experiment contained 60 right-handed participants with an age distribution from twenty to forty-nine. Left-handed users were excluded because of hemispheric specialization for emotion, as stated by the authors. The main purpose of the first experiment was to evaluate how the users responded to sound and the obtained classification algorithm in relation to the different brain waves signals Alfa, Beta, and Gamma. The second experiment consisted of fifty test users. The users were distributed equally in gender between fourteen and fifty-two and musicians and non-musicians, who were asked to produce some musical notes in an isolated room. The isolated room was used in order to remove the possibility of being influenced by other sounds from the environment. In the first few attempts, the users needed about three to four tries before they succeeded in producing a musical note. After refinements with a reinforced stimulus with hand gestures, the prototype produced reliable results. Finally, the authors stated that: “thanks to a BCI device it could be possible to modify the music genre, the rhythm or the intensity of the sounds following the variability of the user’s emotional states, introducing a new modality in-game level achievement.”. Which means that BCI is looking very promising.

On the contrary, when it comes to being influenced by the environment or using music therapy to influence the mental state or emotion of a person, Svansdottir and Snaedal (2006) in a case-control study with thirty-eight patients with severe dementia, showed that music therapy reduces the anxiety and agitation for people with severe Alzheimer Disease. Thus, strengthening the short-term memory which can be essential if using the prototype developed by Folgieri et al. Similarly, to Svansdottir and Snaedal, Kim, Wigram, and Gold (2008) investigated the effects of music therapy on joint attention behaviors in preschool children with autism. Kim et al. conducted a randomized control study with two different conditions. Firstly, a play session with toys and improvisational music therapy. Comparingly, a session analyzed with standardized tools and DVDs to evaluate behavioral changes in the children. The last condition with sessions seemed to show significantly better results than the first condition with toys. This study contained fifteen participants, thirteen boys and two girls with autism who did not have any previous experience in musical therapy. It should be noted that five of the participants dropped out for various reasons before the clinical trial. As a limitation of their study, there were only boys at the trial.

2.3 Music production and education for people with hearing disabilities

In the subsections above, an insight on hearing disability and an introduction to BCI was given. This section will look at music production in relation to hearing disability and in particular, give a perspective on how music education is giving an inclusive experience for those with hearing disabilities.

2.3.1 Music production

The term "production", in music, does include making a melody with instruments and it can also include making a beat on music workstation software such as FL Studio, LMMS, and Audacity, etc. Thus, the production can either be technology-based or build on the interaction between different instruments simultaneously.

Either way, both production types should be inclusive, not excluding. In fact, some instruments may not be usable because of other disabilities such as cerebral palsy, which is a physical disability. For instance, two researchers, Ben Challis and Rob Smith at the University of Glamorgan in 2008 looked into accessibility in music instruments and made something called the Benemin Controller (Challis & Smith, 2008). This is not only for people with hearing disabilities but also for people with any other disability. Figure 3 shows what it looks like.

Figure 3: The Benemin Controller, retrieved from (Challis & Smith, 2008)

It looks like a bow and has eight distance measuring sensors that are used to enable users to control sound through a variety of actions appropriate to their individual needs. Hand gestures and movement will then lead to producing music. In order to observe how the different users would interact with the instrument, a user test was conducted as an observation. Three different user groups were selected. The first user group contained users with severe learning difficulties. The second with moderate and the last with differing levels of mobility problems. The authors say that the preliminary results looked very promising. However, even though the user groups had different user groups, every group was tested in a special needs environment. This could be seen as a limitation for this qualitative user observation study in relation to the principles of Universal Design. On the other hand, as the authors stated: “There are indications that the instrument could be used effectively within a special needs setting as a ‘dedicated’ musical instrument.”. This means that it would benefit the idea of accessibility in an adaptation process for special needs users.

In a similar way to the Benemin Controller, there is developed more assistive technologies to make music production more accessible and usable for people with disabilities such as an accessible MIDI-Controller, which is illustrated in Figure 4 (Challis, 2013). This particular instrument was developed by the same inventors and authors as the Benemin Controller. The authors used the same research method to identify skill-based performance behavior in addition to interaction rules. The users were meant to produce music with improvisation. As a result, the authors stated that the users were able to “move between a palette of rhythmic or pitch-based patterns to create longer and potentially quite complex phrases”. This proves that accessibly designed interfaces are able to strengthen the ability of those with disabilities and reduce the requirement from the interface or society, as mentioned by Fuglerud (2014).

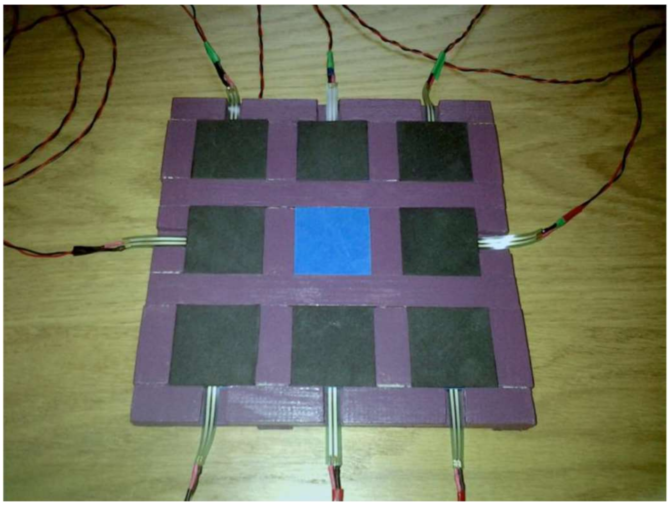

Figure 4: The Midi Controller Interface, retrieved from (Challis, 2013)

However, the instruments that are not usable by people with different types of disabilities, could be useful if they got tweaked in some areas. If Universal Design should be implemented into instruments, a completely new version of the instrument does not comply with the ideas of Universal Design. Rather small tweaks that could dismantle some barriers faced by the persons. In a case that Universal Design is not enough to make use of the instrument. Other adaptive methods or technologies may be used to improve usability, but this does differ from the ideas of Universal Design.

