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Application of Augmented Reality in Music Education

Hatice GUCLU

Necmettin Erbakan University

Sabri KOCER

Necmettin Erbakan University

Ozgur DUNDAR

Necmettin Erbakan University

Abstract: Music Education has been given in many ways from the past to the present, but the development of technology has been the turning point for this education. The increasing use of mobile devices in recent years has offered people the advantages of using technology in education. 3D applications developed for mobile devices have enabled Augmented Reality (AR) technology to be used in many areas. While the importance of Music Education has been better understood recently, its benefits and necessity continue to be the subject of research by many scientists. Studies have observed that in addition to music education, taking an instrument education contributes to the increasing success of students in other lessons. In this thesis study, musical notation education on the flute was aimed for primary school students, and after the necessary teachings were made, it was ensured that two different music pieces were played over the AR-Flute application.

Keywords: Augmented reality, AR in education, AR-flute, Education of instrument, Musical education with technology

Introduction

The increasing use of mobile devices in recent years offers people the advantages of using technology in education. Humanity has learned to live in harmony with mobile devices such as smartphones and tablets. Therefore, the use of portable devices has become an indispensable part of life.

Augmented Reality (AR) technology enables visual and audio information to be included in the real world in real time. Besides, AR can enable the development of video, 3D modeling, images and animations for display presentation in Education. It is also a key element of AR Industry 4.0 (Suwichai, 2014).

AR takes the vision of the real world and adds virtual information to it. In different expressions, AR combines the real and partially virtual world and presents every synthetic light and natural light with its real-world elements. The low cost of Augmented Reality compared to Virtual Reality is an advantage to be considered. HeadMountedDisplay used in Virtual Reality technology, data gloves and a non-traditional interaction tool with concaves are not required and often costly, these devices are also expensive.

In order to gain physical competencies, the person involved in the education process also benefits from important lessons such as music in order to gain internal and spiritual competencies in the same process. All the activities performed as listening, singing, playing and moving are of great importance in the music lesson for the acquisition of values, which are defined as human qualities, which are an individual and social necessity.

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A study conducted during a Science Festival in Denmark showed that children who play a musical instrument also do better in other subjects, such as math or dance. Although increased skills in other subjects are not directly related to the ability to play a musical instrument, music education has shown to improve cognitive skills such as verbal memory and reading ability (Serafin et. al., 2017).

Learning to play a musical instrument is a challenge, especially for children. In this study, notation knowledge for primary school students was emphasized and after the necessary teachings were made, two different pieces of music were played through the application. The application of Ar-Flute starts working by showing the pointers to the camera. There are 11 markers for the nine (Do, Re, Mi, Fa, Sol, La, Si, fine Do, fine Re) notes, two of which are for the song notes to be played. For example, when the pointer with the image of the Do note on the stave is shown to the camera, the explanation of how the user will place his fingers on the 3D Flute will appear. In this way, he will both hear the do sound and see the holes that need to be closed. According to the notation, the holes on the 3D flute will be marked with a red light. Thanks to the mobile software developed in this way, the learning of all notes will be completed, respectively. In the next stage, 2 songs can be played at different tempos.

Our first song after the musical notation training is Happy Birth Day. The reason for choosing this song is its slow tempo. There is note writing of the Happy Birth Day song on the stave on the pointer, and when it is shown to the camera, the 3D flute starts to play the song, and the red light is informed which holes will be closed for the playing notes. In addition, the playing notes appear on the screen the 3D flute next to a different colours with 2D text image. The other song is Little Frog song. The practice system is the same, but the tempo is normal, designed to help the user improve his flute practice

Music Education and Its Importance

Music education not only creates musical knowledge, ability and pleasure, but also enables the acquisition of many individual, social and cultural characteristics. Music has a very effective place in many areas of our brain such as literacy and numeracy. Music helps us express and interact with our emotions. Music helps us understand the world around us and is an ancient and universal language common to every human culture (Brief History of Music Education,2020)..

In his book Plato outlines that in the ideal state the rights to have equal opportunities to study are not given to all citizens. As a result, he proposed to create different training programs for the different classes of future artisans, military and philosopher-kings. "Plato encouraged that children should be separated from their families at an early age and be subject to relevant secular education – literature, music and physical education. The cultivation of moral values was necessary for the development of the character in order to maintain a fair state." Confucius exalted music "If one should desire to know whether a kingdom is well governed, if its morals are good or bad, the quality of its music will furnish the answer" to the point of saying.