Hence, back in 2010 Google (Willard, Presley, Wong, & Smith, 2010), presented a patent application in the US for a universal music production system with added user functionality. Google claims that “the invention enables an open microprocessor and its operating system to provide ergonomic and user-friendly control of editing audio processing configurations of one or more systems, instruments or synthesizers in a music studio edit mode environment and then utilize the studio edit mode Song/performance configurations in a live mode performance environment that disables the user from certain studio edit mode functions.”. However, any case study or user testing is yet to be conducted or not published yet.

On the other hand, there is technology-based music production software such as FL-studio. To analyze these types of software or applications on Windows, a program such as Accessibility Insights (Microsoft, 2019) can be used to acknowledge the accessibility issues with the software.

2.3.2 Inclusive Education

In society, education plays a big role in shaping the future and the surroundings of society (Baird, 2001). The shaping and building of a better future society come from individuals who take their education. Moreover, education is meant for all individuals of society, no matter their disability. Therefore, it should be inclusive by providing the necessary means for them to function at the same level or better as those who recognize themselves without a disability.

For instance, to get a perspective from music teachers who are teaching students with special educational needs (SEN), Wong and Chik (2016) collected data derived from a multiple qualitative case study involving these ten government-funded primary school music teachers. The data was collected through semi-structured interviews in order to yield authentic and credible outcomes. Hence, their findings showed that even though the teachers had taken their initial training course in music education, their initial training did not include any foundation of any inclusive education. As a consequence, none of the ten teachers had any education in teaching SEN students.

Another phenomenological case study which is motivated by the drive of inclusion from the UK education policy is conducted by (Burnard, 2008). Not only does this study show how people with disabilities should be included but also people who are socially excluded as well. The authors state that term inclusion “refers to all children achieving and participating despite challenges stemming from poverty, class, race, religion, linguistic and cultural heritage or gender. “. Hence, this study is more in line with the ideas of universal design. The main purpose of this study was to see how teachers perceive inclusive education practices among youths in secondary school. The area of observation was in the southeast regions of England in so-called “underperforming schools”. To explore the perception of these music teachers a semi-structured interview was conducted. Additionally, artifact prompts were used to explore and discuss their perception further. For instance, curriculum planning documents were looked at in order to discuss key factors regarding the music courses. Finally, their findings showcased that it is not enough to accumulate education strategies in inclusive pedagogies “employed by teachers for supporting troubled and troublesome learners.”

On the other hand, Samuels (2015) showcases how digital musical instruments and interfaces can be designed to enable the participation of people with disabilities in music production. The author’s research method in a year-long ethnographic study with a charity called Drake Music Project Northern Ireland (DMNI) was based on user observation. The user observation involved 10 other Belfast-based musicians in addition to Samuels himself. The different musicians were observed in a music workshop course, where they were taught how to make and produce music and instruments for people with disabilities by improvisation. Additionally, the musicians also had students after doing the workshop. These students had different disabilities. Thus, the musicians tried to use low-cost DIY components to make an instrument for the students. For instance, one student with a sustained brain injury and reduced motor skills who also used a wheelchair had an Audino interface and joystick UI for music production.

The author’s findings suggested that advancement in open-source technologies and low-cost DIY components have made customized music tools easily accessible for use in inclusive music production. However, this study relates more to the ideas of accessibility rather than Universal design, because Universal Design focuses on the usability of the design to the greatest extent possible, without adaptation or specialized design (Weeber, 2019).

Lastly, in relation to hearing disability and actual music theory, which is fundamental in good music production, Quaglia (2015) provides an overview of how Universal Design for Learning (UDL) can develop an inclusive classroom learning environment as well as the curricula. For persons with hearing disability, Quaglia discusses how melodic dictation, which requires an aural skill acquisition and writing down the note that experienced, can be realized by referring to Karpinski (2000). Karpinski responded to the issue of the inadequacies in musical notation that were aurally experienced by developing a cognition-based learning taxonomy that distinguished a sequence of discrete component processes such as hearing. In addition, Quaglia mentions that Aural learning strategies in music theory instruction being one of the main modalities will benefit from a UDL-implemented pedagogy approach. Conclusively, Quaglia suggests that the end result of UDL practices will improve learning for all students. The results and conclusion of Quaglia’s paper are based on secondary data analysis. This means that he looked at different studies and relevant literature for his research question. The use of different studies and term explanations as a reference is one of the strong points in this paper. Thus, the author’s claim has very good grounds and backing.

Similarly to Karpinski’s and Quaglia’s ideas about melodic dictation, Bellini, Bruno, and Nesi (2007) assessed a very accessible solution which maybe has not come across Qualia’s research. Bellini et al. inspired by optical character recognition (OCR), assessed an optical music recognition (OMR) tool. The authors suggested that the OMR tool could be an ideal system for reliable reading and understanding of music notation. In addition, they say that it could be used for music production in educational and entertainment applications. However, the OMR tool relates more to the area of music recognition, which the authors also stated. Still, it could work as a solution for melodic dictation in music education for people with hearing disabilities. Similarly, to Quaglia, Bellini, et al. used the same research method where they used secondary data to conclude their assessment of the OMR tool. The secondary data provided the authors with multiple perspectives of the OMR tool in order to see the most common problem areas in OMR.

3.0 Literature review

In this section, a review of literature which is not directly related to hearing disability, but music and other disabilities. The literature will be reviewed to give an overview of the mainstream employment in Music Production for people with disabilities.

3.1 Employment for people with disabilities in the music sector

Jacko, Cobo, Cobo, Fleming, and Moore (2010) looked at how employment for people with visual disabilities in music production could be improved. The authors essentially were in the fourth year of a model that they developed for training blind and visually impaired people in order for them to get a job in the music production sector and support themselves. The training program was introduced in Miami, were 18 visually impaired graduated and became sound engineers in 2008. FL Studio was one of the programs the graduates became very good at. In addition to work experience, some of the graduates even performed live at venues in Florida. Thus, the observation of the students over the years also inspired other music schools were sighted people also engaged themselves in the training program.

However, a similar approach should also be taken considering people with other disabilities. For people with hearing disabilities, it could be an ethical dilemma, where they could potentially graduate and use the programs if they are sighted. Yet not with the opportunity or possibility to hear the sound they are producing. Thus, they would face difficulties in a real work experience because of the lack of feedback on what the produced music sounds like, or what they could do to improve their sound even more.

4.0 Method

In this section, an overview of the methodology used to write and research the information on this paper and the literature review. Additionally, the software used for analysis will be introduced.

4.1 The overview of the methodology

In order to find information about the selected topic, extensive research was conducted. The extensive research contained a search in literature databases including Google Scholar and Oria.

Firstly, the topic was selected by looking into academic disciplines[3] in research that is related to Computer Science. More specifically, to find a problem domain within the specialization area of Universal Design. After some flexible consideration time and a guest lecture about BCI from Tulpesh Patel, who has thorough knowledge in neuro and computer science. Thus, the choice fell on a multidisciplinary research field, Namely, Brain-Computer Interaction in combination with music education and universal design. In the same manner, research questions were contrived with the basis of hearing disability and music production.

Secondly, extensive research resulted in papers with different research methods and perspectives. These papers were then sorted into taxonomy in order to get a starting point and perspective for the writing process. Some of the papers were also very old. These were included in order to show the attitude towards the main research question. The sorting process mostly looked at what the authors addressed, the research method conducted to address the issue and if they solved it as well. Additionally, the citations inside the papers were also assessed in order to get a more thorough understanding of the addressed issue.

Lastly, since the literature research involved music production, an analysis of the most common music workstation software will be conducted. The analysis will be primarily based on the program Accessibility Insights from Microsoft. The program will analyze the different software based on the principles of Universal Design.

[3] https://en.m.wikipedia.org/wiki/List_of_academic_fields

Moreover, it should be noted that the purpose of this paper was to address the ongoing research on the main research question, not to create a solution. Thus, there was not conducted any experiment or survey.

4.2 Accessibility Insights program

The program from Microsoft can be used to analyze desktop applications and websites in order to find Accessibility Issues. After downloading the program and opening the software which will be analyzed, the analysis workflow is selected, as shown in Figure 5. For this analysis, the Fastpass workflow was selected in order to conduct an automated check on the elements in the desktop application. The Fastpass workflow gave a snapshot and pinpointed the issues and listed them up.