Various studies have found that interacting with music can lead to improved brain development in students. A Northwestern University study found better neural processing in students who played musical instruments compared to students who just listened to music. This study shows that getting music education can be very beneficial in job training.

The National Music Education Association (NAMC) has reported the categories in which music education is beneficial under 4 headings on the Music Education Facts and Figures website. These;

- Success in society,
 - Success at school,
 - Success in development
 - Intelligence and success in life
- listed as.

An example of these advantages can be given as follows:

The National Association For Music Education (NAMC) suggests in their Music Education Facts and Figures website' four categories of benefits of music education; these categories are: success in society, success in school, success in developing intelligence, and success in life. NAMC cites the Texas Commission on Drugs and Alcohol Abuse Report as reported in the January 1988 Houston Chronicle that said "Secondary students

who participated in band or orchestra reported the lowest lifetime and current use of all substances (alcohol, tobacco, illicit drugs)” (Petress, 2005).

Scientific findings have proven that artistic education makes math and science better. In addition, music education improves spatial intelligence in newborn babies and can be a convincing solution for violent youth. Traditional music education places a large emphasis on individual practice. Studies have shown that individual practice is frequently not very productive due to limited feedback and students lacking interest and motivation (Hargreaves, 1999).

According to Gardner, seven types of intelligence are present at different levels in every child from birth, and all intelligence types can be developed throughout life, starting from a young age. Many children can learn to use their voice more accurately with education and begin to sing beautifully; Being enthusiastic or willing to play a musical instrument, likes to listen to music, enjoys singing the songs they learned outside of school, enjoying participating in the choir or similar activities are related to "musical intelligence".

A child who receives a comprehensive musical education leads to the development of many talents;

- comes in a ready-made form for artistic education,
- develops creativity through improvisations,
- expressing oneself with music (language, movement, music),
- realizes his place in society, his duties,
- develops internal and external discipline,
- gets acquainted with the basic rules of music and different instruments, (increases musical knowledge and skills),
- can sing,
- can dance in harmony
- and the child's sense of rhythm, ability to use his voice and musical hearing, music taste, etc. develops

Method

Augmented Reality Technology in Music Education

Augmented Reality is a technology that takes the vision of the real world and adds virtual information on it. AR adds sounds, videos, graphics directly to the look of an existing environment. With the rapid development of modern information technology, multimedia technology and network communication technology, especially augmented reality technology has been widely used in the field of education.

Azuma (1997) provides an overview of a wide range of sciences using augmented reality, such as medical education, military aircraft navigation, and industrial training. His study shows that AR has been used successfully in many educational applications. The main advantage of AR is the perceptual and cognitive representation of instructions on how to use a physical object (eg an instrument) (Azuma, 1997).

The operation and presentation of many education and training resources has been transformed from traditional two-dimensional to three-dimensional. This learning mode change not only enriches the delivery of learning content, but gradually improves learner interaction. Thus, it allows students to experience virtual, self-discovery and interactive learning activities. It effectively motivates learning efficiency (Akçayır et. al., 2016).

In AR, it is accomplished by interacting with a camera from any device, such as a tablet and smartphone, along with beacons. In addition, AR does not require a high-tech webcam to work. This makes AR more accessible to many users. Not everyone can afford to take music and instrument playing lessons due to financial difficulties and impossibilities. In addition, many people live in areas where educational conditions are difficult and there are not enough teachers. AR music education has the potential to solve both of these challenges. It offers convenience for those who want to learn how to play a musical instrument but do not have enough time.

Augmented Reality Trends in Music Education

Playing an instrument requires a lot of brain power, muscle memory and neurological control. People who play instruments have better memory and are able to control their cognitive and motor functions better than those who do not play instruments. Children who receive music education do better in academic areas such as reading and math skills.

Recently, many different applications have been realized by combining Augmented Reality with the technologies used in music education. In Table 1, applications made or designed using AR technology in Music Education are shown. The advantages and disadvantages of prepared articles and studies are presented in the Table 1.