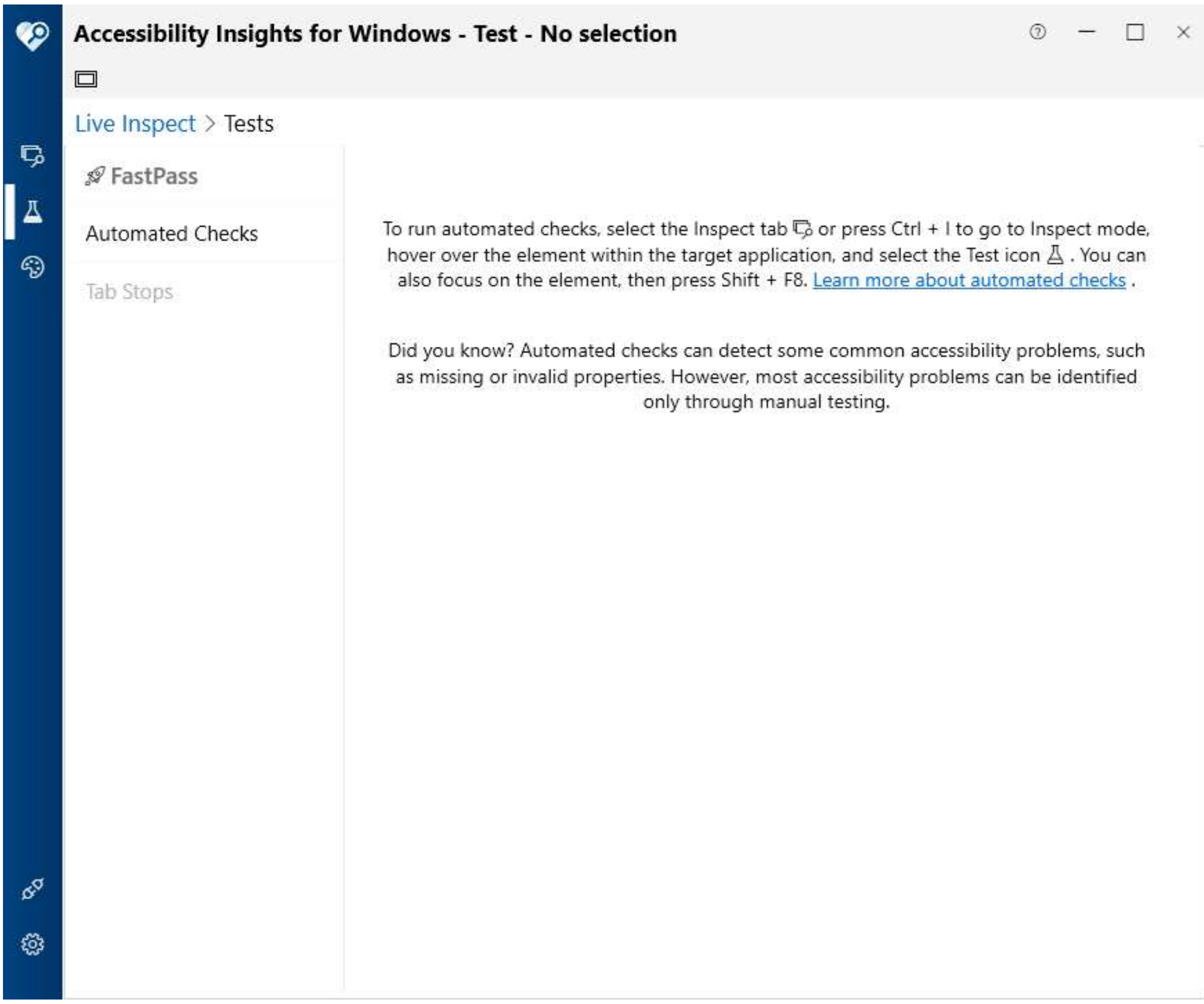

Figure 5: A screenshot of the Accessibility Insights Program downloaded from https://accessibilityinsights.io/ for Windows

5.0 Results

In this section, music production software such as FL Studio, LMMS and Audacity will be analyzed in order to see how they are doing in terms of Universal Design with the program “Accessibility Insights” (Microsoft).

5.1 Analysis of FL studio

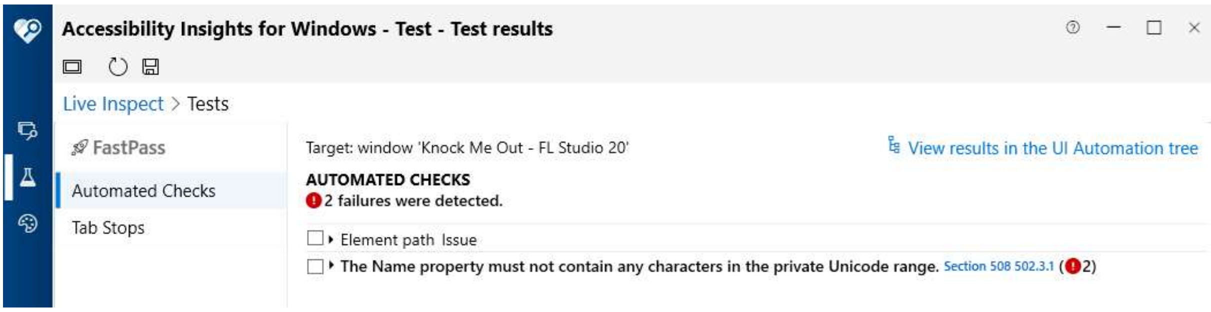

Figure 6: Screenshot of Accessibility Insights after performing a scan on FL Studio

As shown in Figure 6, FL Studio impressively only had two failures affecting the accessibility. Moreover, FL Studio does cost a lot of money, and having only two issues proves why a music producer should purchase FL Studio for music production. Conformingly, manually assessing the main interface of FL Studio shows that it does look simple and intuitive which is one of the principles of Universal Design. Figure 7 illustrates how FL Studio looks in Windows.

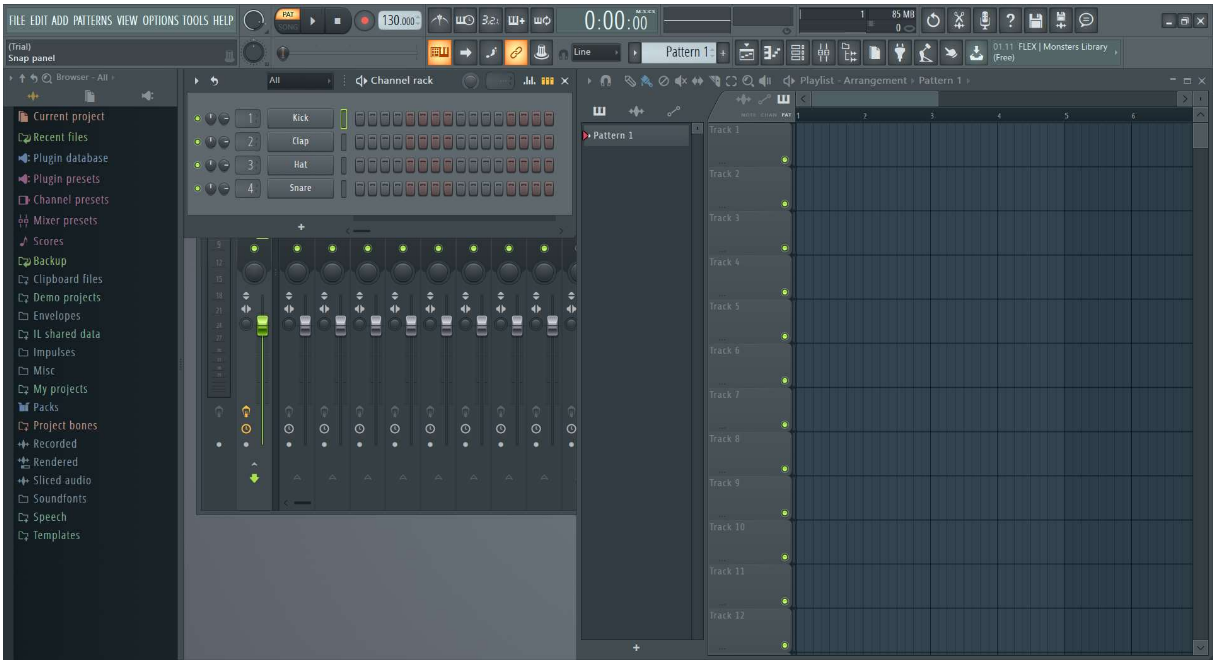

Figure 7: Screenshot of FL Studio 20 downloaded from https://www.image-line.com/downloads/flstudiodownload.html

5.2 Analysis of LMMS

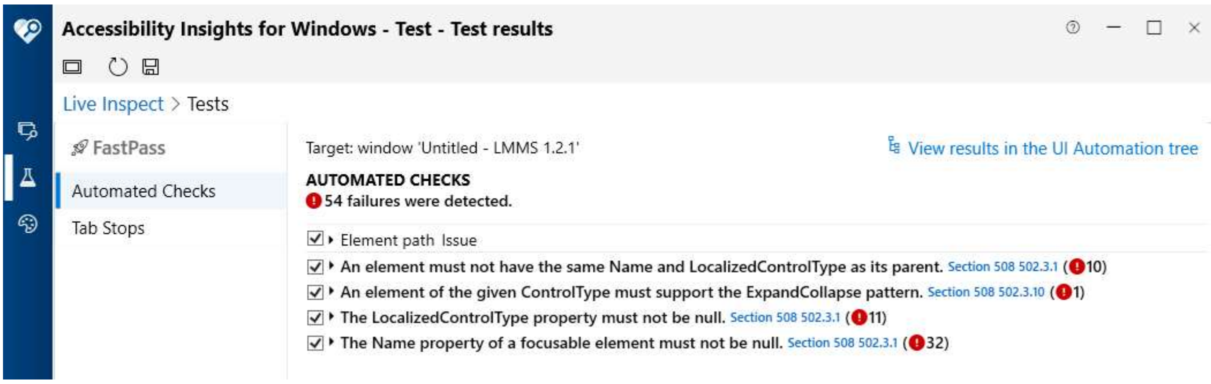

Figure 8: Screenshot of Accessibility Insights after performing a scan on LMMS

Secondly, LMMS was scanned, which is a free program for music production. In contrast to FL Studio, LMMS had a significantly greater number of failures in Accessibility, fifty-four failures. Manually assessing it does also include some difficulties understanding the standard interface, which is shown in Figure 9.