Table. 1 Augmented reality trends in music education

Source	Method/ Model	Advantages and Disadvantages
(Suwichai, 2014)	<p>Augmented Reality (AR) is used to promote traditional folk musical instruments.</p> <p>The method allows users to view and sound the environment in 2D modeling using a trigger image on a postcard via mobile device.</p>	<p>Advantages :</p> <ol style="list-style-type: none"> 1) This approach can encourage participation in the classroom so students will be more eager to learn during the classroom. 2) The method can also be effective for students to improve their understanding and deepen their knowledge. <p>Disadvantages:</p> <ol style="list-style-type: none"> 1) Requires internet usage. 2) Modeling is designed as 2D (2D)
(Serafin et. al., 2017)	<p>Considerations Regarding the Use of Virtual and Augmented Reality Technologies in Music Education have been observed. Virtual and Augmented reality offer an alternative approach to acquiring musical skills, especially in children.</p>	<p>Advantages:</p> <ol style="list-style-type: none"> 1) Virtual Reality and Augmented Reality can be a helpful tool in improving musical skills, which are often known to be boring, repetitive and challenging. <p>Disadvantages:</p> <ol style="list-style-type: none"> 1) The lack of design needs to be taken into account.
(Chow et. al., 2013)	<p>“Music Education using Augmented Reality with a Head Mounted Display “ It is an AR application aimed at increasing learning efficiency and creating an immersive experience for beginner piano students. The opportunity to play is provided to</p>	<p>Advantages:</p> <ol style="list-style-type: none"> 1) It can increase students' interest in music and the process of learning musical instruments. 2) Head-mounted displays can provide the user with instrument playing skills . <p>Disadvantages:</p> <ol style="list-style-type: none"> 1) In practice, performance analysis was not included in the evaluation. 2) The application was designed with an



encourage and encourage the development of musical notation literacy.

expensive system in terms of cost.
3) Appropriate user studies have not been conducted to determine the usability and effectiveness of piano instruction.

(Ana et. al., 2016)
Augmented Reality Musical App to Support Children's Musical
The application works by verifying whether the strings are colored correctly on a printed sheet of music.

Advantages:
1) Augmented Reality can reduce the initial difficulties of traditional teaching materials in learning music.
2) It is an affordable application in terms of cost.
Disadvantages:
1. The Evaluation Population was made with only six children.



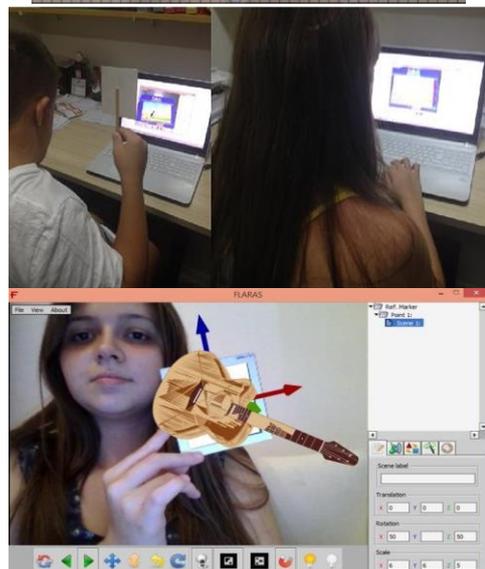
(Carlos et. al., 2016)
He recommends using Augmented Reality to play keyboard instruments.
Used Google Cardboard to allow users to visualize a virtual character and instructions.

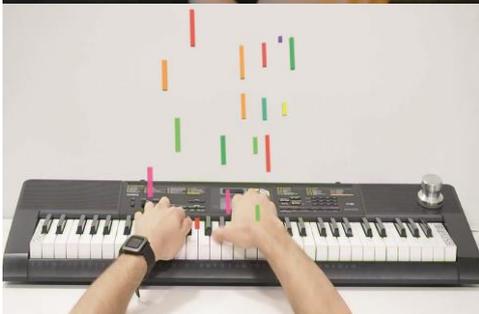
Advantages:
1) Interaction with an animated 3D character can help maintain motivation in teaching music.
Disadvantages:
1) No musical instruments and not allowing users to add their own songs and dance moves for the character



(Martins et. al., 2015)
MUSIC-AR uses Augmented Reality technology. MUSIC-AR,
1) allow children to control virtual items that like sounds,
2) focus on the concept of sound intensity,
3) the duration of the sound and
4) It consists of 4 small applications related to timbre.

Advantages:
1) Children can understand more easily by using Augmented Reality.
2) It motivates children to use technology.
Disadvantages:
1) Inadequate number of games in terms of effectiveness of teaching in practice.