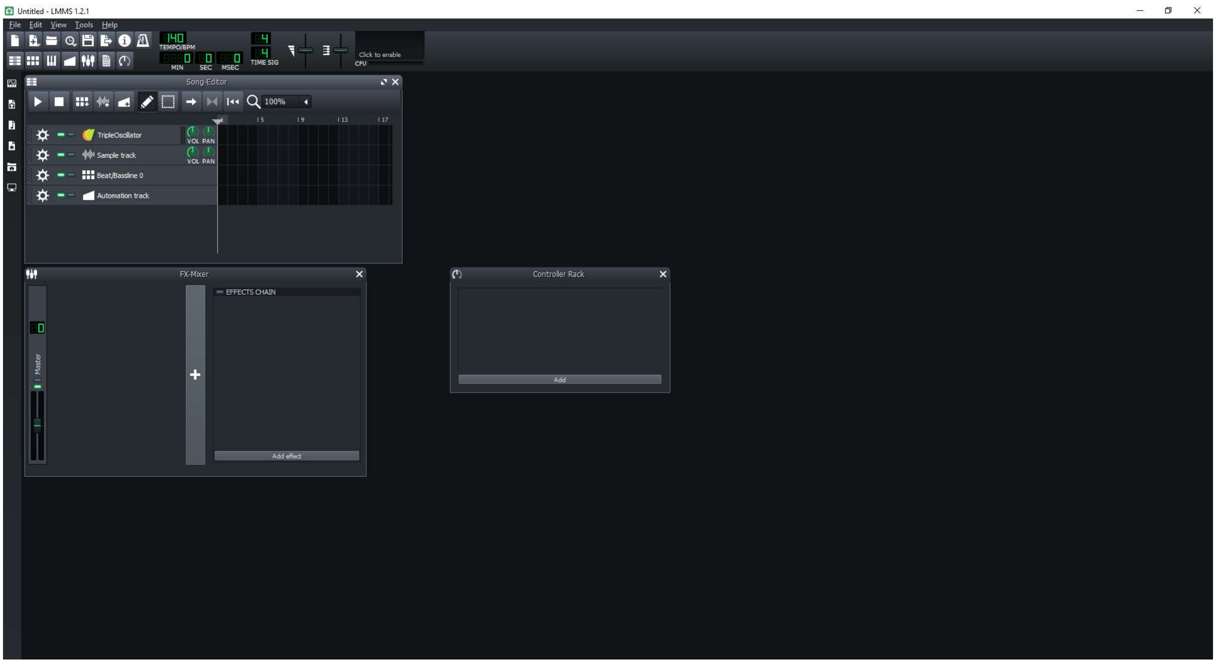

Figure 9: Screenshot of LMMS downloaded from https://lmms.io/

5.3 Analysis of Audacity

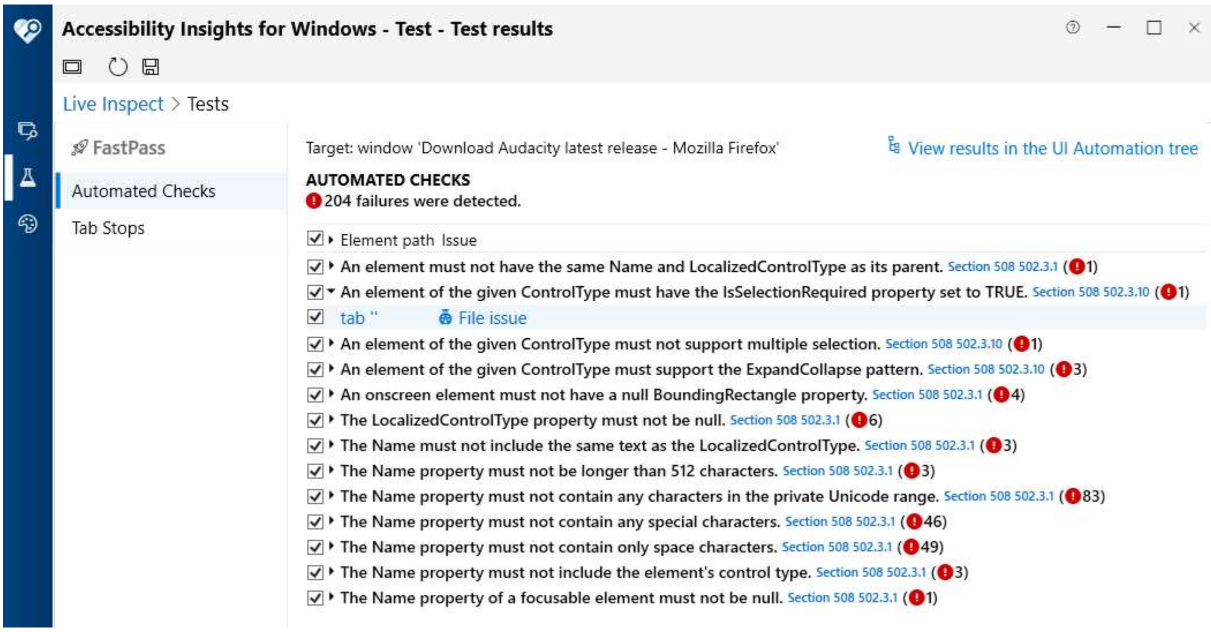

Figure 10: Screenshot of Accessibility Insights after performing a scan on Audacity

Lastly, the common free software for editing sounds and producing music, Audacity was scanned. As a result, Audacity has the most failures of all desktop applications scanned in this paper, 204 failures. A manual assessment shows that Audacity does have an old interface without a change since the first version, as shown in Figure 11.

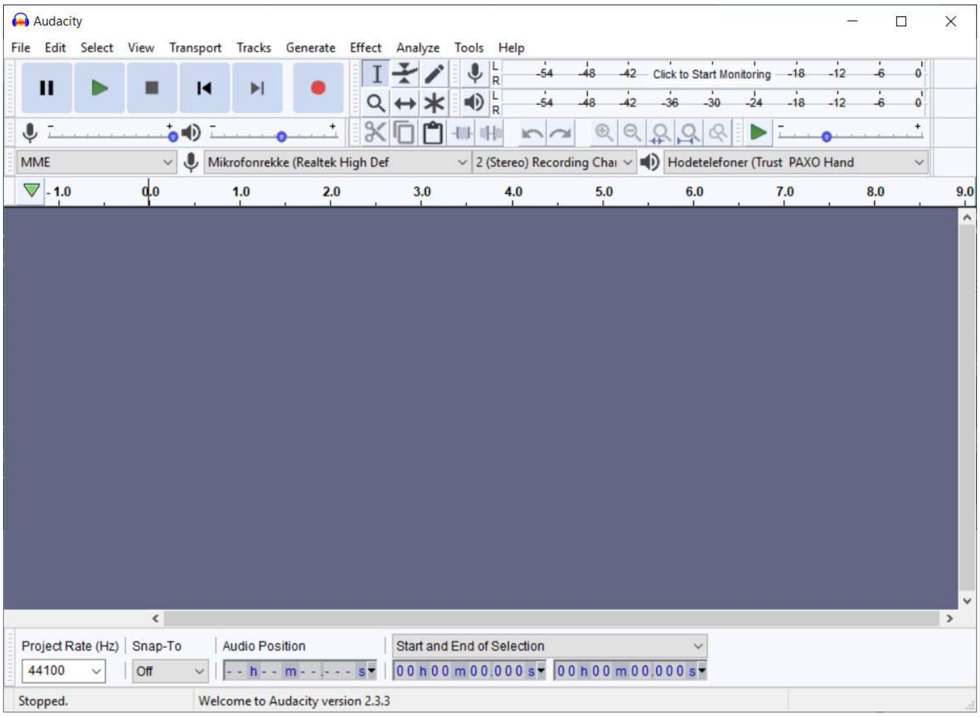

Figure 11: Screenshot of Audacity downloaded from https://www.audacityteam.org/

6.0 Discussion

In this section, a discussion on how the main problem domain is being addressed will be conducted.

Interdisciplinary research in the area of BCI and other technologies has taken big steps forward when it comes to opening doors for people with disabilities. Additionally, it looks like it is not long before society will have a different approach in multiple areas, such as education and workplace in regards to including people rather than excluding people depending on their background, disability or any other barrier.

However, there are still some ethical dilemmas or issues within the area of BCI that need to be taken into consideration. For instance, if BCI were to be used as an assistive technology for people with any form of disability. It could either be accomplished by using the invasive or non-invasive type of BCI, as explained by Panoulas et al. (2010). As a consequence, it could result in the user being harmed if the invasive type of BCI was to be used. Meaning that the brain will be cut open in order to place the BCI on to the Cortex or more specifically the area of the brain which is designated for a certain sense or designated to a muscle.

On the other hand, it could affect the quality of sound transmission to the brain. As a result, it could essentially come down to the user on how good transmission of sound he needs or wants. At the same time, if the non-invasive does essentially change the level or frequency of hearing for a person with profound hearing impairment or sensorineural hearing loss, it would still make a good difference.

In addition to BCI, the different reviewed studies have also addressed other issues and areas related to hearing disability. The work towards a more inclusive education for people with disabilities have opened a lot doors for a slightly different approach in education and workplace. Lane (2006) has been one of the big contributors in the UK for people with hearing disabilities in inclusive education. Similarly to Lane, Burnard (2008) has showcased the approach taken for inclusion in the education sector in the UK, which also is heading towards a positive future. Wong and Chik (2016) showed the perception from the teacher’s point of view in an inclusive education setting, and it looked very promising.

Still, there are still some issues in some areas that need improvements. As the analysis of the different music production workstations showcased, the accessibility or the universal design principles should be fully implemented in order to remove additional barriers. Although, since FL Studio did not have that many issues, it is one therefore prioritized among professional work environments. Hence, it was also used in the training model for the visually impaired in Miami by Jacko et al. (2010). Lastly, Quaglia (2015) has put a great effort into creating new accessible instruments for people with physical disabilities. Even though it might not relate to the ideas of universal design, whereas the instrument is created to produce similar sounds to the instruments that already exist, one can look at it differently and say that it is a new invention in the category of music instruments.

Historically speaking, the attitude towards people with disabilities has also changed. Compared to (Turner, 1848) where people did not think that people with disabilities could one day be able to do the same actions as those who do not recognize themselves with a disability. It might seem like an exaggeration to compare a paper from 1848 to the present day, but gradually the attitude change has been one of the reasons that the technology has driven people towards a more inclusive attitude of people with disabilities. Hence, why laws and regulations in multiple countries have been passed in order to shape a more inclusive society.

All in all, society is heading towards a future where more people will be included in all general and essential areas of a person’s life. All due to the implementation of universal design and new assistive technologies in education, workplace and generally in society. Despite the fact that all the reviewed papers and articles show that society is headed towards a more inclusive society, it should be noted that this does apply or conform with a world-level basis.

7.0 Conclusion and future work

In this section, a conclusion of the problem of being addressed will be made based on the literature reviewed and the software analyzed. Additionally, future work will be discussed.

At first, the main problem domain was introduced. The main problem was that people with disabilities, especially people with hearing disabilities, find it difficult to produce music both physically and technology-based. However, depending on the level of hearing loss, a cochlear implant provides a good opportunity for people with disabilities to produce music.

Secondly, studies related to the problem domain were reviewed to see how the problem domain was addressed from a research perspective. As a result, the studies showed that technology and research are headed towards a good direction when it comes to development and dismantling the barriers created by music production for people with hearing disabilities. BCI is looking like it can have the means of escaping for profound hearing disability and sensorineural hearing loss. Additionally, studies also showcased that music education involving music production is climbing the ladder of accessibility and inclusiveness. The more accessible the education or workplace becomes; the more people are included and motivated.

Finally, new technologies such as BCI and assistive technologies are opening a lot of doors for not only people with hearing disabilities but also for people with any other disability. The doors can either be opening a pathway to a new job position, or they could make people make decisions or actions that they would not have taken before, in a negative sense. The reason being that these persons now could be influenced through another channel.

Conclusively, if all these positive doors would have a positive impact on people with disabilities. It would make sense that Universal Design should be implemented in education to make a barrier-free education and interfaces. It should also be noted when the principles of Universal Design are not enough to dismantle a barrier, an accessibility approach should be taken in order to make the user feel adapted to the interface. Therefore, Universal design and accessibility are essential when making interfaces and education platforms for not only people with disabilities but the same those who do not recognize themselves with a disability. Likewise, when BCI has reached a level where it has made it possible for people with profound hearing disabilities and sensorineural hearing loss to be able to hear, it would be an essential assistive technology for the adaptation process.