<p>(Lim et. al., 2012)</p>	<p>Three different learning modes are proposed that support the natural learning process, including live feedback and performance evaluation, as well as augmenting the system with gamification aspects to achieve early success experiences.</p>	<p>Advantages: 1) It can provide assistance in learning to play the piano without having the experience of traditional music notation. Disadvantages: 1) The complexity of traditional note notation and the lack of notes that cannot match the expressiveness 2) Lack of comprehensive user studies to evaluate learning support</p>	
<p>(Trujano et. al., 2018)</p>	<p>Using Augmented Reality, ARPiano enriches the physical keyboard with motion graphics and descriptions with Effective Music Learning and receives input from the keyboard to support various interactions. The ARPiano has a modular design in the form of Keyboard Components. ARPiano can precisely locate a physical keyboard to cover various objects around the keyboard and on individual keys ARPiano is designed to provide better visual music learning.</p>	<p>Advantages: 1. ARPiano is a highly advanced application in terms of AR technology. 2. An app that will encourage users to learn to play the piano and have fun while learning Disadvantages: 1) It should be noted that the limited field of view of the Hololens makes it difficult to play notes more than an octave and a half apart from each other. For example, in the part where a single high note should be played, they could not see the note coming to the keyboard, causing them to make mistakes. Since it is an application that requires the use of Hololens, it is an expensive application.</p>	 
<p>(Li, 2018)</p>	<p>Application of Augmented Reality Technology in Piano Teaching System Design It is an article that recommends Unity 3D development engine and augmented reality development plugins in the piano teaching system. The application can be used on Android systems. The piano</p>	<p>Advantages: 1) The application can arouse great interest in AR technology in students. 2) It can be easier and exciting to learn compared to classical piano teaching. 3) The cost is low as the required device to use the application is any android-based smart device.. Disadvantages: However, some flaws of this system were also</p>	

teaching system consists of three modules: piano indication and control module, piano playing module and piano sound processing module. The aim is to compare the learning status of students before and after the experiment to show the teaching effect after using the piano teaching system.

Malaysian Music Augmented Reality (MMAR)

It is an Android application that makes music education more interactive and fun for children and aims to learn traditional musical instruments. In general, MMAR consists of four modules: 1) 3D Object Design, 2) Acoustic Model, 3) Instrument Briefing 4) Evaluation.

(Tan et. al., 2018)

found, proving there is still a long way to go for improvement. Some students emphasized that the time devoted to teaching is not equal at all levels..

Advantages:

1) The application is a useful model that makes the education that arouses curiosity in children permanent.

Disadvantages:

1) Limiting instrument training to traditional ones only.



This article presents a piano teaching system that tracks 3D fingers on the real keyboard of the piano. Virtual hands created on the keyboard are created with the signless-based feature of augmented reality.

(Huang et. al., 2011)

Advantages:

1) An interesting and enjoyable application for beginners to play the piano

2) The use of Markerless Augmented Reality can shed light on future applications.

Disadvantages:

1) When the keyboard is divided into several parts by some blocks, the recognition effect is lost.



It can be thought that the applications and researches for AR in music education will continue and should be doing in the following years. This study includes an application of the field of music education. The application will provide Flute training experience using Augmented Reality technology. Although the user age range of Ar-Flute application is 6-12, It is thought that it will attract attention on all age groups. The first reason why the preferred instrument is the flute is that it is an instrument that can be reached by many segments in terms of supply and cost. Generally, people prefer to take flute lessons to improve their musical talent. The benefits of music education are huge and very beneficial to students. Music positively affects the academic performance of the child, helps to develop social skills and provides an outlet for creativity, which is very important to the child's development. Music education takes a child's learning to new heights and, as such, should always be considered an essential part of a child's educational process. Music education develops and improves language skills in children.

Music education takes a child's learning to new heights and therefore the hFlute is one of the oldest instruments invented thousands of years ago, which adds to the permanence of the musical experience. Learning the flute, like almost any instrument, requires patience and perseverance, it will provide a lifetime of fun and satisfaction. It should always be considered an important part of a child's educational process. Music education develops and improves language skills in children. As an instrument that can offer countless different musical ensemble options, the Flute will be the right choice. Some of the different ensembles where flutes are often used include concert and jazz bands, orchestra, wind bands, flute choirs, military bands, and more. However, taking flute lessons can improve more than just playing ability. Playing the flute requires good body coordination, especially with the hands, eyes and mouth . You have to read the notes, play the keys and blow to the mouthpiece of one sitting. Therefore, your body coordination is likely to improve as well. As a windpipe instrument, the flute is played by blowing air into a mouthpiece.

A virtual flute created with Augmented Reality will offer a different experience of the user. The flute, which will function like a real flute in the real world, will attract the attention to the user and can be a solution to the problem of paying attention, which is fundamental to education, and when it is lacking in students, teaching cannot be carried out. Augmented Reality has the potential to be used in music education, to be the newest, most interesting, and to shape many ideas in terms of being developed.