Reference List

Anumanchipalli, G. K., Chartier, J., & Chang, E. F. (2019). Speech synthesis from neural decoding of spoken sentences. *Nature, 568*(7753), 493.

Baird, L. L. (2001). Higher Education's Social Role: Introduction to a JHE Special Issue. *The Journal of Higher Education, 72*(2), 121-123.

Bellini, P., Bruno, I., & Nesi, P. (2007). Assessing optical music recognition tools. *Computer Music Journal, 31*(1), 68-93.

The Brief History of Brain Computer Interfaces (2014). Retrieved from http://www.brainvision.co.uk/blog/2014/04/the-brief-history-of-brain-computer-interfaces/

Burnard, P. (2008). A phenomenological study of music teachers' approaches to inclusive education practices among disaffected youth. *Research Studies in Music Education, 30*(1), 59-75.

Challis, B. P. (2013). *Assistive Synchronised Music Improvisation.* Paper presented at the International Conference on Arts and Technology.

Challis, B. P., & Smith, R. (2008). Inclusive technology and community music. *Proceedings of Accessible Design in the Digital World*.

Ebrahimi, T., Vesin, J.-M., & Garcia, G. (2003). Brain-computer interface in multimedia communication. *IEEE signal processing magazine, 20*(1), 14-24.

Felman, A. (2018). What's to know about deafness and hearing loss? Retrieved from https://www.medicalnewstoday.com/articles/249285.php

Folgieri, R., & Zampolini, R. (2014). BCI promises in emotional involvement in music and games. *Computers in Entertainment (CIE), 12*(1), 4.

Fuglerud, K. S. (2014). Inclusive design of ICT: The challenge of diversity. *University of Oslo, Faculty of Humanitites*.

Hosking, D. L. (2013). Staying the Course: The European Disability Strategy 2010-2020. *Eur. YB Disability L., 4*, 73.

House, W. F. (1976). Cochlear implants. *Annals of Otology, Rhinology & Laryngology, 85*(3_suppl), 3-3.

Jacko, V. A., Cobo, H., Cobo, A., Fleming, R., & Moore, J. E. (2010). Mainstream Employment in Music Production for Individuals Who Are Visually Impaired: Development of a Model Training Program. *Journal of Visual Impairment & Blindness, 104*(9), 519.

Karpinski, G. S. (2000). *Aural skills acquisition: The development of listening, reading, and performing skills in college-level musicians*: Oxford University Press on Demand.

Kim, J., Wigram, T., & Gold, C. (2008). The effects of improvisational music therapy on joint attention behaviors in autistic children: a randomized controlled study. *Journal of autism and developmental disorders, 38*(9), 1758.

Lane, D. (2006). Keys to Music: making Music with Deaf Children in Early Years. In: Huddersfield, West Yorkshire, UK., Music and the Deaf.

Microsoft. (2019). Accessiblity Insights. Retrieved from https://accessibilityinsights.io/

Mueller, J. (2008). *Accessibility for everybody: understanding the Section 508 accessibility requirements*: Apress.

Panoulas, K. J., Hadjileontiadis, L. J., & Panas, S. M. (2010). Brain-computer interface (BCI): types, processing perspectives and applications. In *Multimedia Services in Intelligent Environments* (pp. 299-321): Springer.

Quaglia, B. W. (2015). Planning for student variability: Universal design for learning in the music theory classroom and curriculum. *Music Theory Online, 21*(1).

Reini, P. R. Brain-Computer Interfaces. In D. Hackhofer (Ed.). More-grasp: Institute of Engineering, Austria.

Samuels, K. (2015). The Meanings in Making: Openness, Technology and Inclusive Music Practices for People with Disabilities. *Leonardo Music Journal, 25*, 25-29. doi:10.1162/LMJ_a_00929

Shearer, A. E., Hildebrand, M. S., & Smith, R. J. (2017). Hereditary hearing loss and deafness overview. In *GeneReviews®[Internet]*: University of Washington, Seattle.

Svansdottir, H., & Snaedal, J. (2006). Music therapy in moderate and severe dementia of Alzheimer's type: a case–control study. *International psychogeriatrics, 18*(4), 613-621.

Turner, W. W. (1848). Music among the deaf and dumb. *American Annals of the Deaf and Dumb, 2*(1), 1-6.

Ulrich-Verderber, L. (2019). Meet the Dancer Combining Sign Language & Hip Hop. Retrieved from https://everwideningcircles.com/2019/02/25/shaheem-sanchez-asl-dance-deaf-dancers/

Weeber, J. E. (2019). Ronald L. Mace. Retrieved from https://www.britannica.com/biography/Ronald-L-Mace

Willard, J. D., Presley, M. E., Wong, V. W. T., & Smith, F. A. (2010). Universal music production system with added user functionality. In: Google Patents.

Wilson, B. S., Finley, C. C., Lawson, D. T., Wolford, R. D., Eddington, D. K., & Rabinowitz, W. M. (1991). Better speech recognition with cochlear implants. *Nature, 352*(6332), 236.

Wolpaw, J. R., Birbaumer, N., McFarland, D. J., Pfurtscheller, G., & Vaughan, T. M. (2002). Brain–computer interfaces for communication and control. *Clinical neurophysiology, 113*(6), 767-791.

Wong, M. W.-y., & Chik, M. P.-y. (2016). Teaching students with special educational needs in inclusive music classrooms: experiences of music teachers in Hong Kong primary schools. *Music Education Research, 18*(2), 195-207.

Figure list