Results and Discussion

In this section, Ar-Flute application, which provides flute training developed with Augmented Reality technology, is explained. It is an application intended to be used in Android operating systems, which will give the user the ability to play a simple flute, and will arouse curiosity and desire with its interesting 3D image, mostly for primary school students. There are many platforms to develop an Augmented Reality application. It was created with Ar-Flute Unity and developed with infrastructure supported by vuforia. Unity version 9F1 is used. The technical equipment required to develop the application is a HP pavilion laptop 15-cc106nt model computer.

AR-Flute App Overview

In the Ar-Flute application, there are musical notes and 2 sample songs on the flute. The visuals of 9 notes, “Do, Re, Mi, Fa, Sol, La, Si, Thin Do, Thin Re” were used as a marker (Figure 1). With the explanation explaining how the student should hold the flute, both visual and auditory information is provided by ensuring that the holes that need to be closed according to the notes turn red and the sound of the note is announced to the user at the same time.

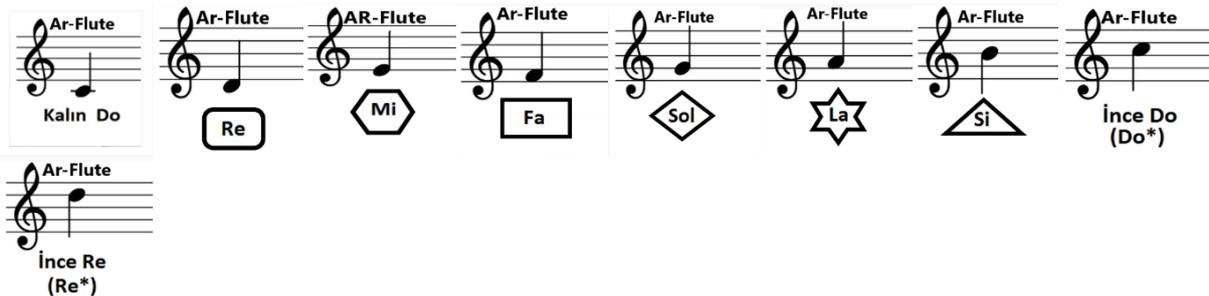


Figure 1 Pointers used in the note training part of the Ar-Flute Application.

The first song to be played to reinforce what the user has learned, who has completed the musical notation training, is the song "Happy Birthday To You" (Figure 2.a). This song has been preferred because it is thought that it will not force the user with simple notes on the first try. At the same time, since today's children are familiar with the melody of this song, it was thought that it would be easier to grasp the melody and that the children would be more eager to play it. The tempo of the song is setting slower than normal , and it is thought that the first experience will progress from easy about difficult . The marker required for the song to play is shown in Figure 2.b

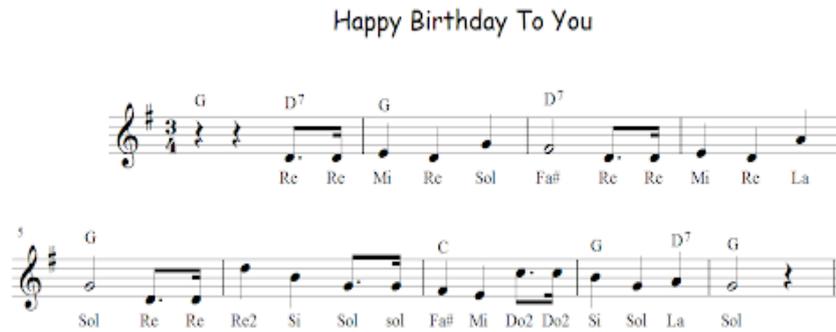


Figure 2.a Flute notes of Happy Birthday To You song.

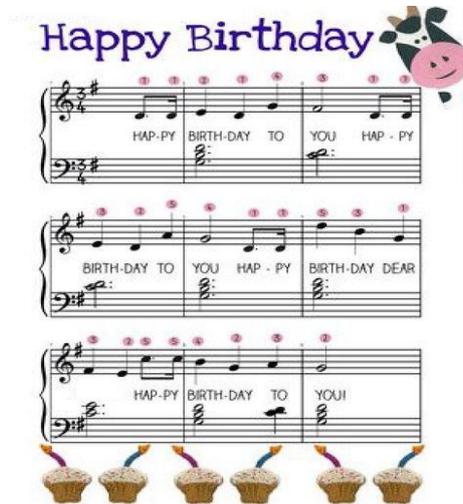


Figure 2.b Necessary pointer to play Happy Birthday To You song in Ar-Flute app.

The second song are the " Little Frog " song , which the children will enjoy while playing and are familiar with the melody of their ears (Figure 3 a) . Its tempo is at normal tempo compared to the first song . The marker used to play the Little Frog song is shown in Figure 3.b.



Figure 3.a Flute notes of Little Frog song

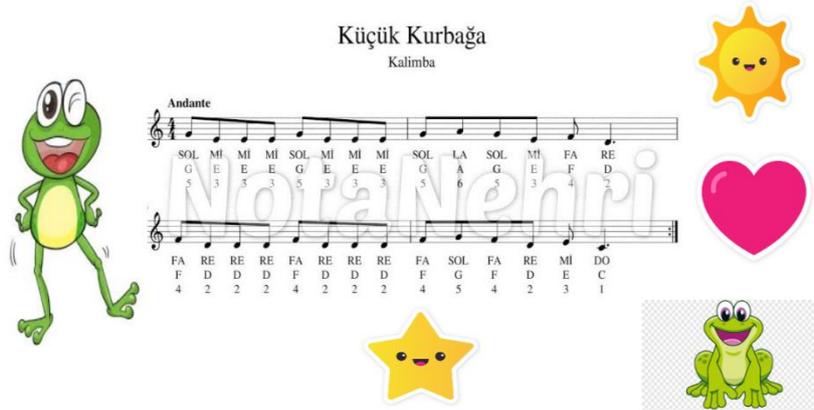


Figure 3.b Necessary marker for Little Frog song to play in Ar-Flute application.

Ar-Flute application can be installed on any device with an android operating system and a camera. After Ar-Flute is loaded, it is opened by double-clicking on it and the device is held on the specially printed card with the note. When the camera notices the note on the card, the 3D Flute appears and starts playing the notes of the song written on the card it is on. While playing, the light comes on in the holes that should be on the fingers according to the notes, and by the student blowing the flute and moving his fingers on the flute according to these lights, Ar-Flute is experienced in the accompaniment of the 3D flute in practice [Figures 4.a and 4.b].

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Figure 4.a Happy Birthday to You Song

Figure 4.b Little Frog Song

Ar-Flute starts playing the song notes when the camera notices the pointer, and red lights appear on the left of the notes played with a randomly assigned color, the sound and the holes that need to be closed according to the note.

Results and Discussion

AR is a new technology that has emerged as the potential for application of education. While much research has been done on AR, very little has been done in the field of music education. In recent years, the number of studies on AR has been increasing due to the effectiveness of this technology. In particular, AR provides an efficient way to represent a model that needs visualization. AR also supports seamless interaction between real and virtual environments.

Technology has become embedded in education and results have shown a positive impact on learning and teaching styles. Lessons powered by technology will lead to more innovative ways of teaching and learning. This is because the use of technology involves real-world problems, available information resources, simulations of concepts, and communication with professionals in the field. It is also believed that learning using technology will complement traditional forms of teaching and learning. The integration of technology also provides a means to increase student learning and engagement. Therefore, recent studies have aimed to better understand from the students' perspective the applications adapted to the lessons, including multimedia, computer-based simulations, animations and statistical software.

Research shows that musical training truly to enlarge your brain, stimulating new neural connections that act as a defense against memory loss, cognitive decline, and decreased auditory function. Your brain works every time you play, and just like training in the gym – the more you play, the greater and longer-lasting the benefits. Music is an excellent tool for memory skills. Remembering the words of a song we listened to after a long time is perhaps the proof of this. On the other hand, students increase their mental abilities in various ways while participating in music education. Studying music is an excellent way to improve memorization skills. In Figures 2.a, 2.b and 2.c, the interest and motivation of the student that has experienced music education with the Ar-Flute application for the first time can be seen.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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Author Information

Hatice GUCLU

Necmettin Erbakan University
Yaka Mah. Yeni Meram Cad. Kasım Halife Sok. Meram /
Konya, Turkey
Contact E-Mail: hatice.erdeve@gmail.com

Sabri KOCER

Necmettin Erbakan University
Yaka Mah. Yeni Meram Cad. Kasım Halife Sok. Meram /
Konya, Turkey

Ozgur DUNDAR

Necmettin Erbakan University
Yaka Mah. Yeni Meram Cad. Kasım Halife Sok. Meram /
Konya, Turkey

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